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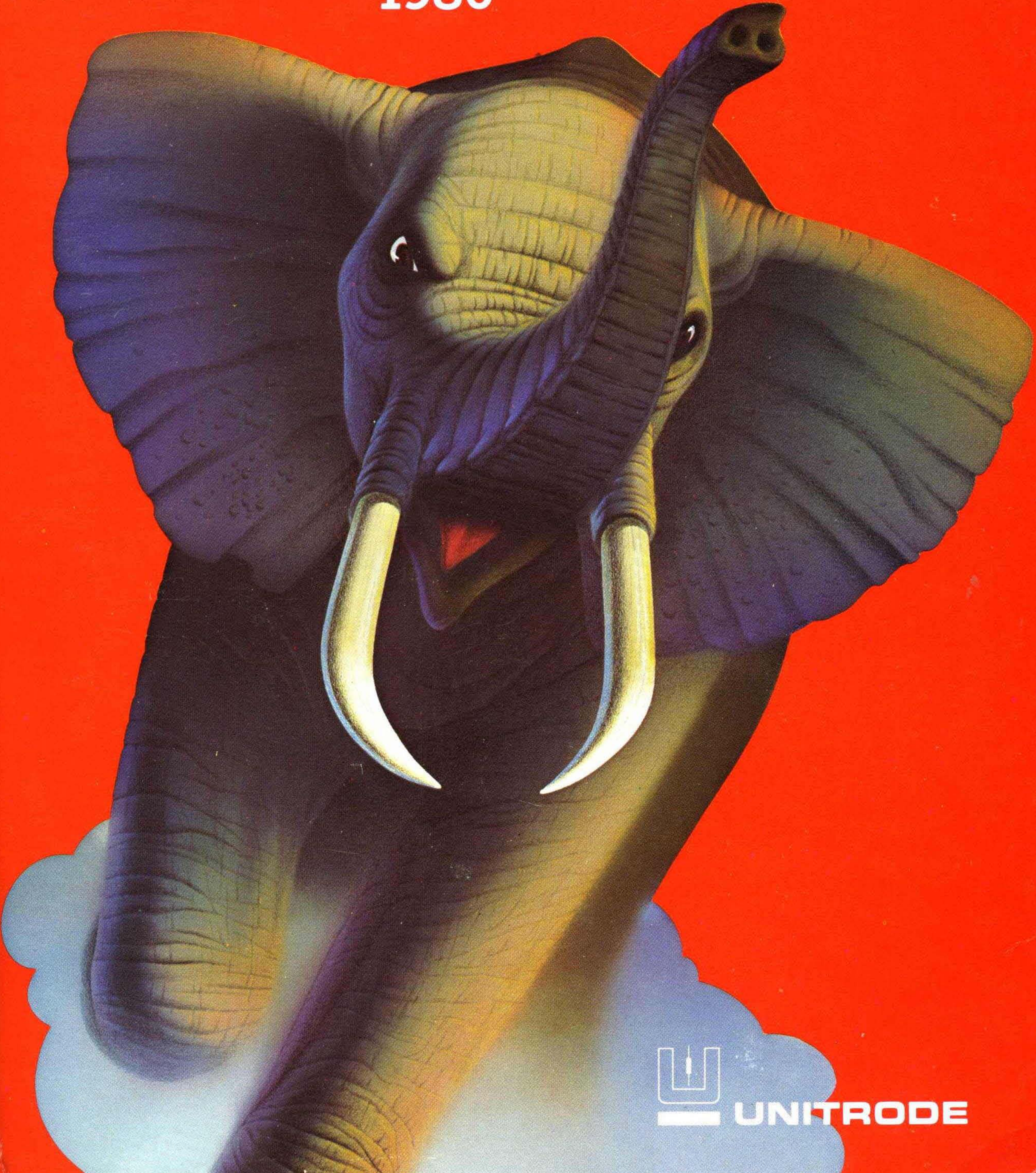

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UNITRODE
SEMICONDUCTOR
DATABOOK
1980

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INTRODUCTION

From its inception 20 years ago, Unitrode has acquired a reputation for maintaining an unusually high level of quality, performance, and reliability in its entire line of silicon semiconductor devices. Excellence was first established with Unitrode's uniquely controlled avalanche, hard-glass passivated Rectifiers and Zener Diodes, and later expanded, through corporate acquisition, to include planar passivated low-power, high-speed SCRs, PUTs and high-speed Power Transistors and Darlingtons.

Unitrode has been at the forefront in meeting the fast changing needs of industry. The Company has also developed:

1) very high speed rectifiers designed to optimize the performance of switching power supplies,
2) the first Hybrid Power Switching Circuits for Switching Regulator applications in the industry,
3) Power Transistors that significantly improve turnoff and $E_{s/b}$ characteristics by utilizing a new transistor design concept,
4) State-of-the-art Schottky rectifiers that offer higher current ratings and better performance characteristics than conventional Schottkys,
5) SCRs fast enough for laser pulse modulators,
6) High Voltage stacks and Multipliers,
7) Doorbell® Rectifier Modules to provide reliable, economic solid-state rectifier tube replacements in high-voltage power supplies,
8) Axial leaded, glass encapsulated, taped and reeled switching diodes.

Unitrode also manufactures monolithic ceramic capacitors available in axial lead and dual-in-line packages, and as chips. The capacitors are available in NPO, X7R and Z5U dielectric formulations.

Doorbell® is a registered trademark of Unitrode Corporation.

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*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER
241	1N5550, J, JTX, JTXV	5.0A; 200V
241	1N5551, J, JTX, JTXV	5.0A; 400V
241	1N5552, J, JTX, JTXV	5.0A; 600V
241	1N5553, J, JTX, JTXV	5.0A; 800V
		RECTIFIER MODULE
357	1N5597, J	10kV
357	1N5600, J	5kV
357	1N5603, J	5kV
		TRANSIENT VOLTAGE SUPPRESSOR
490	1N5610, J, JTX	33V
490	1N5611, J, JTX	43.7V
490	1N5612, J, JTX	54V
490	1N5613, J, JTX	191V
		RECTIFIER
243	1N5614, J, JTX, JTXV	1.0A; 200V
245	1N5615, J, JTX, JTXV	1.0A; 200V
243	1N5616, J, JTX, JTXV	1.0A; 400V
245	1N5617, J, JTX, JTXV	1.0A; 400V
243	1N5618, J, JTX, JTXV	1.0A; 600V
245	1N5619, J, JTX, JTXV	1.0A; 600V
243	1N5620, J, JTX, JTXV	1.0A; 800V
		PIN DIODE
653	1N5767	General Purpose, PIN
		RECTIFIER
247	1N5802	2.5A; 50V
251	1N5802, J, JTX, JTXV	2.5A; 50V
247	1N5803	2.5A; 75V
247	1N5804	2.5A; 100V
251	1N5804, J, JTX, JTXV	2.5A; 100V
247	1N5805	2.5A; 125V
247	1N5806	2.5A; 150V
251	1N5806, J, JTX, JTXV	2.5A; 150V
247	1N5807	6.0A; 50V
251	1N5807, J, JTX, JTXV	6.0A; 50V
247	1N5808	6.0A; 75V
247	1N5809	6.0A; 100V
251	1N5809, J, JTX, JTXV	6.0A; 100V
247	1N5810	6.0A; 125V
247	1N5811	6.0A; 150V
251	1N5811, J, JTX, JTXV	6.0A; 150V
247	1N5812	20.0A; 50V; DO-4
254	1N5812, J, JTX, JTXV	20.0A; 50V; DO-4
247	1N5813	20.0A; 75V; DO-4
247	1N5814	20.0A; 100V; DO-4
254	1N5814, J, JTX, JTXV	20.0A; 100V; DO-4
247	1N5815	20.0A; 125V; DO-4
247	1N5816	20.0A; 150V; DO-4
254	1N5816, J, JTX, JTXV	20.0A; 150V; DO-4
		PIN DIODE
653	1N5957	Low Distortion, AGC Diode
		SCHOTTKY RECTIFIER
256	1N6095	25A; 30V; DO-4
256	1N6096	25A; 40V; DO-4
258	1N6097	50A; 30V; DO-5
258	1N6098	50A; 40V; DO-5
		SCR
*	2N876	.35A@100°C 15V; TO-18
*	2N877	.35A@100°C 30V; TO-18
*	2N878	.35A@100°C 60V; TO-18
*	2N879	.35A@100°C 100V; TO-18
*	2N880	.35A@100°C 150V; TO-18
		SCR
*	2N881	.35A@100°C 200V;TO-18
*	2N882	.35A@100°C 300V;TO-18
*	2N883	.35A@100°C 400V;TO-18
*	2N884	.35A@100°C 15V; TO-18
*	2N885	.35A@100°C 30V; TO-18
*	2N886	.35A@100°C 60V; TO-18
*	2N887	.35A@100°C 100V;TO-18
*	2N888	.35A@100°C 150V;TO-18
*	2N889	.35A@100°C 200V;TO-18
*	2N890	.35A@100°C 300V;TO-18
*	2N891	.35A@100°C 400V;TO-18
*	2N948	.26A@125°C 30V;TO-18
*	2N949	.26A@125°C 60V;TO-18
*	2N950	.26A@125°C 100V;TO-18
*	2N951	.26A@125°C 200V;TO-18
*	2N1595	1.0A@80°C 50V; TO-39
*	2N1596	1.0A@80°C 100V; TO-39
*	2N1597	1.0A@80°C 200V; TO-39
*	2N1598	1.0A@80°C 300V; TO-39
*	2N1599	1.0A@80°C 400V; TO-39
		POWER TRANSISTOR
*	2N1647	NPN; 3.0A; 60V; TO-59
*	2N1648	NPN; 3.0A; 80V; TO-59
*	2N1649	NPN; 3.0A; 60V; TO-59
*	2N1650	NPN; 3.0A; 80V; TO-59
*	2N1714	NPN; 0.75A; 60V; TO-5
*	2N1715	NPN; 0.75A; 100V; TO-5
*	2N1716	NPN; 0.75A; 60V; TO-5
*	2N1717	NPN; 0.75A; 100V; TO-5
*	2N1718	NPN; 0.75A; 60V; TO-5 Stud Mount
*	2N1719	NPN; 0.75A; 100V; TO-5; Stud Mount
*	2N1720	NPN; 0.75A; 60V; TO-5; Stud Mount
*	2N1721	NPN; 0.75A; 100V; TO-5 Stud Mount
		SCR
*	2N1869	1.25A@100°C 15V; TO-9
518	2N1870A, J	1.25A@100°C 30V; TO-9
518	2N1871A, J	1.25A@100°C 60V; TO-9
518	2N1872A, J	1.25A@100°C 100V; TO-9
518	2N1873A	1.25A@100°C 150V; TO-9
518	2N1874A, J	1.25A@100°C 200V; TO-9
522	2N1875	1.25A@100°C 15V; TO-9
522	2N1876	1.25A@100°C 30V; TO-9
522	2N1877	1.25A@100°C 60V; TO-9
522	2N1878	1.25A@100°C 100V; TO-9
522	2N1879	1.25A@100°C 150V; TO-9
522	2N1880	1.25A@100°C 200V; TO-9
524	2N1881	1.0A@100°C 30V; TO-9
524	2N1882	1.0A@100°C 60V; TO-9
524	2N1883	1.0A@100°C 100V; TO-9
524	2N1884	1.0A@100°C 150V; TO-9
524	2N1885	1.0A@100°C 200V; TO-9
*	2N2009	1.3A@80°C 25V; TO-39
*	2N2010	1.3A@80°C 50V; TO-39
*	2N2011	1.3A@80°C 100V; TO-39
*	2N2012	1.3A@80°C 200V; TO-39
*	2N2013	1.3A@80°C 300V; TO-39
*	2N2014	1.3A@80°C 400V; TO-39
		POWER TRANSISTOR
*	2N2150	NPN; 2.0A; 80V; TO-59
54	2N2151, J, JTX	NPN; 2.0A; 80V; TO-59

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		SCR
526	2N2322	1.6A@85°C 25V; TO-39
526	2N2323, J, JTX, JTXV	1.6A@85°C 50V; TO-5
526	2N2323A, J, JTX, JTXV	1.6A@85°C 50V; TO-5
526	2N2324, J, JTX, JTXV	1.6A@85°C 100V; TO-5
526	2N2324A, J, JTX, JTXV	1.6A@85°C 100V; TO-5
526	2N2325	1.6A@85°C 150V; TO-39
526	2N2325A	1.6A@85°C 150V; TO-39
526	2N2326, J, JTX, JTXV	1.6A@85°C 200V; TO-5
526	2N2326A, J, JTX, JTXV	1.6A@85°C 200V; TO-5
526	2N2327	1.6A@85°C 250V; TO-39
526	2N2327A	1.6A@85°C 250V; TO-39
526	2N2328, J, JTX, JTXV	1.6A@85°C 300V; TO-5
526	2N2328A, J, JTX, JTXV	1.6A@85°C 300V; TO-5
526	2N2329, J, JTX, JTXV	1.6A@85°C 400V; TO-5
*	2N2344	1.6A@55°C 25V; TO-39
*	2N2345	1.6A@55°C 50V; TO-39
*	2N2346	1.6A@55°C 100V; TO-39
*	2N2347	1.6A@55°C 150V; TO-39
*	2N2348	1.6A@55°C 200V; TO-39
		POWER TRANSISTOR
*	2N2657	NPN; 5.0A; 60V; TO-5
*	2N2658	NPN; 5.0A; 80V; TO-5
		SCR
*	2N2679	.35A@55°C 30V; TO-18
*	2N2680	.35A@55°C 60V; TO-18
*	2N2681	.35A@55°C 100V; TO-18
*	2N2682	.35A@55°C 200V; TO-18
*	2N2683	.28A@55°C 30V; TO-18
*	2N2684	.28A@55°C 60V; TO-18
*	2N2685	.28A@55°C 100V; TO-18
*	2N2686	.28A@55°C 200V; TO-18
*	2N2687	.28A@55°C 30V; TO-18
*	2N2688	.28A@55°C 60V; TO-18
*	2N2689	.28A@55°C 100V; TO-18
*	2N2690	.28A@55°C 200V; TO-18
		POWER TRANSISTOR
*	2N2858	NPN; 3A; 80V; TO-5
*	2N2859	NPN; 3A; 100V; TO-5
*	2N2877, 2N2878	NPN; 5A; 80V; TO-111
*	2N2879	NPN; 5A; 100V; TO-111
58	2N2880, J, JTX, JTXV	NPN; 5.0A; 80V; TO-59
*	2N2890, 2N2891	NPN; 5A; 80V; TO-5
*	2N2892, 2N2893	NPN; 5A; 80V; TO-59
*	2N2983	NPN; 3A; 80V; TO-5
*	2N2984	NPN; 3A; 120V; TO-5
*	2N2985	NPN; 3A; 80V; TO-5
*	2N2986	NPN; 3A; 120V; TO-5
*	2N2987	NPN; 1A; 80V; TO-5
*	2N2988	NPN; 1A; 100V; TO-5
*	2N2989	NPN; 1A; 80V; TO-5
*	2N2990	NPN; 1A; 100V; TO-5
*	2N2991	NPN; 1A; 80V; TO-5 Stud
*	2N2992	NPN; 1A; 100V; TO-5 Stud
*	2N2993	NPN; 1A; 80V; TO-5 Stud
*	2N2994, 2N2995	NPN; 1A; 100V; TO-5 Stud
		SCR
*	2N3001	.25A@55°C 30V; TO-18
*	2N3002	.25A@55°C 60V; TO-18
*	2N3003	.25A@55°C 100V; TO-18
*	2N3004	.25A@55°C 200V; TO-18
*	2N3005	.25A@55°C 30V; TO-18
*	2N3006	.25A@55°C 60V; TO-18
*	2N3007	.25A@55°C 100V; TO-18
*	2N3008	.25A@55°C 200V; TO-18
		SCR
529	2N3027, J, JTX	500mA@100°C 30V; TO-18
529	2N3028, J, JTX	500mA@100°C 60V; TO-18
529	2N3029, J, JTX	500mA@100°C 100V;TO-18
529	2N3030, J, JTX	.5A@100°C 30V; TO-18
529	2N3031, J, JTX	.5A@100°C 60V; TO-18
529	2N3032, J, JTX	.5A@100°C 100V; TO-18
*	2N3273	2.2A@85°C 100V; TO-39
*	2N3274	2.2A@85°C 200V; TO-39
*	2N3275	2.2A@85°C 300V; TO-39
*	2N3276	2.2A@85°C 400V; TO-39
		POWER TRANSISTOR
62	2N3418, J, JTX, JTXV	NPN; 3.0A; 60V; TO-5
62	2N3419, J, JTX, JTXV	NPN; 3.0A; 80V; TO-5
62	2N3420, J, JTX, JTXV	NPN; 3.0A; 60V; TO-5
62	2N3421, J, JTX, JTXV	NPN; 3.0A; 80V; TO-5
*	2N3445	NPN; 7.5A; 60V; TO-3
*	2N3446	NPN; 7.5A; 80V; TO-3
*	2N3447	NPN; 7.5A; 60V; TO-3
*	2N3448	NPN; 7.5A; 80V; TO-3
*	2N3469	NPN; 5.0A; 25V; TO-5
		SCR
*	2N3555	1.6A; 30V; TO-39
*	2N3556	1.6A; 60V; TO-39
*	2N3557	1.6A; 100V; TO-39
*	2N3558	1.6A; 200V; TO-39
*	2N3559	1.6A; 30V; TO-39
*	2N3560	1.6A; 60V; TO-39
*	2N3561	1.6A; 100V; TO-39
*	2N3562	1.6A; 200V; TO-39
		POWER TRANSISTOR
*	2N3744	NPN; 5.0A; 40V; TO-111
*	2N3745	NPN; 5.0A; 60V; TO-111
*	2N3746	NPN; 5.0A; 80V; TO-111
*	2N3747	NPN; 5.0A; 40V; TO-111
*	2N3748	NPN; 5.0A; 60V; TO-111
58	2N3749, J, JTX, JTXV	NPN; 5.0A; 80V; TO-111
*	2N3750	NPN; 5.0A; 40V; TO-111
*	2N3751	NPN; 5.0A; 60V; TO-111
*	2N3752	NPN; 5.0A; 80V; TO-111
*	2N3850	NPN; 5.0A; 80V; TO-59
*	2N3851	NPN; 5.0A; 80V; TO-59
*	2N3852	NPN; 5.0A; 40V; TO-59
*	2N3853	NPN; 5.0A; 40V; TO-59
66	2N3996, J, JTX, JTXV	NPN; 5.0A; 80V; TO-111
66	2N3997, J, JTX, JTXV	NPN; 5.0A; 80V; TO-111
66	2N3998, J, JTX, JTXV	NPN; 5.0A; 80V; TO-59
66	2N3999, J, JTX, JTXV	NPN; 5.0A; 80V; TO-59
*	2N4000	NPN; 1.0A; 80V; TO-5
*	2N4001	NPN; 1.0A; 100V; TO-5
*	2N4070	NPN; 10.0A; 100V; TO-3
*	2N4075	NPN; 3.0A; 80V; TO-111
*	2N4076	NPN; 3.0A; 80V; TO-111
		SCR
*	2N4108	180mA@25°C 50V; TO-18
*	2N4109	180mA@25°C 100V; TO-18
*	2N4110	180mA@25°C 200V; TO-18
*	2N4144	250mA@75°C 15V; TO-18
*	2N4145	250mA@75°C 30V; TO-18
*	2N4146	250mA@75°C 60V; TO-18
*	2N4147	250mA@75°C 100V; TO-18
*	2N4148	250mA@75°C 150V; TO-18
*	2N4149	250mA@75°C 200V; TO-18

*Contact Unitrode for specifications and ratings.
Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		POWER TRANSISTOR
70	2N4150, J, JTX, JTXV	NPN; 10.0A; 70V; TO-5
		SCR
*	2N4212	1.0A@85°C 25V; TO-39
*	2N4213	1.0A@85°C 50V; TO-39
*	2N4214	1.0A@85°C 100V; TO-39
*	2N4215	1.0A@85°C 150V; TO-39
*	2N4216	1.0A@85°C 200V; TO-39
*	2N4217	1.0A@85°C 250V; TO-39
*	2N4218	1.0A@85°C 300V; TO-39
*	2N4219	1.0A@85°C 400V; TO-39
		POWER TRANSISTOR
*	2N4237-2N4239	NPN; 1.0A
*	2N4300	NPN; 2.0A
74	2N5038, J, JTX, JTXV	NPN; 20.0A; 150V; TO-3
74	2N5039, J, JTX, JTXV	NPN; 20.0A; 120V; TO-3
		SCR
535	2N5060	0.8A@70°C 30V; TO-92
535	2N5061	0.8A@70°C 60V; TO-92
535	2N5062	0.8A@70°C 100V; TO-92
535	2N5063	0.8A@70°C 150V; TO-92
535	2N5064	0.8A@70°C 200V; TO-92
		POWER TRANSISTOR
*	2N5074-2N5075	NPN; 3A; 200V; TO-59
*	2N5076-2N5077	NPN; 3A; 250V; TO-59
*	2N5334	NPN; 3A; 60V; TO-39
*	2N5335	NPN; 3A; 80V; TO-39
*	2N5336-2N5337	NPN; 5A; 80V; TO-39
*	2N5338, 2N5339	NPN; 5A; 100V; TO-39
*	2N5346, 2N5347	NPN; 7A; 80V; TO-59
*	2N5348, 2N5349	NPN; 7A; 100V; TO-59
*	2N5477, 2N5478	NPN; 7A; 80V; TO-59
*	2N5479, 2N5480	NPN; 7A; 100V; TO-59
78	2N5487	NPN; 5A; 80V; TO-5 Low Profile
78	2N5487-1	NPN; 5A; 80V; TO-5
78	2N5487-3	NPN; 5A; 80V; TO-5 Stud
78	2N5488	NPN; 5A; 100V; TO-5 Low Profile
78	2N5488-1	NPN; 5A; 100V; TO-5
78	2N5488-3	NPN; 5A; 100V; TO-5 Stud
81	2N5552	NPN; 10A; 80V; TO-5
81	2N5552-4	NPN; 10A; 80V; TO-5 Stud
83	2N5658	NPN; 20A; 80V; TO-59
83	2N5659	NPN; 20A; 80V; TO-111
85	2N5660, J, JTX, JTXV	NPN; 3A; 200V; TO-66
85	2N5661, J, JTX, JTXV	NPN; 3A; 300V; TO-66
85	2N5662, J, JTX, JTXV	NPN; 3A; 200V; TO-5
85	2N5663, J, JTX, JTXV	NPN; 3A; 300V; TO-5
90	2N5664, J, JTX, JTXV	NPN; 5A; 200V; TO-66
90	2N5665, J, JTX, JTXV	NPN; 5A; 300V; TO-66
90	2N5666, J, JTX, JTXV	NPN; 5A; 200V; TO-5
90	2N5667, J, JTX, JTXV	NPN; 5A; 300V; TO-5
95	2N5671	NPN; 30A; 120V; TO-3
95	2N5672	NPN; 30A; 150V; TO-3
		SCR
539	2N5724	1.6A@85°C 60V; TO-39
539	2N5725	1.6A@85°C 100V; TO-39
539	2N5726	1.6A@85°C 200V; TO-39
539	2N5727	1.6A@85°C 300V; TO-39
539	2N5728	1.6A@85°C 400V; TO-39
		POWER TRANSISTOR
99	2N5838	NPN; 3A; 275V; TO-3
99	2N5839	NPN; 3A; 300V; TO-3
99	2N5840	NPN; 3A; 375V; TO-3

PAGE	PART NUMBER	DESCRIPTION
		PUT
543	2N6027, 2N6028	375mW@25°C 40V; TO-92
		POWER TRANSISTOR
*	2N6077	NPN; 7A; 300V; TO-66
*	2N6078	NPN; 7A; 275V; TO-66
		PUT
547	2N6119	400mW@25°C 40V; TO-18
547	2N6120	400mW@25°C 40V; TO-18
551	2N6137, 2N6138, J, JTX	400mW@25°C 40V; TO-18
		POWER TRANSISTOR
103	2N6232	NPN; 10A; 100V; TO-5
103	2N6232-4	NPN; 10A; 100V; TO-5 Stud
*	2N6233	NPN; 5A; 225V; TO-66
*	2N6234	NPN; 5A; 275V; TO-66
*	2N6235	NPN; 5A; 325V; TO-66
105	2N6249	NPN; 10A; 300V; TO-3
105	2N6250	NPN; 10A; 375V; TO-3
105	2N6251	NPN; 10A; 450V; TO-3
109	2N6306	NPN; 8.0A; 500V; TO-3
109	2N6307	NPN; 8.0A; 600V; TO-3
109	2N6308	NPN; 8.0A; 700V; TO-3
		SCR
*	2N6332	2.0A@80°C 30V; TO-39
*	2N6333	2.0A@80°C 50V; TO-39
*	2N6334	2.0A@80°C 100V; TO-39
*	2N6335	2.0A@80°C 200V; TO-39
*	2N6336	2.0A@80°C 300V; TO-39
*	2N6337	2.0A@80°C 400V; TO-39
		POWER DARLINGTON
113	2N6350, J, JTX	NPN; 10.0A; 80V; TO-33
113	2N6351, J, JTX	NPN; 10.0A; 150V; TO-33
113	2N6352, J, JTX	NPN; 10.0A; 80V; TO-66
113	2N6353,J, JTX	NPN; 10.0A; 150V; TO-66
118	2N6354	NPN; 10.0A; 150V; TO-3
118	2N6496	NPN; 15.0A; 150V; TO-3
122	2N6510	NPN; 7.0A; 250V; TO-3
122	2N6511	NPN; 7.0A; 300V; TO-3
122	2N6512	NPN; 7.0A; 350V; TO-3
122	2N6513	NPN; 7.0A; 400V; TO-3
122	2N6514	NPN; 7.0A; 350V; TO-3
126	2N6542	NPN; 5A; 650V; TO-3
126	2N6543	NPN; 5A; 850V; TO-3
130	2N6544	NPN; 8.0A; 650V; TO-3
130	2N6545	NPN; 8.0A; 850V; TO-3
134	2N6546	NPN; 15A; 650V; TO-3
134	2N6547	NPN; 15A; 850V; TO-3
555	2N6564	0.8A@70°C 300V; TO-92
555	2N6565	0.8A@70°C 400V; TO-92
		SCR
557	2N6681 (IP200)	1A; 100V; TO-92
557	2N6682 (IP202)	1A; 200V; TO-92
557	2N6683 (IP204)	1A; 400V; TO-92
557	2N6684 (IP206)	1A; 600V; TO-92
557	2N6685 (IP208)	1A; 800V; TO-92
*	3L1015	0.5A@75°C 15V; TO-18
*	3L1030	0.5A@75°C 30V; TO-18
*	3L1060	0.5A@75°C 60V; TO-18
*	3L1100	0.5A@75°C 100V; TO-18
*	3L2015	0.5A@100°C 15V; TO-18
*	3L2030	0.5A@100°C 30V; TO-18
*	3L2060	0.5A@100°C 60V; TO-18
*	3L2100	0.5A@100°C 100V; TO-18

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Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		FULL WAVE BRIDGE
431	469-1, J, JTX	1 ph; 10A; 200V
431	469-2, J, JTX	1 ph; 10A; 400V
431	469-3, J, JTX	1 ph; 10A; 600V
433	483-1JTX	3 ph; 25.0A; 200V
433	483-2JTX	3 ph; 25.0A; 400V
433	483-3JTX	3 ph; 25.0A; 600V
435	673-1	1 ph; 1.5A; 100V
435	673-2	1 ph; 1.5A; 200V
435	673-3	1 ph; 1.5A; 300V
435	673-4	1 ph; 1.5A; 400V
435	673-5	1 ph; 1.5A; 500V
435	673-6	1 ph; 1.5A; 600V
437	673-7	1 ph; H.V.; 1200V
437	673-7.5	1 ph; H.V.; 1800V
437	673-8	1 ph; H.V.; 2400V
437	673-8.5	1 ph; H.V.; 3000V
437	673-9	1 ph; H.V.; 3600V
437	673-10	1 ph; H.V.; 4200V
437	673-11	1 ph; H.V.; 4800V
437	673-12	1 ph; H.V.; 5000V
435	676-1	1 ph; 1.0A; 100V
435	676-2	1 ph; 1.0A; 200V
435	676-3	1 ph; 1.0A; 300V
435	676-4	1 ph; 1.0A; 400V
435	676-5	1 ph; 1.0A; 500V
435	676-6	1 ph; 1.0A; 600V
437	676-12	1 ph; H.V.; 1200V
437	676-18	1 ph; H.V.; 1800V
437	676-24	1 ph; H.V.; 2400V
437	676-30	1 ph; H.V.; 3000V
437	676-36	1 ph; H.V.; 3600V
437	676-42	1 ph; H.V.; 4200V
437	676-48	1 ph; H.V.; 4800V
437	676-50	1 ph; H.V.; 5000V
440	678-1	3 ph; 25A; 100V
440	678-2	3 ph; 25A; 200V
440	678-3	3 ph; 25A; 300V
440	678-4	3 ph; 25A; 400V
440	678-5	3 ph; 25A; 500V
440	678-6	3 ph; 25A; 600V
443	679-1	1 ph; 25A; 100V
443	679-2	1 ph; 25A; 200V
443	679-3	1 ph; 25A; 300V
443	679-4	1 ph; 25A; 400V
443	679-5	1 ph; 25A; 500V
443	679-6	1 ph; 25A; 600V
443	680-1	1 ph; 10A; 100V
443	680-2	1 ph; 10A; 200V
443	680-3	1 ph; 10A; 300V
443	680-4	1 ph; 10A; 400V
443	680-5	1 ph; 10A; 500V
443	680-6	1 ph; 10A; 600V
		DOUBLER OR CENTER-TAP
446	681-1	15A; 100V
446	681-2	15A; 200V
446	681-3	15A; 300V
446	681-4	15A; 400V
446	681-5	15A; 500V
446	681-6	15A; 600V
		FULL WAVE BRIDGE
440	682-1	3 ph; 20A; 100V
440	682-2	3 ph; 20A; 200V
440	682-3	3 ph; 20A; 300V
440	682-4	3 ph; 20A; 400V
		FULL WAVE BRIDGE
440	682-5	3 ph; 20A; 500V
440	682-6	3 ph; 20A; 600V
443	683-1	1 ph; 20A; 100V
443	683-2	1 ph; 20A; 200V
443	683-3	1 ph; 20A; 300V
443	683-4	1 ph; 20A; 400V
443	683-5	1 ph; 20A; 500V
443	683-6	1 ph; 20A; 600V
443	684-1	1 ph; 10A; 100V
443	684-2	1 ph; 10A; 200V
443	684-3	1 ph; 10A; 300V
443	684-4	1 ph; 10A; 400V
443	684-5	1 ph; 10A; 500V
443	684-6	1 ph; 10A; 600V
		RECTIFIER MODULE
360	688-10	10kV
360	688-12	12kV
360	688-15	15kV
360	688-18	18kV
360	688-20	20kV
360	688-25	25kV
		DOUBLER OR CENTER-TAP
446	689-1	15A; 100V
446	689-2	15A; 200V
446	689-3	15A; 300V
446	689-4	15A; 400V
446	689-5	15A; 500V
446	689-6	15A; 600V
		FULL WAVE BRIDGE
440	695-1	3 ph; 15A; 100V
440	695-2	3 ph; 15A; 200V
440	695-3	3 ph; 15A; 300V
440	695-4	3 ph; 15A; 400V
440	695-5	3 ph; 15A; 500V
440	695-6	3 ph; 15A; 600V
440	696-1	3 ph; 15A; 100V
440	696-2	3 ph; 15A; 200V
440	696-3	3 ph; 15A; 300V
440	696-4	3 ph; 15A; 400V
440	696-5	3 ph; 15A; 500V
440	696-6	3 ph; 15A; 600V
448	697-1	1 ph; 2.5A; 100V
448	697-2	1 ph; 2.5A; 200V
448	697-3	1 ph; 2.5A; 300V
448	697-4	1 ph; 2.5A; 400V
448	697-5	1 ph; 2.5A; 500V
448	697-6	1 ph; 2.5A; 600V
448	698-1	1 ph; 2.25A; 100V
448	698-2	1 ph; 2.25A; 200V
448	698-3	1 ph; 2.25A; 300V
448	698-4	1 ph; 2.25A; 400V
448	698-5	1 ph; 2.25A; 500V
448	698-6	1 ph; 2.25A; 600V
450	700-1	3 ph; 2.5A; 100V
450	700-2	3 ph; 2.5A; 200V
450	700-3	3 ph; 2.5A; 300V
450	700-4	3 ph; 2.5A; 400V
450	700-5	3 ph; 2.5A; 500V
450	700-6	3 ph; 2.5A; 600V
450	701-1	3 ph; 2.25A; 100V
450	701-2	3 ph; 2.25A; 200V
450	701-3	3 ph; 2.25A; 300V
450	701-4	3 ph; 2.25A; 400V

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PAGE	PART NUMBER	DESCRIPTION
		HIGH VOLTAGE RECTIFIER
370	HVFS10000	10kV
370	HVFS12500	12.5kV
370	HVFS15000	15kV
370	HVFS17500	17.5kV
370	HVFS20000	20kV
372	HVH5000	5.0kV
372	HVH7500	7.5kV
372	HVH10000	10kV
372	HVH12500	12.5kV
372	HVH15000	15kV
372	HVH20000	20kV
372	HVH25000	25kV
374	HVHF5000	5.0kV
374	HVHF7500	7.5kV
374	HVHF10000	10kV
374	HVHF12500	12.5kV
374	HVHF15000	15kV
374	HVHF20000	20kV
374	HVHF25000	25kV
376	HVHJ15K	15kV
376	HVHJ20K	20kV
376	HVHJ22.5K	22.5kV
376	HVHJ25K	25kV
376	HVHJ30K	30kV
376	HVHJ35K	35kV
376	HVHJ37.5K	37.5kV
376	HVHJ40K	40kV
376	HVHJ45K	45kV
378	HVHS2500	2.5kV
378	HVHS5000	5.0kV
378	HVHS7500	7.5kV
378	HVHS10000	10kV
378	HVHS12500	12.5kV
378	HVHS15000	15kV
378	HVHS17500	17.5kV
378	HVHS20000	20kV
380	HVJX15K	15kV
380	HVJX20K	20kV
380	HVJX22.5K	22.5kV
380	HVJX25K	25kV
380	HVJX30K	30kV
380	HVJX35K	35kV
380	HVJX37.5K	37.5kV
380	HVJX40K	40kV
380	HVJX45K	45kV
364	HVX10	1.0kV
364	HVX15	1.5kV
364	HVX20	2.0kV
364	HVX25	2.5kV
364	HVX30	3.0kV
364	HVX40	4.0kV
364	HVX50	5.0kV
364	HVX75	7.5kV
364	HVX100	10kV
		TRIAC
577	IB202	.8A; 200V; TO-92
577	IB204	.8A; 400V; TO-92
577	IB206	.8A; 600V; TO-92
579	ID100	0.5A@100°C 30V; TO-18
579	ID101	0.5A@100°C 60V; TO-18
579	ID102	0.5A@100°C 100V; TO-18
579	ID103	0.5A@100°C 150V; TO-18
579	ID104	0.5A@100°C 200V; TO-18
579	ID105	0.5A@100°C 300V; TO-18
		TRIAC
579	ID106	0.5A@100°C 400V; TO-18
582	ID200	1.6A@70°C 50V; TO-39
582	ID201	1.6A@70°C 100V; TO-39
582	ID202	1.6A@70°C 150V; TO-39
582	ID203	1.6A@70°C 200V; TO-39
582	ID300	1.6A@70°C 300V; TO-39
582	ID301	1.6A@70°C 400V; TO-39
584	IP100	0.8A@70°C 30V; TO-92
584	IP101	0.8A@70°C 60V; TO-92
584	IP102	0.8A@70°C 100V; TO-92
584	IP103	0.8A@70°C 150V; TO-92
584	IP104	0.8A@70°C 200V; TO-92
588	IP105	0.8A@70°C 300V; TO-92
588	IP106	0.8A@70°C 400V; TO-92
557	IP200 (2N6681)	1A; 100V; TO-92
557	IP202 (2N6682)	1A; 200V; TO-92
557	IP204 (2N6683)	1A; 400V; TO-92
557	IP206 (2N6684)	1A; 600V; TO-92
557	IP208 (2N6685)	1A; 800V; TO-92
		HIGH VOLTAGE RECTIFIER
382	KX15	1.5kV
382	KX20	2.0kV
382	KX25	2.5kV
382	KX30	3.0kV
382	KX40	4.0kV
382	KX50	5.0kV
382	KX60	6.0kV
382	KX80	8.0kV
382	KX100	10kV
382	KXS15	1.5kV
382	KXS20	2.0kV
382	KXS25	2.5kV
382	KXS30	3.0kV
382	KXS40	4.0kV
382	KXS50	5.0kV
382	KXS60	6.0kV
382	KXS80	8.0kV
382	KXS100	10kV
		TRIAC
590	L1B04302F	30A; 200V
590	L1B04304F	30A; 400V
590	L1B04306F	30A; 600V
590	L1B04308F	30A; 800V
592	L1B05402F	40A; 200V
592	L1B05404F	40A; 400V
592	L1B05406F	40A; 600V
592	L1B05408F	40A; 800V
594	L2B06202F	20A; 200V
594	L2B06204F	20A; 400V
594	L2B06206F	20A; 600V
594	L2B06208F	20A; 800V
		SCR
596	L2R06102FG	10A; 200V; Fast Turn-off
596	L2R06104FG	10A; 400V; Fast Turn-off
596	L2R06106FG	10A; 600V; Fast Turn-off
596	L2R06108FG	10A; 800V; Fast Turn-off
599	L2R06252F	25A; 200V
599	L2R06254F	25A; 400V
599	L2R06256F	25A; 600V
599	L2R06258F	25A; 800V
		TRIAC
601	L7B08102S	10A; 200V
601	L7B08104S	10A; 400V

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PAGE	PART NUMBER	DESCRIPTION
		SWITCHING REGULATOR POWER CIRCUIT
208	PIC647	15.0A; 100V (Pos.); TO-66
208	PIC655	15.0A; 60V (Neg.); TO-3
208	PIC656	15.0A; 80V (Neg.); TO-3
208	PIC657	15.0A; 100V (Neg.); TO-66
212	PIC730	30A; 30V; (POS); TO-3
212	PIC740	30A; 30V; (POS); TO-3
216	PIC800	8A; 350V; (POS); TO-66
216	PIC801	8A; 400V; (POS); TO-66
216	PIC810	8A; 350V; (NEG); TO-66
216	PIC811	8A; 400V; (NEG); TO-66
		RECTIFIER MODULE
396	PMA101	5.0kV
396	PMA102	7.5kV
396	PMA103	10kV
396	PMA104	15kV
396	PMA105	20kV
396	PMA106	25kV
396	PMA107	30kV
396	PMA108	35kV
396	PMA109	40kV
396	PMA110	50kV
396	PMA111	60kV
396	PMA101X	5.0kV
396	PMA102X	7.5kV
396	PMA103X	10kV
396	PMA104X	15kV
396	PMA105X	20kV
396	PMA106X	25kV
396	PMA107X	30kV
396	PMA108X	35kV
396	PMA109X	40kV
396	PMA110X	50kV
396	PMA111X	60kV
396	PMA201	2.5kV
396	PMA202	5.0kV
396	PMA203	7.5kV
396	PMA204	10kV
396	PMA205	15kV
396	PMA206	20kV
396	PMA207	25kV
396	PMA208	30kV
396	PMA201X	2.5kV
396	PMA202X	5.0kV
396	PMA203X	7.5kV
396	PMA204X	10kV
396	PMA205X	15kV
396	PMA206X	20kV
396	PMA207X	25kV
396	PMA208X	30kV
		DOUBLER OR CENTER-TAP
461	PMB101	2.5kV
461	PMB102	5.0kV
461	PMB103	7.5kV
461	PMB104	10kV
461	PMB105	15kV
461	PMB106	20kV
461	PMB107	30kV
461	PMB101X	2.5kV
461	PMB102X	5.0kV
461	PMB103X	7.5kV
461	PMB104X	10kV
461	PMB105X	15kV
		DOUBLER OR CENTER-TAP
461	PMB106X	20kV
461	PMB107X	30kV
461	PMB201	2.5kV
461	PMB202	5.0kV
461	PMB203	7.5kV
461	PMB204	10kV
461	PMB205	15kV
461	PMB201X	2.5kV
461	PMB202X	5.0kV
461	PMB203X	7.5kV
461	PMB204X	10kV
461	PMB205X	15kV
		FULL WAVE BRIDGE
463	PMC101	2.5kV
463	PMC102	5.0kV
463	PMC103	7.5kV
463	PMC104	10kV
463	PMC105	15kV
463	PMC101X	2.5kV
463	PMC102X	5.0kV
463	PMC103X	7.5kV
463	PMC104X	10kV
463	PMC105X	15kV
463	PMC201	2.5kV
463	PMC202	5.0kV
463	PMC203	7.5kV
463	PMC201X	2.5kV
463	PMC202X	5.0kV
463	PMC203X	7.5kV
465	PMD101	3 ph; 3A; 2.5kV
465	PMD102	3 ph; 3A; 5.0kV
465	PMD103	3 ph; 3A; 7.5kV
465	PMD104	3 ph; 3A; 10kV
465	PMD101X	3 ph; 3A; 2.5kV
465	PMD102X	3 ph; 3A; 5.0kV
465	PMD103X	3 ph; 3A; 7.5kV
465	PMD104X	3 ph; 3A; 10kV
465	PMD201	3 ph; 6A; 2.5kV
465	PMD202	3 ph; 6A; 5.0kV
465	PMD201X	3 ph; 6A; 2.5kV
465	PMD202X	3 ph; 6A; 5.0kV
		RECTIFIER MODULE
398	PME101	2.5kV
398	PME102	4.0kV
398	PME103	8.0kV
398	PME101X	2.5kV
398	PME102X	4.0kV
398	PME103X	8.0kV
		SCHOTTKY RECTIFIER
260	SD41	30A; 45V; DO-5
262	SD51	60A; 45V; DO-5
264	SD241	60A; 45V; TO-3
		RECTIFIER
266	SES5001	2.0A; 50V
266	SES5002	2.0A; 100V
266	SES5003	2.0A; 150V
268	SES5301	5.0A; 50V
268	SES5302	5.0A; 100V
268	SES5303	5.0A; 150V
270	SES5401	8.0A; 50V; sim to TO-220
270	SES5402	8.0A; 100V; sim to TO-220
270	SES5403	8.0A; 150V; sim to TO-220

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PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER
298	UES1104	2.0A; 200V
298	UES1105	2.0A; 300V
298	UES1106	2.0A; 400V
300	UES1301	6A; 50V
300	UES1302	6A; 100V
300	UES1303	6A; 150V
302	UES1304	5.0A; 200V
302	UES1305	5.0A; 300V
302	UES1306	5.0A; 400V
304	UES1401	8.0A; 50V; TO-220
304	UES1402	8.0A; 100V; TO-220
304	UES1403	8.0A; 150V; TO-220
		RECTIFIER, CENTER-TAP
306	UES2401	16A; 50V; sim to TO-220
306	UES2402	16A; 100V; sim to TO-220
306	UES2403	16A; 150V; sim to TO-220
308	UES2601	30A; 50V; TO-3
308	UES2602	30A; 100V; TO-3
308	UES2603	30A; 150V; TO-3
310	UES2604	30A; 200V; TO-3
310	UES2605	30A; 300V; TO-3
310	UES2606	30A; 400V; TO-3
		RECTIFIER MODULE
406	UFB2.5	2.5kV
406	UFB5	5.0kV
406	UFB7.5	7.5kV
406	UFS5	5.0kV
406	UFS7.5	7.5kV
406	UFS10	10.0kV
409	UGB5	5.0kV
409	UGB7.5	7.5kV
409	UGB10	10.0kV
409	UGD5	5.0kV
409	UGD7.5	7.5kV
409	UGD10	10.0kV
409	UGE2.5	2.5kV
409	UGE5	5.0kV
409	UGE7.5	7.5kV
409	UGF2.5	2.5kV
409	UGF5	5.0kV
409	UGF7.5	7.5kV
		PIN DIODE
656	UM4000 series	0.5Ω,3.0pF,25W,100-1200V
661	UM4300 series	1.5Ω,2.2pF,18W,100-1000V
656	UM4900 series	0.5Ω,3.0pF, 37W,100-600V
667	UM6000 series	1.7Ω,0.5pF, 6W,100-1000V
667	UM6200 series	0.4Ω, 1.1pF, 6W, 100-400V
667	UM6600 series	2.5Ω,0.4pF, 4W,100-1000V
672	UM7000 series	1.0Ω,0.9pF,10W,100-1600V
672	UM7100 series	0.6Ω,1.2pF,10W, 100-800V
672	UM7200 series	0.25Ω,2.2pF,10W,100-400V
661	UM7300 series	3.5Ω, 0.7pF, 7.5W, 100-1000V
677	UM9301 series	CATV Attenuator Diodes
680	UM9401 series	2-Way Radio Switch Diodes
680	UM9415	2-Way Radio Switch Diodes
685	UM9441	Radiation Detector
		POWER TRANSISTOR
146	UMT1006	NPN; 5A; 400V; TO-3
146	UMT1007	NPN; 5A; 500V; TO-3
150	UMT1008	NPN; 8A; 300V; TO-3
150	UMT1009	NPN; 8A; 400V; TO-3
154	UMT1011	NPN; 15A; 400V; TO-3
		POWER TRANSISTOR
154	UMT1012	NPN; 15A; 500V; TO-3
158	UMT1203	NPN; 3.0A; 300V; TO-220
158	UMT1204	NPN; 3.0A; 400V; TO-220
162	UMT3584	NPN; 2.0A; 250V; TO-220
162	UMT3585	NPN; 2.0A; 300V; TO-220
166	UMT13004	NPN; 4A; 600V; TO-220
166	UMT13005	NPN; 4A; 700V; TO-220
170	UMT13006	NPN; 8A; 600V; TO-220
170	UMT13007	NPN; 8A; 700V; TO-220
174	UMT13008	NPN; 12A; 600V; TO-220
174	UMT13009	NPN; 12A; 700V; TO-220
178	UPT111	NPN; 1.0A; 40V; TO-5
178	UPT112	NPN; 1.0A; 60V; TO-5
178	UPT113	NPN; 1.0A; 80V; TO-5
178	UPT114	NPN; 1.0A; 100V; TO-5
178	UPT115	NPN; 1.0A; 100V; TO-5
180	UPT211	NPN; 2.0A; 40V; TO-5
180	UPT212	NPN; 2.0A; 60V; TO-5
180	UPT213	NPN; 2.0A; 80V; TO-5
180	UPT214	NPN; 2.0A; 100V; TO-5
180	UPT215	NPN; 2.0A; 100V; TO-5
182	UPT311	NPN; 2.0A; 150V; TO-5
182	UPT312	NPN; 2.0A; 200V; TO-5
182	UPT313	NPN; 2.0A; 250V; TO-5
182	UPT314	NPN; 2.0A; 300V; TO-5
182	UPT315	NPN; 2.0A; 300V; TO-5
182	UPT321	NPN; 2.0A; 150V; TO-66
182	UPT322	NPN; 2.0A; 200V; TO-66
182	UPT323	NPN; 2.0A; 250V; TO-66
182	UPT324	NPN; 2.0A; 300V; TO-66
182	UPT325	NPN; 2.0A; 300V; TO-66
184	UPT521	NPN; 3.5A; 150V; TO-66
184	UPT522	NPN; 3.5A; 200V; TO-66
184	UPT523	NPN; 3.5A; 250V; TO-66
184	UPT524	NPN; 3.5A; 300V; TO-66
184	UPT525	NPN; 3.5A; 300V; TO-66
186	UPT611	NPN; 5.0A; 40V; TO-5
186	UPT612	NPN; 5.0A; 60V; TO-5
186	UPT613	NPN; 5.0A; 80V; TO-5
186	UPT614	NPN; 5.0A; 100V; TO-5
186	UPT615	NPN; 5.0A; 100V; TO-5
188	UPT721	NPN; 5.0A; 150V; TO-66
188	UPT722	NPN; 5.0A; 200V; TO-66
188	UPT723	NPN; 5.0A; 250V; TO-66
188	UPT724	NPN; 5.0A; 300V; TO-66
188	UPT725	NPN; 5.0A; 300V; TO-66
190	UPTA510	NPN; 0.5A; 100V; TO-92
190	UPTA520	NPN; 0.5A; 200V; TO-92
190	UPTA530	NPN; 0.5A; 300V; TO-92
192	UPTB520	NPN; 0.1A; 200V; TO-92
192	UPTB530	NPN; 0.1A; 300V; TO-92
192	UPTB540	NPN; 0.1A; 400V; TO-92
192	UPTB550	NPN; 0.1A; 500V; TO-92
		RECTIFIER
312	UR105	2.0A; 50V
312	UR110	1.0A; 100V
312	UR115	1.0A; 150V
312	UR120	1.0A; 200V
312	UR125	1.0A; 250V
312	UR205	2.0A; 50V
312	UR210	2.0A; 100V
312	UR215	2.0A; 150V
312	UR220	2.0A; 200V
312	UR225	2.0A; 250V
*	UR710	1.0A; 100V
*	UR720	1.0A; 200V

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER MODULE
413	US12	1.2kV
413	US15	1.5kV
413	US18	1.8kV
413	US20	2.0kV
413	US25	2.5kV
413	US30	3.0kV
413	US35	3.5kV
413	US40	4.0kV
413	US45A	4.5kV
413	US50A	5.0kV
413	US60A	6.0kV
413	US70A	7.0kV
413	US80A	8.0kV
413	US100A	10kV
413	US120A	12kV
413	US150A	15kV
413	US180A	18kV
413	US200A	20kV
406	USB2.5	2.5kV
406	USB5	5.0kV
406	USB7.5	7.5kV
406	USB10	10kV
		SCHOTTKY RECTIFIER
315	USD520	75A; 20V; DO-5
315	USD535	75A; 35V; DO-5
315	USD545	75A; 45V; DO-5
		RECTIFIER MODULE
413	USR12	1.2kV
413	USR15	1.5kV
413	USR18	1.8kV
413	USR20	2.0kV
413	USR25	2.5kV
413	USR30	3.0kV
413	USR35	3.5kV
413	USR40A	4.0kV
413	USR45A	4.5kV
413	USR50A	5.0kV
413	USR60A	6.0kV
413	USR70A	7.0kV
413	USR80A	8.0kV
413	USR100A	10kV
413	USR120A	12kV
413	USR150A	15kV
413	USR180A	18kV
406	USS5	5.0kV
406	USS7.5	7.5kV
406	USS10	10kV
406	USS15	15kV
		RECTIFIER
*	UT111 (1N536)	0.75A; 50V
*	UT112 (1N537)	0.75A; 100V
*	UT113 (1N3656)	0.75A; 200V
*	UT114 (1N539)	0.75A; 300V
*	UT115 (1N3657)	0.75A; 400V
*	UT117 (1N547)	0.75A; 500V
*	UT118 (1N3658)	0.75A; 600V
*	UT119	0.75A; 800V
*	UT120	0.75A; 1000V
*	UT211 (1N645)	0.75A; 225V
*	UT212 (1N646)	0.75A; 300V
*	UT213 (1N647)	0.75A; 400V
*	UT214 (1N648)	0.75A; 500V
*	UT215 (1N649)	0.75A; 600V
*	UT221 (1N676)	0.5A; 100V

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER
*	UT222 (1N677)	0.75A; 100V
*	UT223 (1N678)	0.5A; 200V
*	UT224 (1N679)	0.75A; 200V
*	UT225 (1N681)	0.5A; 300V
*	UT226 (1N682)	0.75A; 300V
*	UT227 (1N683)	0.5A; 400V
*	UT228 (1N684)	0.75A; 400V
*	UT229 (1N685)	0.5A; 500V
*	UT231 (1N686)	0.75A; 500V
*	UT232 (1N687)	0.5A; 600V
*	UT233 (1N689)	0.75A; 600V
318	UT234	1.0A; 200V
318	UT235	1.0A; 400V
318	UT236	1.0A; 100V
318	UT237	1.0A; 500V
318	UT238	1.0A; 600V
318	UT242	1.25A; 200V
318	UT244	1.25A; 400V
318	UT245	1.25A; 500V
318	UT247	1.25A; 600V
318	UT249	1.25A; 100V
318	UT251	1.5A; 100V
318	UT252	1.5A; 200V
318	UT254	1.5A; 400V
318	UT255	1.5A; 500V
318	UT257	1.5A; 600V
318	UT258	1.5A; 800V
318	UT261	2.0A; 100V
318	UT262 (1N3981)	2.0A; 200V
318	UT264 (1N3982)	2.0A; 400V
318	UT265	2.0A; 500V
318	UT267 (1N3983)	2.0A; 600V
318	UT268	2.0A; 800V
318	UT347	1.0A; 1000V
318	UT361	1.0A; 800V
318	UT362	1.2A; 800V
318	UT363	1.2A; 1000V
318	UT364	1.5A; 1000V
322	UT2005	2.0A; 50V
322	UT2010	2.0A; 100V
322	UT2020	2.0A; 200V
322	UT2040	2.0A; 400V
322	UT2060	2.0A; 600V
*	UT2080	2.0A; 800V
322	UT3005	3.0A; 50V
322	UT3010	3.0A; 100V
322	UT3020	3.0A; 200V
322	UT3040	3.0A; 400V
322	UT3060	3.0A; 600V
*	UT3080	3.0A; 800V
322	UT4005	4.0A; 50V
322	UT4010 (1N5180)	4.0A; 100V
322	UT4020	4.0A; 200V
322	UT4040 (1N5207)	4.0A; 400V
322	UT4060	4.0A; 600V
*	UT4080	4.0A; 800V
*	UT4100	4.0A; 1000V
326	UT5105	7.5A; 50V
326	UT5110	7.5A; 100V
326	UT5120	7.5A; 200V
*	UT5130	7.5A; 300V
326	UT5140	7.5A; 400V
*	UT5150	7.5A; 500V
326	UT5160	7.5A; 600V
326	UT6105	9.0A; 50V
326	UT6110	9.0A; 100V

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER
326	UT6120	9.0A; 200V
*	UT6130	9.0A; 300V
326	UT6140	9.0A; 400V
326	UT6160	9.0A; 600V
326	UT8105	12.0A; 50V
326	UT8110	12.0A; 100V
326	UT8120	12.0A; 200V
*	UT8130	12.0A; 300V
326	UT8140	12.0A; 400V
326	UT8160	12.0A; 600V
329	UTR01	1.0A; 50V
329	UTR02	2.0A; 50V
329	UTR10	0.5A; 100V
329	UTR11	1.0A; 100V
329	UTR12	2.0A; 100V
329	UTR20	0.5A; 200V
329	UTR21	1.0A; 200V
329	UTR22	2.0A; 200V
329	UTR30	0.5A; 300V
329	UTR31	1.0A; 300V
329	UTR32	2.0A; 300V
329	UTR40	0.5A; 400V
329	UTR41	1.0A; 400V
329	UTR42 (1N5206)	2.0A; 400V
329	UTR50	0.5A; 500V
329	UTR51	1.0A; 500V
329	UTR52	2.0A; 500V
329	UTR60	0.5A; 600V
329	UTR61	1.0A; 600V
329	UTR62	2.0A; 600V
*	UTR70	0.5A; 700V
*	UTR71	1.0A; 700V
333	UTR2305	2.0A; 50V
333	UTR2310	2.0A; 100V
333	UTR2320	2.0A; 200V
333	UTR2340	2.0A; 400V
333	UTR2350	2.0A; 500V
333	UTR2360	2.0A; 600V
333	UTR3305	3.0A; 50V
333	UTR3310	3.0A; 100V
333	UTR3320	3.0A; 200V
333	UTR3340	3.0A; 400V
333	UTR3350	3.0A; 500V
333	UTR3360	3.0A; 600V
333	UTR4305	4.0A; 50V
333	UTR4310	4.0A; 100V
333	UTR4320	4.0A; 200V
333	UTR4340	4.0A; 400V
333	UTR4350	4.0A; 500V
333	UTR4360	4.0A; 600V
337	UTR4405	6.0A; 50V
337	UTR4410	6.0A; 100V
337	UTR4420	6.0A; 200V
*	UTR4430	6.0A; 300V
337	UTR4440	6.0A; 400V
337	UTR5405	7.5A; 50V
337	UTR5410	7.5A; 100V
337	UTR5420	7.5A; 200V
*	UTR5430	7.5A; 300V
337	UTR5440	7.5A; 400V
337	UTR6405	9.0A; 50V
337	UTR6410	9.0A; 100V
337	UTR6420	9.0A; 200V
*	UTR6430	9.0A; 300V
337	UTR6440	9.0A; 400V
340	UTX105	1.0A; 50V
		RECTIFIER
340	UTX110	1.0A; 100V
340	UTX115	1.0A; 150V
340	UTX120	1.0A; 200V
340	UTX125	1.0A; 250V
340	UTX205	2.0A; 50V
340	UTX210	2.0A; 100V
340	UTX215	2.0A; 150V
340	UTX220	2.0A; 200V
340	UTX225	2.0A; 250V
343	UTX3105	3.0A; 50V
343	UTX3110	3.0A; 100V
343	UTX3115	3.0A; 150V
343	UTX3120	3.0A; 200V
*	UTX3125	3.0A; 250V
343	UTX4105	4.0A; 50V
343	UTX4110	4.0A; 100V
343	UTX4115	4.0A; 150V
343	UTX4120	4.0A; 200V
*	UTX4125	4.0A; 250V
		ZENER
499	UZ110-UZ119	3W; 5%
499	UZ120-UZ140	3W; 5%
499	UZ210-UZ219	3W; 10%
499	UZ220-UZ240	3W; 10%
499	UZ706-UZ760	3W; 5%
499	UZ770-UZ790	3W; 5%
499	UZ806-UZ860	3W; 10%
499	UZ870-UZ890	3W; 10%
501	UZ4110-UZ4120	5W; 5%
501	UZ4210-UZ4220	5W; 10%
501	UZ4706-UZ4791	5W; 5%
501	UZ4806-UZ4891	5W; 10%
503	UZ5110-UZ5119	5W; 5%
503	UZ5120	5W; 5%
503	UZ5210-UZ5240	5W; 10%
503	UZ5310-UZ5340	5W; 20%
503	UZ5706-UZ5760	5W; 5%
503	UZ5770-UZ5790	5W; 5%
503	UZ5806-UZ5860	5W; 10%
503	UZ5870-UZ5890	5W; 10%
505	UZ7110	10W; 5%
505	UZ7110L	6W; 5%
505	UZ7210	10W; 10%
505	UZ7210L	6W; 10%
505	UZ7706L-UZ7750L	6W; 5%
505	UZ7756-UZ7790	10W; 5%
505	UZ7706-UZ7750	10W; 5%
505	UZ7756L-UZ7790L	6W; 5%
505	UZ7806-UZ7850	10W; 10%
505	UZ7806L-UZ7850L	6W; 10%
505	UZ7856-UZ7890	10W; 10%
505	UZ7856L-UZ7890L	6W; 10%
507	UZ8110-UZ8120	1W; 5%
507	UZ8210-UZ8220	1W; 10%
507	UZ8706-UZ8790	1W; 5%
507	UZ8806-UZ8890	1W; 10%
*	UZS306-UZS440	3W; 5%
*	UZS506-UZS640	3W; 10%
		HIGH VOLTAGE RECTIFIER
417	VX15	15kV
417	VX20	20kV
417	VX25	25kV
417	VX30	30kV
417	VX40	40kV

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		HIGH VOLTAGE RECTIFIER
417	VX50	50kV
419	VXS15	15kV
419	VXS20	20kV
419	VXS25	25kV
419	VXS30	30kV
419	VXS40	40kV
419	VXS50	50kV

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

FAST RECOVERY SILICON POWER RECTIFIERS

Schottky

Type	V_{RWM}	Ratings and Specifications
25A		
1N6095 1N6096	30V 40V	Surge Current, I_{FSM} .... 400A Maximum Junction Temperature, T_J .... 150°C Forward Voltage, V_F .... 0.86V Reverse Current, I_R .... 250mA Package: **DO-4**
30A		
USD420 USD435 USD445	20V 35V 45V	Surge Current, I_{FSM} .... 600A Maximum Junction Temperature, T_J .... 175°C Forward Voltage, V_F .... 0.50V Reverse Current, I_R .... 100mA Package: **DO-4**
30A		
SD41	45V @ T_J = 25°C 35V @ T_J = 125° C	Surge Current, I_{FSM} .... 600A Maximum Junction Temperature, T_J .... 150°C Forward Voltage, V_F .... 0.55V Reverse Current, I_R .... 125mA Package: **DO-4**
50A		
1N6097 1N6098	30V 40V	Surge Current, I_{FSM} .... 800A Maximum Junction Temperature, T_J .... 175°C Forward Voltage, V_F .... .86 @ 157A Reverse Current, I_R @ Rated V_{RWM}, 125°C .... 250mA Package: **DO-5**
60A		
SD51	45V @ T_J = 25°C 35V @ T_J = 125° C	Surge Current, I_{FSM} .... 800A Maximum Junction Temperature, T_J .... 150°C Forward Voltage, V_F .... .6V @ 60A Reverse Current, I_R @ 35V, 125°C .... 200mA Package: **DO-5**
75A		
USD520 USD535 USD545	20V 35V 45V	Surge Current, I_{FSM} .... 1000A Maximum Junction Temperature, T_J .... 175°C Forward Voltage, V_F .... .6V @ 60A Reverse Current, I_R @ V_{RWM}, 125°C .... 50mA Package: **DO-5**

Schottky Center-Tap Rectifiers

Type	V_{RWM}	Ratings and Specifications (per diode)
30A		
USD320C USD335C USD345C	20V 35V 45V	Average Forward Current .... 30A Surge Current, I_{FSM} .... 600A Maximum Junction Temperature, T_J .... 175°C Forward Voltage, V_F .... .47V @ 20A Reverse Current, I_R .... 100mA Package: **TO-3 Center-Tap**
30A		
SD241	45V	Average Forward Current .... 30A Surge Current, I_{FSM} .... 400A Maximum Junction Temperature, T_J .... 150°C Forward Voltage, V_F .... .47V @ 20A Reverse Current, I_R .... 100mA Package: **TO-3 Center-Tap**

P/N JUNCTION RECTIFIERS

Low Voltage, Ultra-Fast Recovery (t_{rr} ≤50nS)

Type	V_{RWM}	Ratings and Specifications
1A		
UES1001 UES1002 UES1003	50V 100V 150V	Surge Current, I_{FSM} .... 30A Forward Voltage, V_F .... .895V @ 1A Reverse Recovery Time, t_{rr} .... 25nS Package: **Axial Leaded Glass**
2.5A		
UES1101 UES1102 UES1103	50V 100V 150V	Surge Current, I_{FSM} .... 35A Forward Voltage, V_F .... .895V @ 2A Reverse Recovery Time, t_{rr} .... 25nS Package: **Axial Leaded Glass**
6A		
UES1301 UES1302 UES1303	50V 100V 150V	Surge Current, I_{FSM} .... 125A Forward Voltage, V_F .... .850V @ 6A Reverse Recovery Time, t_{rr} .... 30nS Package: **Axial Leaded Glass**
8A		
UES1401 UES1402 UES1403	50V 100V 150V	Surge Current, I_{FSM} .... 80A Forward Voltage, V_F .... .895V @ 8A Reverse Recovery Time, t_{rr} .... 35nS Package: **Sim. to TO-220**
25A		
UES701 UES702 UES703	50V 100V 150V	Surge Current, I_{FSM} .... 400A Forward Voltage, V_F .... .825V @ 25A Reverse Recovery Time, t_{rr} .... 35nS Package: **DO-4**
70A		
UES801 UES802 UES803	50V 100V 150V	Surge Current, I_{FSM} .... 800A Forward Voltage, V_F .... .840V @ 70A Reverse Recovery Time, t_{rr} .... 50nS Package: **DO-5**

High Voltage, Ultra-Fast Recovery (t_{rr} ≤ 50nS)

Type	V_{RWM}	Ratings and Specifications
2A		
UES1104 UES1105 UES1106	200V 300V 400V	Surge Current, I_{FSM} .... 20A Forward Voltage, V_F .... 1.15V @ 1A Reverse Recovery Time, t_{rr} .... 50nS Package: **Axial Leaded Glass**
5A		
UES1304 UES1305 UES1306	200V 300V 400V	Surge Current, I_{FSM} .... 70A Forward Voltage, V_F .... 1.1V @ 3A Reverse Recovery Time, t_{rr} .... 50nS Package: **Axial Leaded Glass**
20A		
UES704 UES705 UES706	200V 300V 400V	Surge Current, I_{FSM} .... 400A Forward Voltage, V_F .... 1.15V @ 20A Reverse Recovery Time, t_{rr} .... 50nS Package: **DO-4**
50A		
UES804 UES805 UES806	200V 300V 400V	Surge Current, I_{FSM} .... 800A Forward Voltage, V_F .... 1.15V @ 50A Reverse Recovery Time, t_{rr} .... 50nS Package: **DO-5**

P/N JUNCTION RECTIFIERS (continued)

Ultra-Fast Recovery Center-Tap Rectifiers ($t_{rr} \leq$ 50nS)

Type	V_{RWM}	Ratings and Specifications
16A UES2401 UES2402 UES2403	 50V 100V 150V	Surge Current, I_{FSM} ... 80A Forward Voltage, V_F ... .895V @ 8A Reverse Recovery Time, t_{rr} ... 35nS Package: **TO-220**
30A UES2601 UES2602 UES2603	 50V 100V 150V	Surge Current, I_{FSM} ... 400A Forward Voltage, V_F ... .825V @ 15A Reverse Recovery Time, t_{rr} ... 35nS Package: **TO-3**
UES2604 UES2605 UES2606	200V 300V 400V	Surge Current, I_{FSM} ... 400A Forward Voltage, V_F ... 1.15V @ 15A Reverse Recovery Time, t_{rr} ... 50nS Package: **TO-3**

Super-Fast Recovery Rectifiers (t_{rr} = 100nS)

Type	V_{RWM}	Ratings and Specifications
2A SES5001 SES5002 SES5003	 50V 100V 150V	Surge Current, I_{FSM} ... 35A Forward Voltage, V_F ... .895V @ 1A Reverse Recovery Time, t_{rr} ... 100nS Package: **Axial Leaded Glass**
5A SES5301 SES5302 SES5303	 50V 100V 150V	Surge Current, I_{FSM} ... 110A Forward Voltage, V_F ... .895V @ 5A Reverse Recovery Time, t_{rr} ... 100nS Package: **Axial Leaded Glass**
8A SES5401 SES5402 SES5403	 50V 100V 150V	Surge Current, I_{FSM} ... 70A Forward Voltage, V_F ... .945V @ 8A Reverse Recovery Time, t_{rr} ... 100nS Package: **Sim. to TO-220**
20A SES5701 SES5702 SES5703	 50V 100V 150V	Surge Current, I_{FSM} ... 400A Forward Voltage, V_F ... .830V @ 20A Reverse Recovery Time, t_{rr} ... 100nS Package: **DO-4**
60A SES5801 SES5802 SES5803	 50V 100V 150V	Surge Current, I_{FSM} ... 800A Forward Voltage, V_F ... .850V @ 60A Reverse Recovery Time, t_{rr} ... 100nS Package: **DO-5**

Super-Fast Recovery Center-Tap Rectifiers (t_{rr} = 100nS)

Type	V_{RWM}	Ratings and Specifications
16A SES5401C SES5402C SES5403C	 50V 100V 150V	Surge Current, I_{FSM} ... 70A Forward Voltage, V_F ... .945V @ 8A Reverse Recovery Time, t_{rr} ... 100nS Package: **TO-220**
25A SES5601C SES5602C SES5603C	 50V 100V 150V	Surge Current, I_{FSM} ... 400A Forward Voltage, V_F ... .830V @ 12.5A Reverse Recovery Time, t_{rr} ... 100nS Package: **TO-3**

POWER SUPPLY DESIGNERS' GUIDE

NPN POWER SWITCHING TRANSISTORS

Type	$V_{CEO(sus)}$ (V)	Min. h_{FE} @ I_C (A)	Max. $V_{CE(sat)}$ @ I_C (V) (A)	Max. Fall Time (t_f) @ $I_C/I_{B1}/I_{B2}$ (μs) @ (A)	Max. $E_{s/b}$ (μJ)	Pkg.

Plastic Packaging

Type	$V_{CEO(sus)}$ (V)	Min. h_{FE} @ I_C (A)	Max. $V_{CE(sat)}$ @ I_C (V) (A)	Max. Fall Time (t_f) @ $I_C/I_{B1}/I_{B2}$ (μs) @ (A)	Max. $E_{s/b}$ (μJ)	Pkg.
2.0A						
UMT3584	250	8 @ 1.0	0.75 @ 1.0	3.0 @ 1/.1/.1	200	**TO-220**
UMT3585	300	8 @ 1.0	0.75 @ 1.0	3.0 @ 1/.1/.1	200	**TO-220**
4.0A						
UMT13004	300	8 @ 2.0	0.6 @ 2.0	0.9 @ 2/.4/.4	—	**TO-220**
UMT13005	400	8 @ 2.0	0.6 @ 2.0	0.9 @ 2/.4/.4	—	**TO-220**
8.0A						
UMT13006	300	6 @ 5.0	1.5 @ 5.0	0.7 @ 5/1/1	—	**TO-220**
UMT13007	400	6 @ 5.0	1.5 @ 5.0	0.7 @ 5/1/1	—	**TO-220**
12.0A						
UMT13008	300	6 @ 8.0	1.5 @ 8.0	0.7 @ 8/1.6/1.6	—	**TO-220**
UMT13009	400	6 @ 8.0	1.5 @ 8.0	0.7 @ 8/1.6/1.6	—	**TO-220**

Metal Can Packaging

Type	$V_{CEO(sus)}$ (V)	Min. h_{FE} @ I_C (A)	Max. $V_{CE(sat)}$ @ I_C (V) (A)	Max. Fall Time (t_f) @ $I_C/I_{B1}/I_{B2}$ (μs) @ (A)	Max. $E_{s/b}$ (μJ)	Pkg.
3.0A						
2N5838	250	10 @ 2.0	1.0 @ 3.0	1.5 @ 3/.375/.375	450	**TO-3**
2N5839	275	10 @ 2.0	1.5 @ 2.0	1.5 @ 2/.2/.2	450	**TO-3**
2N5840	350	10 @ 2.0	1.5 @ 2.0	1.5 @ 2/.2/.2	450	**TO-3**
5.0A						
2N6542	300	7 @ 3.0	1.0 @ 3.0	0.8 @ 3/.6/.6	180	**TO-3**
UMT1006	350	7 @ 3.0	1.0 @ 3.0	0.4 @ 3/.6/.6	540	**TO-3**
UMT1007	400	7 @ 3.0	1.0 @ 3.0	0.4 @ 3/.6/.6	540	**TO-3**
2N6543	400	7 @ 3.0	1.0 @ 3.0	0.8 @ 3/.6/.6	180	**TO-3**
8.0A						
2N6306	250	15 @ 3.0	0.8 @ 3.0	0.4 @ 3/.6/1.5	180	**TO-3**
2N6307	300	15 @ 3.0	0.8 @ 3.0	0.4 @ 3/.6/1.5	180	**TO-3**
2N6544	300	7 @ 5.0	1.5 @ 5.0	1.0 @ 5/1/1	500	**TO-3**
UMT1008	300	7 @ 5.0	1.5 @ 5.0	0.4 @ 5/1/1	1500	**TO-3**
2N6308	350	12 @ 3.0	1.5 @ 3.0	0.4 @ 3/.6/1.5	180	**TO-3**
2N6545	400	7 @ 5.0	1.5 @ 5.0	1.0 @ 5/1/1	500	**TO-3**
UMT1009	400	7 @ 5.0	1.5 @ 5.0	0.4 @ 5/1/1	1500	**TO-3**
10.0A						
2N6354	120	10 @ 10.0	1.0 @ 10.0	0.2 @ 5/.5/.5	300	**TO-3**
2N6249	200	10 @ 10.0	1.5 @ 10.0	1.0 @ 10/1/1	2500	**TO-3**
2N6250	275	8 @ 10.0	1.5 @ 10.0	1.0 @ 10/1.25/1.25	2500	**TO-3**
2N6251	350	6 @ 10.0	1.5 @ 10.0	1.0 @ 10/1.67/1.67	2500	**TO-3**
15.0A						
2N6496	100	12 @ 8.0	1.0 @ 8.0	0.3 @ 8/.8/.8	5700	**TO-3**
2N6546	300	6 @ 10.0	1.5 @ 10.0	0.7 @ 10/2/2	2000	**TO-3**
UMT1011	350	6 @ 10.0	1.0 @ 10.0	0.4 @ 10/2/2	6000	**TO-3**
UMT1012	400	6 @ 10.0	1.0 @ 10.0	0.4 @ 10/2/2	6000	**TO-3**
2N6547	400	6 @ 10.0	1.5 @ 10.0	0.7 @ 10/2/2	2000	**TO-3**
20.0A						
2N5039	75	20 @ 10.0	1.0 @ 10.0	0.5 @ 10/1/1	13000	**TO-3**
2N5038	90	20 @ 12.0	1.2 @ 12.0	0.5 @ 12/1.2/1.2	13000	**TO-3**
30.0A						
2N5671	90	20 @ 15.0	0.75 @ 15.0	0.5 @ 15/1.2/1.2	20000	**TO-3**
2N5672	120	20 @ 15.0	0.75 @ 15.0	0.5 @ 15/1.2/1.2	20000	**TO-3**

POWER SUPPLY DESIGNERS' GUIDE

SWITCHING REGULATOR POWER OUTPUT CIRCUITS

The PIC600 through PIC657 series of devices consist of a driver transistor, a fast switching output transistor, a suitably matched fast recovery catch diode and thick film resistors in a hybrid circuit, designed, constructed and specified for use in high current switching regulator applications. Specific ratings for each type is summarized in this table.

Type	Output Current, Pk.	Input/Output Voltage	Polarity	Fall Time		On-State Volt. @ I (V) @ (I)	Pkg.
				Volt. (nS)	Cur. (nS)		
PIC600	5A	60	Pos.	75	150	1.5 @ 2	**4 PIN TO-66 (Isolated)**
PIC601		80	Pos.				
PIC602		100	Pos.				
PIC610		60	Neg.				
PIC611		80	Neg.				
PIC612		100	Neg.				
PIC625	15A	60	Pos.	175	300	1.5 @ 7	**4 PIN TO-66 (Isolated)**
PIC626		80	Pos.				
PIC627		100	Pos.				
PIC635		60	Neg.	300	300		
PIC636		80	Neg.				
PIC637		100	Neg.				
PIC645	20A	60	Pos.	150	300	1.5 @ 7	**3 PIN TO-3**
PIC646		80	Pos.				
PIC647		100	Pos.				
PIC655		60	Neg.	300	300		
PIC656		80	Neg.				
PIC657		100	Neg.				

The PIC730 and 740 series offer a Schottky diode in place of the fast recovery PN catch diode, to permit higher operating efficiencies in switching regulator designs.

PIC730	30A	30	Pos.	350	300	1 @ 20	**3 PIN TO-3**
PIC740		40	Pos.				

The PIC800 through 811 series are high voltage (up to 400V) versions of the PIC600 series. Applications include high voltage buck or flyback regulators, and, in combination, half bridge or full bridges, as well as deflection circuits and DC motor drives.

PIC800	8A	350	Pos.	200	200	1.5 @ 5	**4 PIN TO-66 (Isolated)**
PIC801		400					
PIC810	8A	350	Neg.	200	200	1.5 @ 5	**4 PIN TO-66 (Isolated)**
PIC811		400					

TRANSIENT VOLTAGE SUPPRESSORS

Type	Stand-Off Voltage	Breakdown Voltage, BV(min.)	Ratings and Specifications
TVS305	5V	6V	Peak Pulse Power (1mS duration) .... 150W Continuous Power .... 3W 1 Picosecond Transient Response Time Package: **Axial Leaded Glass** Additional Voltages Available
TVS310	10	11.1	
TVS312	12	13.8	
TVS315	15	16.7	
TVS318	18	20.4	
TVS324	24	28.4	
TVS328	28	30.7	
TVS348	48	54	
TVS360	60	67	
TVS410	100	111	
TVS420	200	234	
TVS430	300	342	
TVS505	5V	6V	Peak Pulse Power (1mS duration) .... 500W Continuous Power .... 5W 1 Picosecond Transient Response Time Package: **Axial Leaded Glass** Additional Voltages Available
TVS510	10	11.1	
TVS512	12	13.8	
TVS515	15	16.7	
TVS518	18	20.4	
TVS524	24	28.4	
TVS528	28	30.7	

THYRISTORS – SCRs

Crowbars

Type	V_{DRM}, V_{RRM}	Ratings and Specifications
25A		Surge Current, I_{TSM} .... 250A On-State Voltage, V_{TM} .... 2.1V @ 50A di/dt .... 150A/μS dv/dt .... 200V/μS Package: **Metalized ceramic substrate on TO-3 Flange** Other SCRs available with current ratings up to 55A
L2R06252F	200V	
L2R06254F	400V	
L2R06256F	600V	
L2R06258F	800V	

Inverter Power Switches

Type	V_{DRM}, V_{RRM}	Ratings and Specifications
10A		Surge Current, I_{TSM} .... 120A On-State Voltage, V_{TM} .... 10V @ 100A di/dt .... 150A/μS dv/dt .... 400V/μS Circuit Commutated Turn-Off Time, T_q .... 6μS Package: **Metalized ceramic substrate on TO-3 Flange** 5A Version also available
L2R06102FG	200V	
L2R06104FG	400V	
L2R06106FG	600V	
L2R06108FG	800V	

SILICON POWER RECTIFIERS

Schottky

TYPE	OUTPUT CURRENT	V_{RWM}	MAXIMUM FORWARD VOLTAGE	MAXIMUM REVERSE CURRENT	SURGE CURRENT	PACKAGE
SD51	60A	45V	0.6V @ 60A	200mA @ 35V T_C = 125°C	800A	DO-5
USD520	75A	20V	0.6V @ 60A	50mA @ V_{RWM} T_C = 125°C	1000A	DO-5
USD535		35V				
USD545		45V				

High Efficiency, Fast Switching

TYPE	OUTPUT CURRENT	V_{RWM}	MAXIMUM FORWARD VOLTAGE	REVERSE RECOVERY TIME	PACKAGE	MIL-S-19500
1N5802	2.5A	50V	.875V @ 1A	25nS	Axial	/477 *
1N5804		100V			Axial	/477
1N5806		150V			Axial	/477
1N5807	6.0A	50V	.875V @ 4A	30nS	Axial	/477 *
1N5809		100V			Axial	/477
1N5811		150V			Axial	/477
1N5812	20A	50V	.900V @ 10A	35nS	DO-4	/478 *
1N5814		100V			DO-4	/478
1N5816		150V			DO-4	/478
UES501	50A	50V	.95V @ 50A	50nS	DO-5	N/A
UES503		100V			DO-5	
UES505		150V			DO-5	

*Series available as JAN, JANTX and JANTXV

General Purpose, Fast Recovery

TYPE	OUTPUT CURRENT	V_{RWM}	MAXIMUM FORWARD VOLTAGE	REVERSE RECOVERY TIME	PACKAGE	MIL-S-19500
1N4942	1A	200V	1.3V @ 1A	150nS	Axial	/359 *
1N4944	1A	400V	1.3V @ 1A	150nS	Axial	/359
1N4946	1A	600V	1.3V @ 1A	250nS	Axial	/359
1N5615	1A	200V	1.6V @ 3A	150nS	Axial	/429 *
1N5617	1A	400V	1.6V @ 3A	250nS	Axial	/429
1N5619	1A	600V	1.6V @ 3A	250nS	Axial	/429
1N5186	3A	100V	1.5V @ 9A	150nS	Axial	/424 **
1N5187	3A	200V	1.5V @ 9A	200nS	Axial	/424
1N5188	3A	400V	1.5V @ 9A	250nS	Axial	/424
1N5189	3A	600V	1.5V @ 9A	400nS	Axial	/424
1N5415	3A	50V	1.5V @ 9A	150nS	Axial	/411 *
1N5416	3A	100V	1.5V @ 9A	150nS	Axial	/411
1N5417	3A	200V	1.5V @ 9A	150nS	Axial	/411
1N5418	3A	400V	1.5V @ 9A	150nS	Axial	/411
1N5419	3A	500V	1.5V @ 9A	250nS	Axial	/411
1N5420	3A	600V	1.5V @ 9A	400nS	Axial	/411
1N3909	30A	50V	1.4V @ 95A	200nS	DO-5	/308 **
1N3910	30A	100V	1.4V @ 95A	200nS	DO-5	/308
1N3911	30A	200V	1.4V @ 95A	200nS	DO-5	/308
1N3912	30A	300V	1.4V @ 95A	200nS	DO-5	/308
1N3913	30A	400V	1.4V @ 95A	200nS	DO-5	/308

* Series available at JAN, JANTX and JANTXV
** Series available as JAN and JANTX

SILICON POWER RECTIFIERS (continued)

General Purpose, Standard Recovery

TYPE	OUTPUT CURRENT	V_{RWM}	MAXIMUM FORWARD VOLTAGE	SURGE CURRENT	PACKAGE	MIL-S-19500
1N457	75mA	60V	1.0V @ 20mA	225mA	DO-7	/193 ***
1N458	55mA	125V	1.0V @ 7mA	165mA	DO-7	/193
1N459	40mA	175V	1.0V @ 3mA	120mA	DO-7	/193
1N483B	200mA	70V	1.0V @ 100mA	2A	DO-7	/118 **
1N485B	200mA	180V	1.0V @ 100mA	2A	DO-7	/118
1N645-1	400mA	270V	1.0V @ 400mA	5A	DO-35	/240 *
1N4245	1A	200V	1.3V @ 3A	25A	Axial	/286 *
1N4246	1A	400V	1.3V @ 3A	25A	Axial	/286
1N4247	1A	600V	1.3V @ 3A	25A	Axial	/286
1N4248	1A	800V	1.3V @ 3A	25A	Axial	/286
1N4249	1A	1000V	1.3V @ 3A	25A	Axial	/286
1N5614	1A	200V	1.3V @ 3A	30A	Axial	/427 *
1N5616	1A	400V	1.3V @ 3A	30A	Axial	/427
1N5618	1A	600V	1.3V @ 3A	30A	Axial	/427
1N5620	1A	800V	1.3V @ 3A	30A	Axial	/427
1N3611	2A	200V	1.1V @ 1A	20A	Axial	/228 **
1N3612	2A	400V	1.1V @ 1A	20A	Axial	/228
1N3613	2A	600V	1.1V @ 1A	20A	Axial	/228
1N3614	2A	800V	1.1V @ 1A	20A	Axial	/228
1N5550	3A	200V	1.2V @ 9A	100A	Axial	/420 *
1N5551	3A	400V	1.2V @ 9A	100A	Axial	/420
1N5552	3A	600V	1.2V @ 9A	100A	Axial	/420
1N5553	3A	800V	1.2V @ 9A	100A	Axial	/420

* Series available as JAN and JANTX and JANTXV
** Series available as JAN and JANTX
*** Series available as JAN only

High Efficiency, Center-Tap Rectifiers and Doublers

TYPE	V_{RWM}	MAXIMUM FORWARD VOLTAGE	REVERSE RECOVERY TIME	OUTPUT CURRENT	SURGE CURRENT	PACKAGE
UES2601	50V	.930V @ 15A	35nS	30A	400A	TO-3
UES2602	100V			30A		TO-3
UES2603	150V			30A		TO-3

SWITCHING DIODES

Low Current

TYPE	OUTPUT CURRENT	V_{RWM}	MAXIMUM FORWARD VOLTAGE	REVERSE RECOVERY TIME	PACKAGE	MIL-S-19500
1N914	75 mA	100V	1.0V @ 10 mA	5nS	DO-35	/116 **
1N3064	75 mA	75V	1.0V @ 10 mA	4nS	DO-7	/144 **
1N4148-1	150 mA	100V	1.0V @ 10 mA	5nS	DO-35	/116 *
1N4153	150 mA	75V	.88V @ 20 mA	4nS	DO-35	/337 *
1N4150-1	200 mA	75V	.74V @ 10 mA	4nS	DO-35	/231 *
1N4454-1	200 mA	75V	1.0V @ 10 mA	4nS	DO-35	/144 *
1N3600	200 mA	75V	.74V @ 10 mA	4nS	DO-7	/231 *
1N4500	300 mA	80V	.77V @ 20 mA	6nS	DO-35	/403 *

* Available as JAN, JANTX and JANTXV
** Available as JAN and JANTX

NPN POWER SWITCHING TRANSISTORS

TYPE	MAXIMUM COLLECTOR CURRENT	$V_{CEO(sus)}$ (V)	MINIMUM h_{FE} @ I_C (A)	MAXIMUM $V_{CE(sat)}$ @ I_C	MAXIMUM FALL-TIME (t_f)	PACKAGE	MIL-S-19500
2N5660	2A	200V	40 @ .5A	.4V @ 1A	0.4 µS	TO-66	/454 *
2N5661	2A	300V	25 @ .5A	.4V @ 1A	0.6 µS	TO-66	/454
2N5662	2A	200V	40 @ .5A	.4V @ 1A	0.4 µS	TO-5	/454
2N5663	2A	300V	25 @ .5A	.4V @ 1A	0.6 µS	TO-5	/454
2N3418	3A	60V	20 @ 1A	.5V @ 2A	1.2 µS	TO-5	/393 *
2N3419	3A	80V	20 @ 1A	.5V @ 2A	1.2 µS	TO-5	/393
2N3420	3A	60V	40 @ 1A	.5V @ 2A	1.2 µS	TO-5	/393
2N3421	3A	80V	40 @ 1A	.5V @ 2A	1.2 µS	TO-5	/393
2N2151	5A	80V	40 @ 1A	1.0V @ 1A	—	TO-59	/277 **
2N2880	5A	80V	40 @ 1A	.25V @ 1A	0.3 µS	TO-59	/315 *
2N3749	5A	80V	40 @ 1A	.25V @ 1A	0.3 µS	TO-111	/315
2N3996	5A	80V	40 @ 1A	.25V @ 1A	0.8 µS	TO-111	/374 *
2N3997	5A	80V	80 @ 1A	.25V @ 1A	1.0 µS	TO-111	/374
2N3998	5A	80V	40 @ 1A	.25V @ 1A	0.8 µS	TO-59	/374
2N3999	5A	80V	80 @ 1A	.25V @ 1A	1.0 µS	TO-59	/374
2N5664	5A	200V	40 @ 1A	.4V @ 3A	0.8 µS	TO-66	/455 *
2N5665	5A	300V	25 @ 1A	.4V @ 3A	1.0 µS	TO-66	/455
2N5666	5A	200V	40 @ 1A	.4V @ 3A	0.8 µS	TO-5	/455
2N5667	5A	300V	25 @ 1A	.4V @ 3A	1.0 µS	TO-5	/455
2N6544	8A	300V	7 @ 5A	1.5V @ 3A	0.9 µS	TO-3	N/A
UMT1008	8A	300V	7 @ 5A	1.5V @ 3A	0.4 µS	TO-3	N/A
2N6545	8A	400V	7 @ 5A	1.5V @ 5A	0.9 µS	TO-3	N/A
UMT1009	8A	400V	7 @ 5A	1.5V @ 5A	0.4 µS	TO-3	N/A
2N4150	10A	70V	10 @ 10A	0.6V @ 5A	0.4 µS	TO-5	/394 *
2N6354	10A	120V	10 @ 10A	1.0V @ 10A	0.2 µS	TO-3	N/A
2N6496	15A	100V	12 @ 8A	1.0V @ 8A	0.3 µS	TO-3	N/A
2N5038	20A	90V	20 @ 12A	1.2V @ 12A	0.5 µS	TO-3	/439 *
2N5039	20A	75V	20 @ 10A	1.0V @ 10A	0.5 µS	TO-3	/439

*Series available as JAN, JANTX, and JANTXV
** Series available as JAN and JANTX

POWER DARLINGTONS

TYPE	D.C. COLLECTOR CURRENT	B_{VCEO}	MINIMUM h_{FE} @ 5A	PACKAGE	MIL-S-19500
2N6350	5A	80V	2000	TO-33	/472 **
2N6351	5A	150V	1000	TO-33	/472
2N6352	5A	80V	2000	TO-66	/472
2N6353	5A	150V	1000	TO-66	/472

**Series available as JAN, JANTX

POWER ZENERS AND TRANSIENT SUPPRESSORS

TYPE	AVERAGE D.C. POWER	BREAKDOWN VOLTAGE RANGE	PEAK POWER	PACKAGE	MIL-S-19500
1N4461-83	1.5W	6.8V-56V	140W	Axial	/406 *
1N4954-96	5.0W	6.8V-390V	900W	Axial	/356 *
1N5610-13	6.0W	33V-191V	1500W	Axial	/434 **
UZ7706-7110	10W	6.8V-100V	2000W	Stud Mount	N/A

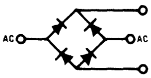
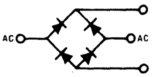
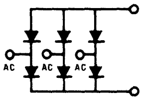
*Series available as JAN, JANTX and JANTXV
**Series available as JAN and JANTX

SWITCHING REGULATOR POWER OUTPUT CIRCUITS

TYPE	OUTPUT CURRENT, PK.	INPUT/OUTPUT VOLTAGE*	POLARITY	FALL-TIME VOLTAGE (V)	FALL-TIME CURRENT (nS)	ON-STATE VOLT. @ CURR. (V) @ (I)	PACKAGE
PIC600	5A	60	Pos.	75	150	1.5 @ 2	4 PIN TO-66 (Isolated)
PIC601		80	Pos.				
PIC602		100	Pos.				
PIC610		60	Neg.				
PIC611		80	Neg.				
PIC612		100	Neg.				
PIC625	15A	60	Pos.	175	300	1.5 @ 7	4 PIN TO-66 (Isolated)
PIC626		80	Pos.				
PIC627		100	Pos.				
PIC635		60	Neg.	300	300		
PIC636		80	Neg.				
PIC637		100	Neg.				
PIC645	20A	60	Pos.	150	300	1.5 @ 7	3 PIN TO-3
PIC646		80	Pos.				
PIC647		100	Pos.				
PIC655		60	Neg.	300	300		
PIC656		80	Neg.				
PIC657		100	Neg.				

BRIDGE RECTIFIERS

40 Hz - 5KHz

TYPE	CONFIGURATION	OUTPUT CURRENT	REVERSE VOLTAGE	SPECIFICATIONS	MIL-S-19500
469-1 469-2 469-3	Single Phase 	10A	200V 400V 600V	V_F@15.7A, 1.35V Max I_R @ V_R, 2μA Max I_{SURGE}, 100A	/469*
SPA25 SPB25 SPC25 SPD25	Single Phase 	25A	100V 200V 400V 600V	V_F @ 39A, 1.4V Max I_R @ V_R, 2μA Max I_{SURGE}, 150A	/446*
483-1 483-2 483-3	Three Phase 	25A	200V 400V 600V	V_F @ 39A, 1.3 V Max I_R @ V_R, 3μA Max I_{SURGE}, 150A	/483**

* Series available as JAN and JANTX
** Series available as JANTX only

HIGH VOLTAGE DOORBELL® MODULES

40 Hz - 5KHz

TYPE	OUTPUT CURRENT	REVERSE VOLTAGE	MAXIMUM REVERSE CURRENT @ V_R	MAXIMUM FORWARD VOLTAGE	SURGE CURRENT	MIL-S-19500
1N5597	1A	10KV	1μA	19V @ 1A	30A	/404*
1N5600	2A	5KV	5μA	10V @ 2A	80A	
1N5603	5A	5KV	5μA	10V @ 5A	200A	

* Series available as JAN only

MILITARY DESIGNERS' GUIDE

THYRISTORS

Silicon Control Rectifiers

TYPE	D.C. ON STATE CURRENT	V_{DRM}	MAXIMUM I_{GT}	MAXIMUM V_{GT}	PACKAGE	MIL-S-19500
2N3027	.5A	30V	20μA	.6V	TO-18	/419 **
2N3028	.5A	60V	20μA	.6V	TO-18	/419
2N3029	.5A	100V	20μA	.6V	TO-18	/419
2N3030	.5A	30V	20μA	.6V	TO-18	/419
2N3031	.5A	60V	20μA	.6V	TO-18	/419
2N3032	.5A	100V	20μA	.6V	TO-18	/419
2N1870A	1.25A	30V	200μA	.8V	TO-9	/198 ***
2N1871A	1.25A	60V	200μA	.8V	TO-9	/198
2N1872A	1.25A	100V	200μA	.8V	TO-9	/198
2N1873A	1.25A	150V	200μA	.8V	TO-9	N/A
2N1874A	1.25A	200V	200μA	.8V	TO-9	/198
2N2323A	1.6A	50V	20μA	.6V	TO-5	/276 *
2N2324A	1.6A	100V	20μA	.6V	TO-5	/276
2N2325A	1.6A	150V	20μA	.6V	TO-5	N/A
2N2326A	1.6A	200V	20μA	.6V	TO-5	/276
2N2327A	1.6A	250V	20μA	.6V	TO-5	N/A
2N2328A	1.6A	300V	20μA	.6V	TO-5	/276
2N2329A	1.6A	400V	20μA	.6V	TO-5	/276
CM100	5A	60V	200μA	.8V	TO-59	N/A
CM101	5A	100V	200μA	.8V	TO-59	N/A
CM102	5A	200V	200μA	.8V	TO-59	N/A
CM103	5A	300V	200μA	.8V	TO-59	N/A
CM104	5A	400V	200μA	.8V	TO-59	N/A

* Series available as JAN and JANTX and JANTXV
** Series available as JAN and JANTX
*** Series available as JAN only

Ultra Fast Switching

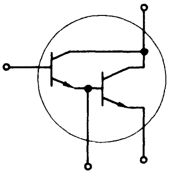
TYPE	D.C. ON STATE CURRENT	V_{DRM}	RISE TIME	COMMUTATED TURN-OFF TIME	PACKAGE
GA200	.4A	60V	25nS	2.0μS	TO-18
GA201	.4A	100V	20nS	2.0μS	TO-18
GB200	6A	60V	25nS	2.0μS	TO-59
GB201	6A	100V	20nS	2.0μS	TO-59

PROGRAMMABLE UNIJUNCTION TRANSISTORS

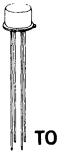
TYPE	V_{AK}	PEAK CURRENT	VALLEY CURRENT	PACKAGE	MIL-S-19500
2N6137	40V	2μA @ R_G=1 MEGΩ	1.5mA @ R_G=200Ω	TO-18	/493 *

* Series available as JAN, JANTX and JANTXV

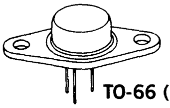
POWER DARLINGTONS



External bias types — for fast switching or other special purpose applications



TO-33



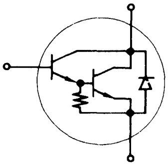
TO-66 (3-Pin)

NPN Power Darlingtons

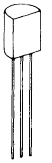
Maximum Collector Current		2A				5A			
Package Style		**TO-33**		**TO-66 (3-Pin)**		**TO-33**		**TO-66 (3-Pin)**	
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\ (sus)}$	60V	U2T301		U2T401					
	80V					2N6350* U2T101		2N6352* U2T201	
	150V		U2T305		U2T405		2N6351* U2T105		2N6353* U2T205
h_{FE} Minimum		1000 @ 2A		1000 @ 2A		2000 @ 5A	1000 @ 5A	2000 @ 5A	1000 @ 5A
V_{CE}(sat) Maximum		1.5V @ 2A	2.5V @ 2A	1.5V @ 2A	2.5V @ 2A	1.5V @ 5A	2.5V @ 5A	1.5V @ 5A	2.5V @ 5A
t_f Typical		0.3μs				0.5μs			

*Available as JAN and JANTX types.

Plastic NPN Power Darlingtons

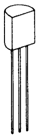


Plastic Package and multiple types with integral bias resistance and shunt diode for maximum economy in standard applications

	Maximum Collector Current		5A (PEAK)
 TO-92	**Package Style**		**TO-92**
	COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\ (sus)}$	60V	U2TA506
		80V	U2TA508
		100V	U2TA510
	h_{FE} Minimum		500 @ 3A
	V_{CE} (sat) Maximum		1.5V @ 3A
	t_f Typical		0.8μs

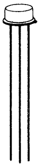
NPN POWER SWITCHING TRANSISTORS

.5-30A, 60-500V



TO-92

TO-5



Pancake
TO-5

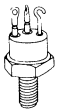
LOW VOLTAGE

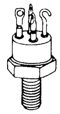
Maximum Collector Current		1 AMP (PEAK)	2 AMP	3 AMP		5 AMP	
Package Style		**TO-92**	**TO-5**	**TO-5**		**Pancake TO-5**	
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\,(sus)}$	60V		UPT212	2N3418*	2N3420*	2N2855	2N2854
	80V		UPT213	2N3419*	2N3421*	2N2850	2N5487
	100V	UPTA510	UPT214 UPT215			2N5488	
h_{FE} Minimum		25 @ .1A	30 @ .5A	20 @ 1A	40 @ 1A	40 @ 1A	100 @ 1A
V_{CE} (sat) Max.		1V @ .5A	1V @ 2A	.5V @ 2A	.5V @ 2A	.25V @ 1A	
t_f Maximum		0.2µs (typical)	0.1µs (typical)	1.2µs ($t_{OFF}=t_s+t_f$)		0.15µs (2N2855) 0.25µs (2N5488)	0.15µs (2N2854) 0.25µs (2N5487)

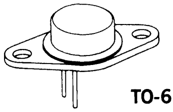
HIGH VOLTAGE

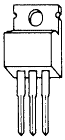
Maximum Collector Current		.5 AMP (PEAK)	1 AMP (PEAK)	2 AMP	
Package Style		**TO-92**	**TO-92**	**TO-5**	
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\,(sus)}$	150V			UPT311	
	200V	UPTB520	UPTA520	UPT312	2N5662*
	250V			UPT313	
	275V				
	300V	UPTB530	UPTA530	UPT314 UPT315	2N5663*
	350V				
	400V	UPTB540			
	500V	UPTB550			
h_{FE} Minimum		20 @ 25mA	25 @ .1A	30 @ .5A	40 @ .5A (2N5662) 25 @ .5A (2N5663)
V_{CE} (sat) Max.		1.2v @ 50mA	1V @ .5A	1V @ 2A	.4V @ 1A
t_f Maximum		1.0µs (typical)	0.2µs (typical)	0.3µs (typical)	0.4µs (2N5662) 0.6µs (2N5663)

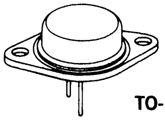
*Available as JAN, JANTX, JANTXV.


TO-59


TO-111


TO-66


TO-220


TO-3

LOW VOLTAGE

Maximum Collector Current		5 AMP				
Package Style		**TO-5**	**TO-59**		**TO-111**	
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\,(sus)}$	60V	UPT612				
	80V	UPT613	2N2151** 2N2880* 2N3998*	2N3999*	2N3749* 2N3996*	2N3997*
	100V	UPT614 UPT615				
h_{FE} Minimum		30 @ 1A	40 @ 1A	80 @ 1A	40 @ 1A	80 @ 1A
V_{CE} (sat) Max.		1V @ 5A	.25V @ 1A (1V @ 1A for 2N2151)			
t_f Maximum		0.1μs (typical)	0.3μs (2N2880) 0.8μs (2N3998)	1.0μs	0.3μs (2N3749) 0.8μs (2N3996)	1.0μs

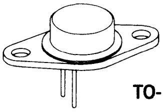
HIGH VOLTAGE

Maximum Collector Current		2 AMP			3 AMP			4 AMP
Package Style		**TO-66**		**TO-220**	**TO-66**	**TO-220**	**TO-3**	**TO-220**
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\,(sus)}$	150V	UPT321			UPT521			
	200V	UPT322	2N5660*		UPT522			
	250V	UPT323		UMT3584	UPT523		2N5838	
	275V						2N5839	
	300V	UPT324 UPT325	2N5661*	UMT3585	UPT524 UPT525	UMT1203		UMT13004
	350V						2N5840	
	400V					UMT1204		UMT13005
	500V							
h_{FE} Minimum		30 @ .5A	40 @ .5A (2N5660) 25 @ .5A (2N5661)	25 @ 1A	25 @ 1A	7 @ 2A	10 @ 2A	8 @ 2A
V_{CE} (sat) Max.		1V @ 2A	.4V @ 1A	0.75V @ 1A	1V @ 3A	3V @ 3A	1.5V @ 2A	0.6V @ 2A
t_f Maximum		0.3μs (typical)	0.4μs (2N5660) 0.6μs (2N5661)	3.0μs	0.4μs (typical)	0.7μs	1.5μs	0.9μs

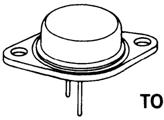
*Available as JAN, JANTX, JANTXV.
**Available as JAN, JANTX.

NPN POWER SWITCHING TRANSISTORS

.5-30A, 60-500V



TO-66



TO-3

TO-5

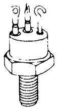
LOW VOLTAGE

Maximum Collector Current		10 AMP			
Package Style			**TO-5**		**TO-3**
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\ (SUS)}$	70V		2N4150**		
	75V				
	80V			2N5552	
	90V				
	100V	2N6232			
	120V				2N6354
h_{FE} Minimum		25 @ 5A	50 @ 5A	50 @ 5A	10 @ 10A
V_{CE} (sat) Max.		0.7V @ 5A	0.6V @ 5A	0.5V @ 5A	1.0 @ 10A
t_f Maximum		0.8μs	0.5μs	0.45μs	0.2μs

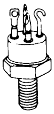
HIGH VOLTAGE

Maximum Collector Current		5 AMP							8 AMP
Package Style		**TO-5**		**TO-66**			**TO-3**		**TO-220**
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\ (SUS)}$	150V					UPT721			
	200V	2N5666*		2N5664*		UPT722			
	250V					UPT723			
	275V								
	300V		2N5667*		2N5665*	UPT724 UPT725	2N6542		UMT13006
	350V							UMT1006	
	400V						2N6543	UMT1007	UMT13007
h_{FE} Minimum		40 @ 1A	25 @ 1A	40 @ 1A	25 @ 1A	25 @ 1A	7 @ 3A	7 @ 3A	6 @ 5A
V_{CE} (sat) Max.				0.4 @ 3A		1V @ 3A	1.0V @ 3A	1.0V @ 3A	1.5V @ 5A
t_f Maximum		0.8μs	1.0μs	0.8μs	1.0μs	0.5μs (typical)	0.8μs	0.4μs	0.7μs

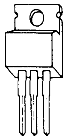
*Available as JAN, JANTX, JANTXV.



TO-59



TO-111



TO-220

LOW VOLTAGE

Maximum Collector Current		10 AMP		15 AMP	20 AMP		30 AMP
Package Style		**TO-59**	**TO-111**	**TO-3**	**TO-3**		**TO-3**
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\ (sus)}$	70V						
	75V					2N5039*	
	80V	2N5658	2N5659				
	90V				2N5038*		2N5671
	100V			2N6496			
	120V						2N5672
h_{FE} Minimum		50 @ 5A		12 @ 8A	20 @ 12A	20 @ 10A	20 @ 15A
V_{CE} (sat) Max.		0.5V @ 5A		1.0V @ 8A	1.2V @ 12A	1.0V @ 10A	0.75V @ 15A
t_f Maximum		0.5μs		0.5μs	0.5μs		0.5μs

*Available as JAN, JANTX, JANTXV.

HIGH VOLTAGE

Maximum Collector Current		8 AMP			10 AMP			12 AMP	15 AMP	
Package Style		**TO-3**			**TO-3**			**TO-220**	**TO-3**	
COLLECTOR-EMITTER SUSTAINING VOLTAGE $V_{CEO\ (sus)}$	150V									
	200V				2N6249					
	250V	2N6306								
	275V					2N6250				
	300V	2N6307		UMT1008 2N6544				UMT13008		2N6546
	350V		2N6308				2N6251		UMT1011	
	400V			UMT1009 2N6545				UMT13009	UMT1012	2N6547
h_{FE} Minimum		15 @ 3A	12 @ 3A	7 @ 5A	10 @ 10A	8 @ 10A	6 @ 10A	6 @ 8A	6 @ 10A	6 @ 10A
V_{CE} (sat) Max.		0.8V @ 3A	1.5V @ 3A	1.5V @ 5A	1.5V @ 10A	1.5V @ 10A	1.5V @ 10A	1.5V @ 8A	1.0V @ 10A	1.5V @ 10A
t_f Maximum		0.4μs		0.9μs (2N6544, 5) 0.4μs (UMT1008, 9)	1.0μs	1.0μs	1.0μs	0.7μs	0.4μs	0.7μs

POWER TRANSISTORS
2 Amp, 80V, Planar NPN

JAN & JANTX 2N2151

FEATURES
- Meets MIL-S-19500/277
- Collector-Base Voltage: up to 150V
- D.C. Collector Current: 2A
- Beta Guaranteed at 3 Current Levels
- Characterized for Safe Operating Area

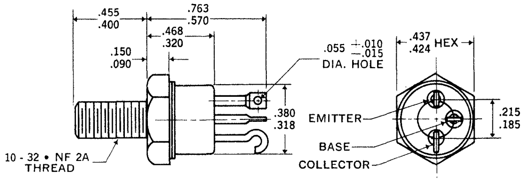
DESCRIPTION
Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply pulse amplifier and similar high efficiency power switching applications.

ABSOLUTE MAXIMUM RATINGS

	JAN & JANTX 2N2151
Collector-Base Voltage, V_{CBO}	150V
Collector-Emitter Voltage, V_{CEO}	100V
Emitter-Base Voltage, V_{EBO}	8V
D.C. Collector Current, I_C	2A
Base Current, I_B	2A
Power Dissipation	
100°C Case	30W
Operating Temperature Range	—55°C to 175°C
Storage Temperature Range	—65°C to 200°C

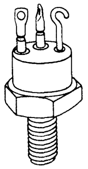
MECHANICAL SPECIFICATIONS

JAN & JANTX2N2151



Dimensions in inches.

TO-59

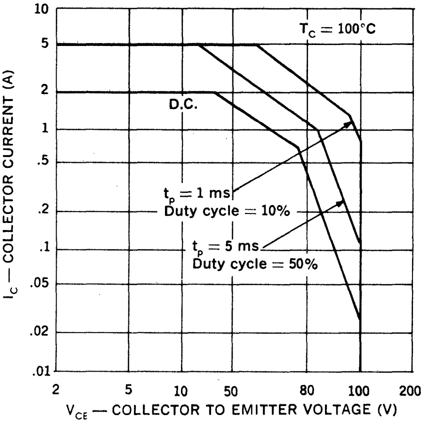


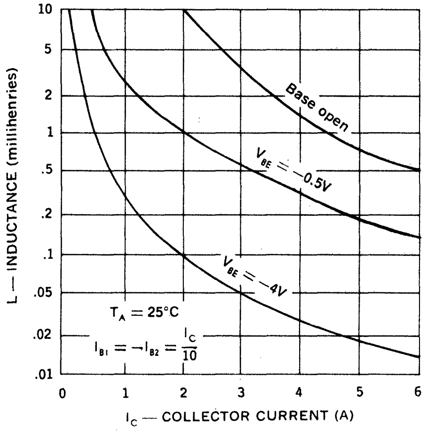
UNITRODE

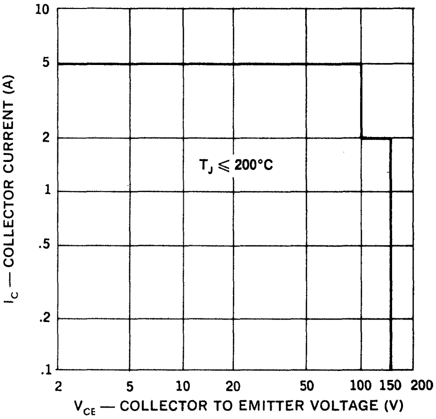
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

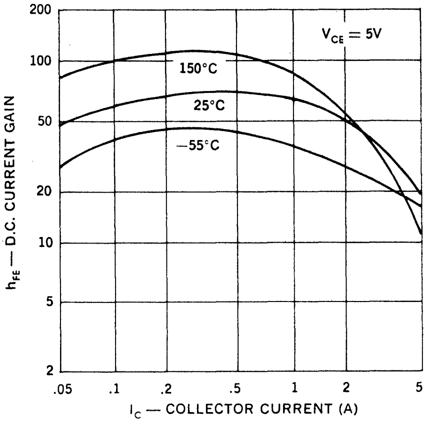
Test	Symbol	Min.	Max.	Units	/277C Sub-group	Method	MIL-STD-750 Test Conditions
25°C							
Collector-Base Breakdown Voltage	BV_{CBO}	150	—	Vdc	A-2	3001	I_C = 100uAdc, Cond. D
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}	100	—	Vdc	A-2	3011	I_C = 50mAdc, Cond. D
Collector-Emitter Cutoff Current	I_{CES}	—	5	uAdc	A-2	3041	V_{CE} = 120Vdc, V_{BE} = 0, Cond. C
Collector-Emitter Cutoff Current	I_{CEX}	—	5	uAdc	A-2	3041	V_{CE} = 120Vdc, V_{EB} = 1Vdc, Cond. A
Collector-Emitter Cutoff Current	I_{CEO}	—	10	uAdc	A-2	3041	V_{CE} = 80Vdc, Cond. D
Collector-Base Cutoff Current	I_{CBO}	—	5	uAdc	A-2	3036	V_{CB} = 120Vdc, Cond. D
Emitter-Base Cutoff Current	I_{EBO}	—	2	uAdc	A-2	3061	V_{EB} = 8Vdc, Cond. D
D.C. Current Gain (Note 1)	h_{FE}	40	120	—	A-3	3076	I_C = 1Adc, V_{CE} = 5Vdc
D.C. Current Gain (Note 1)	h_{FE}	40	120	—	A-3	3076	I_C = 0.5Adc, V_{CE} = 5Vdc
D.C. Current Gain (Note 1)	h_{FE}	40	—	—	A-3	3076	I_C = 0.1Adc, V_{CE} = 5Vdc
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	0.1	1.0	Vdc	A-3	3071	I_C = 1Adc, I_B = 0.1Adc
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.2	Vdc	A-3	3066	I_C = 1Adc, I_B = 0.1Adc, Cond. A
Base-Emitter Voltage (Note 1)	V_{BE}	—	1.2	Vdc	A-3	3066	I_C = 1Adc, V_{CE} = 5Vdc, Cond. B
A.C. Current Gain	h_{fe}	40	160	—	A-5	3206	I_C = 0.1Adc, V_{CE} = 30Vdc, f = 1kHz
Gain-Bandwidth Product	f_T	10	70	MHz	A-5	3306	I_C = 0.1Adc, V_{CE} = 30Vdc, f = 10MHz
Output Capacitance	C_{ob}	—	160	pf	A-5	3236	V_{CB} = 20Vdc, I_E = 0, f = $1MH_Z$
Thermal Resistance	θ_{J-C}	—	2.5	$^{o}C/_{W}$	C-1	3151	
100°C							
Forward-Biased Second Breakdown	$I_{S/B}$	2	—	Adc	B-9	—	V_{CE} = 15Vdc, t = 60 sec, see curve
Forward-Biased Second Breakdown	$I_{S/B}$	200	—	mAdc	B-9	—	V_{CE} = 57Vdc, t = 60 sec, see curve
Forward-Biased Second Breakdown	$I_{S/B}$	25	—	mAdc	B-9	—	V_{CE} = 100Vdc, t = 60 sec, see curve
Unclamped Inductive Sweep	$E_{S/B}$	20	—	mj	B-5	—	I_C = 2Adc, L = 10mh
Clamped Inductive Sweep	$E_{S/B}$	80	—	mj	B-6	—	I_C = 2Adc, L = 40mh, V_{clamp} = 150V
150°C							
Collector-Emitter Cutoff Current	I_{CES}	—	100	uAdc	A-4	3041	V_{CE} = 120Vdc, V_{BE} = 0, Cond. C
Collector-Emitter Cutoff Current	I_{CEX}	—	100	uAdc	A-4	3041	V_{CE} = 120Vdc, V_{EB} = 1Vdc
Emitter-Base Cutoff Current	I_{EBO}	—	20	uAdc	A-4	3061	V_{EB} = 8Vdc, Cond. D
–55°C							
D.C. Current Gain (Note 1)	h_{FE}	20	—	—	A-4	3076	I_C = 0.5Adc, V_{CE} = 5Vdc

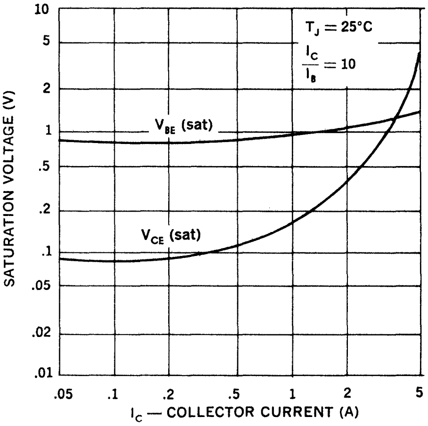
Note: 1. Pulse length = 300 μs; duty cycle $\leqslant$2%.

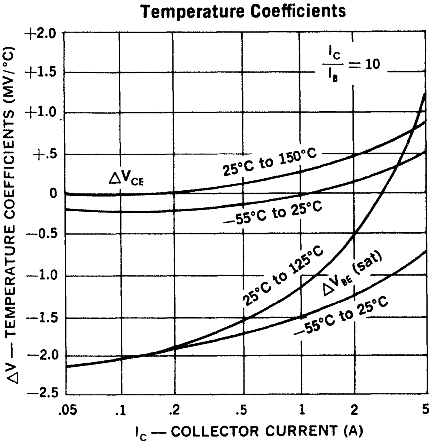

Forward Bias Safe Operating Area


Unclamped Reverse Bias Second Breakdown

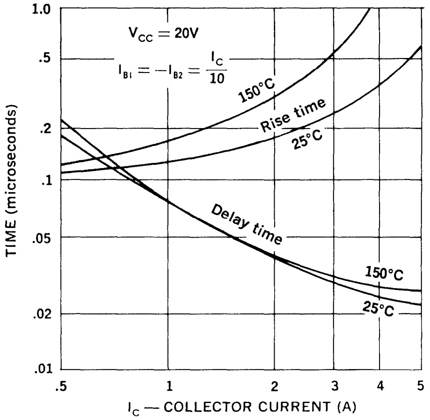

Reverse Bias Safe Operating Area Clamped Inductive Switching


D.C. Current Gain

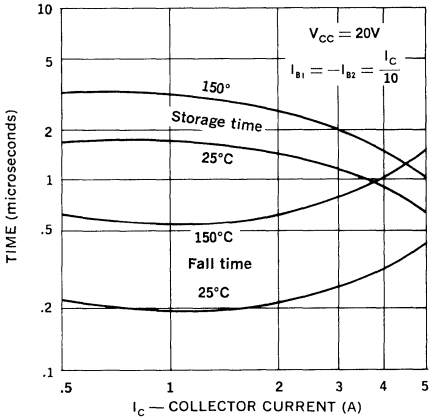

Saturation Voltages


Saturation Voltage Temperature Coefficients

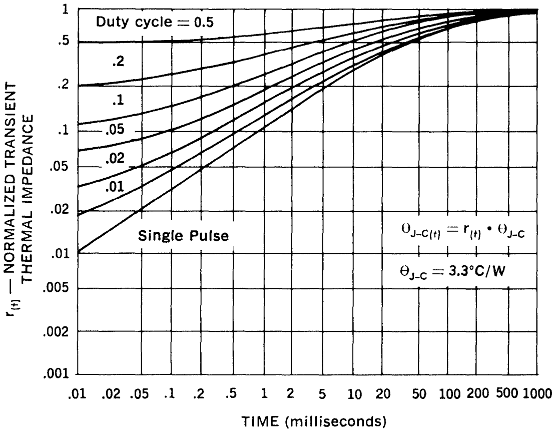
Switching Speed Characteristics



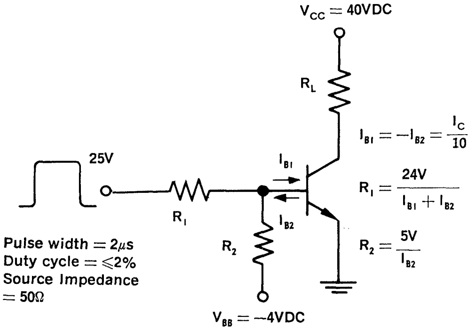
Switching Speed Characteristics



Thermal Response



Switching Speed Circuit



Pulse width = 2μs
Duty cycle = ≤2%
Source Impedance
= 50Ω

POWER TRANSISTORS
5 Amp, 80V, Planar, NPN

JAN, JANTX, & JANTXV 2N2880
JAN, JANTX, & JANTXV 2N3749

FEATURES
- Meets MIL-S-19500/315
- Collector-Base Voltage: 110V
- Fast Switching: t_r, t_f = 300nSec max
- Low Saturation Voltage: 0.25V max @ 1A

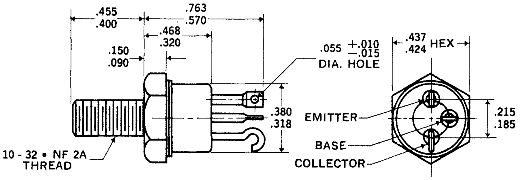
DESCRIPTION
Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply, pulse amplifier and similar high efficiency power switching applications.

ABSOLUTE MAXIMUM RATINGS

	JAN, JANTX, JANTXV 2N2880 2N3749
Collector-Base Voltage, V_{CBO}	110V
Collector-Emitter Voltage, V_{CEO}	80V
Emitter-Base Voltage, V_{EBO}	8V
D.C. Collector Current, I_C	5A
Power Dissipation	
25°C Ambient	2W
100°C Case	30W
Operating and Storage Temperature Range	−65°C to +200°C

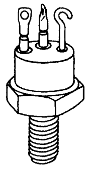
MECHANICAL SPECIFICATIONS

JAN, JANTX, & JANTXV 2N2880

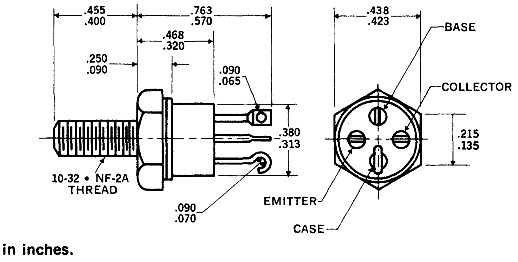


Dimensions in inches.

TO-59

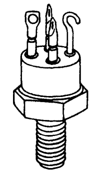


JAN, JANTX, & JANTXV 2N3749



Dimensions in inches.

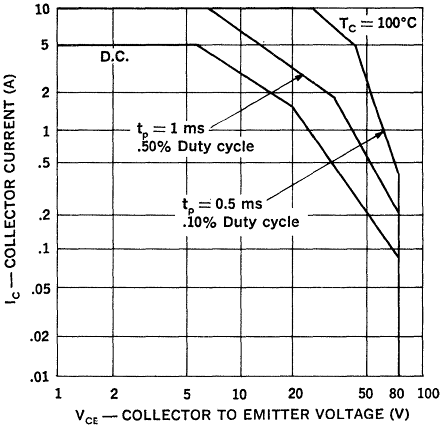
TO-111



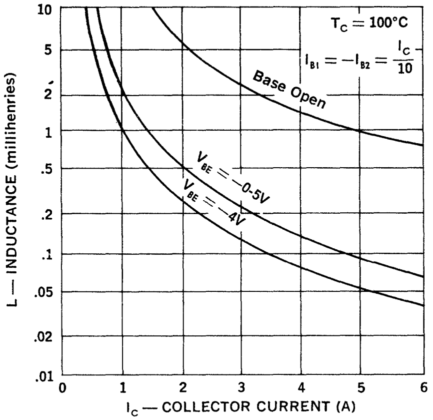
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

TEST	SYMBOL	MIN.	MAX.	UNITS	/315 Sub group	MIL - STD - 750	
						METHOD	TEST CONDITIONS
Visual and Mechanical	—	—	—		A-1	2071	See Mechanical Data
Collector-Base Voltage	BV_{CBO}	110	—	Vdc	A-2	3001	$I_C = 10\mu Adc$, Cond. D
Collector-Emitter Voltage (1.)	BV_{CEO}	80	—	Vdc	A-2	3011	$I_C = 0.1Adc$, Cond. D
Emitter-Base Voltage	BV_{EBO}	8	—	Vdc	A-2	3026	$I_E = 10\mu Adc$, Cond. D
Collector-Emitter Cutoff Current	I_{CEO}	—	100	μAdc	A-2	3041	$V_{CE} = 60Vdc$, Cond. D
Collector-Emitter Cutoff Current	I_{CEX}	—	10	μAdc	A-2	3041	$V_{CE} = 110Vdc$, $V_{EB} = 0.5Vdc$, Cond. A
Collector-Base Cutoff Current	I_{CBO}	—	0.4	μAdc	A-2	3036	$V_{CB} = 80Vdc$, Cond. D
Emitter-Base Cutoff Current	I_{EBO}	—	0.4	μAdc	A-2	3061	$V_{EB} = 6Vdc$, Cond. D
D.C. Current Gain (1.)	h_{FE}	40	—	—	A-3	3076	$I_C = 50mAdc$, $V_{CE} = 5Vdc$
D.C. Current Gain (1.)	h_{FE}	40	120	—	A-3	3076	$I_C = 1Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (1.)	h_{FE}	15	—	—	A-3	3076	$I_C = 5Adc$, $V_{CE} = 5Vdc$
Collector Saturation Voltage (1.)	$V_{CE\,(sat)}$	—	0.25	Vdc	A-3	3071	$I_C = 1Adc$, $I_B = 0.1Adc$
Collector Saturation Voltage (1.)	$V_{CE\,(sat)}$	—	2	Vdc	A-3	3071	$I_C = 5Adc$, $I_B = 0.5Adc$
Base Saturation Voltage (1.)	$V_{BE\,(sat)}$	—	1.2	Vdc	A-3	3066	$I_C = 1Adc$, $I_B = 0.1Adc$
Base On-Voltage (1.)	$V_{BE\,(on)}$	—	1.2	Vdc	A-3	3066	$I_C = 1Adc$, $V_{CE} = 2Vdc$
A.C. Current Gain	h_{FE}	40	120	—	A-4	3206	$I_C = 50mAdc$, $V_{CE} = 5Vdc$, $f = 1KHz$
Gain-Bandwidth Product	f_T	20	120	MHz	A-4	3306	$I_C = 1Adc$, $V_{CE} = 10Vdc$, $f = 10MHz$
Output Capacitance	C_{ob}	—	150	pf	A-4	3236	$V_{CB} = 10Vdc$, $I_E = 0$, $f = 1MHz$
Switching Parameters							
Delay Time	t_d	—	60	ns	A-4	—	See Switching Speed Circuit
Rise Time	t_r	—	300	ns	A-4	—	
Storage Time	t_s	—	1.7	μs	A-4	—	
Fall Time	t_f	—	300	ns	A-4	—	
Thermal Resistance	θ_{JC}	—	3.33	°C/W	C-1	3151	
100°C							
Forward-Biased Second Breakdown	$I_{S/B}$	5	—	Adc	B-5	3051	$V_{CE} = 6Vdc$, $t = 60Sec$, $T_C = 100°C$
Forward-Biased Second Breakdown	$I_{S/B}$	80	—	mAdc	B-5	3051	$V_{CE} = 80Vdc$, $t = 60Sec$, $T_C = 100°C$
Clamped Reverse-Biased Second Breakdown	$E_{S/B}$	12.5	—	mj	B-7	—	$I_C = 5A$, $L = 1mH$, $V_{Clamp} = 110V$, $T_C = 100°C$
Unclamped Reverse-Biased Second Breakdown	$E_{S/B}$	12.5	—	mj	B-6	3053	$I_C = 5A$, $L = 1mH$ Base Open
Unclamped Reverse-Biased Second Breakdown	$E_{S/B}$	12.8	—	mj	B-6	3053	$I_C = 1.6A$, $L = 10mH$ Base Open
150°C							
Collector-Emitter Cutoff Current	I_{CEX}	—	50	μA	A-5	3041	$V_{CE} = 80Vdc$, $V_{EB} = 0.5Vdc$ Cond. A, $T_A = 150°C$
−65°C							
D.C. Current Gain (1.)	h_{FE}	15	—	—	A-5	3076	$I_C = 1Adc$, $V_{CE} = 5Vdc$ $T_A = -65°C$

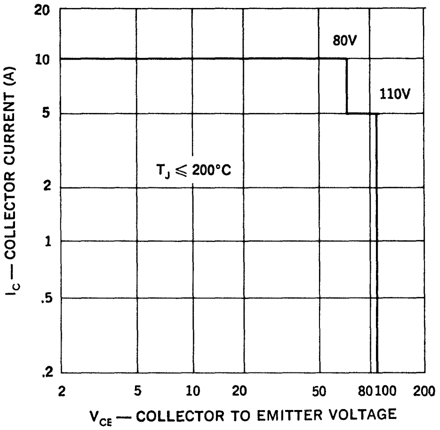
Note 1. Pulse Width = 300μSec, duty cycle ⩽ 2%



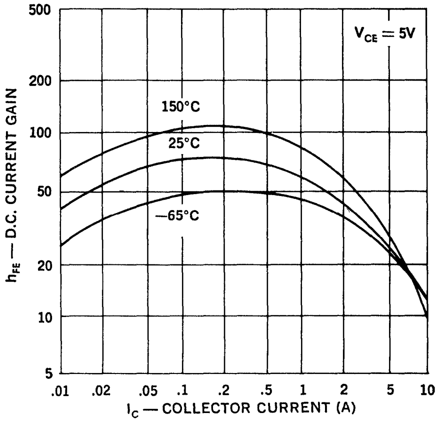
Forward Bias Safe Operating Area



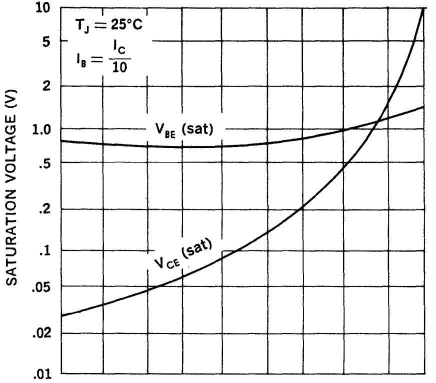
Unclamped Reverse Bias Second Breakdown



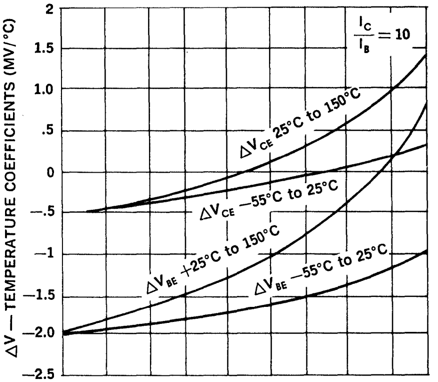
Reverse Bias Safe Operating Area Clamped Inductive Switching



D.C. Current Gain 2N2880-2N3749

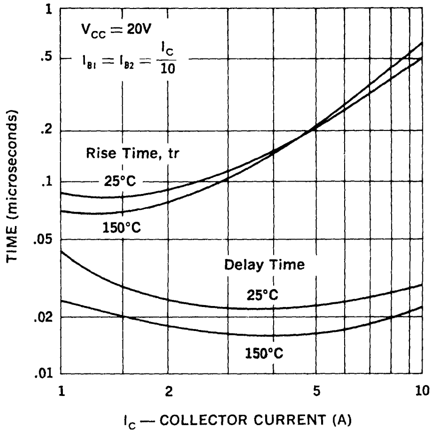


Saturation Voltages

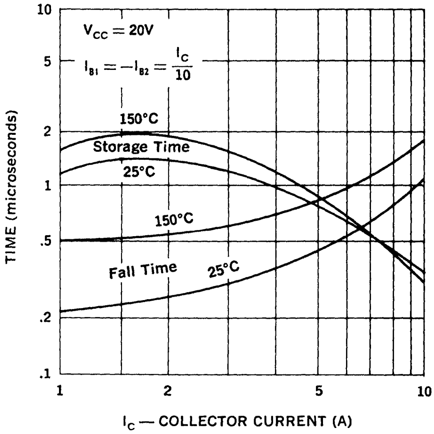


Saturation Voltage Temperature Coefficients

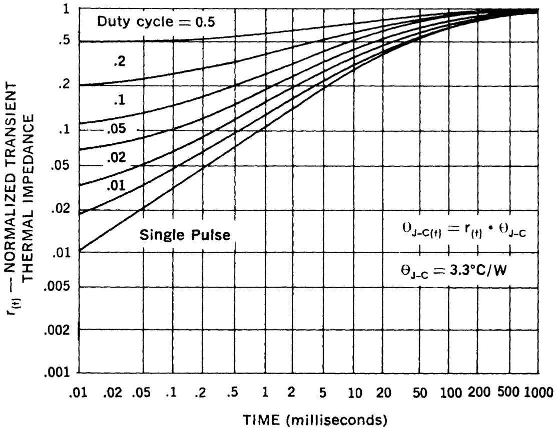
Switching Speed Characteristics



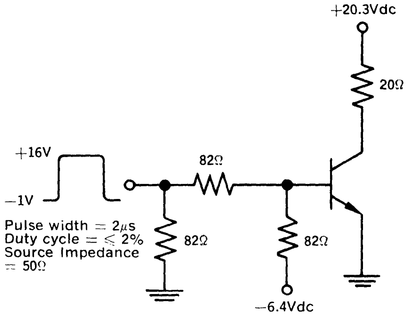
Switching Speed Characteristics



Thermal Response



Switching Speed Circuit



NOTES:

1. $I_C \approx 1A$, $I_{B1} \approx -I_{B2} \approx 100mA$
2. The values of collector current and base current are nominal. The actual values will vary slightly with transistor parameters.

POWER TRANSISTORS

3 Amp, 80V, Planar NPN

JAN, JANTX, & JANTXV 2N3418
JAN, JANTX, & JANTXV 2N3419
JAN, JANTX, & JANTXV 2N3420
JAN, JANTX, & JANTXV 2N3421

FEATURES

- Meets MIL-S-19500/393
- Collector-Base Voltage: up to 125V
- Peak Collector Current: 5A
- High Power Dissipation in TO-5: 15W @ $T_C = 100°C$
- Fast Switching

DESCRIPTION

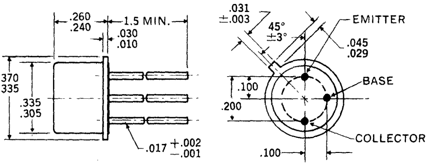
Unitrode power transistors provide a unique combination of low saturation voltage, high gain, and fast switching. They are ideally suited for power supply, pulse amplifier and similar high frequency power switching applications.

ABSOLUTE MAXIMUM RATINGS

	JAN, JANTX, & JANTXV 2N3418 2N3420	JAN, JANTX, & JANTXV 2N3419 2N3421
Collector-Base Voltage, V_{CBO}	85V	125V
Collector-Emitter Voltage, V_{CEO}	60V	80V
Emitter-Base Voltage, V_{EBO}	8V	8V
D.C. Collector Current, I_C	3A	3A
Peak Collector Current, I_C	5A	5A
Power Dissipation		
25°C Ambient	1.0W	1.0W
100°C Case	15W	15W
Operating and Storage Temperature Range	−65°C to +200°C	

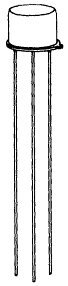
MECHANICAL SPECIFICATIONS

JAN, JANTX, & JANTXV 2N3418-2N3421



Dimensions in inches.

TO-5

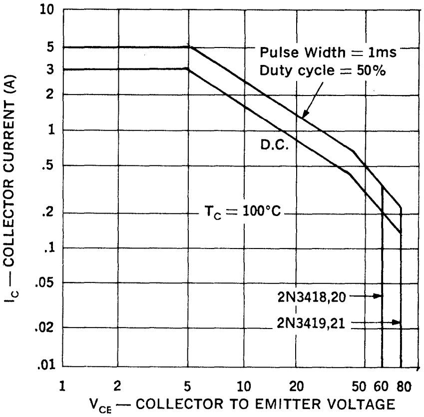


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

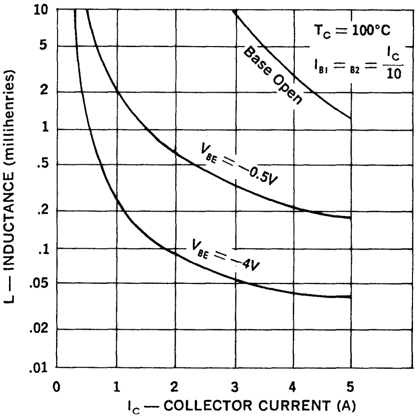
TEST	SYMBOL	MIN.	MAX.	UNITS	/393 Sub-group	MIL - STD - 750	
						METHOD	TEST CONDITIONS
Visual and Mechanical	—	—	—	—	A-1	2071	See Mechanical Data
Collector-Emitter Breakdown Voltage (1.)	BV_{CEO}				A-2	3011	$I_C = 50mAdc$, Cond. D
2N3418, 2N3420		60	—	Vdc			
2N3419, 2N3421		80	—	Vdc			
Collector-Emitter Cutoff Current	I_{CEX}				A-2	3041	$V_{EB} = 0.5Vdc$, Cond. A
2N3418, 2N3420		—	0.5	μAdc			$V_{CE} = 80Vdc$
2N3419, 2N3421		—	0.5	μAdc			$V_{CE} = 120Vdc$
Collector-Emitter Cutoff Current	I_{CEO}				A-2	3041	Cond. D
2N3418, 2N3420		—	5.0	μAdc			$V_{CE} = 45Vdc$
2N3419, 2N3421		—	5.0	μAdc			$V_{CE} = 60Vdc$
Emitter-Base Cutoff Current	I_{EBO}	—	0.5	μAdc	A-2	3061	$V_{EB} = 6Vdc$, Cond. D
Emitter-Base Cutoff Current	I_{EBO}	—	10	μAdc	A-2	3061	$V_{EB} = 8Vdc$, Cond. D
D.C. Current Gain (1.)	h_{FE}				A-3	3076	$I_C = 100mAdc$, $V_{CE} = 2Vdc$
2N3418, 2N3419		20	—	—			
2N3420, 2N3421		40	—	—			
D.C. Current Gain (1.)	h_{FE}				A-3	3076	$I_C = 1Adc$, $V_{CE} = 2Vdc$
2N3418, 2N3419		20	60	—			
2N3420, 2N3421		40	120	—			
D.C. Current Gain (1.)	h_{FE}				A-3	3076	$I_C = 2Adc$, $V_{CE} = 2Vdc$
2N3418, 2N3419		15	—	—			
2N3420, 2N3421		30	—	—			
D.C. Current Gain (1.)	h_{FE}				A-3	3076	$I_C = 5Adc$, $V_{CE} = 5Vdc$
2N3418, 2N3419		10	—	—			
2N3420, 2N3421		15	—	—			
Collector-Emitter Saturation Voltage (1.)	$V_{CE(sat)}$	—	0.25	Vdc	A-3	3071	$I_C = 1Adc$, $I_B = 0.1Adc$
Collector-Emitter Saturation Voltage (1.)	$V_{CE(sat)}$	—	0.5	Vdc	A-3	3071	$I_C = 2Adc$, $I_B = 0.2Adc$
Base-Emitter Saturation Voltage (1.)	$V_{BE(sat)}$	0.6	1.2	Vdc	A-3	3066	$I_C = 1Adc$, $I_B = 0.1Adc$
Base-Emitter Saturation Voltage (1.)	$V_{BE(sat)}$	0.7	1.4	Vdc	A-3	3066	$I_C = 2Adc$, $I_B = 0.2Adc$
Gain Bandwidth Product	f_T	40	160	MHz	A-4	3306	$I_C = 0.1Adc$, $V_{CE} = 10Vdc$, $f = 20MHz$
Output Capacitance	C_{ob}	—	150	pf	A-4	3236	$V_{CB} = 10Vdc$, $I_E = 0$, $f = 1MHz$
Switching Parameters							
Turn-on Time	t_{on}	—	0.3	μS	A-4	—	$I_C = 1Adc$, $I_{B1} = -I_{B2} = 0.1Adc$
Turn-off Time	t_{off}	—	1.2	μS	A-4	—	See Switching Speed Circuit
100°C							
Forward Biased Second Breakdown	$I_{S/b}$	3	—	Adc	B-6	3005	$V_{CE} = 5Vdc$, $t = 60sec$, $T_C = 100°C$
Forward Biased Second Breakdown	$I_{S/b}$	1	—	Adc	B-6	3005	$V_{CE} = 15Vdc$, $t = 60sec$, $T_C = 100°C$
Forward Biased Second Breakdown	$I_{S/b}$	0.4	—	Adc	B-6	3005	$V_{CE} = 37Vdc$, $t = 60sec$, $T_C = 100°C$
Forward Biased Second Breakdown	$I_{S/b}$				B-6	3005	$t = 60sec$, $T_C = 100°C$
2N3418, 2N3420		185	—	mAdc			$V_{CE} = 60Vdc$
2N3419, 2N3421		120	—	mAdc			$V_{CE} = 80Vdc$
Unclamped Reverse Biased Second Breakdown	$E_{S/b}$	45	—	mj	B-7	—	$I_C = 3Adc$, $L = 10mH$, Base Open
Clamped Reverse Biased Second Breakdown	$E_{S/b}$	180	—	mj	B-8	—	$I_C = 3Adc$, $L = 40mH$, V clamp = Rated V_{CBO}
150°C							
Collector-Emitter Cutoff Current	I_{CEX}				A-5	3041	$V_{EB} = 0.5Vdc$, Cond. A, $T_A = 150°C$
2N3418, 2N3420		—	50	μAdc			$V_{CE} = 80Vdc$,
2N3419, 2N3421		—	50	μAdc			$V_{CE} = 120Vdc$,
−55°C							
D.C. Current Gain (1.)	h_{FE}	10	—	—	A-5	3076	$I_C = 1Adc$, $V_{CE} = 2Vdc$, $T_A = -55°C$

Note: 1. Pulse width = 300μSec, duty cycle ⩽ 2%.

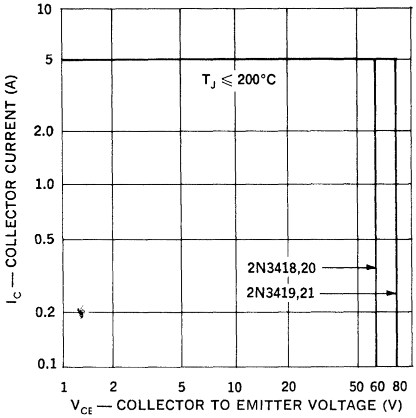
Forward Bias Safe Operating Area



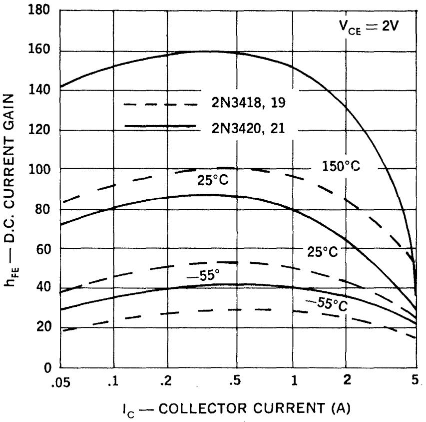
Unclamped Reverse Bias Second Breakdown



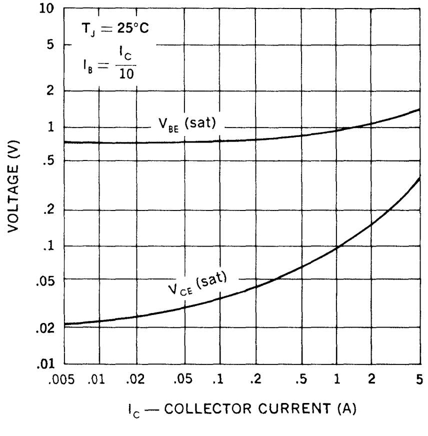
Reverse Bias Safe Operating Area Clamped Inductive Switching



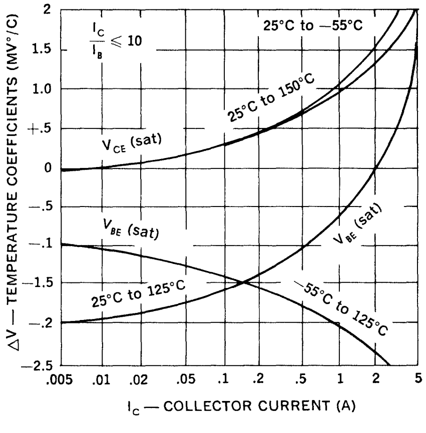
D.C. Current Gain Vs. Collector Current



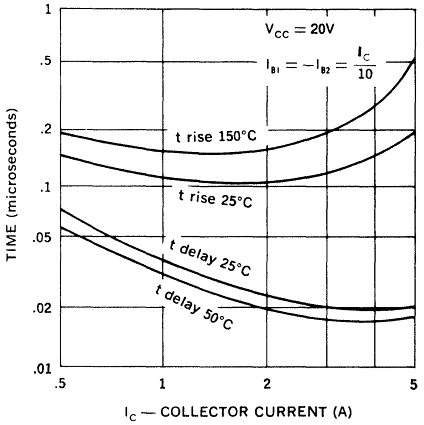
Saturation Voltage



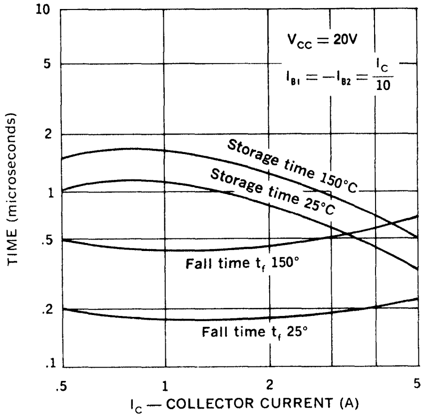
Saturation Voltage Temperature Coefficients



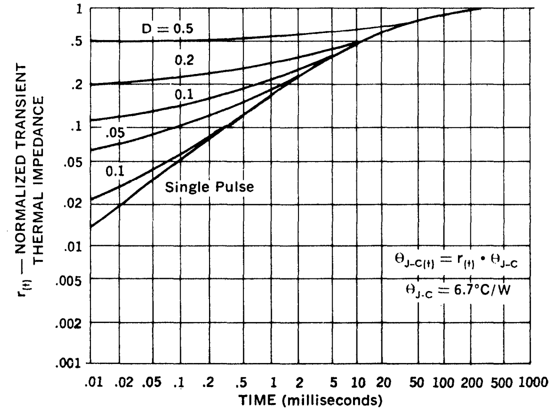
Switching Speed Characteristics



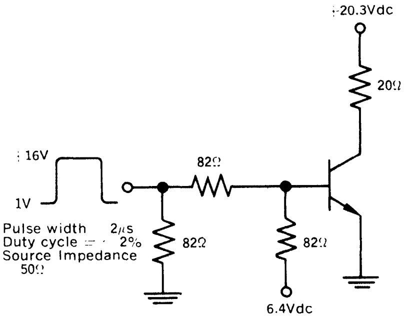
Switching Speed Characteristics



Thermal Response



Switching Speed Circuit



POWER TRANSISTORS

5 Amp, 80V, Planar NPN

JAN, JANTX, & JANTXV 2N3996
JAN, JANTX, & JANTXV 2N3997
JAN, JANTX, & JANTXV 2N3998
JAN, JANTX, & JANTXV 2N3999

FEATURES

- Meets MIL-S-19500/374*
- Collector-Base Voltage: Up to 100V
- D.C. Collector Current: 5A
- Fast Switching
- Beta Guaranteed at 3 Current Levels

DESCRIPTION

Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply pulse amplifier and similar high efficiency power switching applications.

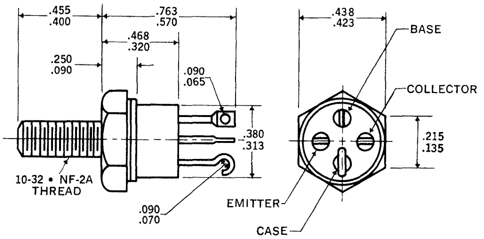
ABSOLUTE MAXIMUM RATINGS

JAN, JANTX, & JANTXV 2N3996
JAN, JANTX, & JANTXV 2N3997
JAN, JANTX, & JANTXV 2N3998
JAN, JANTX, & JANTXV 2N3999

Collector-Base Voltage, V_{CBO}	100V
Collector-Emitter Voltage, V_{CER}	80V
Emitter-Base Voltage, V_{EBO}	8V
D.C. Collector Current, I_C	5V
Power Dissipation	
25°C Ambient	2W
100°C Case	30W
Operating and Storage Temperature Range	—65°C to 200°C

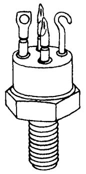
MECHANICAL SPECIFICATIONS

JAN, JANTX, & JANTXV 2N3996, 2N3997

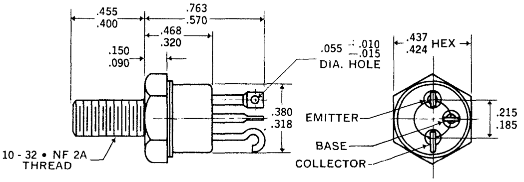


Dimensions in inches.

TO-111

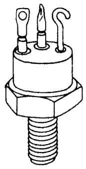


JAN, JANTX, & JANTXV 2N3998, 2N3999



Dimensions in inches.

TO-59



UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)†

Test	Symbol	2N3996* 2N3998* Min.	Max.	2N3997* 2N3999* Min.	Max.	Units	Test Conditions
D.C. Current Gain	h_{FE}	30	—	60	—	—	I_C=50 mA, V_{CE}=2V
D.C. Current Gain (Note 1)	h_{FE}	40	120	80	240	—	I_C=1A, V_{CE}=2V
D.C. Current Gain (Note 1)	h_{FE}	15	—	20	—	—	I_C=5A, V_{CE}=5V
D.C. Current Gain, —55°C (Note 1)	h_{FE}	10	—	20	—	—	I_C=1A, V_{CE}=2V
Collector Saturation Voltage (Note 1)	V_{CF} (sat)	—	0.25	—	0.25	V	I_C=1A, I_B=100 mA
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	2	—	2	V	I_C=5A, I_B=500 mA
Base Saturation Voltage (Note 1)	V_{BE} (sat)	0.6	1.2	0.6	1.2	V	I_C=1A, I_B=100 mA
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.6	—	1.6	V	I_C=5A, I_B=500 mA
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}	80	—	80	—	V	I_C=50 mA, I_B=0
Emitter-Base Cutoff Current	I_{EBO}	—	0.5	—	0.5	μA	V_{BE}=5V, I_C=0
Emitter-Base Cutoff Current	I_{EBO}	—	10	—	10	μA	V_{BE}=8V, I_C=0
Collector Cutoff Current	I_{CES}	—	5	—	5	μA	V_{CE}=90V, R_{BE}=0
Collector Cutoff Current	I_{CEO}	—	10	—	10	μA	V_{CE}=60V, I_B=0
Collector Cutoff Current, 150°C	I_{CES}	—	50	—	50	μA	V_{CE}=90, R_{BE}=0
Collector Capacitance	C_{ob}	—	150	—	150	pf	V_{CB}=10V, I_E=0, f=1 MHz
A.C. Current Gain (High Frequency)	h_{fe}	4	—	4	—	—	I_C=1A, V_{CE}=5V, f=10 MHz
Switching Speeds Turn-on Time	t_{on}	—	0.3	—	0.3	μs	I_C=1A
Turn-off Time	t_{off}	—	1.5	—	2	μs	I_{b1}=100mA, I_{b2}= —100 mA

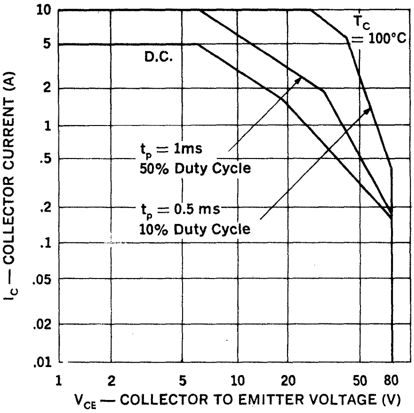
Notes:

1. Pulse Length=300μs; duty cycle ⩽2%

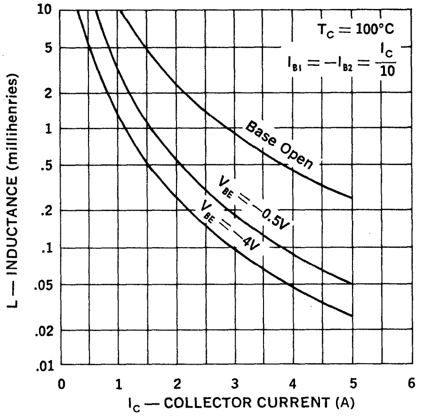
† All Values in This Table are JEDEC Registered

*Also applicable to JAN and JANTX versions

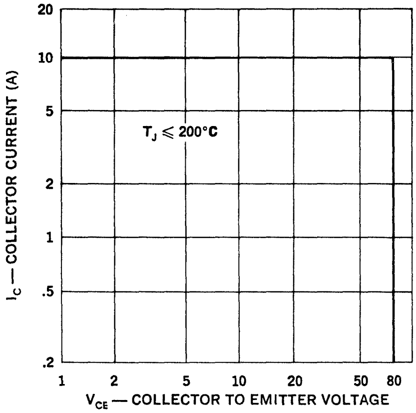
Forward Bias Safe Operating Area



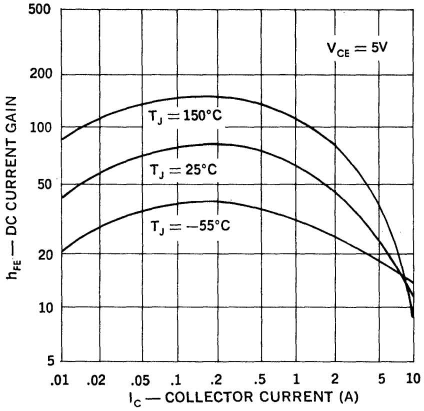
Unclamped Reverse Bias Second Breakdown



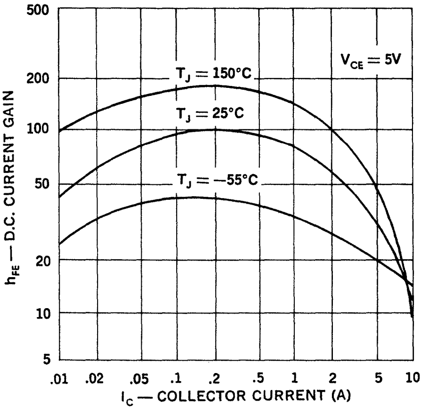
Reverse Bias Safe Operating Area Clamped Inductive Switching



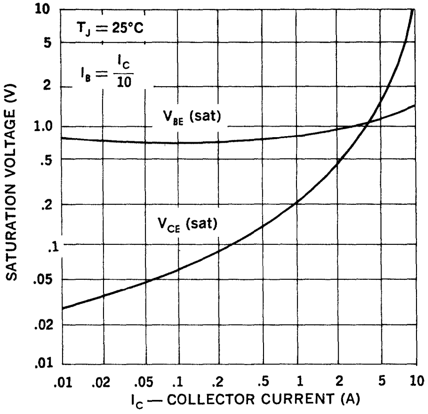
D.C. Current Gain 2N3996-2N3998



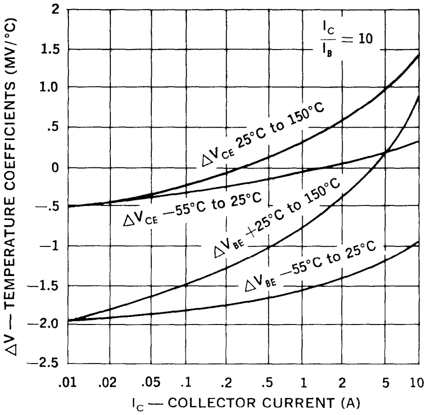
D.C. Current Gain 2N3997-2N3999



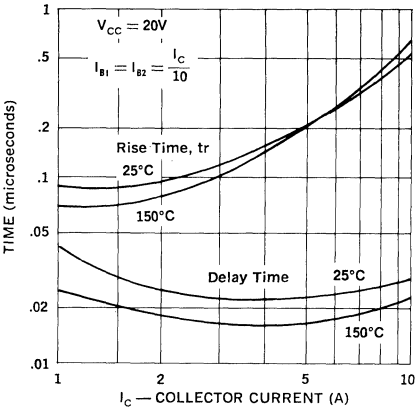
Saturation Voltage



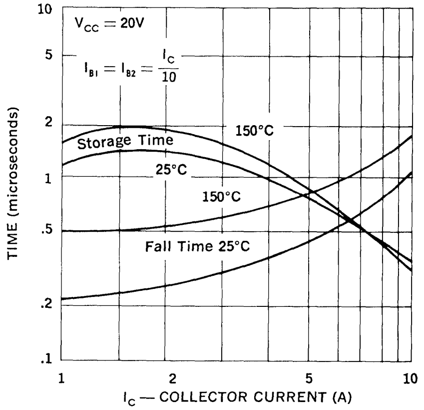
Saturation Voltage Temperature Coefficients



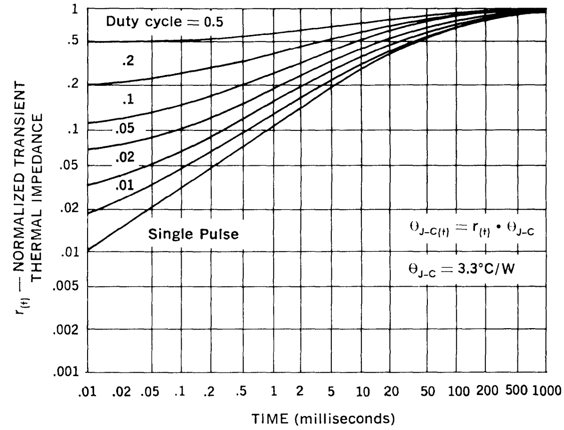
Switching Speed Characteristics



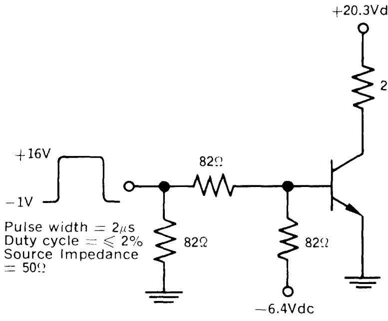
Switching Speed Characteristics



Thermal Response



Switching Speed Circuit



Pulse width = 2μs
Duty cycle = ≤ 2%
Source Impedance = 50Ω

NOTES:

1. $I_C \approx 1A$, $I_{B1} \approx -I_{B2} \approx 100mA$
2. The values of collector current and base current are nominal. The actual values will vary slightly with transistor parameters.

POWER TRANSISTORS
10 Amp, 70V, Planar NPN

JAN, JANTX & JANTXV 2N4150

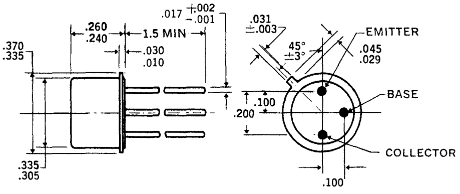
FEATURES
- Meets MIL-S-19500/394
- Collector-Base Voltage: up to 100V
- Peak Collector Current: 10A
- Fast Switching
- Low Saturation Voltage

DESCRIPTION
Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply pulse amplifier and similar high efficiency power switching applications.

ABSOLUTE MAXIMUM RATINGS	JAN & JANTX 2N4150
Collector-Base Voltage, V_{CBO}	100V
Collector-Emitter Voltage, V_{CER}	70V
Emitter-Base Voltage, V_{EBO}	5V
Peak Collector Current, I_C	10A
Power Dissipation	
25°C Ambient	1.5W
100°C Case	5W
Operating and Storage Temperature Range	−65°C to 200°C

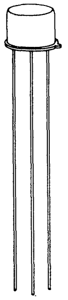
MECHANICAL SPECIFICATIONS

JAN, JANTX & JANTXV 2N4150



Dimensions in inches.

TO-5



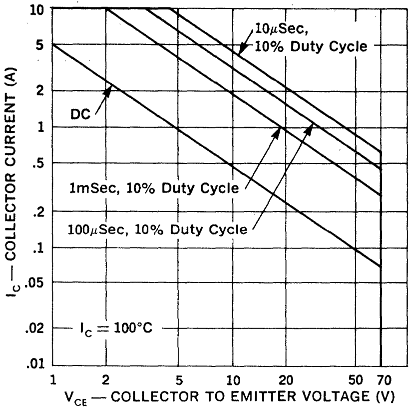
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

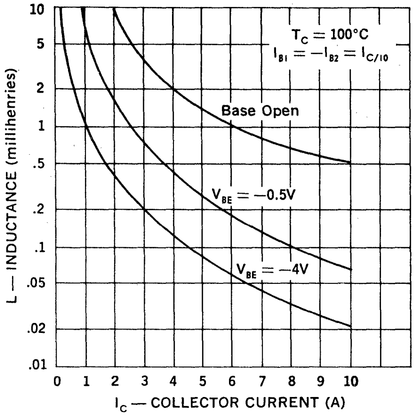
Test	Symbol	Min.	Max.	Units	/394 Sub group	Method	MIL-STD-750 Test conditions
Visual and Mechanical					A-1	2071	See Mechanical Data
25°C							
Collector-Base Breakdown Voltage	BV_{CBO}	100	—	Vdc	A-2	3001	$I_C = 10uAdc$; Cond. D
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}	70	—	Vdc	A-2	3011	$I_C = 0.1Adc$; Cond. D
Emitter-Base Breakdown Voltage	BV_{EBO}	7	—	Vdc	A-2	3026	$I_E = 10uAdc$; Cond. D
Collector-Emitter Cutoff Current	I_{CEO}	—	10	µAdc	A-2	3041	$V_{CE} = 60Vdc$; Cond. D
Collector-Emitter Cutoff Current	I_{CEX}	—	10	µAdc	A-2	3041	$V_{CE} = 100Vdc$, $V_{EB} = 0.5Vdc$; Cond. A
Collector-Base Cutoff Current	I_{CBO}	—	0.1	µAdc	A-2	3036	$V_{CB} = 80Vdc$; Cond. D
Emitter-Base Cutoff Current	I_{EBO}	—	0.1	µAdc	A-2	3061	$V_{EB} = 5Vdc$; Cond. D
D.C. Current Gain (Note 1)	h_{FE}	40	120	—	A-3	3076	$I_C = 5Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	10	—	—	A-3	3076	$I_C = 10Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	50	—	—	A-3	3076	$I_C = 1Adc$, $V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	$V_{CE}(sat)$	—	0.6	Vdc	A-4	3071	$I_C = 5Adc$, $I_B = 0.5Adc$
Collector Saturation Voltage (Note 1)	$V_{CE}(sat)$	—	2.5	Vdc	A-4	3071	$I_C = 10Adc$, $I_B = 1Adc$
Base Saturation Voltage (Note 1)	$V_{BE}(sat)$	—	1.5	Vdc	A-4	3066	$I_C = 5Adc$, $I_B = 0.5Adc$; Cond. A
Base Saturation Voltage (Note 1)	$V_{BE}(sat)$	—	2.5	Vdc	A-4	3066	$I_C = 10Adc$, $I_B = 1Adc$; Cond. A
A.C. Current Gain	h_{fe}	40	160	—	A-4	3206	$I_C = 50mAdc$, $V_{CE} = 5Vdc$, f = 1KHz
Gain-Bandwidth Product	f_T	15	75	MHz	A-4	3306	$I_C = 0.2Adc$, $V_{CE} = 10Vdc$, f =10MHz
Output Capacitance	C_{ob}	—	350	pf	A-4	3236	$V_{CB} = 10Vdc$, $I_E = 0$, f = 1MHz
Thermal Resistance	θ_{J-C}	—	20	°C/W	C-1	3151	
Switching Speeds							
Delay Time	t_d	—	50	ns	A-4	—	$V_{CC} = 20V$ $I_C = 5A$ $I_{B1} = I_{B2}$, $I_{B1} = 0.5A$
Rise Time	t_r	—	500	ns	A-4	—	
Storage Time	t_s	—	1.5	µs	A-4	—	
Fall Time	t_f	—	500	ns	A-4	—	
100°C							
Forward-Biased Second Breakdown	$I_{S/B}$	5	—	Adc	B-6	3005	V_{CE} — 1Vdc, t = 60Sec,
Forward-Biased Second Breakdown	$I_{S/B}$	70	—	mAdc	B-6	3005	V_{CE} — 70Vdc, t = 60Sec,
Unclamped Reverse Biased Second Breakdown	$E_{S/B}$	12.5	—	mj	B-7	—	$I_C = 5Adc$, L = 1mh
Clamped Reverse Biased Second Breakdown	$E_{S/B}$	200	—	mj	B-8	—	$I_C = 5Adc$, L = 40mh, $V_{clamp} = 70V$
150°C							
Collector-Emitter Cutoff Current	I_{CEX}	—	100	µAdc	A-5	3041	$V_{CE} = 80Vdc$, $V_{EB} = 0.5Vdc$, Cond. A
−55°C							
D.C. Current Gain (Note 1)	h_{FE}	20	—	—	A-5	3076	$I_C = 5Adc$, $V_{CE} = 5Vdc$

Note: 1. Pulse length = 300µs; duty cycle ⩽2%.

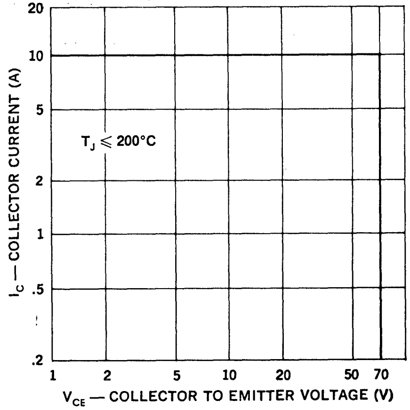
Forward Bias Safe Operating Area



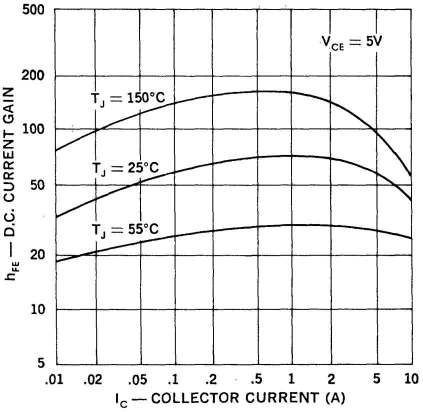
Unclamped Reverse Bias Second Breakdown



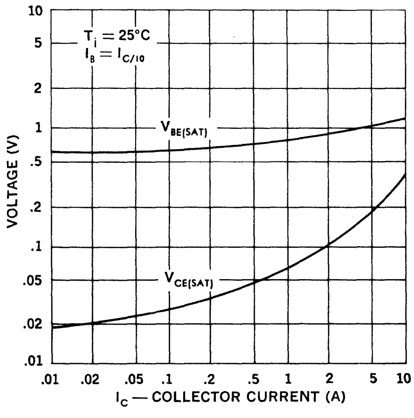
Reverse Bias Safe Operating Area Clamped Inductive Switching



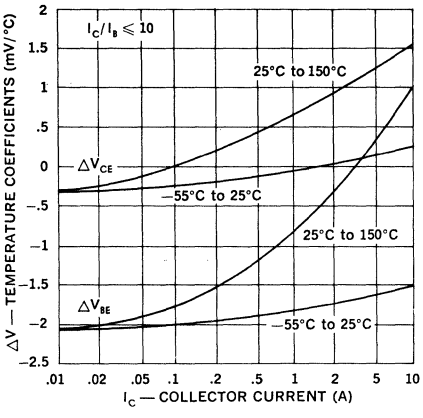
D.C. Current Gain



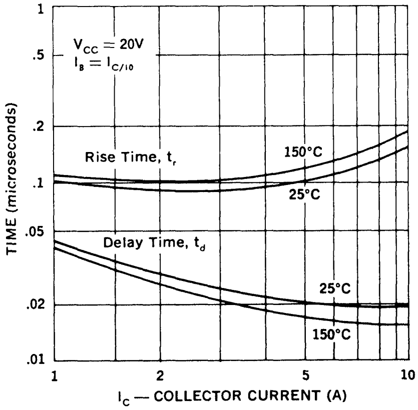
Saturation Voltages



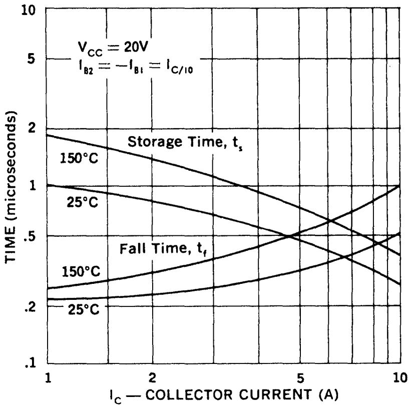
Saturation Voltage Temperature Coefficients



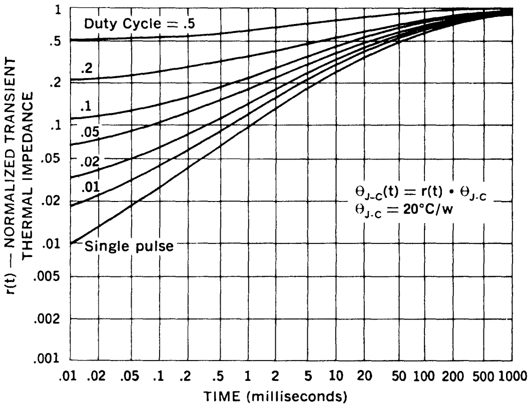
Switching Speed Characteristics



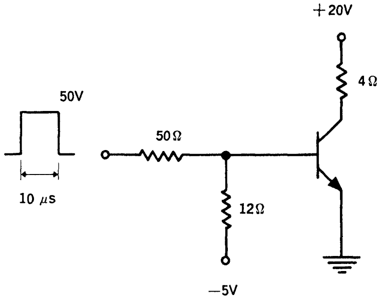
Switching Speed Characteristics



Thermal Response



Switching Speed Circuit



$I_C = 5A$, $I_{B1} = -I_{B2} = .5A$

POWER TRANSISTORS

20 Amp, 150V, Double Diffused NPN Mesa

JAN, JANTX, JANTXV 2N5038
JAN, JANTX, JANTXV 2N5039

FEATURES

- Collector-Base Voltage: up to 150V
- Peak Collector Current: 30A
- t_{on} Time $\leqslant$500 nS
- t_{off} Time $\leqslant 2\ \mu$S
- Qualified to MIL-S-19500/439

DESCRIPTION

These MIL approved double diffused glass passivated mesa power transistors combine fast-switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in switching regulators, converters, inverters and switching-control amplifiers.

ABSOLUTE MAXIMUM RATINGS

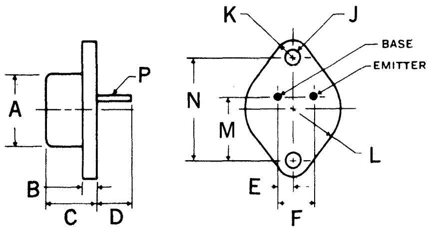
	JAN, JANTX & JANTXV 2N5038	JAN, JANTX & JANTXV 2N5039
Collector-Base Voltage, V_{CBO}	150V	125V
Collector-Emitter Sustaining Voltage, $V_{CER\ (SUS)}$ (1)	110V	95V
$V_{CEO\ (SUS)}$	90V	75V
Emitter-Base Voltage, V_{EBO}	7V	7V
Collector Current, I_C continuous	20A	20A
Collector Current, I_{CM} peak	30A	30A
Base Current, I_B continuous	5A	5A
Power Dissipation, 25°C Case	140W	140W
Operating and Storage Temperature Range	−65 to 200°C	

(1) With $R_{BE} \leqslant 50\Omega$

MECHANICAL SPECIFICATIONS

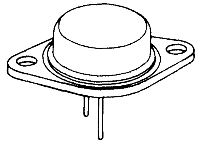
JAN, JANTX, JANTXV 2N5038, 2N5039

NOTE:
Leads may be soldered to within $^1/_{16}$" of base provided temperature-time exposure is less than 260°C for 10 seconds.



	ins.	mm
A	.875 MAX.	2.22 MAX.
B	.135 MAX.	0.34 MAX.
C	.250—.450	0.64—1.14
D	.312 MIN.	0.79 MIN.
E	.205—.225	0.52—0.57
F	.420—.440	1.07—1.12
J	.151—.161 DIA.	0.38—0.41
K	.188 MAX. RAD.	0.48 MAX. RAD.
L	.525 MAX. RAD.	1.33 MAX. RAD.
M	.655—.675	1.66—1.71
N	1.177—1.197	2.99—3.04
P	.038—.043 DIA.	0.10—0.11 DIA.

TO-3



UNITRODE

Electrical Specifications (at 25°C unless noted)

Test	Symbol	2N5038		2N5039		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	—	—	30	150	—	$I_C = 0.5, V_{CE} = 5V$
		50	200	—	—		$I_C = 2A, V_{CE} = 5V$
D.C. Current Gain (Note 1)	h_{FE}	—	—	20	—	—	$I_C = 10A, V_{CE} = 5V$
		20	—	—	—		$I_C = 12A, V_{CE} = 5V$
D.C. Current Gain −65°C	h_{FE}	—	—	10	—	—	$I_C = 10A, V_{CE} = 5V$
		10	—	—	—		$I_C = 12A, V_{CE} = 5V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	—	—	1.0	V	$I_C = 10A, I_B = 1.0A$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.0	—	—	V	$I_C = 12A, I_B = 1.2A$
		—	2.5	—	2.5		$I_C = 20A, I_B = 5A$
Base-Emitter Voltage (Note 1)	V_{BE}	—	—	—	1.8	V	$I_C = 10A, V_{CC} = 5V$
		—	1.8	—	—	V	$I_C = 12A, V_{CC} = 5V$
Collector-Emitter Sustaining Voltage (Notes 2, 3)	$V_{CEO\,(sus)}$	90	—	75	—	V	$I_C = 0.2A, L = 15mH$
Collector-Emitter Sustaining Voltage (Notes 2, 3)	$V_{CEX\,(sus)}$	150	—	125	—	V	$I_C = 0.2A, L = 2mH$ $V_{BE} = -1.5V$ $I_B = 0$ $R_{BE} = 100\,\Omega$
Collector-Emitter Sustaining Voltage (Notes 2, 3)	$V_{CER\,(sus)}$	110	—	95	—	V	$R_{BE} = 50\,\Omega, I_C = 0.2A, L = 15\,mH$
Emitter-Base Voltage	V_{EBO}	7.0	—	7.0	—	V	$I_E = 25mA$
Collector Cutoff Current	I_{CBO}	—	—	—	25	mA	$V_{CB} = 125V$
		—	25	—	—		$V_{CB} = 150V$
Collector Cutoff Current	I_{CEO}	—	—	—	10	mA	$V_{CE} = 55V$
		—	10	—	—		$V_{CE} = 70V$
Collector Cutoff Current	I_{CEX}	—	—	—	5.0	mA	$V_{CE} = 85V, V_{BE} = -1.5V$
		—	5.0	—	—		$V_{CE} = 100V, V_{BE} = -1.5V$
Collector Cutoff Current, 150°C	I_{CEX}	—	—	—	10	mA	$V_{CE} = 85V, V_{BE} = -1.5V$
		—	10	—	—		$V_{CE} = 100V, V_{BE} = -1.5V$
Emitter Cutoff Current	I_{EBO}	—	5.0	—	5.0	mA	$V_{BE} = -5V$
Magnitude of Small Signal Forward — Current Transfer Ratio	$\lvert h_{fe} \rvert$	12	48	12	48	—	$V_{CE} = 10V, I_C = 2A, f = 5\,MHz$
Collector Capacitance	C_{ob}	—	500	—	500	pF	$V_{CB} = 10V, f = 1\,MHz$
Thermal Resistance: Junction-to-Case	$R\Theta_{JC}$	—	1.25	—	1.25	°C/W	$V_{CE} = 10V, I_C = 10A$

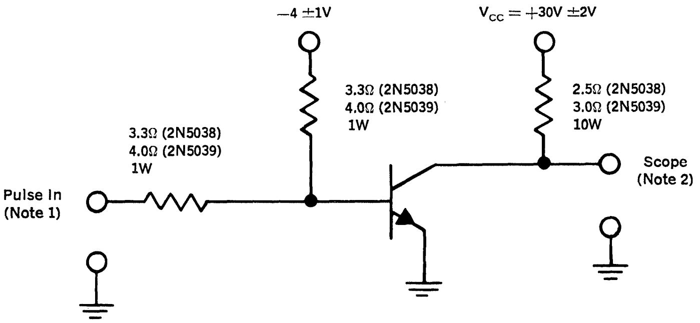
Notes

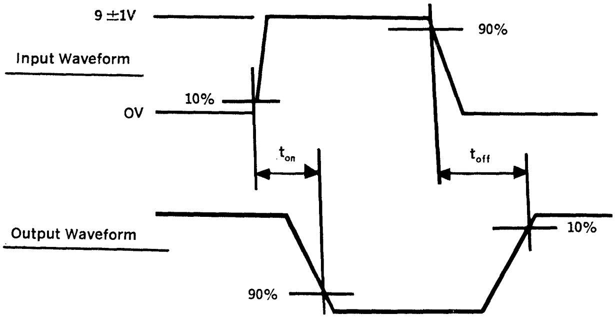
1. Pulse length = 250 μS; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50 μS; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.
3. Unclamped Inductive Load.

Electrical Specifications (at 25°C unless noted)

Test	Symbol	2N5038 MIN.	2N5038 MAX.	2N5039 MIN.	2N5039 MAX.	Units	Test Conditions
Second Breakdown Energy	$E_{s/b}$ clamped	14	—	14	—	mJ	$I_C = 20$Adc, L = 70µH, 0.1Ω $V_{CC} = 75$V, 90V $R_L = 3.75$Ω, 4.5Ω
	$E_{s/b}$ unclamped	5.06	—	5.06	—		$I_C = 4.5$Adc, L = 500µH, 0.1Ω $V_{CC} = 10$Vdc
Forward Bias Second Breakdown Collector Current	$I_{s/b}$	5.0	—	5.0	—	A	$V_{CE} = 28$V, t = 1s, non-rep.
		0.9	—	0.9	—		$V_{CE} = 45$V, t = 1s, non-rep.
Switching Speeds Turn-on Time	t_{on}	—	0.5	—	—	µS	$I_C = 12$Adc $I_{B1} = I_{B2} = 1.2$Adc $V_{CC} = 30$Vdc ±2V
Turn-on Time	t_{on}	—	—	—	0.5	µS	$I_C = 10$Adc $I_{B1} = I_{B2} = 1$Adc $V_{CC} = 30$Vdc ±2V
Turn-off Time	t_{off}	—	—	—	2.0	µS	$I_C = 10$Adc $I_{B1} = I_{B2} = 1.0$Adc $V_{CC} = 30$Vdc ±2V
Turn-off Time	t_{off}	—	2.0	—	—	µS	$I_C = 12$Adc $I_{B1} = I_{B2} = 1.2$Adc $V_{CC} = 30$Vdc ±2V

Switching Time Test Circuit

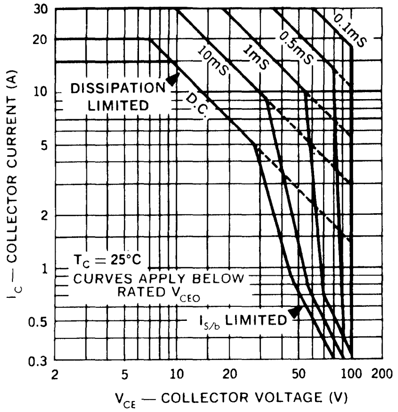




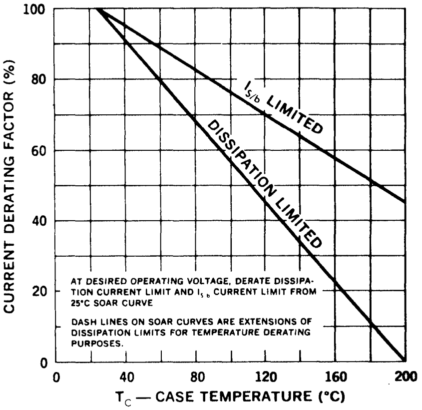
Notes

1. The rise time (t_r) and fall time (t_f) of the applied pulse shall be each ⩽20 nanoseconds; duty cycle ⩽2%; generator source impedance shall be 50 ohms; Pulse width = 20 µS
2. Output sampling oscilloscope: Z_{in} ⩾100K ohms; C_{in} ⩽50pf; rise time ⩽20 nanoseconds.

Forward Bias Safe Operating Area for 2N5038 and 2N5039



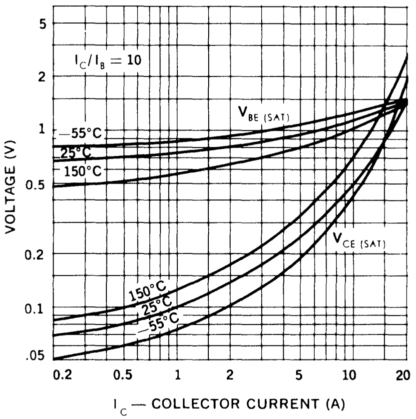
Power Derating



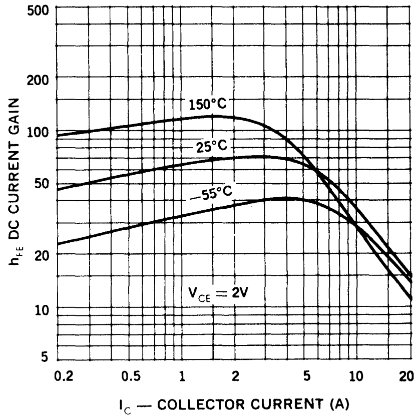
AT DESIRED OPERATING VOLTAGE, DERATE DISSIPATION CURRENT LIMIT AND $I_{s/b}$ CURRENT LIMIT FROM 25°C SOAR CURVE

DASH LINES ON SOAR CURVES ARE EXTENSIONS OF DISSIPATION LIMITS FOR TEMPERATURE DERATING PURPOSES.

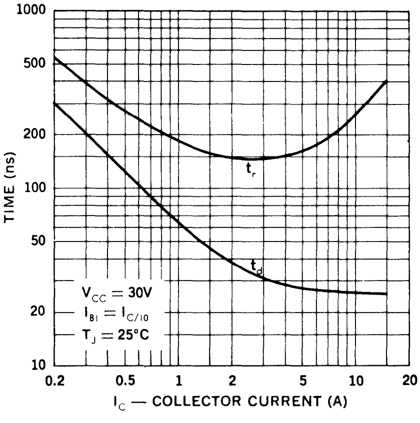
Saturation Voltages



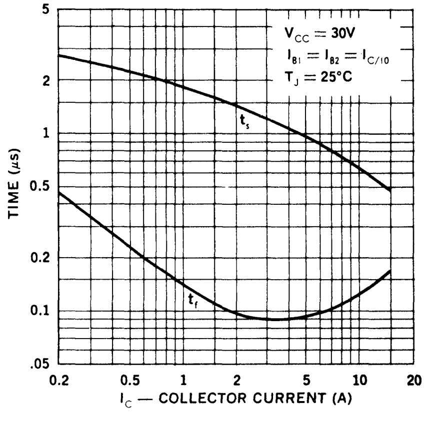
DC Current Gain



Turn-On Time



Turn-Off Time



POWER TRANSISTORS
5 Amp, 150V, Planar NPN

2N5487
2N5488
5487-1
5487-3
5488-1
5488-3

FEATURES
- Collector-Base Voltage: up to 150V
- D.C. Collector Current: 5A
- Peak Collector Current: 10A
- Fast Switching
- Low Saturation Voltage
- High Gain

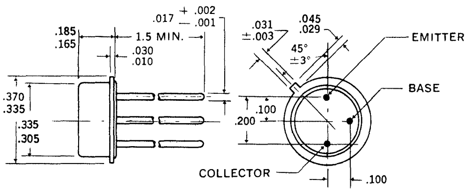
DESCRIPTION
Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply pulse amplifier and similar high efficiency power switching applications.

ABSOLUTE MAXIMUM RATINGS

	2N5487 **5487-1** **5487-3**	**2N5488** **5488-1** **5488-3**
Collector-Base Voltage, V_{CBO}	120V	150V
Collector-Emitter Voltage, V_{CER}	120V	150V
Emitter-Base Voltage, V_{EBO}	8V	8V
D.C. Collector Current, I_C	5A	10A
Peak Collector Current, I_C	10A	10A
Power Dissipation		
25°C Ambient	1.25W	1.25W
100°C Case	15W	15W
Operating and Storage Temperature Range	−65°C to 200°C	

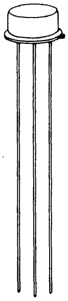
MECHANICAL SPECIFICATIONS

2N5487 2N5488

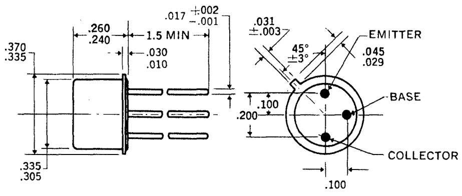


Dimensions in inches.

Pancake TO-5

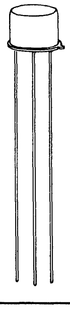


5487-1 5488-1



Dimensions in inches.

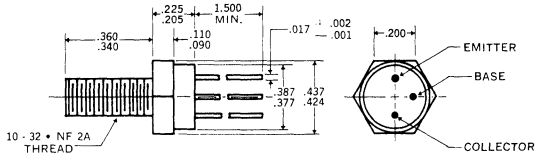
TO-5



UNITRODE

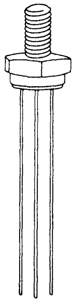
MECHANICAL SPECIFICATIONS

5487-3 5488-3



Dimensions in inches.

Low Profile
7/16 Hex



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)†

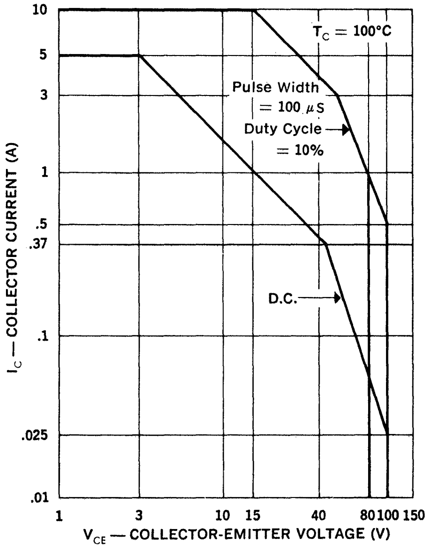
Test	Symbol	2N5487 Min.	2N5487 Max.	2N5488 Min.	2N5488 Max.	Units	Test Conditions
D.C. Current Gain (Note 3)	h_{FE}	100	300	40	120	—	$I_C = 1A, V_{CE} = 2V$
D.C. Current Gain	h_{FE}	80		35		—	$I_C = 50mA, V_{CE} = 2V$
D.C. Current Gain (Note 3)	h_{FE}	25		15		—	$I_C = 5A, V_{CE} = 5V$
Collector Saturation Voltage (Note 3)	V_{CE} (sat)		0.25		0.25	V	$I_C = 1A, I_B = 100mA$
Collector Saturation Voltage (Note 3)	V_{CE} (sat)		1.0		1.0	V	$I_C = 5A, I_B = 500mA$
Base Saturation Voltage (Note 3)	V_{BE} (sat)		1.2		1.2	V	$I_C = 1A, I_B = 100mA$
Base Saturation Voltage (Note 3)	V_{BE} (sat)		1.8		1.8	V	$I_C = 5A, I_B = 500mA$
Collector-Emitter Breakdown Voltage (Note 3)	BV_{CER}	120		150		V	$I_C = 10mA, R_{BE} = 10$ ohms
Collector-Emitter Breakdown Voltage (Note 3)	BV_{CEO}	80		100		V	$I_C = 100mA, I_B = 0$
Emitter-Base Breakdown Voltage	BV_{EBO}	8		8		V	$I_E = 10\mu A, I_C = 0$
Collector Cutoff Current	I_{CES}		0.1			μA	$V_{CE} = 80V, R_{BE} = 0$
Collector Cutoff Current	I_{CES}				0.1	μA	$V_{CE} = 100V, R_{BE} = 0$
Collector Cutoff Current	I_{CES}		10			μA	$V_{CE} = 120V, R_{BE} = 0$
Collector Cutoff Current	I_{CES}				10	μA	$V_{CE} = 150V, R_{BE} = 0$
Collector Cutoff Current, 150°C	I_{CES}		50			μA	$V_{CE} = 80V, R_{BE} = 0$
Collector Cutoff Current, 150°C	I_{CES}				50	μA	$V_{CE} = 100V, R_{BE} = 0$
Collector Capacitance	C_{ob}		75		75	pf	$V_{CB} = 10V, I_E = 0$
A.C. Current Gain	h_{fe}	4		4			$I_C = 200mA, V_{CE} = 5V, f = 10MHz$
Switching Speeds Turn-on Time	t_{on}		125		125	ns	$I_C = 1A$ 2N5487 See Fig. 1
Turn-off Time	t_{off}		450		550	ns	2N5488 See Fig. 2

Notes:

1. The device may be switched between maximum rated collector current and maximum rated collector-emitter voltage along a resistive load line provided the switching time is less than 10 microseconds. Switching at low speed through regions of high instantaneous power dissipation may cause second breakdown to occur, with consequent damage to the device.
2. Steady state limits based on a maximum junction temperature of 200°C. High pulse power dissipation may cause second breakdown. Consult the factory on high power, low duty cycle application.
3. Pulse length = 300 μs; duty cycle $\leqslant$2%.

†All values in this table are JEDEC registered.

Maximum Safe Operating Area



Switching Speed Circuit

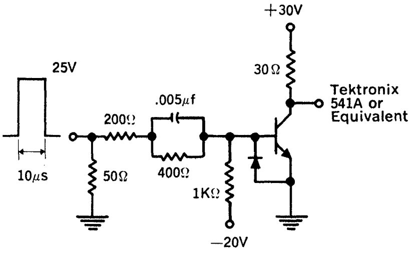


Figure 1

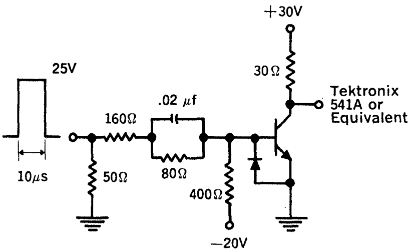


Figure 2

POWER TRANSISTORS

2N5552 5552-4

10 Amp, 120V, Planar NPN

FEATURES

- Collector-Base Voltage: up to 120V
- Peak Collector Current: 10A
- Fast Switching
- Beta Guaranteed at 3 Current Levels

DESCRIPTION

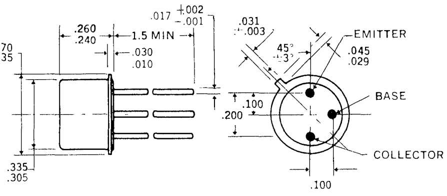
Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply pulse amplifier and similar high efficiency power switching applications.

ABSOLUTE MAXIMUM RATINGS

	2N5552 **5552-4**
Collector-Base Voltage, V_{CBO}	120V
Collector-Emitter Voltage, V_{CEO}	80V
Emitter-Base Voltage, V_{EBO}	7V
D.C. Collector Current, I_C	10A
Power Dissipation	
25°C Ambient	1.25W
100°C Case	5W
Operating and Storage Temperature Range	—65°C to 200°C

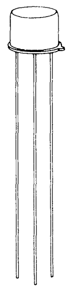
MECHANICAL SPECIFICATIONS

2N5552

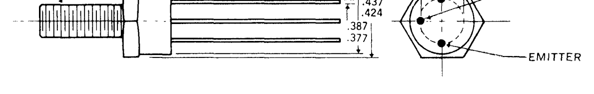


Dimensions in inches.

TO-5

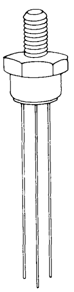


5552-4



Dimensions in inches.

TO-5 (Stud)



UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)†

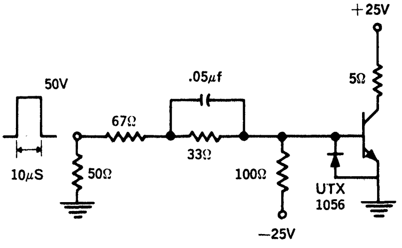
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain	h_{FE}	40	250	—	$I_C = 0.5A$, $V_{CE} = 2V$
D.C. Current Gain (Note 2)	h_{FE}	50	150	—	$I_C = 5A$, $V_{CE} = 5V$
D.C. Current Gain (Note 2)	h_{FE}	30	—	—	$I_C = 10A$, $V_{CE} = 5V$
Collector Saturation Voltage (Note 2)	V_{CE} (sat)	—	0.5	V	$I_C = 5A$, $I_B = 0.5A$
Collector Saturation Voltage (Note 2)	V_{CE} (sat)	—	1.0	V	$I_C = 10A$, $I_B = 1A$
Base Saturation Voltage (Note 2)	V_{BE} (sat)	—	1.3	V	$I_C = 5A$, $I_B = 0.5A$
Base Saturation Voltage (Note 2)	V_{BE} (sat)	—	1.8	V	$I_C = 10A$, $I_B = 1A$
Collector-Emitter Sustaining Voltage (Note 2)	BV_{CER}	120	—	V	$I_C = 100mA$, $R_{BE} = 10\Omega$
Collector-Emitter Sustaining Voltage (Note 2)	V_{CEO} (sus)	80	—	V	$I_C = 100mA$, $I_B = 0$
Collector-Emitter Voltage (Note 2)	BV_{CES}	120	—	V	$I_C = 0.2\mu A$, $R_{BE} = 0$
Emitter-Base Breakdown Voltage	BV_{EBO}	7	—	V	$I_E = 10\mu A$, $I_C = 0$
Collector Cutoff Current	I_{CES}	—	0.2	μA	$V_{CE} = 120V$, $R_{BE} = 0$
Collector Cutoff Current, 150°C	I_{CES}	—	0.1	mA	$V_{CE} = 80$, $R_{BE} = 0$, $T = 150°C$
Collector Capacitance	C_{obo}	—	150	pf	$V_{CB} = 10$, $I_E = 0$, $f = 1MHz$
A.C. Current Gain	h_{fe}	3	—	—	$I_C = 0.5A$, $V_{CE} = 5V$ $f = 10MHz$
Switching Speeds Turn-on Time	t_{on}	—	100	ns	$I_C = 5A$
Turn-off Time	t_{off}	—	700	ns	$I_{b1} = 250ma$ $I_{b2} = -250ma$

Notes:

1. The device may be switched between maximum rated collector current and maximum rated collector — emitter voltage along a resistive load line provided the switching time is less than 10 microseconds. Switching at low speed through regions of high instantaneous power dissipation may cause second breakdown to occur, with consequent damage to the device.
2. Pulse length = 300 μs; duty cycle $\leq$2%.

† All values in this table are JEDEC registered.

Switching Speed Circuit



POWER TRANSISTORS

20 Amp, 80V, Planar NPN

2N5658
2N5659

FEATURES

- Collector-Base Voltage: up to 120V
- Peak Collector Current: 20A
- High Gain
- Fast Switching

DESCRIPTION

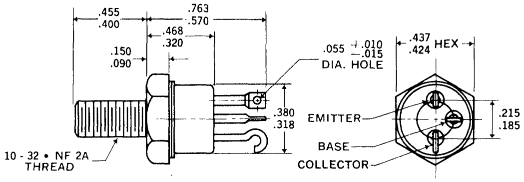
Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply pulse amplifier and similar high efficiency power switching applications.

ABSOLUTE MAXIMUM RATINGS

	2N5658 **2N5659**
Collector-Base Voltage, V_{CBO}	120V
Collector-Emitter Voltage, V_{CEO}	80V
Emitter-Base Voltage, V_{EBO}	7V
Peak Collector Current, I_C	20A
Power Dissipation	
100°C Case	30W
Operating and Storage Temperature Range	—65°C to 200°C

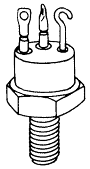
MECHANICAL SPECIFICATIONS

2N5658

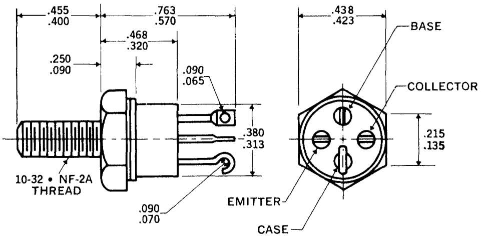


Dimensions in inches.

TO-59



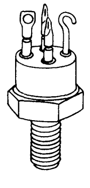
2N5659



Dimensions in inches.

Collector Isolated from Case.

TO-111



UNITRODE

Electrical Specifications (at 25°C unless noted)†

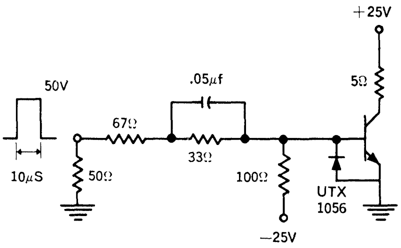
Test	Symbol	Min.	Max.	Units	Test Conditions		
D.C. Current Gain	h_{FE}	40	250	—	$I_C = 0.5A$,	$V_{CE} = 2V$	
D.C. Current Gain	h_{FE}	50	150	—	$I_C = 5A$,	$V_{CE} = 5V$	(Note 1)
D.C. Current Gain	h_{FE}	30		—	$I_C = 10A$,	$V_{CE} = 5V$	(Note 1)
Collector Saturation Voltage	V_{CE} (sat)		.5	V	$I_C = 5A$,	$I_B = 0.5A$	(Note 1)
Collector Saturation Voltage	V_{CE} (sat)		1.0	V	$I_C = 10A$,	$I_B = 1A$	(Note 1)
Base Saturation Voltage	V_{BE} (sat)		1.3	V	$I_C = 5A$,	$I_B = 0.5A$	(Note 1)
Base Saturation Voltage	V_{BE} (sat)		1.8	V	$I_C = 10A$,	$I_B = 1A$	(Note 1)
Collector-Emitter Breakdown Voltage	BV_{CER}	120		V	$I_C = 100mA$,	$R_{BE} = 10\Omega$	
Collector-Emitter Breakdown Voltage	BV_{CES}	120		V	$I_C = 0.2\mu A$,	$R_{BE} = 0$	
Collector-Emitter Breakdown Voltage	BV_{CEO}	80		V	$I_C = 100mA$,	$I_B = 0$	(Note 1)
Emitter-Base Breakdown Voltage	BV_{EBO}	7		V	$I_E = 10\mu A$,	$I_C = 0$	
Collector Cutoff Current	I_{CES}		0.2	μA	$V_{CE} = 120V$,	$R_{BE} = 0$	
Collector Cutoff Current, 150°C	I_{CES}		0.1	mA	$V_{CE} = 80V$,	$R_{BE} = 0$,	$T = 150°C$
Collector Capacitance	C_{obo}		150	pf	$V_{CB} = 10V$,	$I_E = 0$,	$f = 1MHz$
A.C. Current Gain	h_{fe}	3			$I_C = 0.5A$,	$V_{CE} = 5V$,	$f = 10MHz$
Switching Speeds Turn-on Time	t_{on}		150	ns	$I_C = 5A$		
Switching Speeds Turn-off Time	t_{off}		800	ns	$I_{b1} = 250mA$ Note 2.	$I_{b2} = -250mA$	

Notes:

1. Pulse length = 300 μs; duty cycle ≤2%
2. Measured in saturated switching speed circuit.

† All Values in This Table are JEDEC Registered.

Switching Speed Circuit



POWER TRANSISTORS
2 Amp, 300V, Planar NPN

JAN, JANTX, & JANTXV 2N5660
JAN, JANTX, & JANTXV 2N5661
JAN, JANTX, & JANTXV 2N5662
JAN, JANTX, & JANTXV 2N5663

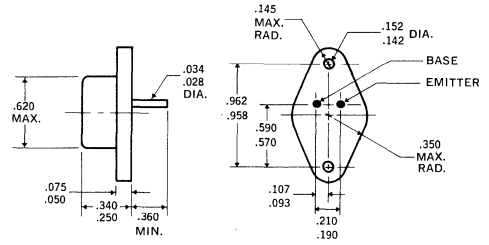
FEATURES
- Meets MIL-S-19500/454
- Collector-Base Voltage: up to 400V
- D.C. Collector Current: 5A
- Peak Collector Current: 10A
- Fast Switching

DESCRIPTION
Unitrode high voltage transistors provide a unique combination of low saturation voltage, fast switching, and excellent gain. They are ideally suited for off-line power supply designs and other applications where the increased voltage rating adds to system reliability.

ABSOLUTE MAXIMUM RATINGS	JAN, JANTX, & JANTXV 2N5660	JAN, JANTX, & JANTXV 2N5661	JAN, JANTX, & JANTXV 2N5662	JAN, JANTX, & JANTXV 2N5663
Collector-Base Voltage, V_{CBO}	250V	400V	250V	400V
Collector-Emitter Voltage, V_{CEO}	200V	300V	200V	300V
Emitter-Base Voltage, V_{EBO}	6V	6V	6V	6V
D.C. Collector Current, I_C	2A	2A	2A	2A
Peak Collector Current, I_C	5A	5A	5A	5A
Power Dissipation				
25°C Ambient	2.0W	2.0W	1.2W	1.2W
100°C Case	20W	20W	15W	15W
Operating and Storage Temperature Range				—65°C to 200°C

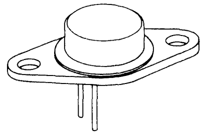
MECHANICAL SPECIFICATIONS

JAN, JANTX, & JANTXV 2N5660 JAN, JANTX, & JANTXV 2N5661

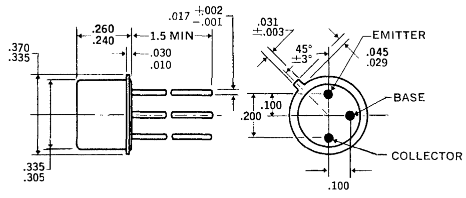


Dimensions in inches.

TO-66

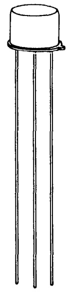


JAN, JANTX, & JANTXV 2N5662 JAN, JANTX, & JANTXV 2N5663



Dimensions in inches.

TO-5



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)
2N5660, 2N5662

Test	Symbol	Min.	Max.	Units	/454 Sub group	MIL-STD-750	
						Method	Test conditions
Visual and mechanical					A-1	2071	See Mechanical Data
25°C							
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}*	250	—	Vdc	A-2	3011	I_C = 10mAdc; R_{BE} = 100Ω; Cond. B
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}*	200	—	Vdc	A-2	3011	I_C = 10mAdc; Cond. D
Emitter-Base Breakdown Voltage	BV_{EBO}*	6	—	Vdc	A-2	3026	I_E = 10μAdc; Cond. D
Collector-Emitter Cutoff Current	I_{CES}*	—	0.2	μAdc	A-2	3041	V_{CE} = 200Vdc; Cond. C
Collector-Base Cutoff Current	I_{CBO}	—	0.1	μAdc	A-2	3036	V_{CB} = 200Vdc; Cond. D
Collector-Base Cutoff Current	I_{CBO}	—	1.0	mAdc	A-2	3036	V_{CB} = 250Vdc; Cond. D
D.C. Current Gain (Note 1)	h_{FE}*	40	—	—	A-3	3076	I_C = 50mAdc, V_{CE} = 2Vdc
D.C. Current Gain (Note 1)	h_{FE}*	40	120	—	A-3	3076	I_C = 0.5Adc, V_{CE} = 5Vdc
D.C. Current Gain (Note 1)	h_{FE}*	15	—	—	A-3	3076	I_C = 1Adc, V_{CE} = 5Vdc
D.C. Current Gain (Note 1)	h_{FE}	5	—	—	A-3	3076	I_C = 2Adc, V_{CE} = 5Vdc
Collector Saturation Voltage (Note 1)	$V_{CE}(sat)$*	—	0.4	Vdc	A-3	3071	I_C = 1Adc, I_B = 0.1Adc
Collector Saturation Voltage (Note 1)	$V_{CE}(sat)$	—	0.8	Vdc	A-3	3071	I_C = 2Adc, I_B = 0.4Adc
Base Saturation Voltage (Note 1)	$V_{BE}(sat)$*	—	1.2	Vdc	A-3	3066	I_C = 1Adc, I_B = 0.1Adc; Cond. A
Base Saturation Voltage (Note 1)	$V_{BE}(sat)$	—	1.5	Vdc	A-3	3066	I_C = 2Adc, I_B = 0.4Adc; Cond. A
Gain-Bandwidth Product	f_T*	20	70	MHz	A-4	3306	I_C = 0.1Adc, V_{CE} = 5Vdc, f = 10MHz
Output Capacitance	C_{ob}	—	45	pf	A-4	3236	V_{CB} = 10Vdc, I_E = 0, f = 1MHz
Thermal Resistance	Θ_{J-C}				C-1	3151	
2N5660		—	5.0	°C/W			
2N5662		—	6.7	°C/W			
Switching Speeds Turn-on time	t_{on}*	—	0.25	μs	A-4	—	I_C = 0.5Adc
Turn-off time	t_{off}*	—	0.85	μs	A-4	—	
100°C							
Forward Biased Second Breakdown							
2N5660	$I_{s/b}$	2	—	Adc	B-6	3051	V_{CE} = 10Vdc, t = 1Sec
	$I_{s/b}$	0.5	—	Adc	B-6	3051	V_{CE} = 40Vdc, t = 1Sec
	$I_{s/b}$	36	—	mAdc	B-6	3051	V_{CE} = 200Vdc, t = 1Sec
2N5662	$I_{s/b}$	2	—	Adc	B-7	3051	V_{CE} = 7.5 Vdc, t = 1Sec
	$I_{s/b}$	0.6	—	Adc	B-7	3051	V_{CE} = 25Vdc, t = 1Sec
	$I_{s/b}$	27	—	mAdc	B-7	3051	V_{CE} = 200Vdc, t = 1Sec
Unclamped Reverse Biased Second Breakdown	$E_{s/b}$	0.2	—	mj	B-8	3053	I_C = 2Adc, L = 0.1 mh
Clamped Reverse Biased Second Breakdown	$E_{s/b}$	80	—	mj	B-9	3053	I_C = 2Adc, L = 40mh, V_{clamp} = 200V
150°C							
Collctor-Emitter Cutoff Current	I_{CES}*	—	100	μAdc	A-5	3041	V_{CE} = 200Vdc, Cond. C
−65°C							
D.C. Current Gain (Note 1)	h_{FE}	15	—	—	A-6	3076	I_C = 0.5Adc, V_{CE} = 5Vdc

Notes
1. Pulse length = 300 μs; duty cycle ≤2%.
* Those parameters marked with a * are JEDEC registered and devices meeting these specifications are available as commercial 2N devices.

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)
2N5661, 2N5663

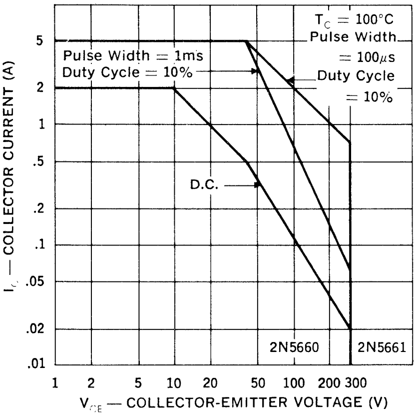
Test	Symbol	Min.	Max.	Units	/454 Sub group	MIL-STD-750	
						Method	Test conditions
Visual and mechanical					A-1	2071	See Mechanical Data
25°C							
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}*	400	—	Vdc	A-2	3011	$I_C = 10mAdc$; $R_{BE} = 100\Omega$; Cond. B
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}*	300	—	Vdc	A-2	3011	$I_C = 10mAdc$; Cond. D
Emitter-Base Breakdown Voltage	BV_{EBO}*	6	—	Vdc	A-2	3026	$I_E = 10\mu Adc$; Cond. D
Collector-Emitter Cutoff Current	I_{CES}*	—	0.2	μAdc	A-2	3041	$V_{CE} = 300Vdc$; Cond. C
Collector-Base Cutoff Current	I_{CBO}	—	0.1	μAdc	A-2	3036	$V_{CB} = 300Vdc$; Cond. D
Collector-Base Cutoff Current	I_{CBO}	—	1.0	mAdc	A-2	3036	$V_{CB} = 400Vdc$; Cond. D
D.C. Current Gain (Note 1)	h_{FE}*	25	—	—	A-3	3076	$I_C = 50mAdc$, $V_{CE} = 2Vdc$
D.C. Current Gain (Note 1)	h_{FE}*	25	75	—	A-3	3076	$I_C = 0.5Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}*	15	—	—	A-3	3076	$I_C = 1Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	5	—	—	A-3	3076	$I_C = 2Adc$, $V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	$V_{CE}(sat)$*	—	0.4	Vdc	A-3	3071	$I_C = 1Adc$, $I_B = 0.1Adc$
Collector Saturation Voltage (Note 1)	$V_{CE}(sat)$	—	0.8	Vdc	A-3	3071	$I_C = 2Adc$, $I_B = 0.4Adc$
Base Saturation Voltage (Note 1)	$V_{BE}(sat)$*	—	1.2	Vdc	A-3	3066	$I_C = 1Adc$, $I_B = 0.1Adc$; Cond. A
Base Saturation Voltage (Note 1)	$V_{BE}(sat)$	—	1.5	Vdc	A-3	3066	$I_C = 2Adc$, $I_B = 0.4Adc$; Cond. A
Gain-Bandwith Product	f_T*	20	70	MHz	A-4	3306	$I_C = 0.2Adc$, $V_{CE} = 10Vdc$, $f = 10MHz$
Output Capacitance	C_{ob}	—	45	pf	A-4	3236	$V_{CB} = 10Vdc$, $I_E = 0$, $f = 1MHz$
Thermal Resistance	θ_{J-C}				C-1	3151	
2N5661		—	5.0	°C/W			
2N5663		—	6.7	°C/W			
Switching Speeds Turn-on time	t_{on}*	—	0.25	μs	A-4	—	$I_C = 0.5Adc$
Turn-off time	t_{off}*	—	1.2	μs	A-4	—	
100°C							
Forward Biased Second Breakdown							
2N5661	$I_{S/B}$	2	—	Adc	B-6	3051	$V_{CE} = 10Vdc$, $t = 1Sec$
	$I_{S/B}$	0.5	—	Adc	B-6	3051	$V_{CE} = 40Vdc$, $t = 1Sec$
	$I_{S/B}$	19	—	mAdc	B-6	3051	$V_{CE} = 300Vdc$, $t = 1Sec$
2N5663	$I_{S/B}$	2	—	Adc	B-7	3051	$V_{CE} = 7.5 Vdc$, $t = 1Sec$
	$I_{S/B}$	0.6	—	Adc	B-7	3051	$V_{CE} = 25Vdc$, $t = 1Sec$
	$I_{S/B}$	14	—	mAdc	B-7	3051	$V_{CE} = 300Vdc$, $t = 1Sec$
Unclamped Reverse Biased Second Breakdown	$E_{S/B}$	0.2	—	mj	B-8	3053	$I_C = 2Adc$, $L = 0.1 mh$
Clamped Reverse Biased Second Breakdown	$E_{S/B}$	80	—	mj	B-9	3053	$I_C = 2Adc$, $L = 40mh$, $V_{clamp} = 300V$
150°C							
Collector-Emitter Cutoff Current	I_{CES}*	—	100	μAdc	A-5	3041	$V_{CE} = 300Vdc$, Cond. C
−65°C							
D.C. Current Gain (Note 1)	h_{FE}	10	—	—	A-6	3076	$I_C = 0.5Adc$, $V_{CE} = 5Vdc$

Notes

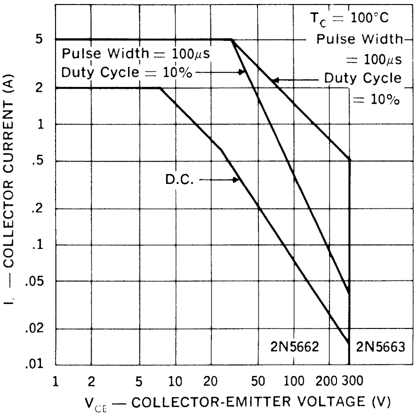
1. Pulse length = 300 μs; duty cycle ⩽2%.

* Those parameters marked with a * are JEDEC registered and devices meeting these specifications are available as commercial 2N devices.

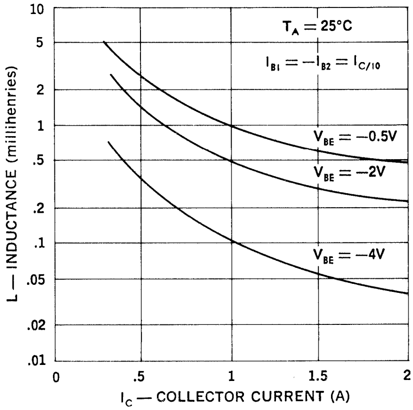
Forward Bias Safe Operating Area 2N5660, 2N5661



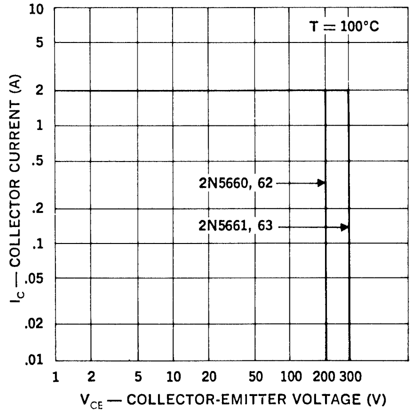
Forward Bias Safe Operating Area 2N5662, 2N5663



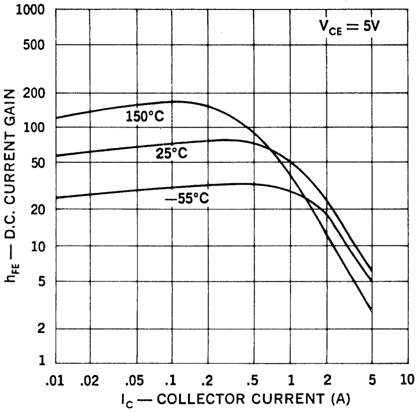
Unclamped Reverse Bias Second Breakdown



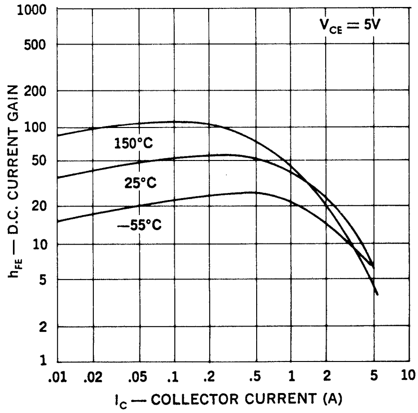
Reverse Bias Safe Operating Area Clamped Inductive Switching

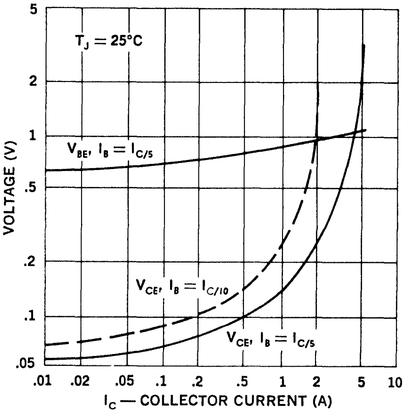


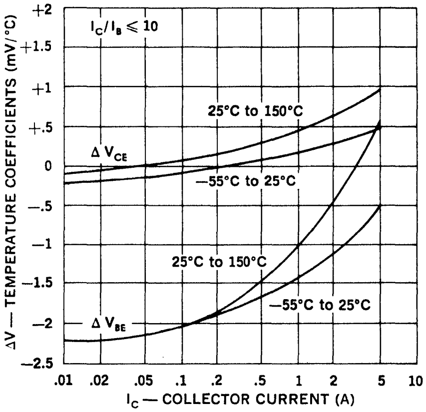
D.C. Current Gain 2N5660, 2N5662

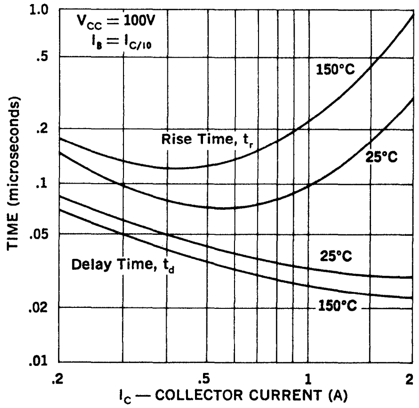


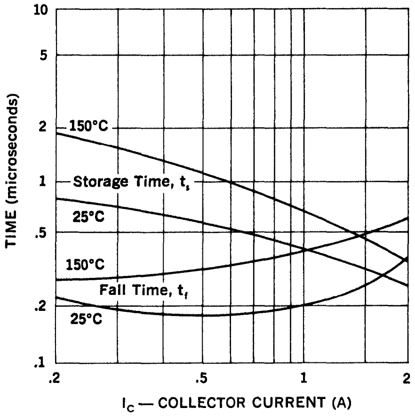
D.C. Current Gain 2N5661, 2N5663

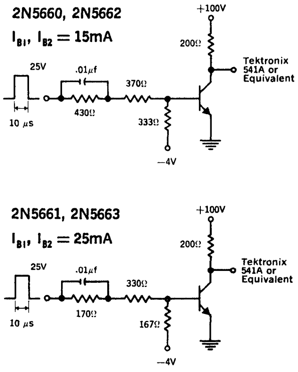


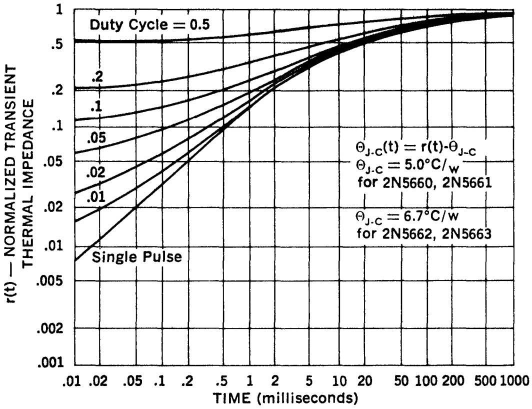

Saturation Voltages


Saturation Voltage Temperature Coefficients


Switching Speed Characteristics


Switching Speed Characteristics


Switching Speed Circuits


Thermal Response

POWER TRANSISTORS
5 Amp, 300V, Planar NPN

JAN, JANTX, & JANTXV 2N5664
JAN, JANTX, & JANTXV 2N5665
JAN, JANTX, & JANTXV 2N5666
JAN, JANTX, & JANTXV 2N5667

FEATURES

- Meets MIL-S-19500/455
- Collector-Base Voltage: up to 400V
- D.C. Collector Current: 5A
- Peak Collector Current: 10A
- Fast Switching

DESCRIPTION

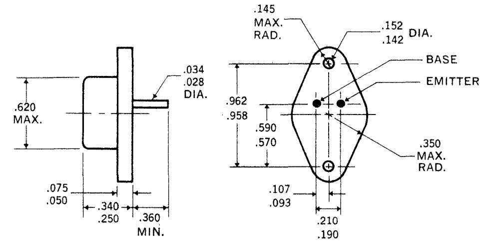
Unitrode high voltage transistors provide a unique combination of low saturation voltage, fast switching, and excellent gain. They are ideally suited for off-line power supply designs and other applications where the increased voltage rating adds to system reliability.

ABSOLUTE MAXIMUM RATINGS

	JAN, JANTX, & JANTXV 2N5664	JAN, JANTX, & JANTXV 2N5665	JAN, JANTX, & JANTXV 2N5666	JAN, JANTX, & JANTXV 2N5667
Collector-Base Voltage, V_{CBO}	250V	400V	250V	400V
Collector-Emitter Voltage, V_{CEO}	200V	300V	200V	300V
Emitter-Base Voltage, V_{EBO}	6V	6V	6V	6V
D.C. Collector Current, I_C	5A	5A	5A	5A
Peak Collector Current, I_C	10A	10A	10A	10A
Power Dissipation				
25°C Ambient	2.5W	2.5W	1.2W	1.2W
100°C Case	30W	30W	15W	15W
Operating and Storage Temperature Range	—65°C to 200°C			

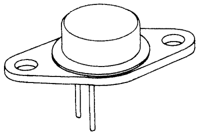
MECHANICAL SPECIFICATIONS

JAN, JANTX, & JANTXV 2N5664 JAN, JANTX, & JANTXV 2N5665

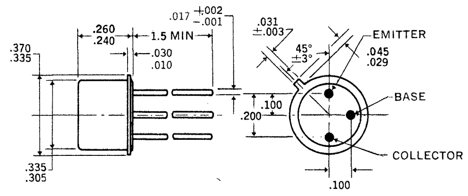


Dimensions in inches.

TO-66

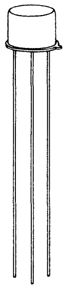


JAN, JANTX, & JANTXV 2N5666 JAN, JANTX, & JANTXV 2N5667



Dimensions in inches.

TO-5



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)
2N5664, 2N5666

Test	Symbol	Min.	Max.	Units	/455 Sub group	MIL-STD-750	
						Method	Test conditions
Visual and mechanical					A-1	2071	See Mechanical Data
25°C							
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}*	250	—	Vdc	A-2	3011	$I_C = 10mAdc$; $R_{BE} = 100\,\Omega$, Cond. B
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}*	200	—	Vdc	A-2	3011	$I_C = 10mAdc$; Cond. D
Emitter-Base Breakdown Voltage	BV_{EBO}*	6.0	—	Vdc	A-2	3026	$I_E = 10\mu Adc$; Cond. D
Collector-Emitter Cutoff Current	I_{CES}*	—	0.2	μAdc	A-2	3041	$V_{CE} = 200Vdc$; Cond. C
Collector-Base Cutoff Current	I_{CBO}	—	0.1	μAdc	A-2	3036	$V_{CB} = 200Vdc$; Cond. D
Collector-Base Cutoff Current	I_{CBO}	—	1.0	mAdc	A-2	3036	$V_{CB} = 250Vdc$; Cond. D
D.C. Current Gain (Note 1)	h_{FE}*	40	—	—	A-3	3076	$I_C = 0.5Adc$. $V_{CE} = 2Vdc$
D.C. Current Gain (Note 1)	h_{FE}*	40	120	—	A-3	3076	$I_C = 1Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}*	15	—	—	A-3	3076	$I_C = 3Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	5	—	—	A-3	3076	$I_C = 5Adc$, $V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)*	—	0.4	Vdc	A-3	3071	$I_C = 3Adc$, $I_B = 0.3Adc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.0	Vdc	A-3	3071	$I_C = 5Adc$, $I_B = 1Adc$
Base Saturation Voltage (Note 1)	V_{BE} (sat)*	—	1.2	Vdc	A-3	3066	$I_C = 3Adc$, $I_B = 0.3Adc$; Cond. A
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.5	Vdc	A-3	3066	$I_C = 5Adc$, $I_B = 1Adc$; Cond. A
Gain-Bandwith Product	f_T*	20	70	MHz	A-4	3306	$I_C = 0.5Adc$, $V_{CE} = 5Vdc$, $f = 10MHz$
Output Capacitance	C_{ob}	—	90	pf	A-4	3236	$V_{CB} = 10Vdc$, $I_E = 0$, $f = 1MHz$
Thermal Resistance	θ_{J-C}				C-1	3151	
2N5664		—	3.3	°C/W			
2N5666		—	6.7	°C/W			
Switching Speeds Turn-on Time	t_{on}*	—	0.25	μs	A-4	—	$I_C = 1Adc$
Switching Speeds Turn-off Time	t_{off}*	—	1.5	μs	A-4	—	
100°C							
Forward Biased Second Breakdown 2N5664	$I_{S/B}$	5	—	Adc	B-6	3051	$V_{CE} = 6Vdc$, $t = 1sec$
	$I_{S/B}$	0.75	—	Adc	B-6	3051	$V_{CE} = 40Vdc$, $t = 1sec$
	$I_{S/B}$	43	—	mAdc	B-6	3051	$V_{CE} = 200Vdc$, $t = 1sec$
2N5666	$I_{S/B}$	5	—	Adc	B-7	3051	$V_{CE} = 3Vdc$, $t = 1sec$
	$I_{S/B}$	0.4	—	Adc	B-7	3051	$V_{CE} = 37.5Vdc$, $t = 1sec$
	$I_{S/B}$	27	—	mAdc	B-7	3051	$V_{CE} = 200Vdc$, $t = 1sec$
Unclamped Reverse Biased Second Breakdown	$E_{S/B}$	1.25	—	mj	B-8	3053	$I_C = 5Adc$, $L = 0.1mh$
Clamped Reverse Biased Second Breakdown	$E_{S/B}$	500	—	mj	B-9	3053	$I_C = 5Adc$, $L = 40mh$, $V_{clamp} = 200V$
150°C							
Collector-Emitter Cutoff Current	I_{CES}*	—	100	μAdc	A-5	3041	$V_{CE} = 200Vdc$, Cond. C
—65°C							
D.C. Current Gain (Note 1)	h_{FE}	15	—	—	A-6	3076	$I_C = 1Adc$, $V_{CE} = 5Vdc$

Notes

1. Pulse length = 300 μs; duty cycle ≤2%.

* Those parameters marked with a * are JEDEC registered and devices meeting these specifications are available as commercial 2N devices.

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)
2N5665, 2N5667

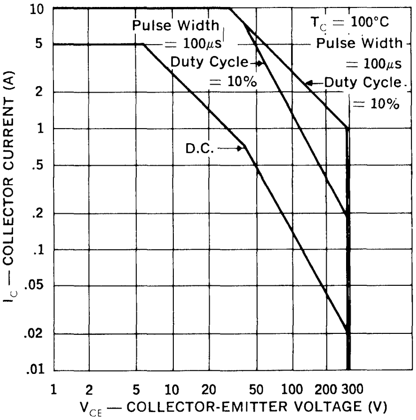
Test	Symbol	Min.	Max.	Units	/455 Sub group	MIL-STD-750 Method	Test conditions
Visual and mechanical					A-1	2071	See Mechanical Data
25°C							
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}*	400	—	Vdc	A-2	3011	$I_C = 10mAdc$; $R_{BE} = 100\,\Omega$, Cond. B
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}*	300	—	Vdc	A-2	3011	$I_C = 10mAdc$; Cond. D
Emitter-Base Breakdown Voltage	BV_{EBO}*	6	—	Vdc	A-2	3026	$I_E = 10\mu Adc$; Cond. D
Collector-Emitter Cutoff Current	I_{CES}*	—	0.2	μAdc	A-2	3041	$V_{CE} = 300Vdc$; Cond. C
Collector-Base Cutoff Current	I_{CBO}	—	0.1	μAdc	A-2	3036	$V_{CB} = 300Vdc$; Cond. D
Collector-Base Cutoff Current	I_{CBO}	—	1.0	mAdc	A-2	3036	$V_{CB} = 400Vdc$; Cond. D
D.C. Current Gain (Note 1)	h_{FE}*	25	—	—	A-3	3076	$I_C = 0.5Adc$, $V_{CE} = 2Vdc$
D.C. Current Gain (Note 1)	h_{FE}*	25	75	—	A-3	3076	$I_C = 1Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}*	10	—	—	A-3	3076	$I_C = 3Adc$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	5	—	—	A-3	3076	$I_C = 5Adc$, $V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)*	—	0.4	Vdc	A-3	3071	$I_C = 3Adc$, $I_B = 0.6Adc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.0	Vdc	A-3	3071	$I_C = 5Adc$, $I_B = 1Adc$
Base Saturation Voltage (Note 1)	V_{BE} (sat)*	—	1.2	Vdc	A-3	3066	$I_C = 3Adc$, $I_B = 0.6Adc$; Cond. A
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.5	Vdc	A-3	3066	$I_C = 5Adc$, $I_B = 1Adc$; Cond. A
Gain-Bandwith Product	f_T*	20	70	MHz	A-4	3306	$I_C = 0.5Adc$, $V_{CE} = 5Vdc$, $f = 10MHz$
Output Capacitance	C_{ob}	—	90	pf	A-4	3236	$V_{CB} = 10Vdc$, $I_E = 0$, $f = 1MHz$
Thermal Resistance	θ_{J-C}				C-1	3151	
2N5665		—	3.3	°C/W			
2N5667		—	6.7	°C/W			
Switching Speeds Turn-on time	t_{on}*	—	0.25	μs	A-4	—	$I_C = 1Adc$
Turn-off time	t_{off}*	—	2.0	μs	A-4	—	
100°C							
Forward Biased Second Breakdown 2N5665	$I_{S/B}$	5	—	Adc	B-6	3051	$V_{CE} = 6Vdc$, $t = 1sec$
	$I_{S/B}$	0.75	—	Adc	B-6	3051	$V_{CE} = 40Vdc$, $t = 1$ sec
	$I_{S/B}$	21	—	mAdc	B-6	3051	$V_{CE} = 300Vdc$, $t = 1sec$
2N5667	$I_{S/B}$	5	—	Adc	B-7	3051	$V_{CE} = 3Vdc$, $t = 1sec$
	$I_{S/B}$	0.4	—	Adc	B-7	3051	$V_{CE} = 37.5Vdc$, $t = 1sec$
	$I_{S/B}$	14	—	nAdc	B-7	3051	$V_{CE} = 300Vdc$, $t = 1sec$
Unclamped Reverse Biased Second Breakdown	$E_{S/B}$	1.25	—	mj	B-8	3053	$I_C = 5Adc$, $L = 0.1mh$
Clamped Reverse Biased Second Breakdown	$E_{S/B}$	500	—	mj	B-9	3053	$I_C = 5Adc$, $L = 40mh$, $V_{clamp} = 300V$
150°C							
Collector-Emitter Cutoff Current	I_{CES}*	—	100	μAdc	A-5	3041	$V_{CE} = 300Vdc$, Cond. C
−65°C							
D.C. Current Gain (Note 1)	h_{FE}	10	—	—	A-6	3076	$I_C = 1Adc$, $V_{CE} = 5Vdc$

Notes

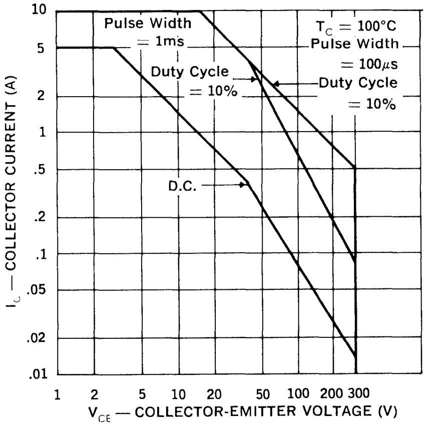
1. Pulse length = 300 μs; duty cycle ≤2%.

* Those parameters marked with a * are JEDEC registered and devices meeting these specifications are available as commercial 2N devices.

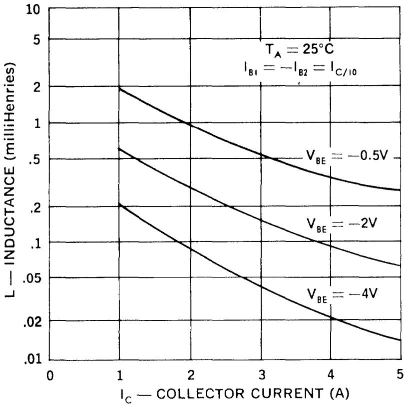
Forward Bias Safe Operating Area
2N5664, 2N5665



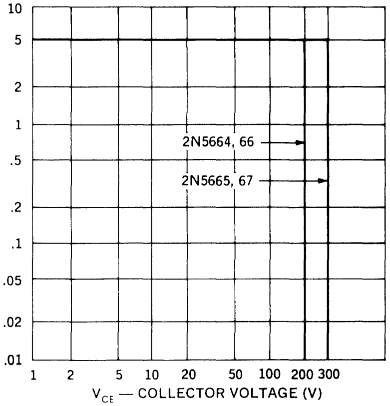
Forward Bias Safe Operating Area
2N5666, 2N5667



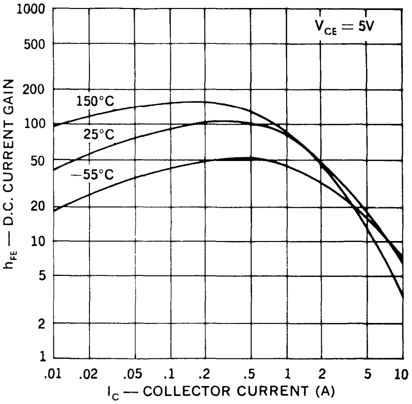
Unclamped Reverse Bias Second Breakdown



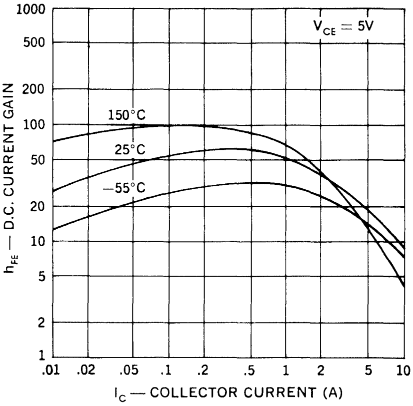
Reverse Bias Safe Operating Area Clamped Inductive Switching



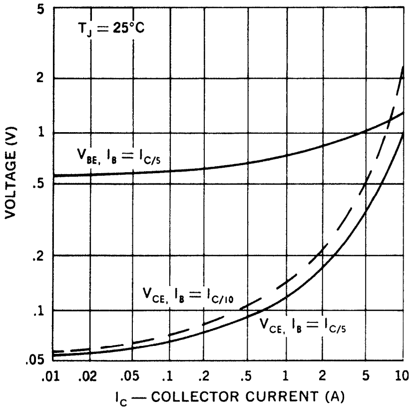
D.C. Current Gain
2N5664, 2N5666



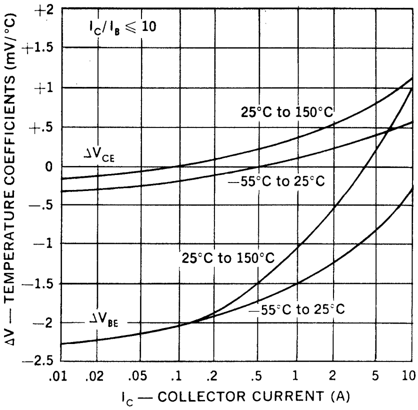
D.C. Current Gain
2N5665, 2N5667



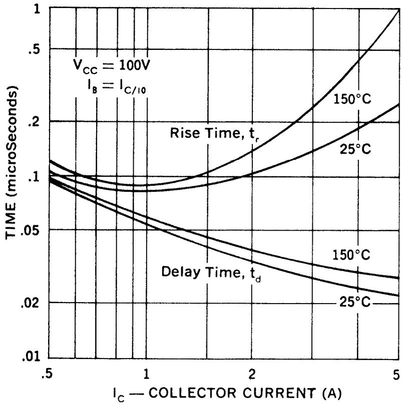
Saturation Voltages



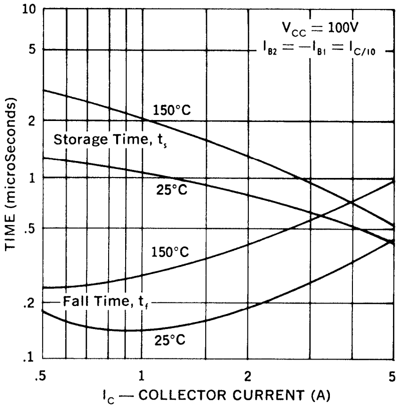
Saturation Voltage Temperature Coefficients



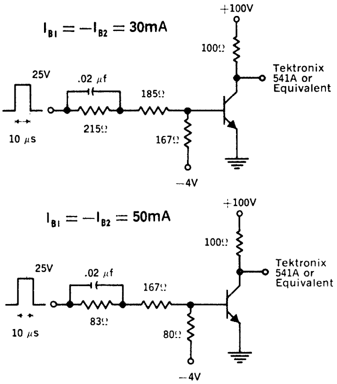
Switching Speed Characteristics



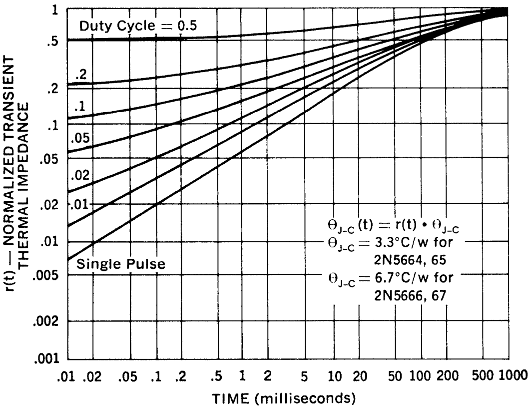
Switching Speed Characteristics



Switching Speed Circuits



Thermal Response



POWER TRANSISTORS

30A, 150V, Fast Switching, Silicon NPN Mesa

2N5671
2N5672

FEATURES

- Collector-Base Voltage: up to 150V
- DC Collector Current = 30A
- Low $V_{CE\,(SAT)}$ = 0.75V Max.
- $t_{on} = 0.5\mu S$ } @ $I_C = 15A$
- $t_{fall} = 0.5\mu S$ } @ $I_C = 15A$

DESCRIPTION

These glass passivated power transistors combine fast-switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in switching regulators, converters, inverters and switching-control amplifiers.

ABSOLUTE MAXIMUM RATINGS *

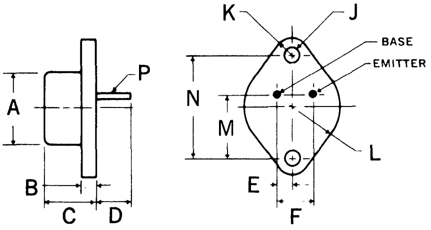
	2N5671	2N5672
* Collector-to-Base Voltage, V_{CBO}	120V	150V
Collector-Emitter Sustaining Voltage, $V_{CEX\,(SUS)}$	120V	150V
$V_{CER\,(SUS)}$	110V	140V
$V_{CEO\,(SUS)}$	90V	120V
* Emitter-Base Voltage, V_{EBO}	7V	7V
* Collector Current, I_C continuous	30A	30A
* Base Current, I_B continuous	10A	10A
* Power Dissipation, 25°C Case	140W	140W
* Operating and Storage Temperature Range	—65 to 200°C	

* JEDEC registered values.

MECHANICAL SPECIFICATIONS

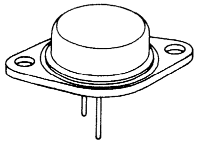
NOTE:
Leads may be soldered to within 1/16" of base provided temperature-time exposure is less than 260°C for 10 seconds.

2N5671 -2N5672



	Ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.205-.225	5.21-5.72
F	.420-.440	10.67-11.18
J	.151-.161 DIA.	3.84-4.09 DIA.
K	.188 MAX. RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.655-.675	16.64-17.15
N	1.177-1.197	29.90-30.40
P	.038-.043 DIA.	9.65-10.92 DIA.

TO-3



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

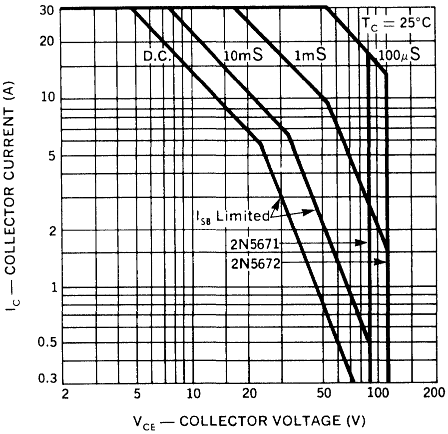
Test	Symbol	2N5671		2N5672		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
* D.C. Current Gain (Note 1)	h_{FE}	20	100	20	100		$I_C = 15A, V_{CE} = 2V$
D.C. Current Gain (Note 1)	h_{FE}	20	—	20	—		$I_C = 20A, V_{CE} = 5V$
* Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	0.75	—	0.75	V	$I_C = 15A, I_B = 1.2A$
* Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.5	—	1.5	V	$I_C = 15A, I_B = 1.2A$
Base to Emitter Voltage (Note 1)	V_{BE}	—	1.6	—	1.6	V V	$I_C = 15A, V_{CE} = 5V$
* Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	90	—	120	—	V	$I_C = 0.2A, I_B = 0$
* Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEX\,(sus)}$	120	—	150	—	V	$I_C = 0.2A$ $V_{BE} = -1.5V$ $I_B = 0$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CER\,(sus)}$	110	—	140	—	V	$R_{BE} = 50\Omega, I_C = 0.2A$
* Emitter-Cutoff Current	I_{EBO}	10	—	10	—	mA	$V_{EB} = 7.0V$
Collector Cutoff Current	I_{CEO}	—	10	—	10	mA	$V_{CE} = 80V$
* Collector Cutoff Current	I_{CEV}	—	12	—	—	mA	$V_{CE} = 110V, V_{BE} = -1.5V$
		—	—	—	10		$V_{CE} = 135V, V_{BE} = -1.5V$
		—	15	—	10		$V_{CE} = 100V, V_{BE} = -1.5V, T_C = 150°C$
Magnitude of Small Signal Forward — Current Transfer Ratio	h_{fe}	10	—	10	—		$V_{CE} = 10V, I_C = 2A, f = 5MHz$
Collector Capacitance	C_{ob}	—	900	—	900	pF	$V_{CB} = 10V, f = 1 MHz$
* Second Breakdown Energy	$E_{s/b}$	20	—	20	—	mJ	$V_{BE} = 4V, I_C = 15A$ $R_{BE} = 20\Omega, L = 180\mu H$
Forward Bias Second Breakdown Collector Current	$I_{s/b}$	5.8	—	5.8	—	A	$V_{CE} = 24V, t = 1s$, non-rep.
		0.9	—	0.9	—		$V_{CE} = 45V, t = 1s$, non-rep.
* Switching Speeds: Turn-on Time (Delay + Rise)	t_{on}	—	0.5	—	0.5	μS	$I_C = 15A$ $I_{B1} = I_{B2} = 1.2A$ $V_{CC} = 30V$
Storage Time	t_s	—	1.5	—	1.5	μS	
Fall Time	t_f	—	0.5	—	0.5	μS	
Thermal Resistance: Junction-to-Case	$R\theta_{JC}$	1.25	—	1.25	—	°C/W	$V_{CE} = 40V, I_C = 0.5A$

Notes

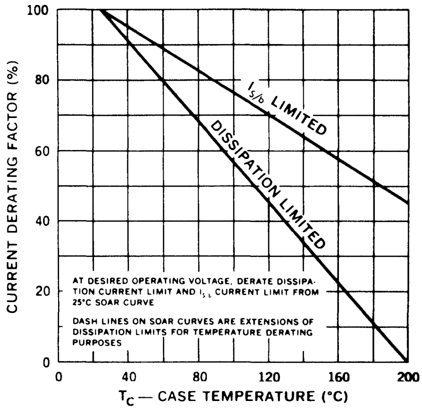
1. Pulse length = 250μS; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50μS; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.

* JEDEC registered values.

Forward Bias Safe Operating Area



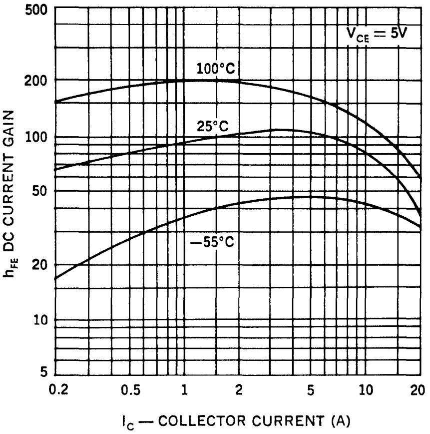
Power Derating



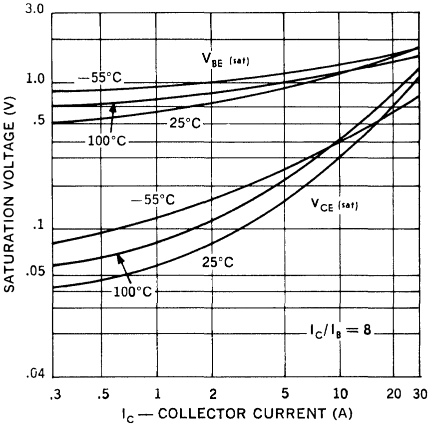
AT DESIRED OPERATING VOLTAGE, DERATE DISSIPATION CURRENT LIMIT AND $I_{S/b}$ CURRENT LIMIT FROM 25°C SOAR CURVE

DASH LINES ON SOAR CURVES ARE EXTENSIONS OF DISSIPATION LIMITS FOR TEMPERATURE DERATING PURPOSES

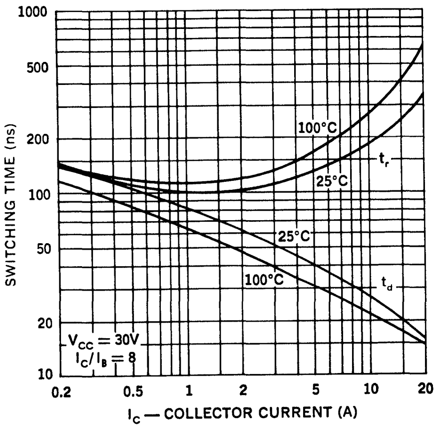
DC Current Gain



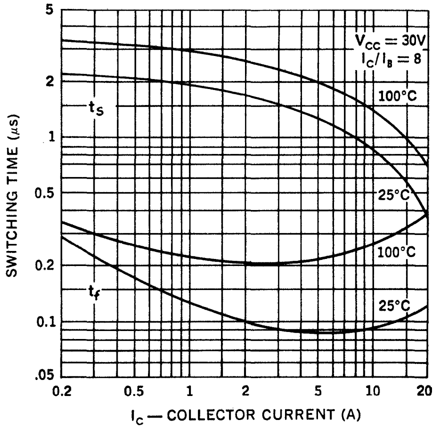
Transistor — Saturation Voltages



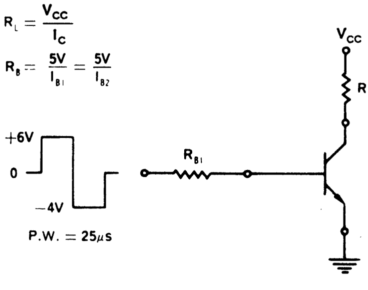
Resistive — Turn-On Time



Resistive Turn-Off Time



Switching Time Test Circuit


$$R_L = \frac{V_{CC}}{I_C}$$

$$R_B = \frac{5V}{I_{B1}} = \frac{5V}{I_{B2}}$$

POWER TRANSISTORS
3A, 375V
Silicon NPN Mesa

2N5838
2N5839
2N5840

FEATURES
- Collector-Base Voltage: up to 375V
- Peak Collector Current: 5A
- Low Saturation Voltage
- High Second Breakdown Energy

DESCRIPTION
These high voltage glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

ABSOLUTE MAXIMUM RATINGS *

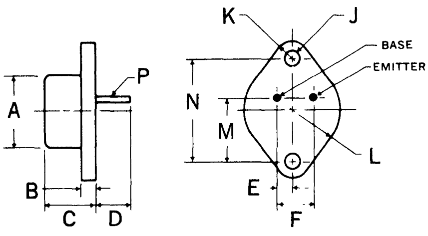
	2N5838	2N5839	2N5840
Collector-Base Voltage, V_{CBO}	275V	300V	375V
Collector-Emitter Voltage, V_{CEO}	250V	275V	350V
Emitter-Base Voltage, V_{EBO}	6V	6V	6V
Collector Current, I_C continuous	3A	3A	3A
Collector Current, I_{CM}, peak	5A	5A	5A
Base Current, I_B, continuous	1.5A	1.5A	1.5A
Power Dissipation, P_T 25°C Case	100W	100W	100W
Operating and Storage Temperature Range		−65 to +200°C	

* JEDEC registered values.

MECHANICAL SPECIFICATIONS

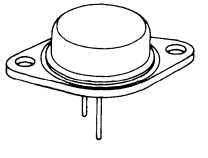
NOTE:
Leads may be soldered to within 1/16" of base provided temperature-time exposure is less than 260°C for 10 seconds.

2N5838 2N5839 2N5840



	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.205-.225	5.21-5.72
F	.420-.440	10.67-11.18
J	.151-.161 DIA.	3.84-4.09 DIA.
K	.188 MAX. RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.655-.675	16.64-17.15
N	1.177-1.197	29.90-30.40
P	.038-.043 DIA.	9.65-10.92 DIA.

TO-3



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

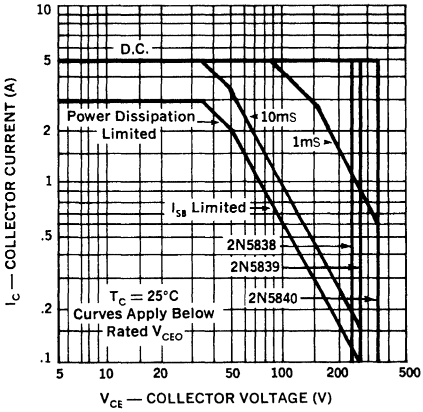
Test	Symbol	2N5838		2N5839		2N5840		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	20	—	20	—	20	—		$I_C = 0.5A, V_{CE} = 5V$
* D.C. Current Gain (Note 1)	h_{FE}	—	—	10	50	10	50		$I_C = 2A, V_{CE} = 3V$
* D.C. Current Gain (Note 1)	h_{FE}	8	40	—	—	—	—	V	$I_C = 3A, V_{CE} = 2V$
* Collector Saturation Voltage (Note 1)	$V_{CE(sat)}$	—	—	—	1.5	—	1.5	V	$I_C = 2A, I_B = 0.2A$
* Collector Saturation Voltage (Note 1)	$V_{CE(sat)}$	—	1.0	—	—	—	—	V	$I_C = 3A, I_B = 0.375A$
* Base Saturation Voltage (Note 1)	$V_{BE(sat)}$	—	—	—	2.0	—	2.0	V	$I_C = 2A, I_B = 0.2A$
* Base Saturation Voltage (Note 1)	$V_{BE(sat)}$	—	2.0	—	—	—	—	V	$I_C = 3A, I_B = 0.375A$
* Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO(SUS)}$	250	—	275	—	350	—	V	$I_C = 200mA, I_B = 0$
* Collector-Emitter Sustaining Voltage	V_{CEX}	275	—	300	—	375	—	V	$I_C = 0.1A, V_{BE} = -1.5V,$ $L = 10mH$
* Emitter-Base Cutoff Current	I_{EBO}	—	1.0	—	1.0	—	1.0	mA	$V_{EB} = 6V$
Collector Cutoff Current	I_{CEO}	—	2.0	—	—	—	—	—	$V_{CE} = 200V$
		—	—	—	2.0	—	2.0	mA	$V_{CE} = 250V$
* Collector Cutoff Current	I_{CEV}	—	5.0	—	—	—	—	mA	$V_{CE} = 265V$
		—	—	—	2.0	—	—		$V_{CE} = 290V$ $V_{BE} = -1.5V$
		—	—	—	—	—	2.0		$V_{CE} = 360V$
* Collector Cutoff Current, 150°C	I_{CEV}	—	8.0	—	—	—	—	mA	$V_{CE} = 265V$
		—	—	—	5.0	—	—		$V_{CE} = 290V$ $V_{BE} = -1.5V$
		—	—	—	—	—	5.0		$V_{CE} = 360V$
Forward Bias Second Breakdown	$I_{S/b}$	—	2.5A	—	2.5A	—	2.5A		$V_{CE} = 40V, t_p = 1$ Sec.
* Second Breakdown Energy	$E_{S/b}$	0.45	—	0.45	—	0.45	—	mJ	$R_{BE} = 50\Omega, L = 100\mu H$
Collector Capacitance	C_{ob}	—	150	—	150	—	150	pF	$V_{CB} = 10V, I_E = 0, f = 1$ MHz
* Small Signal High Frequency Gain	h_{fe}	5	—	5	—	5	—	MHz	$I_C = .2A, V_{CE} = 10V, f = 1$ MHz
* Switching Speeds:									
Delay Time	t_d	—	—	—	0.7	—	0.7	μS	$I_C = 2A, V_{CE} = 200V,$ $I_{B1} = I_{B2} = (0.2A)$
	t_d	—	0.6	—	—	—	—		$I_C = 3A, V_{CE} = 200V,$ $I_{B1} = I_{B2} = (.375A)$
Rise Time	t_r	—	—	—	1.5	—	1.75	μS	$I_C = 2A, V_{CE} = 200V,$ $I_{B1} = I_{B2} = (0.2A)$
	t_r	—	1.5	—	—	—	—		$I_C = 3A, V_{CE} = 200V,$ $I_{B1} = I_{B2} = (.375A)$
Storage Time	t_s	—	—	—	3.75	—	3.75	μS	$I_C = 2A, V_{CE} = 200V,$ $I_{B1} = I_{B2} = (0.2A)$
	t_s	—	3.0	—	—	—	—		$I_C = 3A, V_{CE} = 200V,$ $I_{B1} = I_{B2} = (.375A)$
Fall Time	t_f	—	—	—	1.5	—	1.5	μS	$I_C = 2A, V_{CE} = 200V,$ $I_{B1} = I_{B2} = (0.2A)$
	t_f	—	1.5	—	—	—	—		$I_C = 3A, V_{CE} = 200V,$ $I_{B1} = I_{B2} = (.375A)$
Thermal Resistance	$R\Theta_{JC}$	—	1.75	—	1.75	—	1.75	°C/W	

Notes

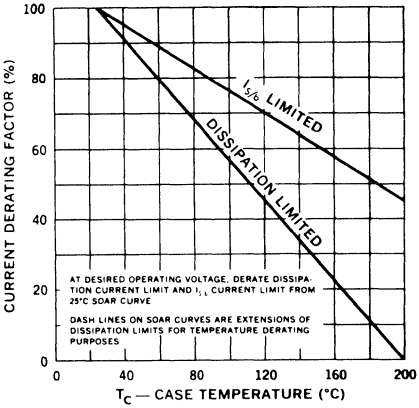
1. Pulse length = 250μS; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50μS; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.

* JEDEC registered values.

Forward Bias Safe Operating Area



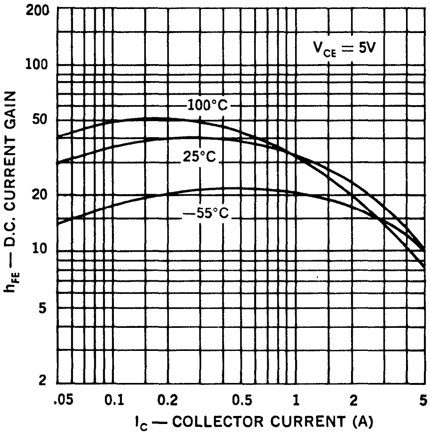
Power Derating



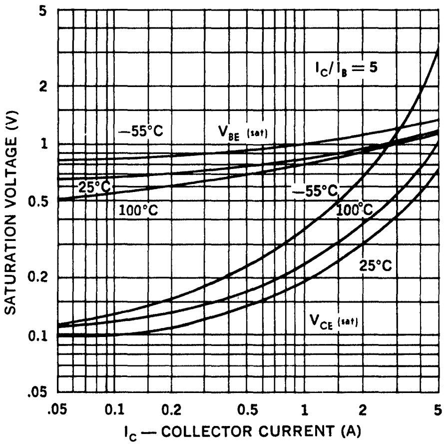
AT DESIRED OPERATING VOLTAGE, DERATE DISSIPATION CURRENT LIMIT AND $I_{S/b}$ CURRENT LIMIT FROM 25°C SOAR CURVE

DASH LINES ON SOAR CURVES ARE EXTENSIONS OF DISSIPATION LIMITS FOR TEMPERATURE DERATING PURPOSES

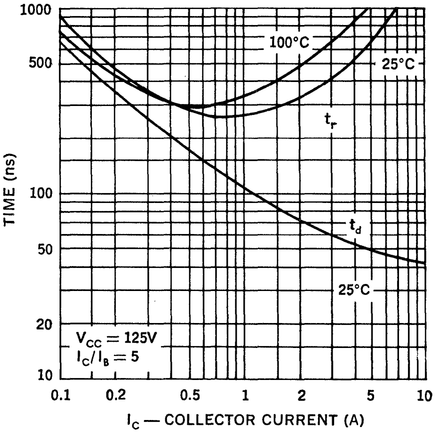
D.C. Current Gain



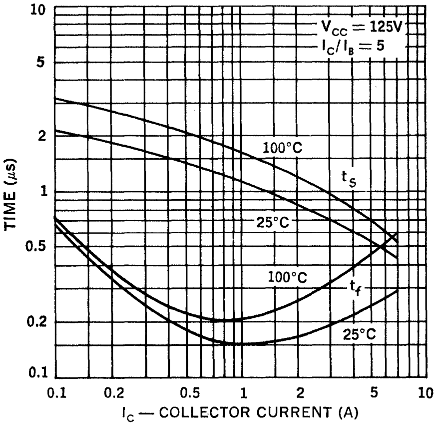
Saturation Voltages



Resistive — Turn-On Time



Resistive — Turn-Off Time

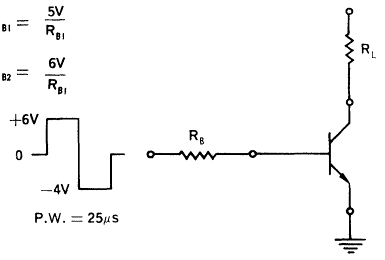


Switching Time Test Circuit

$R_L = \frac{200V}{I_C}$

$I_{B1} = \frac{5V}{R_{B1}}$

$I_{B2} = \frac{6V}{R_{B1}}$



POWER TRANSISTORS

10 Amp, 100V, Planar NPN

2N6232 6232-4

FEATURES

- Collector-Base Voltage: up to 140V
- D.C. Collector Current: 10A
- Fast Switching
- Low Saturation Voltage

DESCRIPTION

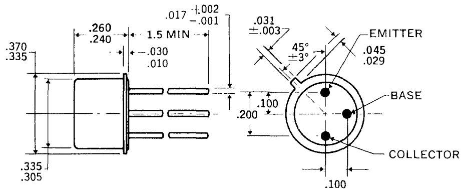
Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply, pulse amplifier and similar high efficiency power switching applications.

ABSOLUTE MAXIMUM RATINGS

	2N6232 6232-4
Collector-Base Voltage, V_{CBO}	140V
Collector-Emitter Voltage, V_{CEO}	100V
Emitter-Base Voltage, V_{EBO}	7V
D.C. Collector Current, I_C	10A
Power Dissipation	
25°C Ambient	1.25W
100°C Case	15W
Operating and Storage Temperature Range	—65°C to 200°C

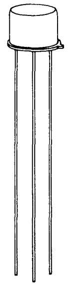
MECHANICAL SPECIFICATIONS

2N6232

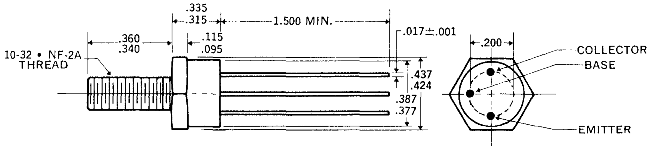


Dimensions in inches.

TO-5

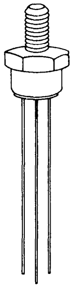


6232-4



Dimensions in inches.

TO-5 (Stud)



UNITRODE

Electrical Specification (at 25°C unless noted) †

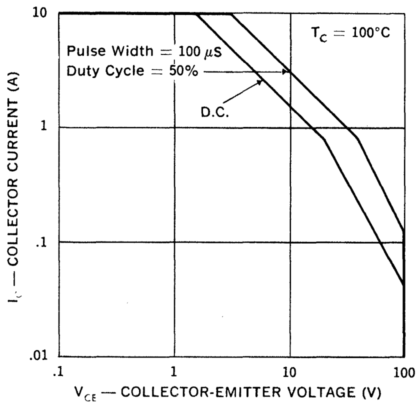
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain	h_{FE}	40	250	—	$I_C = 0.5A, V_{CE} = 2V$
D.C. Current Gain (Note 2)	h_{FE}	25	100	—	$I_C = 5A, V_{CE} = 2V$
D.C. Current Gain (Note 2)	h_{FE}	20	—	—	$I_C = 10A, V_{CE} = 5V$
Collector Saturation Voltage (Note 2)	V_{CE} (sat)	—	0.7	V	$I_C = 5A, I_B = 0.5A$
Collector Saturation Voltage (Note 2)	V_{CE} (sat)	—	1.4	V	$I_C = 10A, I_B = 1A$
Base Saturation Voltage (Note 2)	V_{BE} (sat)	—	1.4	V	$I_C = 5A, I_B = 0.5A$
Base Saturation Voltage (Note 2)	V_{BE} (sat)	—	1.8	V	$I_C = 10A, I_B = 1A$
Collector-Emitter Sustaining Voltage (Note 2)	BV_{CER}	140	—	V	$I_C = 10mA, R_{BE} = 10\Omega$
Collector-Emitter Sustaining Voltage (Note 2)	V_{CEO} (sus)	100	—	V	$I_C = 100mA, I_B = 0$
Emitter-Cutoff Current	I_{EBO}	—	10	μA	$V_{EB} = 7V$
Collector Cutoff Current	I_{CES}	—	0.2	μA	$V_{CE} = 140V, R_{BE} = 0$
Collector Cutoff Current, 150°C	I_{CES}	—	0.1	mA	$V_{CE} = 100V, R_{BE} = 0$
Collector Capacitance	C_{obo}	—	150	pf	$V_{CB} = 10, I_E = 0, f = 1MHz$
A.C. Current Gain	h_{fe}	3	—	—	$I_C = 0.5A, V_{CE} = 5V$ $f = 10MHz$
Switching Speeds Turn-on Time Turn-off Time	t_{on} t_{off}	— —	250 1.2	ns μs	$I_C = 5A$ $I_{b1} = 500mA$ $I_{b2} = -500mA$

Notes:

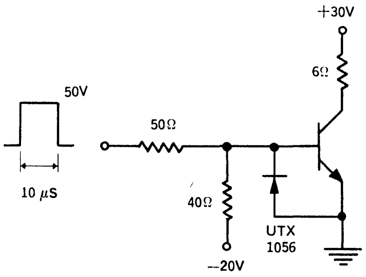
1. The device may be switched between maximum rated collector current and maximum rated collector — emitter voltage along a resistive load line provided the switching time is less than 10 microseconds. Switching at low speed through regions of high instantaneous power dissipation may cause second breakdown to occur, with consequent damage to the device.
2. Pulse length = 300 μs; duty cycle ⩽2%.
3. Measured in saturated switching speed circuit.

† All values in this table are JEDEC registered.

Maximum Safe Operating Area



Switching Speed Circuit



POWER TRANSISTORS

10A, 450V, Fast Switching, Silicon NPN Mesa

2N6249
2N6250
2N6251

FEATURES

- Collector-Base Voltage: up to 450V
- Peak Collector Current: 30A
- Low Saturation Voltage
- Maximum Safe Area of Operation

DESCRIPTION

These high voltage glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{s/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

ABSOLUTE MAXIMUM RATINGS

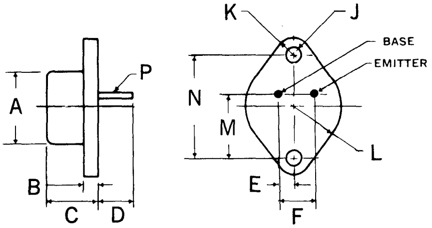
	2N6249	2N6250	2N6251
* Collector-Base Voltage, V_{CBO}	300V	375V	450V
* Collector-Emitter Voltage, V_{CEO}	200V	275V	350V
Emitter-Base Voltage, V_{EBO}	6V	6V	6V
* Collector Current, I_C continuous	10A	10A	10A
Collector Current, I_{CM} peak	30A	30A	20A
* Base Current, I_B continuous	10A	10A	10A
* Power Dissipation, P_T 25°C Case	175W	175W	175W
* Operating and Storage Temperature Range	—65 to +200°C		

* JEDEC registered values.

MECHANICAL SPECIFICATIONS

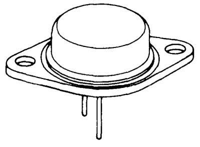
NOTE:
Leads may be soldered to within $^1/_{16}$" of base provided temperature-time exposure is less than 260°C for 10 seconds.

2N6249-2N6251



	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.205-.225	5.21-5.72
F	.420-.440	10.67-11.18
J	.151-.161 DIA.	3.84-4.09 DIA.
K	.188 MAX. RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.655-.675	16.64-17.15
N	1.177-1.197	29.90-30.40
P	.038-.043 DIA.	9.65-10.92 DIA.

TO-3



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

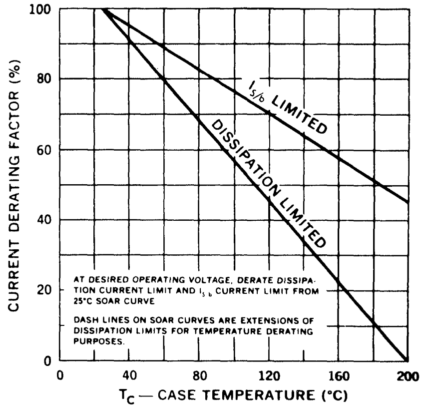
Test	Symbol	2N6249		2N6250		2N6251		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
* D.C. Current Gain (Note 1)	h_{FE}	10	50	8	50	6	50		$I_C = 10A, V_{CE} = 3.0V$
* Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.5	—	1.5	—	1.5	V	$I_C = 10A$ $I_B = 1.0A$ (2N6249) $I_B = 1.25A$ (2N6250) $I_B = 1.67A$ (2N6251)
* Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	2.25	—	2.25	—	2.25	V	
* Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	200	—	275	—	350	—	V	$I_C = 200mA$
* Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEX\,(sus)}$	225	—	300	—	375	—	V	$I_C = 200mA, R_{BE} = 50\Omega$ $L = 14mH$
* Emitter Base Cutoff Current	I_{EBO}	—	1.0	—	1.0	—	1.0	mA	$V_{EB} = 6V$
Collector Cutoff Current	I_{CEO}	—	5.0	—	5.0	—	5.0	mA	$V_{CE} = 50V$ less than rated $V_{CEO\,(SUS)}$
* Collector Cutoff Current	I_{CEV}	—	5.0	—	5.0	—	5.0	mA	$V_{BE} = -1.5V$ $V_{CE} =$ rated $V_{CER\,(SUS)}$
* Collector Cutoff Current, 125°	I_{CEV}	—	10	—	10	—	10	mA	
* Second Breakdown Energy	$E_{S/b}$	—	2.5	—	2.5	—	2.5	mJ	$I_C = 10A, L = 50\mu H$ $R_{BE} = 50\Omega, V_{BE\,(off)} = -4V$
* Forward Bias Second Breakdown	$I_{S/b}$	5.8 0.3	— —	5.8 0.3	— —	5.8 0.3	— —	A	$V_{CE} = 30V$ $V_{CE} = 100V$
* Thermal Resistance	$R\Theta_{JC}$	—	1.0	—	1.0	—	1.0	°C/W	$V_{CE} = 10V, I_C = 5A$
* High Frequency Gain	$\|h_{FE}\|$	2.5	—	2.5	—	2.5	—		$I_C = 1A, V_{CE} = 10V, f = 1$ MHz
* Switching Speeds:									$I_C = 10A$
Rise Time	t_r	0.8	2.0	0.8	2.0	0.8	2.0	μS	$I_{B1} = I_{B2} = 1.0A$ (2N6249)
Storage Time	t_s	1.8	3.5	1.8	3.5	1.8	3.5		$I_{B1} = I_{B2} = 1.25A$ (2N6250)
Fall Time	t_f	0.5	1.0	0.5	1.0	0.5	1.0		$I_{B1} = I_{B2} = 1.67A$ (2N6251)

Notes

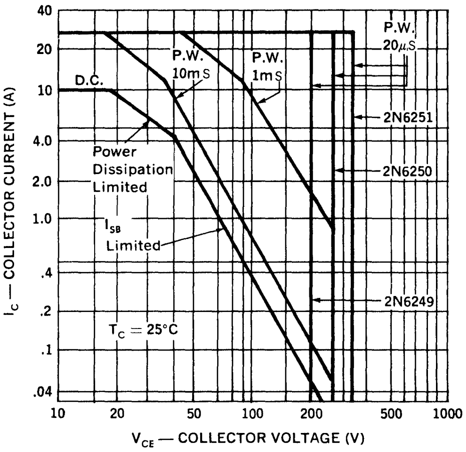
1. Pulse length = 250μS; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50μS; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.

* JEDEC registered values.

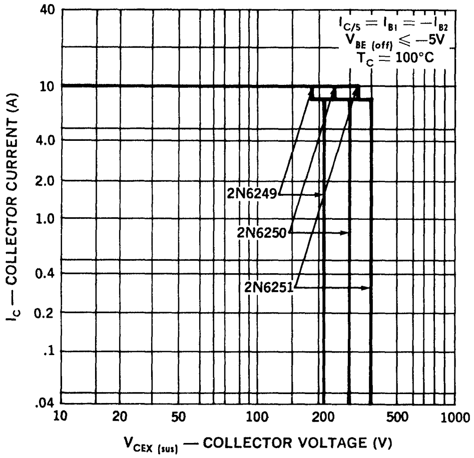
Power Derating



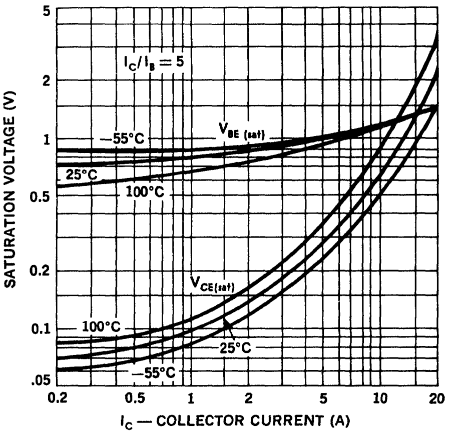
Forward Bias Safe Operating Area



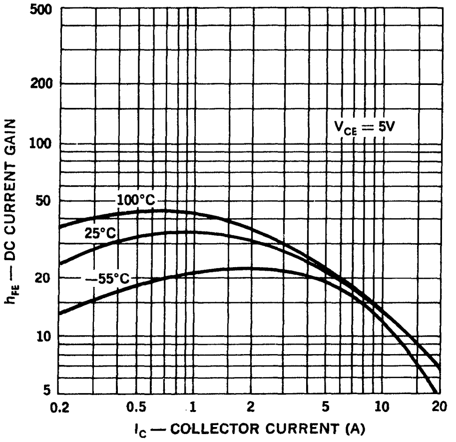
Reverse Biased Safe Operating Area



Saturation Voltages



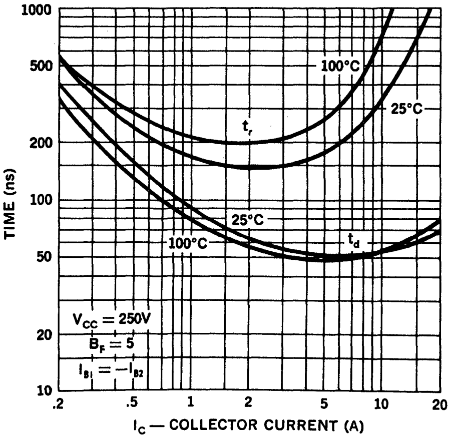
DC Current Gain



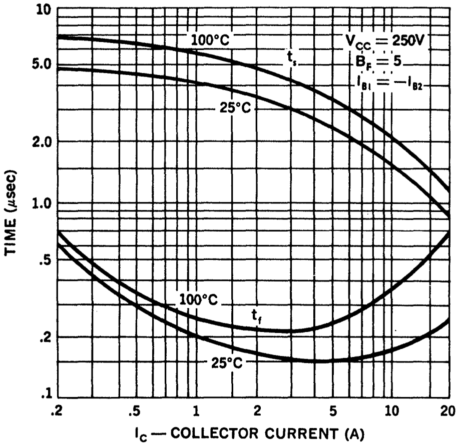
Typical Inductive Load Switching Performance

I_C Amps	T_J °C	t_s µS	t_{fv} nS	t_{fi} nS
3	25	.8	.14	.025
	100	1.10	.18	.035
5	25	.9	.14	.025
	100	1.2	.16	.030
10	25	1.2	.05	.050
	100	1.5	.12	.100

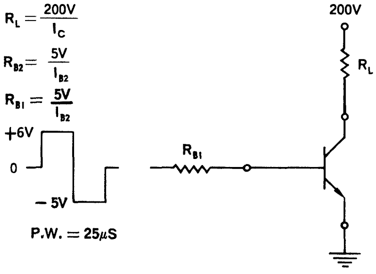
Resistive Turn-On Time



Resistive Turn-Off Time



Switching Time Test Circuit



POWER TRANSISTORS

8 Amp, 700V, Triple Diffused NPN Mesa

2N6306
2N6307
2N6308

FEATURES

- Collector-Base Voltage: up to 700V
- Peak Collector Current: 16A
- Rise Time: ≤ 600 ns } @ $I_C = 3A$
- Fall Time: ≤ 400 ns } @ $I_C = 3A$

DESCRIPTION

These high voltage triple diffused glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

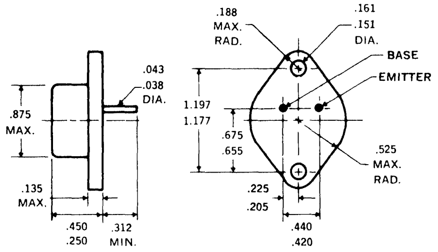
ABSOLUTE MAXIMUM RATINGS *

	2N6306	2N6307	2N6308
Collector-Base Voltage, V_{CBO}	500V	600V	700V
Collector-Emitter Voltage, V_{CEO}	250V	300V	350V
Emitter-Base Voltage, V_{EBO}	8V	8V	8V
Collector Current, I_C continuous	8A	8A	8A
Collector Current, I_{CM}, peak	16A	16A	16A
Base Current, I_B, continuous	4A	4A	4A
Power Dissipation, P_T 25°C Case	125W	125W	125W
Operating and Storage Temperature Range		−65 to +200°C	

* JEDEC registered values.

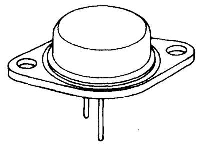
MECHANICAL SPECIFICATIONS

2N6306 2N6307 2N6308



Dimensions in inches.

TO-3



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)*

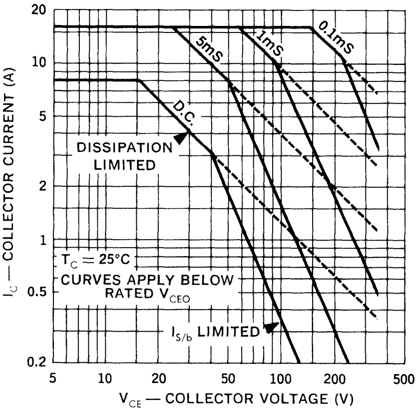
Test	Symbol	2N6306		2N6307		2N6308		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	15	75	15	75	12	60		$I_C = 3A, V_{CE} = 5V$
D.C. Current Gain (Note 1)	h_{FE}	4	—	4	—	3	—		$I_C = 8A, V_{CE} = 5V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	0.8	—	1.0	—	1.5	V	$I_C = 3A, I_B = 0.6A$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	5.0	—	5.0	—	—	V	$I_C = 8A, I_B = 2A$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	—	—	—	—	5.0	V	$I_C = 8A, I_B = 2.67A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	2.3	—	2.3	—	—	V	$I_C = 8A, I_B = 2A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	—	—	—	—	2.5	V	$I_C = 8A, I_B = 2.67A$
Base-Emitter Voltage (Note 1)	$V_{BE\,(on)}$	—	1.3	—	1.3	—	1.5	V	$I_C = 3A, V_{CE} = 5V$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(SUS)}$	250	—	300	—	350	—	V	$I_C = 100mA, I_B = O$
Emitter-Base Cutoff Current	I_{EBO}	—	1.0	—	1.0	—	1.0	mA	$V_{EB} = 8V$
Collector Cutoff Current	I_{CEO}	—	0.5	—	—	—	—	mA	$V_{CE} = 250V$
		—	—	—	0.5	—	—		$V_{CE} = 300V$
		—	—	—	—	—	0.5		$V_{CE} = 350V$
Collector Cutoff Current	I_{CEV}	—	0.5	—	—	—	—	mA	$V_{CE} = 500V$ $V_{BE} = -1.5V$
		—	—	—	0.5	—	—		$V_{CE} = 600V$
		—	—	—	—	—	0.5		$V_{CE} = 700V$
Collector Cutoff Current, 150°C	I_{CEV}	—	2.5	—	—	—	—	mA	$V_{CE} = 500V$ $V_{BE} = -1.5V$
		—	—	—	2.5	—	—		$V_{CE} = 600V$
		—	—	—	—	—	2.5		$V_{CE} = 700V$
Second Breakdown Energy	$E_{S/b}$	—	180	—	180	—	180	mJ	$I_C = 3.0A, L = 40\,mH$ $R_{BE} = 3K\Omega, V_{BB2} = 1.5V$
Collector Capacitance	C_{ob}	—	250	—	250	—	250	pF	$V_{CB} = 10V, I_E = 0, f = 1\,MHz$
Gain-Bandwidth Product	f_T	5	—	5	—	5	—	MHz	$I_C = .3A, V_{CE} = 10V, f = 1\,MHz$
Switching Speeds: Rise Time	t_r	—	0.6	—	0.6	—	0.6	μs	$V_{CC} = 125V, I_C = 3A$ $I_{B1} = 0.6A$
Storage Time	t_s	—	1.6	—	1.6	—	1.6	μs	$V_{CC} = 125V, I_C = 3A$ $I_{B1} = 0.6A, I_{B2} = 1.5A$ Pulse Width = 25 μs
Storage Time	t_s	—	0.8	—	0.8	—	0.8	μs	$V_{CC} = 125V, I_C = 3A$ $I_{B1} = 0.6A, I_{B2} = 1.5A$ Pulse Width = 5.0 μs
Fall Time	t_f	—	0.4	—	0.4	—	0.4	μs	$V_{CC} = 125V, I_C = 3A$ $I_{B1} = 0.6A, I_{B2} = 1.5A$
Thermal Resistance	$R\theta_{JC}$	—	1.0	—	1.0	—	1.0	°C/W	

Notes

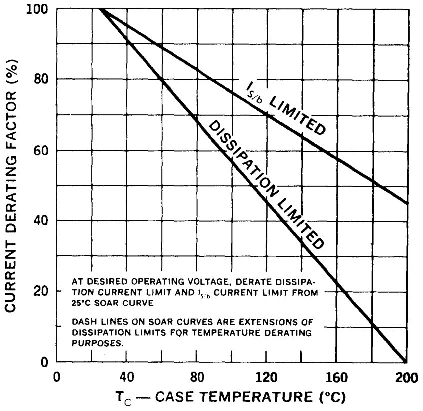
1. Pulse length = 250 μs; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50 μs; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.

* JEDEC registered values.

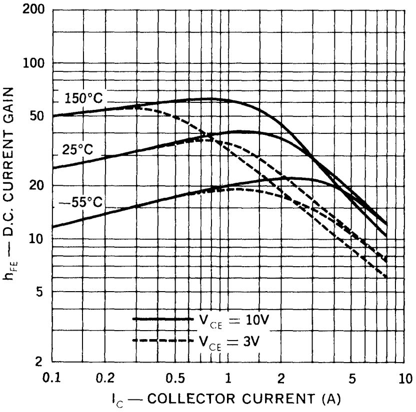
Forward Bias Safe Operating Area



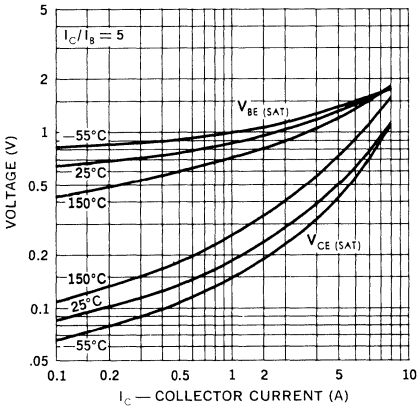
Power Derating



D.C. Current Gain



Saturation Voltages

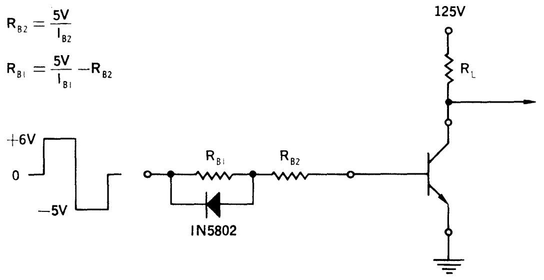


Switching Time Test Circuit

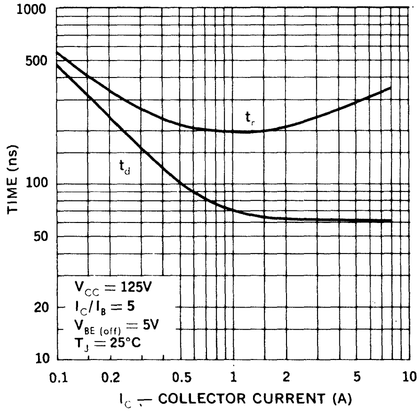
$R_L = \frac{125V}{I_C}$

$R_{B2} = \frac{5V}{I_{B2}}$

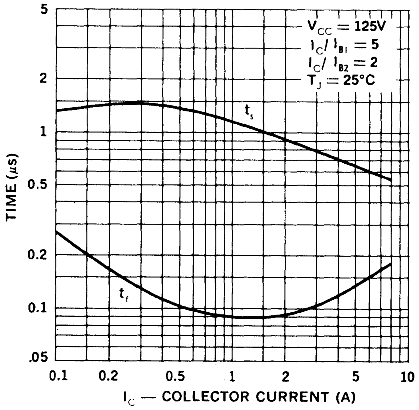
$R_{B1} = \frac{5V}{I_{B1}} - R_{B2}$



Turn-On Time



Turn-Off Time



POWER DARLINGTONS
5 Amp, 150V, NPN

JAN & JANTX 2N6350
JAN & JANTX 2N6351
JAN & JANTX 2N6352
JAN & JANTX 2N6353

FEATURES
- High Current Gain: up to 2000 min. @ $I_C = 5A$
- Low Saturation Voltage: as low as 1.5V max. @ $I_C = 2A$
- Peak Current: to 10A
- JAN/JANTX versions meet MIL-S-19500/472

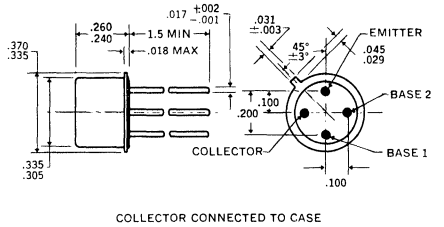
DESCRIPTION
Unitrode NPN Darlingtons consist of a two transistor circuit on a single monolithic planar chip. The 2N6350 series is characterized for fast switching applications.

ABSOLUTE MAXIMUM RATINGS

	TO-33		3 PIN TO-66	
	JAN & JANTX 2N6350	JAN & JANTX 2N6351	JAN & JANTX 2N6352	JAN & JANTX 2N6353
Collector — Emitter Voltage	80V	150V	80V	150V
Emitter — Base Voltages				
V_{EB2}	6V	6V	6V	6V
V_{EB1}	12V	12V	12V	12V
D.C. Collector Current	5A	5A	5A	5A
Peak Collector Current	10A	10A	10A	10A
Base 1 Current	0.5A	0.5A	0.5A	0.5A
Power Dissipation				
25°C Ambient	1W	1W	2W	2W
100°C Case	5W	5W	25W	25W
Thermal Resistance				
Junction-to-Case	20°C/W		4°C/W	
Operating and Storage Temperature Range	−65°C to 200°C		−65°C to 200°C	

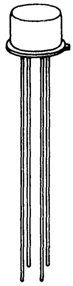
MECHANICAL SPECIFICATIONS

JAN & JANTX 2N6350 JAN & JANTX 2N6351

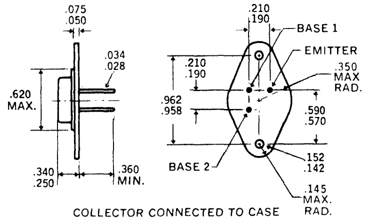


Dimensions in inches.

TO-33

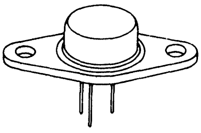


JAN & JANTX 2N6352 JAN & JANTX 2N6353



Dimensions in inches.

3 PIN TO-66

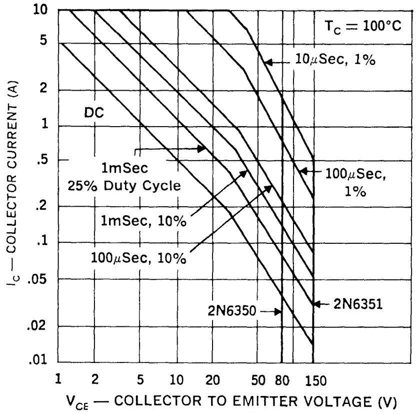


UNITRODE

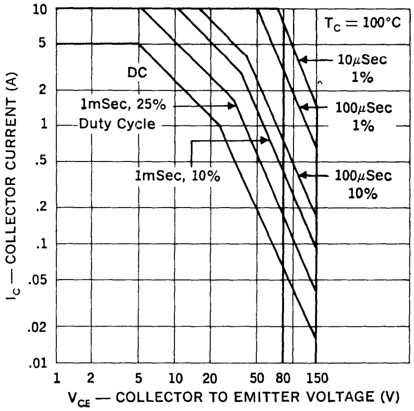
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

					MIL-STD-750	
Test	Symbol	Min.	Max.	Units	Method	Test Conditions
Visual and Mechanical					2071	See Mechanical Data
25°C						
Collector-Emitter Breakdown Voltage	BV_{CEO}				3011	$I_C = 25mA$, $R_{FE1} = 2.2K$, $R_{BE2} = 100$ Ohms
2N6350, 2N6352		80		Vdc		
2N6351, 2N6353		150		Vdc		
Emitter Base Breakdown Voltage, Base 1	BV_{EBO1}	12		Vdc	3026	$I_E = 12mA$ Base 1 Open
Emitter Base Breakdown Voltage, Base 2	BV_{EBO2}	6		Vdc	3026	$I_E = 12mA$ Base 2 Open
Collector — Emitter Cutoff Current	I_{CEX}		1.0	μAdc	3041	$V_{CE} = BV_{CEO}$ Rating
D.C. Current Gain	h_{FE}				3076	$V_{CE} = 5Vdc$; $I_C = 1.0A$ (pulse)
2N6350, 2N6352		2000				$R_{BE2} = 1K$
2N6351, 2N6353		1000				
D.C. Current Gain	h_{FE}				3076	$V_{CE} = 5Vdc$; $I_C = 5.0Adc$ (pulse)
2N6350, 2N6352		2000	10000			$R_{BE2} = 100$ Ohms
2N6351, 2N6353		1000	10000			
D.C. Current Gain	h_{FE}				3076	$V_{CE} = 5Vdc$; $I_C = 10Adc$ (pulse)
2N6350, 2N6352		400				$R_{BE2} = 100$ Ohms
2N6351, 2N6353		200				
Collector Saturation Voltage	V_{CE} (sat)				3071	$I_C = 5.0Adc$, $R_{BE2} = 100$ Ohms
2N6350, 2N6352			1.5	Vdc		$I_{B1} = 5mAdc$ (pulse)
2N6351, 2N6353			1.5	Vdc		$I_{B1} = 10mAdc$ (pulse)
Base Saturation Voltage	V_{BE1} (on)		2.5	Vdc	3066	$I_C = 5.0Adc$ (pulse), $V_{CE} = 5Vdc$ $R_{BE2} = 100$ Ohms
A.C. Current Gain	$\|h_{FE}\|$	5	25		3066	$V_{CE} = 10Vdc$, $I_C = 1.0Adc$, $f = 10MHz$ $R_{BE2} = 100$ Ohms
Output Capacitance	C_{OBO1}		40	pf	3236	$V_{CB1} = 10Vdc$, $100KHz \leqslant f \leqslant 1MHz$ Base 2 open
Turn-on Time	t_{on}		0.5	μs	3251	$V_{CC} = 30Vdc$; $I_C = 5.0Adc$ See Switching Speed Circuit
Turn-off Time	t_{off}		1.2	μs	3251	$V_{CC} = 30Vdc$; $I_C = 5.0Adc$ See Switching Speed Circuit
150°C						
Collector-Emitter Cutoff Current	I_{CEX}		1.0	μAdc	3041	$V_{EB1} = 2Vdc$, $R_{BE2} = 100$ Ohms $V_{CE} = BV_{CEO}$ Rating
−65°C						
D.C. Current Gain	h_{FE}				3076	$V_{CE} = 5Vdc$, $I_C = 5.0Adc$ (pulse)
2N6350, 2N6352		400				$R_{BE2} = 100$ Ohms
2N6351, 2N6353		200				

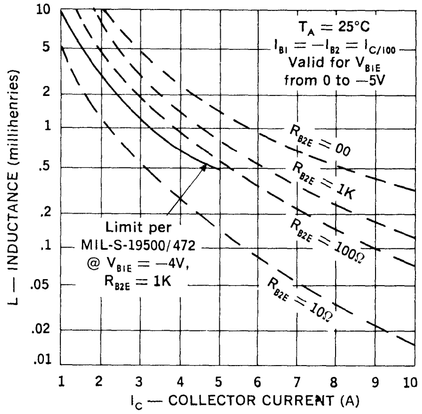
Forward Bias
Safe Operating Area
2N6350, 2N6351



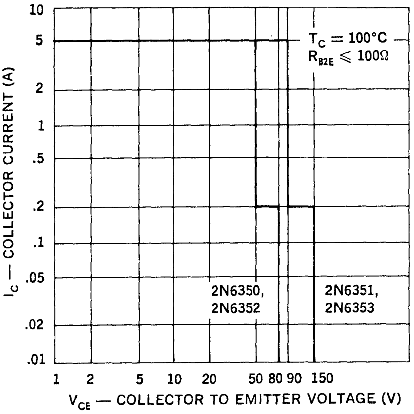
Forward Bias
Safe Operating Area
2N6352, 2N6353



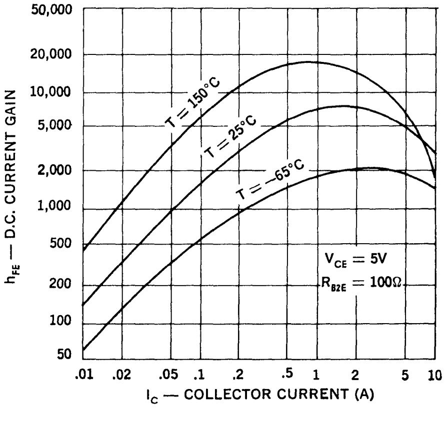
Unclamped Reverse Bias
Second Breakdown



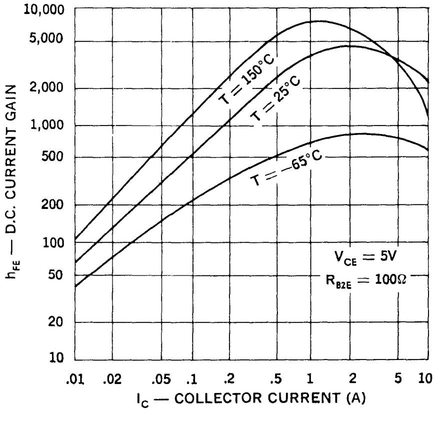
Reverse Bias
Safe Operating Area
Clamped Inductive Switching



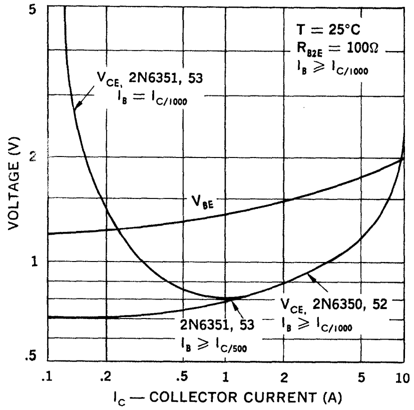
D.C. Current Gain
2N6350, 2N6352



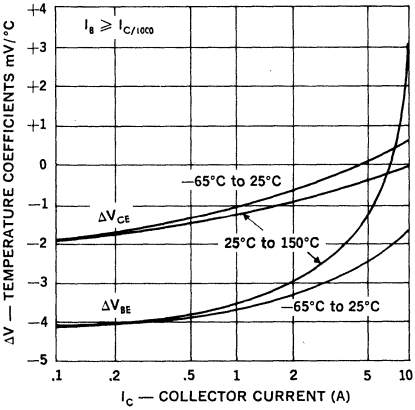
D.C. Current Gain
2N6351, 2N6353



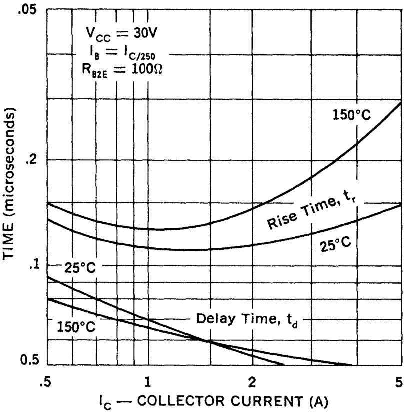
Saturation Voltages



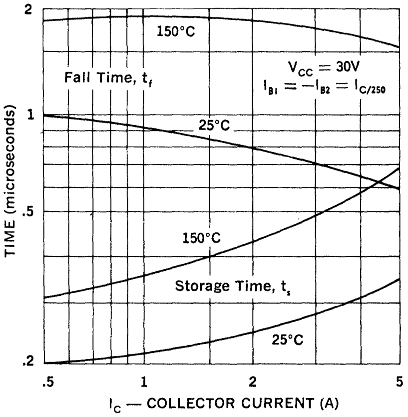
Saturation Voltage Temperature Coefficients



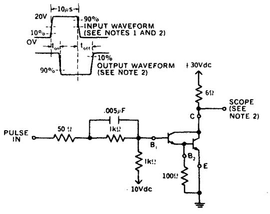
Switching Speed Characteristics



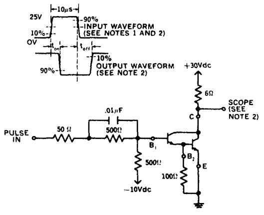
Switching Speed Characteristics



2N6350 & 52 Switching Speed Circuit



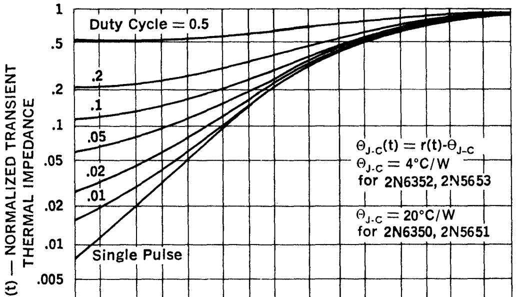
2N6351 & 3 Switching Speed Circuit



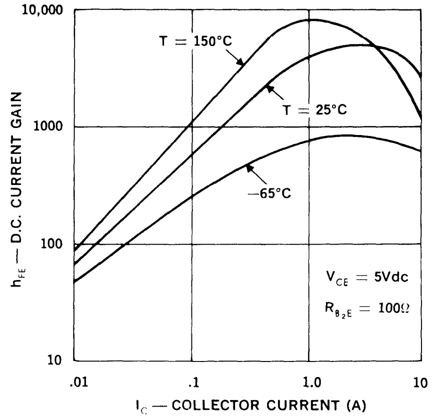
NOTES:

1. The input waveform is supplied by a pulse generator with the following characteristics: $t_r \leq 15$ ns, $t_f \leq 15$ ns, $Z_{out} = 50\Omega$, PW = 10 μs, Duty cycle ≤ 2%.
2. Output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $Z_{in} \geq 10$ MΩ, $C_{in} \leq 11.5$ pF.
3. Resistors shall be noninductive types.
4. The DC power supplies may require additional by-passing in order to minimize ringing.

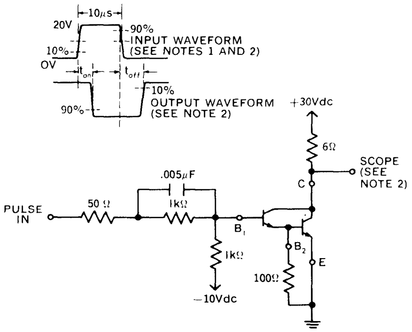
Thermal Response



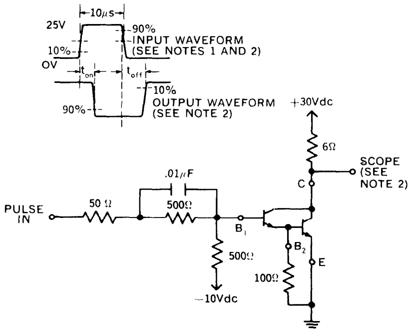
D.C. Current Gain vs. Collector Current
2N6350 — 2N6353



2N6350 & 52 Switching Speed Circuit



2N6351 & 3 Switching Speed Circuit



NOTES:

1. The input waveform is supplied by a pulse generator with the following characteristics: $t_r \leqslant 15$ ns, $t_f \leqslant 15$ ns, $Z_{out} = 50\Omega$, PW = 10 μs, Duty cycle ⩽ 2%.
2. Output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant 15$ ns, $Z_{in} \geqslant 10$ MΩ, $C_{in} \leqslant 11.5$ pF.
3. Resistors shall be noninductive types.
4. The DC power supplies may require additional by-passing in order to minimize ringing.

POWER TRANSISTORS

20 Amp, 150 V, Double Diffused NPN Mesa

2N6354
2N6496

FEATURES

- Collector-Base Voltage: up to 150V
- Peak Collector Current: 30A
- Rise Time: ≤ 500ns } @ I_C up to 12A
- Fall Time: ≤ 500ns }

DESCRIPTION

These double diffused glass passivated mesa power transistors combine fast-switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in switching regulators, converters, inverters and switching-control amplifiers.

ABSOLUTE MAXIMUM RATINGS*

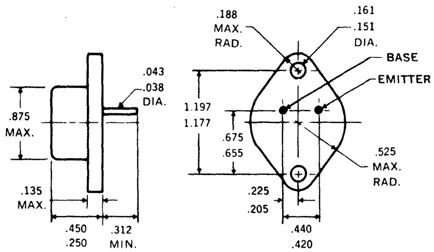
	2N6354	2N6496
Collector-Base Voltage, V_{CBO}	150V	150V
Collector-Emitter Sustaining Voltage, $V_{CER\ (SUS)}$ (1)	—	130V
$V_{CEO\ (SUS)}$	120V	110V
Emitter-Base Voltage, V_{EBO}	6.5V	7V
Collector Current, I_C continuous	10A	15A
Collector Current, I_{CM} peak	12A	—
Base Current, I_B continuous	5A	5A
Power Dissipation, 25°C Case	140W	140W
Operating and Storage Temperature Range	—65 to 200°C	

(1) With $R_{BE} \leqslant 50\Omega$

* JEDEC registered values.

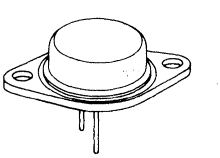
MECHANICAL SPECIFICATIONS

2N6354, 2N6496



Dimensions in inches.

TO-3



UNITRODE

Electrical Specifications (at 25°C unless noted)

Test	Symbol	2N6354		2N6496		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
* D.C. Current Gain (Note 1)	h_{FE}	—	—	—	—		$I_C = 2A, V_{CE} = 5V$
		20	150	—	—		$I_C = 5A, V_{CE} = 2V$
* D.C. Current Gain (Note 1)	h_{FE}	—	—	12	100		$I_C = 8A, V_{CE} = 2V$
		10	100	—	—		$I_C = 10A, V_{CE} = 2V$
* D.C. Current Gain (Note 1)	h_{FE}	—	—	—	—		$I_C = 10A, V_{CE} = 5V$
		—	—	—	—		$I_C = 12A, V_{CE} = 5V$
* Collector Saturation Voltage (Note 1)	$V_{CE\ (sat)}$	—	0.5	—	—	V	$I_C = 5A, I_B = .5A$
		—	—	—	1.0		$I_C = 8A, I_B = .8A$
Collector Saturation Voltage (Note 1)	$V_{CE\ (sat)}$	—	1.0	—	—	V	$I_C = 10A, I_B = 1.0A$
Collector Saturation Voltage (Note 1)	$V_{CE\ (sat)}$	—	—	—	—	V	$I_C = 12A, I_B = 1.2A$
		—	—	—	—		$I_C = 20A, I_B = 5A$
Base Saturation Voltage (Note 1)	$V_{BE\ (sat)}$	—	1.3*	—	—	V	$I_C = 5A, I_B = 0.5A$
		—	—	—	2.0		$I_C = 8A, I_B = 0.8A$
* Base Saturation Voltage (Note 1)	$V_{BE\ (sat)}$	—	2.0	—	—	V	$I_C = 10A, I_B = 1A$
		—	—	—	—	V	$I_C = 20A, I_B = 5A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\ (sus)}$	120	—	100	—	V	$I_C = 0.2A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEX\ (sus)}$	—	—	—	—	V	$I_C = 0.2A$ $V_{BE} = —1.5V$ $I_B = 0$ $R_{BE} = 100\ \Omega$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CER\ (sus)}$	—	—	130	—	V	$R_{BE} = 50\ \Omega, I_C = 0.2A$
		130	—	—	—		$R_{BE} = 100\ \Omega, I_C = 0.2A$
* Emitter-Base Voltage	V_{EBO}	6.5	—	—	—	V	$I_E = 5mA$
		—	—	7.0	—		$I_E = 50mA$
* Collector Cutoff Current	I_{CBO}	—	5	—	—	mA	$V_{CB} = 150V$
Collector Cutoff Current	I_{CEO}	—	—	—	—	mA	$V_{CE} = 55V$
		—	—	—	—		$V_{CE} = 70V$
		—	20	—	—		$V_{CE} = 100V$
* Collector Cutoff Current	I_{CEV}	—	—	—	—	mA	$V_{CE} = 110V, V_{BE} = —1.5V$
		—	—	—	20		$V_{CE} = 130V, V_{BE} = 0$
		—	—	—	—		$V_{CE} = 140V, V_{BE} = —1.5V$
		—	10	—	—		$V_{CE} = 140V, V_{BE} = 0$
* Collector Cutoff Current, 125°C	I_{CEV}	—	20	—	—	mA	$V_{CE} = 140V$
* Collector Cutoff Current, 150°C	I_{CEV}	—	—	—	—	mA	$V_{CE} = 85V, V_{BE} = —1.5V$
		—	—	—	—		$V_{CE} = 100V, V_{BE} = —1.5V$
		—	—	—	25		$V_{CE} = 130V, V_{BE} = 0V$
* Emitter Cutoff Current	I_{EBO}	—	—	—	—	mA	$V_{BE} = —5V$
		—	5.0	—	—		$V_{BE} = —6.5V$
		—	—	—	50		$V_{BE} = —7V$
Magnitude of Small Signal Forward — Current Transfer Ratio	$\lvert h_{fe} \rvert$	—	—	12	—		$V_{CE} = 10V, I_C = 2A, f = 5\ MHz$
		8.0	—	—	—		$V_{CE} = 10V, I_C = 1A, f = 10\ MHz$
Collector Capacitance	C_{ob}	—	300	—	300	pF	$V_{CB} = 10V, f = 1\ MHz$
Thermal Resistance: Junction-to-Case	$R_{\theta JC}$	—	—	—	1.25	°C/W	$V_{CE} = 10V, I_C = 10A$
		—	1.25	—	—		$V_{CE} = 20V, I_C = 1A$

Notes

1. Pulse length = 250 μs; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50 μs; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.

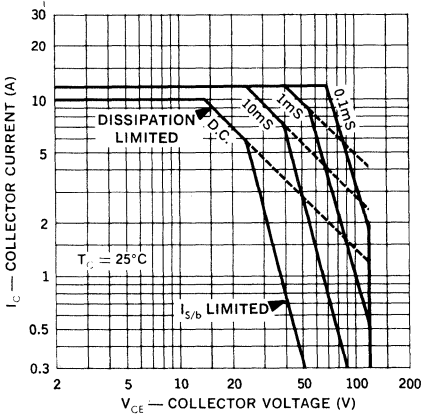
* JEDEC registered values.

Electrical Specifications (at 25°C unless noted)

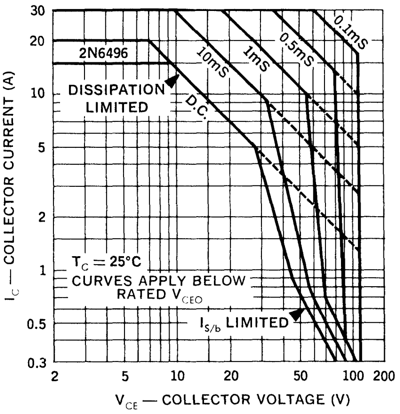
Test	Symbol	2N6354		2N6496		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
Second Breakdown Energy	$E_{S/b}$	0.3	—	—	—	mJ	$I_C = 5A$, $V_{BE} = -1.0V$ $R_{BE} = 51\ \Omega$, $L = 25\mu H$
		—	—	5.7	—		$I_C = 8A$, $V_{BE} = -4.0V$ $R_{BE} = 20\ \Omega$, $L = 180\mu H$
		—	—	—	—		$I_C = 13A$, $V_{BE} = -4.0V$ $R_{BE} = 20\ \Omega$, $L = 180\mu H$
Forward Bias Second Breakdown Collector Current	$I_{S/b}$	5.5	—	—	—	A	$V_{CE} = 25V$, $t = 1s$, non-rep.
		—	—	5.0	—		$V_{CE} = 28V$, $t = 1s$, non-rep.
		—	—	0.9	—		$V_{CE} = 45V$, $t = 1s$, non-rep.
* Switching Speeds							
Rise Time	t_r	—	0.3	—	—	μs	$I_C = 5A$
Storage Time	t_s	—	1.0	—	—		$I_{B1} = I_{B2} = .5A$
Fall Time	t_f	—	0.2	—	—		$V_{CC} = 30V$
Rise Time	t_r	—	—	—	0.5	μs	$I_C = 8A$
Storage Time	t_s	—	—	—	1.5		$I_{B1} = I_{B2} = .8A$
Fall Time	t_f	—	—	—	0.3		$V_{CC} = 30V$
Rise Time	t_r	—	—	—	—	μs	$I_C = 10A$
Storage Time	t_s	—	—	—	—		$I_{B1} = I_{B2} = 1.0A$
Fall Time	t_f	—	—	—	—		$V_{CC} = 30V$
Rise Time	t_r	—	—	—	—	μs	$I_C = 12A$
Storage Time	t_s	—	—	—	—		$I_{B1} = I_{B2} = 1.2A$
Fall Time	t_f	—	—	—	—		$V_{CC} = 30V$

* JEDEC registered values.

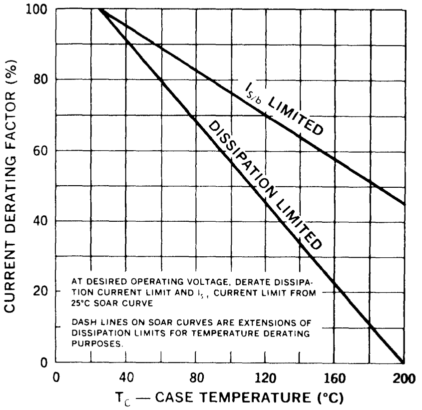
Forward Bias Safe Operating Area for 2N6354



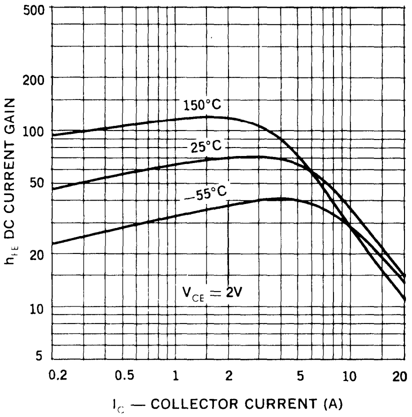
Forward Bias Safe Operating Area for 2N6496



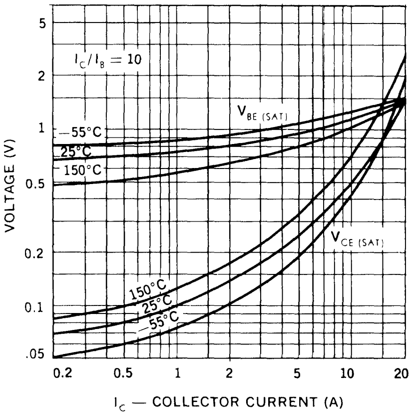
Power Derating



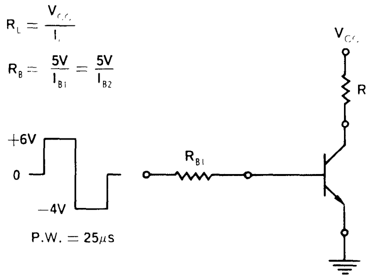
DC Current Gain



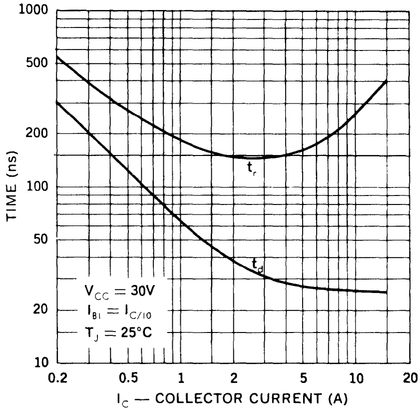
Saturation Voltages



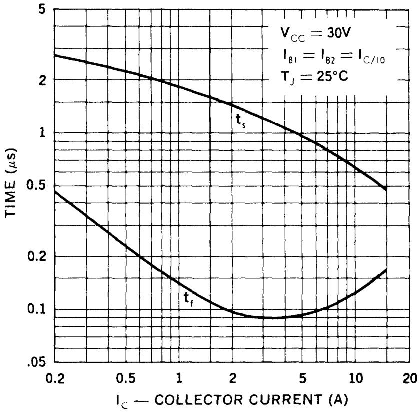
Switching Time Test Circuit



Turn-On Time



Turn-Off Time



POWER TRANSISTORS

7 Amp, 400V, Triple Diffused NPN Mesa

2N6510
2N6511
2N6512
2N6513
2N6514

FEATURES

- Collector-Base Voltage: up to 400V
- Peak Collector Current: 10A
- Rise Time: $\leq 1.5\mu s$ } @ $I_C = 4A$
- Fall Time: $\leq 1.5\mu s$ }

DESCRIPTION

These high voltage triple diffused glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

ABSOLUTE MAXIMUM RATINGS

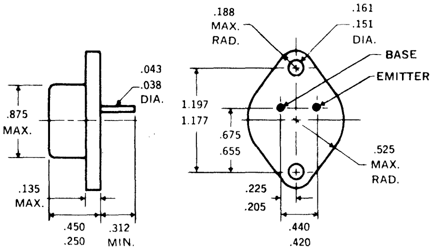
	2N6510	2N6511	2N6512	2N6513	2N6514
*Collector Base Voltage, V_{CPO}	250V	300V	350V	400V	350V
Collector-Emitter Sustaining Voltage, $V_{CER\ (sus)\ (1)}$	250V	300V	350V	400V	350V
*Collector-Emitter Sustaining Voltage, $V_{CEO\ (sus)}$	200V	250V	300V	350V	300V
*Emitter-Base Voltage, V_{EBO}	6V	6V	6V	6V	6V
*Collector Current, I_C continuous	7A	7A	7A	7A	7A
*Base Current, I_B	10A	10A	10A	10A	10A
*Emitter Current, I_E	3A	3A	3A	3A	3A
*Power Dissipation, P_T 25°C Case	120W	120W	120W	120W	120W
*Operating and Storage Temperature Range	−65 to +200°C				

(1) $R_{BE} = 50\Omega$

*JEDEC registered values

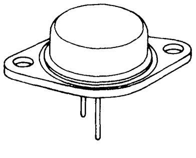
MECHANICAL SPECIFICATIONS

2N6510 2N6511 2N6512 2N6513 2N6514



Dimensions in inches.

TO-3



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	2N6510		2N6514		Units	Test Conditions
		Min.	Max.	Min.	Max.		
*D.C. Current Gain (Note 1)	h_{FE}	10	50	—	—		$I_C = 3A, V_{CE} = 3V$
		—	—	10	50		$I_C = 5A, V_{CE} = 3V$
*Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.5	—	—	V	$I_C = 3A, I_B = 0.6A$
		—	—	—	1.5		$I_C = 5A, I_B = 1A$
		—	2.5	—	2.5		$I_C = 7A, I_B = 3A$
*Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.7	—	—	V	$I_C = 3A, I_B = 0.6A$
		—	—	—	1.7		$I_C = 5A, I_B = 1A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	200*	—	300*	—	V	$I_C = 0.2A$
	$V_{CER\,(sus)}$	250	—	350	—	V	$I_C = 0.2A, R_{BE} = 50\Omega$
*Collector Cutoff Current	I_{CEV}	—	5.0	—	—	mA	$V_{CE} = 250V, V_{BE} = -1.5V$
		—	—	—	5.0		$V_{CE} = 350V, V_{BE} = -1.5V$
*Collector Cutoff Current 100°C	I_{CEV}	—	10	—	—	mA	$V_{CE} = 250V, V_{BE} = -1.5V$
		—	—	—	10		$V_{CE} = 350V, V_{BE} = -1.5V$
*Switching Speeds							
Delay Time	t_d	—	0.2	—	—	μs	$V_{CC} = 200V$ $I_C = 3A$ $I_{B1} = I_{B2} = 0.6A$
Rise Time	t_r	—	1.5	—	—		
Storage Time	t_s	—	5.0	—	—		
Fall Time	t_f	—	1.5	—	—		
Delay Time	t_d	—	—	—	0.2	μs	$V_{CC} = 200V$ $I_C = 5A$ $I_{B1} = I_{B2} = 1A$
Rise Time	t_r	—	—	—	1.5		
Storage Time	t_s	—	—	—	5.0		
Fall Time	t_f	—	—	—	1.5		

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	2N6511		2N6512		2N6513		Units	Test Conditions
		Min.	Max.	Min.	Max.	Min.	Max.		
*D.C. Current Gain (Note 1)	h_{FE}	10	50	10	50	10	50		$I_C = 4A, V_{CE} = 3V$
*Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.5	—	1.5	—	1.5	V	$I_C = 4A, I_B = 0.8A$
		—	2.5	—	2.5	—	2.5		$I_C = 7A, I_B = 3A$
*Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.7	—	1.7	—	1.7	V	$I_C = 4A, I_B = 0.8A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	250	—	300	—	350	—	V	$I_C = 0.2A$
	$V_{CER\,(sus)}$	300	—	350	—	400	—	V	$I_C = 0.2A, R_{BE} = 50\Omega$
*Collector Cutoff Current	I_{CEV}	—	5.0	—	—	—	—	mA	$V_{CE} = 300V, V_{BE} = -1.5V$
		—	—	—	5.0	—	—		$V_{CE} = 350V, V_{BE} = -1.5V$
		—	—	—	—	—	5.0		$V_{CE} = 400V, V_{BE} = -1.5V$
*Collector Cutoff Current, 100°C	I_{CEV}	—	10	—	—	—	—	mA	$V_{CE} = 300V, V_{BE} = -1.5V$
		—	—	—	10	—	—		$V_{CE} = 300V, V_{BE} = -1.5V$
		—	—	—	—	—	10		$V_{CE} = 400V, V_{BE} = -1.5V$
*Switching Speeds									
Delay Time	t_d	—	0.2	—	0.2	—	0.2	μs	$V_{CC} = 200V$ $I_C = 4A$ $I_{B1} = I_{B2} = 0.8A$
Rise Time	t_r	—	1.5	—	1.5	—	1.5		
Storage Time	t_s	—	5.0	—	5.0	—	5.0		
Fall Time	t_f	—	1.5	—	1.5	—	1.5		

Notes

1. Pulse length = 250 μs; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≊ 50 μs; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.

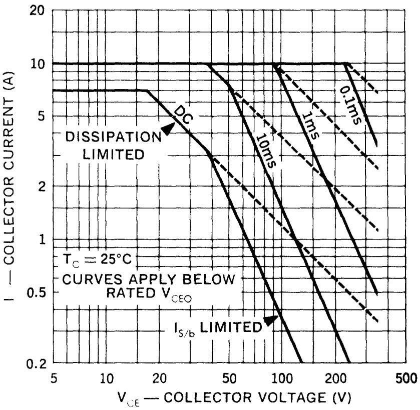
* JEDEC registered values.

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)*

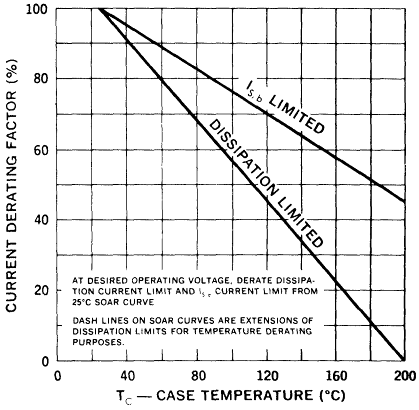
Test	Symbol	All Types		Units	Test Conditions
		Min.	Max.		
Emitter-Base Cutoff Current	I_{EBO}	—	3.0	mA	$V_{EB} = 6V$
Magnitude of Common Emitter Small-Signal Short Circuit Forward Current Transfer Ratio	$\|h_{fe}\|$	3	9		$I_C = 1A$ $V_{CE} = 10V$ $f = 1MHz$
Forward-Bias Second Breakdown Collector Current	$I_{S/b}$	3.16	—	A	$V_{CE} = 35V$, $t = 1s$, non-rep.
		0.1	—	A	$V_{CE} = 200V$, $t = 1s$, non-rep.
Collector Capacitance	C_{ob}	100	200	pF	$V_{CB} = 10V$, $f = 1MHz$
Thermal Resistance, Junction-to-Case	$R\theta_{JC}$	—	1.46	°C/W	$V_{CE} = 20V$, $I_C = 5A$

* All values in this table are JEDEC registered.

Forward Bias Safe Operating Area

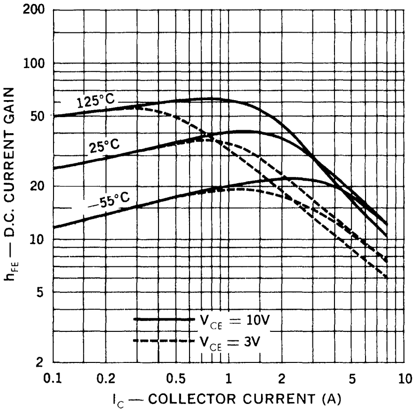


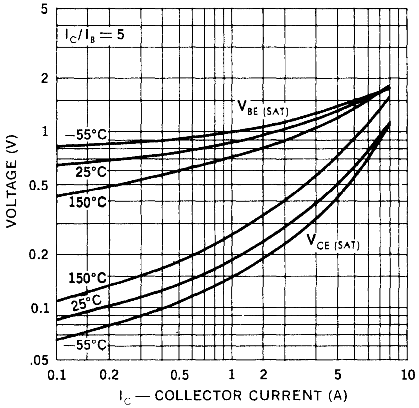
Power Derating

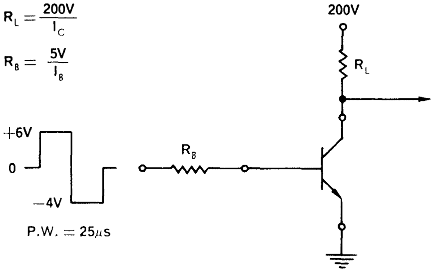


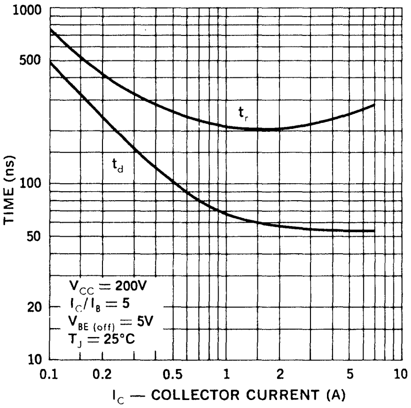
AT DESIRED OPERATING VOLTAGE, DERATE DISSIPATION CURRENT LIMIT AND $I_{S/b}$ CURRENT LIMIT FROM 25°C SOAR CURVE

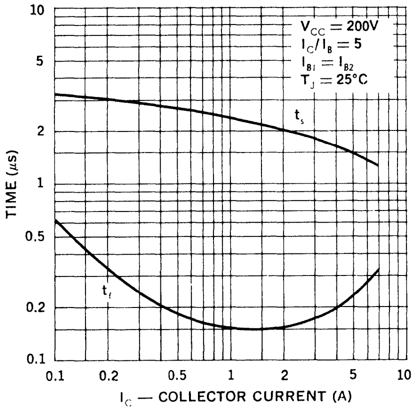
DASH LINES ON SOAR CURVES ARE EXTENSIONS OF DISSIPATION LIMITS FOR TEMPERATURE DERATING PURPOSES.


D.C. Current Gain


Saturation Voltages


Switching Time Test Circuit


Turn-On Time


Turn-Off Time

POWER TRANSISTORS

5A, 850V, Fast Switching, Silicon NPN Mesa

2N6542
2N6543

FEATURES

- Collector-Base Voltage: up to 850V
- Peak Collector Current: 10A
- Rise Time: $\leqslant 0.7\mu S$ }
- Fall Time: $\leqslant 0.8\mu S$ } @ $I_C = 3A$
- Key Parameters characterized at 100°C

DESCRIPTION

These high voltage glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{s/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

ABSOLUTE MAXIMUM RATINGS *

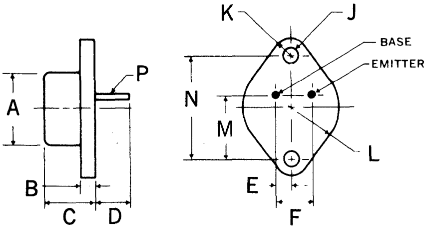
	2N6542	2N6543
Collector-Base Voltage, V_{CBO}	650V	850V
Collector-Emitter Voltage, $V_{CEO\ (SUS)}$	300V	400V
Emitter-Base Voltage, V_{EBO}	9V	9V
Collector Current, I_C, continuous	5A	5A
Collector Current, I_C peak	10A	10A
Base Current, I_B, continuous	5A	5A
Power Dissipation, 25°C Case	100W	100W
Derating Factor	.571W/°C	.571W/°C
Operating and Storage Temperature Range	—65 to 200°C	

* JEDEC registered values.

MECHANICAL SPECIFICATIONS

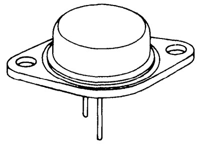
NOTE:
Leads may be soldered to within $^1/_{16}$" of base provided temperature-time exposure is less than 260°C for 10 seconds.

2N6542 2N6543



	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.205-.225	5.21-5.72
F	.420-.440	10.67-11.18
J	.151-.161 DIA.	3.84-4.09 DIA.
K	.188 MAX. RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.655-.675	16.64-17.15
N	1.177-1.197	29.90-30.40
P	.038-.043 DIA.	9.65-10.92 DIA.

TO-3



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)*

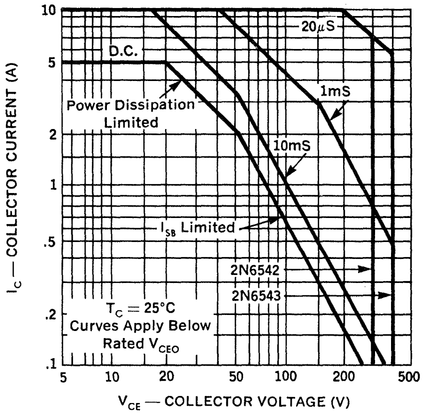
Test	Symbol	2N6542		2N6543		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	12	60	12	60		$I_C = 1.5A, V_{CE} = 2V$
D.C. Current Gain (Note 1)	h_{FE}	7	35	7	35		$I_C = 3.0A, V_{CE} = 2V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.0	—	1.0	V	$I_C = 3.0A, I_B = 0.6A$
Collector Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{CE\,(sat)}$	—	2.0	—	2.0	V	$I_C = 3.0A, I_B = 0.6A$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	5.0	—	5.0	V	$I_C = 5.0A, I_B = 1.0A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.4	—	1.4	V	$I_C = 3.0A, I_B = 0.6A$
Base Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{BE\,(sat)}$	—	1.4	—	1.4	V	$I_C = 3.0A, I_B = 0.6A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	300	—	400	—	V	$I_C = 0.1A, I_B = 0$
Collector-Emitter Sustaining Voltage $T_C = 100°C$ (Note 2)	$V_{CEX\,(sus)}$	350	—	450	—	V	$L = 180\mu H, I_C = 2.6A$ $V_{BE} = -5V$ V_{CE} clamped to rated $V_{CEX\,(sus)}$
Collector-Emitter Sustaining Voltage $T_C = 100°C$ (Note 2)	$V_{CEX\,(sus)}$	200	—	300	—	V	$L = 180\mu H, I_C = 5A$ $V_{BE\,(off)} = -5V$ V_{CE} clamp to V_{CEO} —100V
Emitter-Base Cutoff Current	I_{E3O}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	—	0.5	—	—	mA	$V_{CE} = 650V, V_{BE} = -1.5V$
		—	—	—	0.5		$V_{CE} = 850V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	—	2.5	—	—	mA	$V_{CE} = 650V, V_{BE} = -1.5V$
		—	—	—	2.5		$V_{CE} = 850V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CER}	—	3.0	—	—	mA	$V_{CE} = 650V, R = 50\Omega$
		—	—	—	3.0		$V_{CE} = 850V, R = 50\Omega$
Output Capacitance, Common Base	C_{obo}	50	150	50	150	pF	$V_{CB} = 10V, f = 1$ MHz
Gain-Bandwidth Product	F_T	6	24	6	24	MHz	$V_{CE} = 10V, I_C = 0.2A, f = 1$ MHz
Forward Bias Second Breakdown	$I_{S/b}$	200	—	200	—	mA	P.W. = 1 sec. single shot $V_{CE} = 100V$
Energy Second Breakdown (unclamped)	$E_{S/b}$	180	—	180	—	μJ	$I_C = 3.0A$ $L = 40\mu H, V_{BE\,(off)} = 4.0$ Vdc
Resistive Switching Speeds							
Delay Time	t_d	—	0.05	—	0.05	μS	$I_C = 3.0A, t_p = 100\mu sec$
Rise Time	t_r	—	0.7	—	0.7		$V_{CC} = 250V$
Storage Time	t_s	—	4.0	—	4.0		$I_{B1} = I_{B2} = 0.6A$
Fall Time	t_f	—	0.8	—	0.8		$V_{BE\,(off)} = 5V$
Inductive Switching Speeds							$I_C = 3.0A$
$T_C = 100°C$							$I_B = 0.6A, V_{BE\,(off)} = 5.0$ Vdc
Storage Time	t_f	—	4.0	—	4.0	μS	$V_{BE\,(off)} = 5V$
Fall Time	t_s	—	0.8	—	0.8		V_{CE} clamp = rated $V_{CEX\,(sus)}$
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	—	1.75	—	1.75	°C/W	

Notes

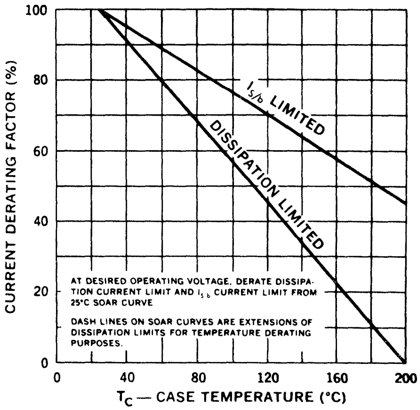
1. Pulse length $= 250\mu S$; duty cycle $\leqslant 1\%$.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\cong 50\mu S$; duty cycle $\leqslant 1\%$. Voltage clamped at maximum collector-emitter voltage.

* JEDEC registered values.

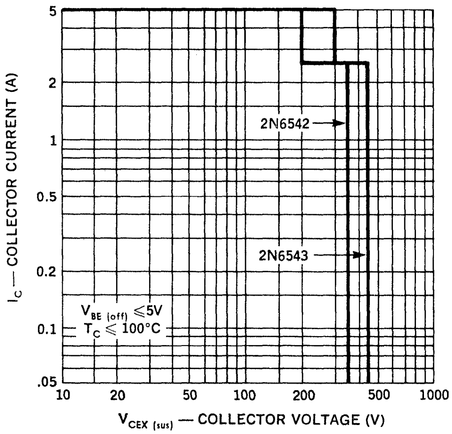
Forward Bias Safe Operating Area



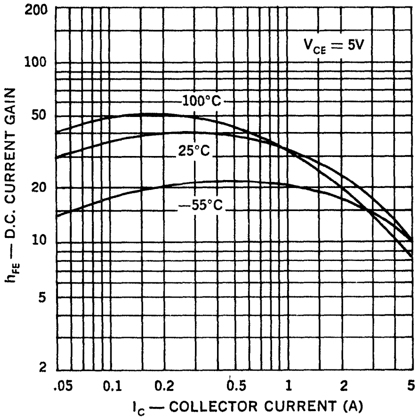
Power Derating



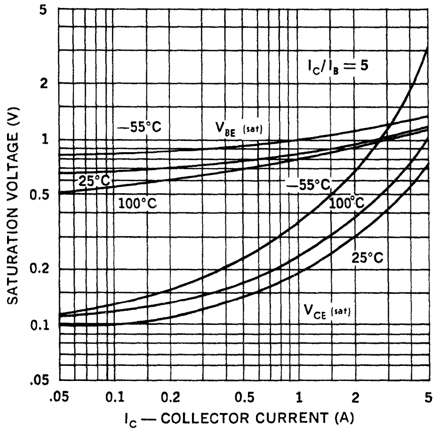
Reverse Biased Safe Operating Area



D.C. Current Gain



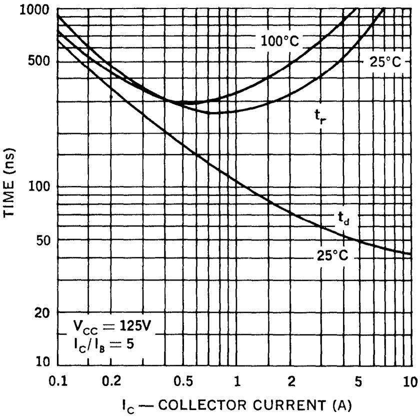
Saturation Voltages



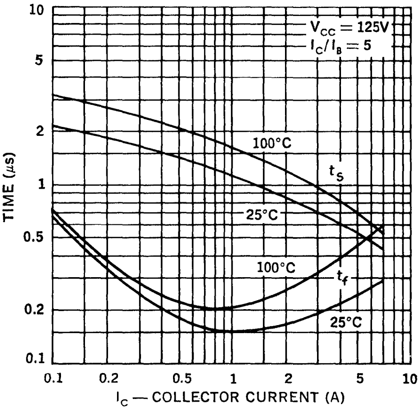
Typical Inductive Load Switching Performance

I_C Amps	T_J °C	t_s µS	t_{fv} nS	t_{fi} nS
3.0	25	.45	70	10
	100	.575	100	20
5.0	25	.475	25	4
	100	.60	45	10
8.0	25	.525	20	10
	100	.625	45	15

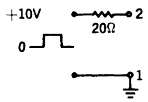
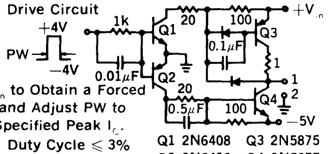
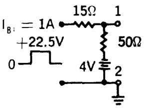
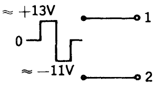
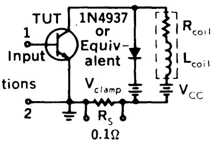
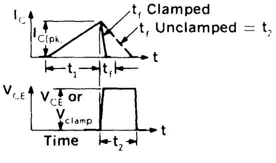
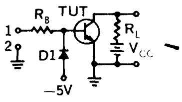
Resistive Turn-On Time



Resistive Turn-Off Time



TEST CONDITIONS FOR DYNAMIC PERFORMANCE

	$V_{CEO(SUS)}$	$V_{CEX\ (SUS)}$ AND INDUCTIVE SWITCHING	$E_{S/b}$	RESISTIVE SWITCHING
INPUT CONDITIONS	 PW Varied to Attain $I_C = 100mA$	 Set $+V_{in}$ to Obtain a Forced $h_{FE} = 5$ and Adjust PW to Attain Specified Peak I_C. Duty Cycle ⩽ 3% f = 1kHz Q1 2N6408 Q3 2N5875 Q2 2N6406 Q4 2N5877 Diodes 1N4933	 PW Varied to Attain I_C	 $I_C = 3A$ PW ⩽ 100µs t_r ⩽ 5ns t_f ⩽ 50ns Duty Cycle ⩽ 2%
CIRCUIT VALUES	$L_{coil} = 80mH$ $V_{CC} = 10V$ $R_{coil} = 0.7\Omega$ V_{clamp} (Unclamped)	$L_{coil} = 180\mu H$ $R_{coil} = 0.05\Omega$ $V_{CC} = 20V$ $f_o = 500kHz$ V_{clamp} = Rated V_{CEX} Value	$L_{coil} = 40\mu H$ $V_{CC} = 10V$ $R_{coil} = 0.2\Omega$ V_{clamp} (Unclamped)	$V_{CC} = 250V$ $R_L = 83\Omega$ D1 = 1N5820 or Equiv. $R_B = 20\Omega$
TEST CIRCUITS	INDUCTIVE TEST CIRCUIT See Above For Detailed Conditions 	OUTPUT WAVEFORMS 	t_1 Adjusted to Obtain I_C $t_1 \approx \frac{L_{coil}\ (I_{Cpk})}{V_{CC}}$ $t_2 \approx \frac{L_{coil}\ (I_{Cpk})}{V_{clamp}}$ Test Equipment Tektronix Scope 475 or Equivalent	RESISTIVE TEST CIRCUIT 

POWER TRANSISTORS

8 Amp, 850V, Triple Diffused, NPN, Mesa

2N6544
2N6545

FEATURES

- Collector-Base Voltage: up to 850V
- Peak Collector Current: 16A
- Rise Time: $\leqslant 1.0\mu s$ } @ $I_C = 5A$
- Fall Time: $\leqslant 1.0\mu s$ }
- Key Parameters characterized at 100°C

DESCRIPTION

These high voltage triple diffused glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{s/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

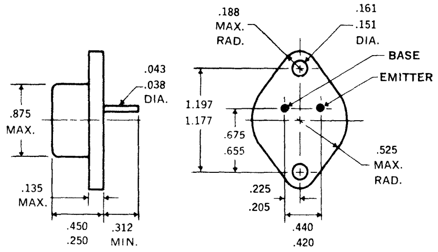
ABSOLUTE MAXIMUM RATINGS *

	2N6544	2N6545
Collector-Base Voltage, V_{CBO}	650V	850V
Collector-Emitter Voltage, $V_{CEO\,(SUS)}$	300V	400V
Emitter-Base Voltage, V_{EBO}	9V	9V
Collector Current, I_C, continuous	8A	8A
Base Current, I_B, continuous	8A	8A
Emitter Current, I_E, continuous	16A	16A
Power Dissipation, 25°C Case	125W	125W
Derating Factor	.714W/°C	.714W/°C
Operating and Storage Temperature Range	—65 to 200°C	

* JEDEC registered values.

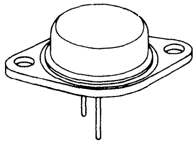
MECHANICAL SPECIFICATIONS

2N6544 2N6545



Dimensions in inches.

TO-3



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)*

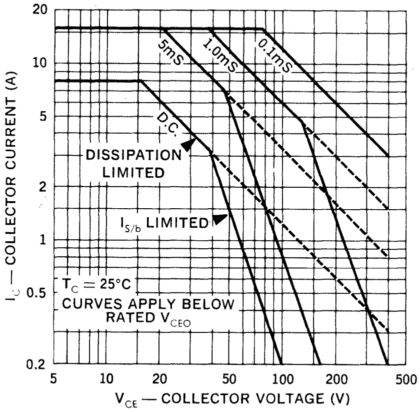
Test	Symbol	2N6544		2N6545		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	12	60	12	60		$I_C = 2.5A, V_{CE} = 3V$
D.C. Current Gain (Note 1)	h_{FE}	7	35	7	35		$I_C = 5.0A, V_{CE} = 3V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.5	—	1.5	V	$I_C = 5.0A, I_B = 1.0A$
Collector Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{CE\,(sat)}$	—	2.5	—	2.5	V	$I_C = 5.0A, I_B = 1.0A$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	5.0	—	5.0	V	$I_C = 8.0A, I_B = 2.0A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.6	—	1.6	V	$I_C = 5.0A, I_B = 1.0A$
Base Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{BE\,(sat)}$	—	1.6	—	1.6	V	$I_C = 5.0A, I_B = 1.0A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	300	—	400	—	V	$I_C = 0.1A$
Collector-Emitter Sustaining Voltage $T_C = 100°C$ (Note 2)	$V_{CEX\,(sus)}$	350	—	450	—	V	$L = 180\mu H, I_C = 4.5A$ $V_{BE} = -5V$ V_{CE} clamped to rated $V_{CEX\,(sus)}$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	— —	0.5 —	— —	— 0.5	mA	$V_{CE} = 650V, V_{BE} = -1.5V$ $V_{CE} = 850V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	— —	2.5 —	— —	— 2.5	mA	$V_{CE} = 650V, V_{BE} = -1.5V$ $V_{CE} = 850V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CER}	— —	3.0 —	— —	— 3.0	mA	$V_{CE} = 650V, R = 50\Omega$ $V_{CE} = 850V, R = 50\Omega$
Output Capacitance, Common Base	C_{obo}	100	200	100	200	pF	$V_{CB} = 10V, f = 1\ MHz$
Gain-Bandwidth Product	F_T	6	24	6	24	MHz	$V_{CE} = 10V, I_C = 0.3A, f = 1\ MHz$
Energy Second Breakdown (unclamped)	$E_{S/b}$	500	—	500	—	μJ	$I_C = 5.0A$ $I_B = 1.0A$ $L = 40\mu H$
Resistive Switching Speeds Delay Time Rise Time Storage Time Fall Time	 t_d t_r t_s t_f	 — — — —	 0.05 1.0 4.0 1.0	 — — — —	 0.05 1.0 4.0 1.0	μs	$I_C = 5.0A$ $V_{CC} = 125V$ $I_{B1} = I_{B2} = 1.0A$ $V_{BE\,(off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$ Storage Time Fall Time	 t_s t_f	 — —	 4.0 0.9	 — —	 4.0 0.9	μs	$I_C = 5.0A$ $I_B = 1.0A$ $V_{BE\,(off)} = 5V$ V_{CE} clamp = rated $V_{CEX\,(sus)}$
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	—	1.4	—	1.4	°C/W	

Notes

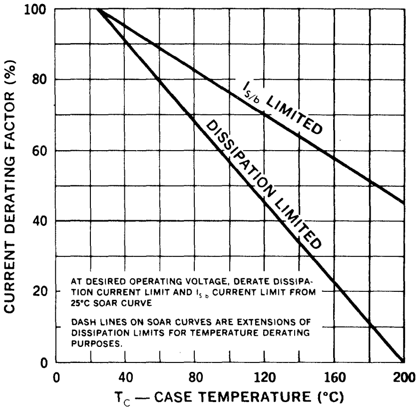
1. Pulse length = 250 μs; duty cycle $\leqslant 1\%$.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\cong$ 50 μs; duty cycle $\leqslant 1\%$. Voltage clamped at maximum collector-emitter voltage.

* JEDEC registered values.

Forward Bias Safe Operating Area



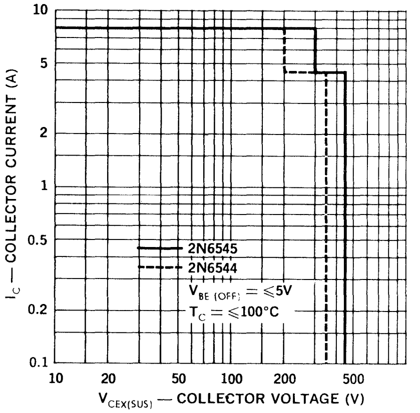
Power Derating



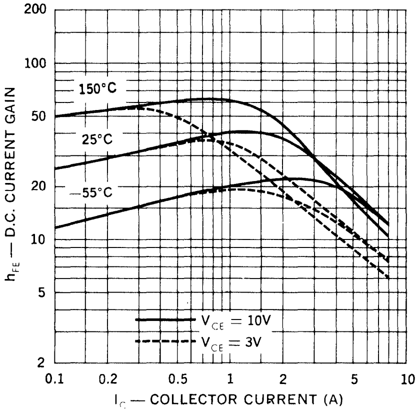
AT DESIRED OPERATING VOLTAGE, DERATE DISSIPATION CURRENT LIMIT AND $I_{S/b}$ CURRENT LIMIT FROM 25°C SOAR CURVE

DASH LINES ON SOAR CURVES ARE EXTENSIONS OF DISSIPATION LIMITS FOR TEMPERATURE DERATING PURPOSES.

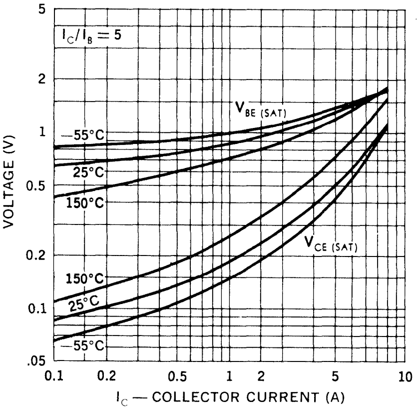
Reverse Biased Safe Operating Area



D.C. Current Gain



Saturation Voltages

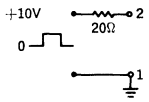
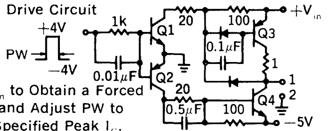
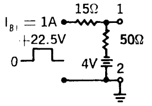
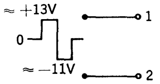
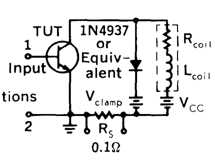
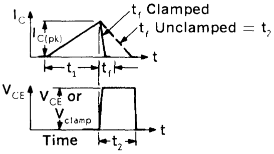
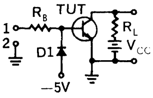


Inductive Load Switching Performance

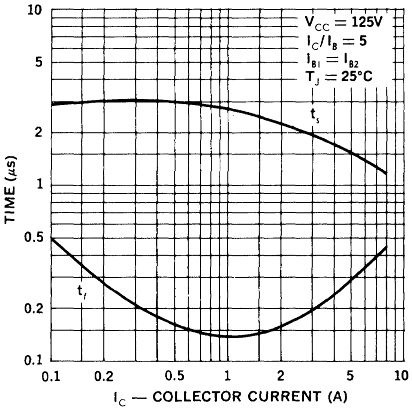
I_C Amps	T_J °C	t_s μs	t_{fv} μs	t_{fi} μs
3.0	25	.90	.07	.07
	100	1.40	.12	.15
5.0	25	.98	.10	.11
	100	1.52	.15	.20
8.0	25	1.10	.14	.11
	100	1.70	.20	.18

t_{fv} = voltage fall time; 10-90%
t_{fi} = current fall time; 10-90%

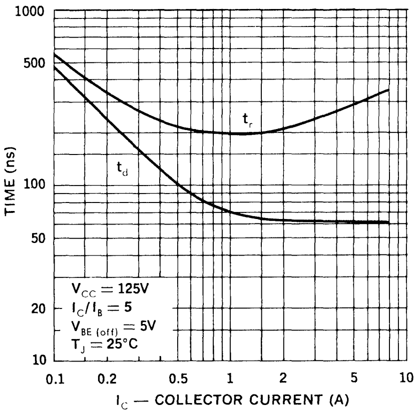
TEST CONDITIONS FOR DYNAMIC PERFORMANCE

	$V_{CEO(SUS)}$	$V_{CEX\ (SUS)}$ AND INDUCTIVE SWITCHING	$E_{S/b}$	RESISTIVE SWITCHING
INPUT CONDITIONS	 PW Varied to Attain $I_C = 100mA$	Drive Circuit  Set $+V_{in}$ to Obtain a Forced $h_{FE} = 5$ and Adjust PW to Attain Specified Peak I_C. Duty Cycle ⩽ 3% f = 1kHz Q1 2N6408 Q3 2N5875 Q2 2N6406 Q4 2N5877 Diodes 1N4933	 PW Varied to Attain I_C	 **$I_C = 3A$** **$PW \leqslant 100\mu s$** **$t_f \leqslant 5ns$** **$t_f \leqslant 50ns$** **Duty Cycle ⩽ 2%**
CIRCUIT VALUES	$L_{coil} = 80mH$ $V_{CC} = 10V$ $R_{coil} = 0.7\Omega$ V_{clamp} (Unclamped)	$L_{coil} = 180\mu H$ $R_{coil} = 0.05\Omega$ $V_{CC} = 20V$ $f_o = 500kHz$ V_{clamp} = Rated V_{CEX} Value	$L_{coil} = 40\mu H$ $V_{CC} = 10V$ $R_{coil} = 0.2\Omega$ V_{clamp} (Unclamped)	**$V_{CC} = 250V$** **$R_L = 83\Omega$** **D1 = 1N5820 or Equiv.** **$R_B = 20\Omega$**
TEST CIRCUITS	INDUCTIVE TEST CIRCUIT See Above For Detailed Conditions	 OUTPUT WAVEFORMS 	t_1 Adjusted to Obtain I_C $t_1 \approx \frac{L_{coil}\ (I_{Cpk})}{V_{CC}}$ $t_2 \approx \frac{L_{coil}\ (I_{Cpk})}{V_{clamp}}$ Test Equipment Tektronix Scope 475 or Equivalent	RESISTIVE TEST CIRCUIT 

Turn-Off Time



Turn-On Time



POWER TRANSISTORS

15A, 850V, Fast Switching, Silicon NPN Mesa

2N6546
2N6547

FEATURES

- Collector-Base Voltage: up to 850V
- Peak Collector Current: 30A
- Rise Time: $\leqslant 0.7\mu S$ } @ $I_C = 10A$
- Fall Time: $\leqslant 0.7\mu S$ }
- Key Parameters characterized at 100°C

DESCRIPTION

These high voltage glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

ABSOLUTE MAXIMUM RATINGS *

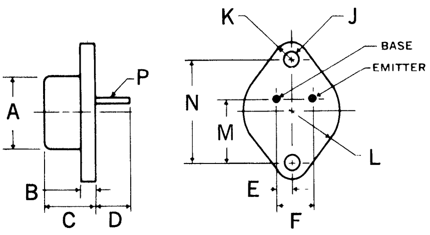
	2N6546	2N6547
Collector-Base Voltage, V_{CBO}	650V	850V
Collector-Emitter Voltage, $V_{CEO\ (SUS)}$	300V	400V
Emitter-Base Voltage, V_{EBO}	9V	9V
Collector Current, I_C, continuous	15A	15A
Collector Current, I_C peak	30A	30A
Base Current, I_B, continuous	10A	10A
Emitter Current, I_E, continuous	25A	25A
Power Dissipation, 25°C Case	175W	175W
Derating Factor	1W/°C	1W/°C
Operating and Storage Temperature Range	—65 to 200°C	

* JEDEC registered values.

MECHANICAL SPECIFICATIONS

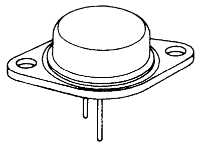
NOTE:
Leads may be soldered to within 1/16" of base provided temperature-time exposure is less than 260°C for 10 seconds.

2N6546 2N6547



	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.205-.225	5.21-5.72
F	.420-.440	10.67-11.18
J	.151-.161 DIA.	3.84-4.09 DIA.
K	.188 MAX. RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.655-.675	16.64-17.15
N	1.177-1.197	29.90-30.40
P	.038-.043 DIA.	9.65-10.92 DIA.

TO-3



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)*

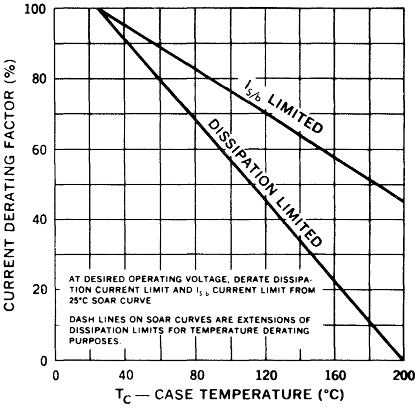
Test	Symbol	2N6546		2N6547		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	12	60	12	60		$I_C = 5.0A, V_{CE} = 2.0V$
D.C. Current Gain (Note 1)	h_{FE}	6	30	6	30		$I_C = 10A, V_{CE} = 2.0V$
Collector Saturation Voltage (Note 1)	$V_{CE(sat)}$	—	1.5	—	1.5	V	$I_C = 10A, I_B = 2.0A$
Collector Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{CE(sat)}$	—	2.5	—	2.5	V	$I_C = 10A, I_B = 2.0A$
Collector Saturation Voltage (Note 1)	$V_{CE(sat)}$	—	5.0	—	5.0	V	$I_C = 15A, I_B = 3.0A$
Base Saturation Voltage (Note 1)	$V_{BE(sat)}$	—	1.6	—	1.6	V	$I_C = 10A, I_B = 2.0A$
Base Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{BE(sat)}$	—	1.6	—	1.6	V	$I_C = 10A, I_B = 2.0A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO(sus)}$	300	—	400	—	V	$I_C = 0.1A, I_B = 0$
Collector-Emitter Sustaining Voltage $T_C = 100°C$ (Note 2)	$V_{CEX(sus)}$	350	—	450	—		$L = 180\mu H, I_C = 8.0A$ $V_{BE} = 5V, I_B = 2.0A$ V_{CE} clamped to rated $V_{CEX(sus)}$
Collector-Emitter Sustaining Voltage $T_C = 100°C$	$V_{CEX(sus)}$	200	—	300	—	V	$L = 180\mu H, I_C = 15A$ $V_{BE} = -5V, I_B = 3.0A$ V_{CE} clamp to V_{CEO} $-100V$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	— —	1 —	— —	— 1	mA	$V_{CE} = 650V, V_{BE} = -1.5V$ $V_{CE} = 850V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	— —	4 —	— —	— 4	mA	$V_{CE} = 650V, V_{BE} = -1.5V$ $V_{CE} = 850V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CER}	— —	5 —	— —	— 5	mA	$V_{CE} = 650V, R = 50\Omega$ $V_{CE} = 850V, R = 50\Omega$
Output Capacitance, Common Base	C_{obo}	180	360	180	360	pF	$V_{CB} = 10V, f = 1$ MHz
Gain-Bandwidth Product	F_T	6	24	6	24	MHz	$V_{CE} = 10V, I_C = 0.5A, f = 1$ MHz
Energy Second Breakdown (unclamped)	$E_{s/b}$	2	—	2	—	mJ	$I_C = 10A$ $V_{BE(off)} = 4.0V$ $L = 40\mu H$
Resistive Switching Speeds Delay Time Rise Time Storage Time Fall Time	 t_d t_r t_s t_f	 — — — —	 0.05 0.7 4.0 0.7	 — — — —	 0.05 0.7 4.0 0.7	μS	$I_C = 10A$ $V_{CC} = 250V$ $I_{B1} = I_{B2} = 2.0A$ $V_{BE(off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$ Storage Time Fall Time	 t_s t_f	 — —	 5.0 1.5	 — —	 5.0 1.5	μS	$I_C = 10A$ $I_B = 2.0A$ $V_{BE(off)} = 5V$ V_{CE} clamp = rated $V_{CEX(sus)}$
Inductive Switching Speeds $T_C = 25°C$ Storage Time Fall Time	 t_s t_f	 2.0 typical 0.09 typical				μS	$I_C = 10A$ (pk) V_{CE} clamp = rated V_{CEX} $I_{B1} = 2.0A$ $V_{BE(off)} = 5.0$ Vdc $T_C = 25°C$
Thermal Resistance, Junction-to-Case	$R\Theta_{JC}$	—	1.0	—	1.0	°C/W	

Notes

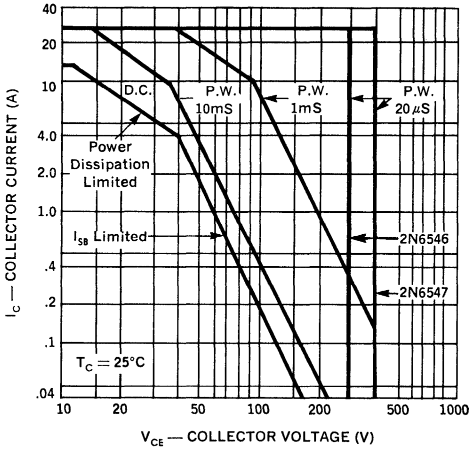
1. Pulse length $= 250\mu S$; duty cycle $\leqslant 1\%$.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\approx 50\mu S$; duty cycle $\leqslant 1\%$. Voltage clamped at maximum collector-emitter voltage.

* JEDEC registered values.

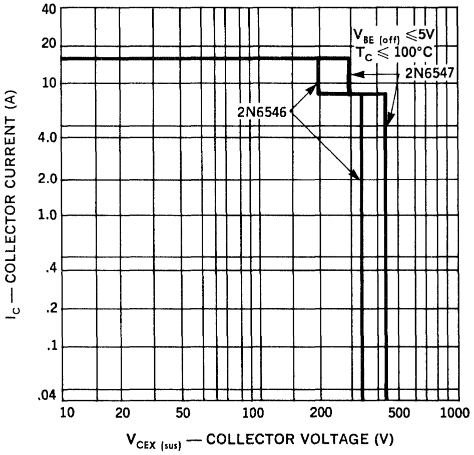
Power Derating



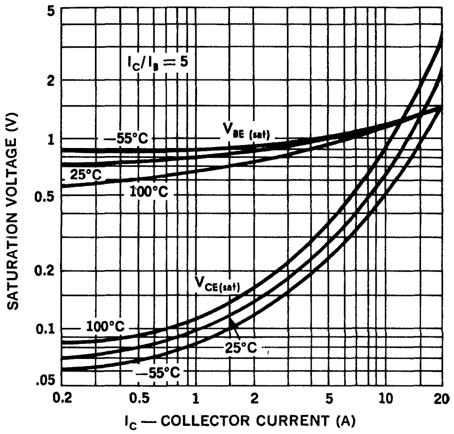
Forward Bias Safe Operating Area



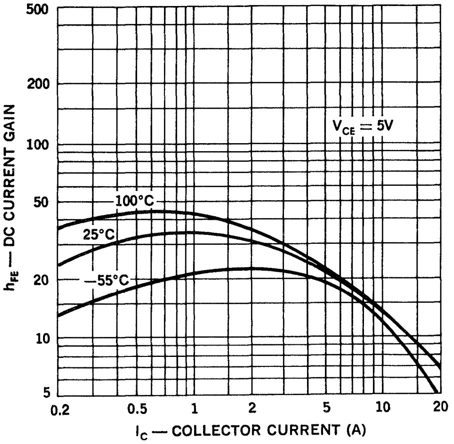
Reverse Biased Safe Operating Area



Saturation Voltages



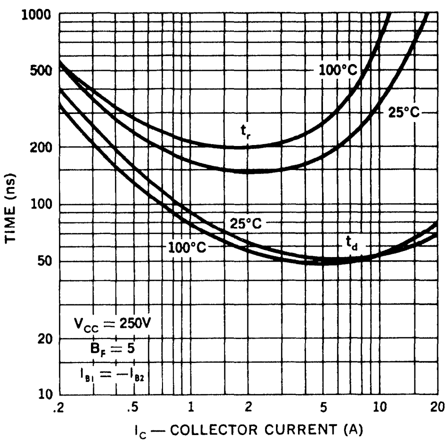
DC Current Gain



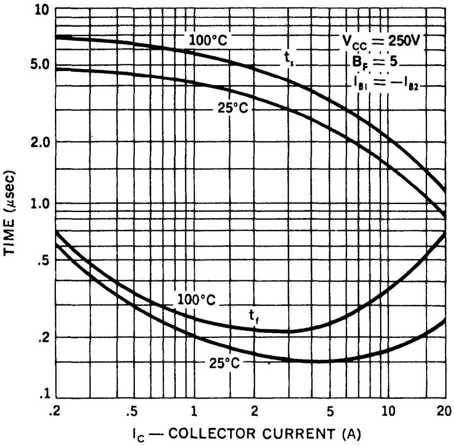
Typical Inductive Load Switching Performance

I_C Amps	T_J °C	t_s µS	t_{fv} nS	t_{fi} nS
3	25 100	.8 1.10	.14 .18	.025 .030
5	25 100	.90 1.20	.14 .16	.025 .030
10	25 100	1.20 1.50	.05 .12	.050 .10

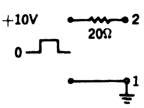
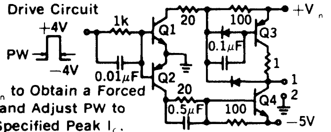
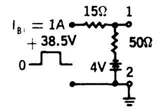
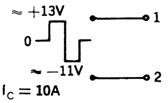
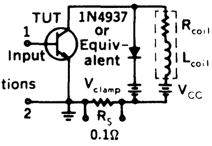
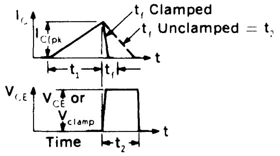
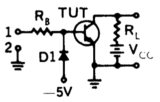
Resistive Turn-On Time



Resistive Turn-Off Time



TEST CONDITIONS FOR DYNAMIC PERFORMANCE

	$V_{CEO(SUS)}$	$V_{CEX(SUS)}$ AND INDUCTIVE SWITCHING	$E_{S/b}$	RESISTIVE SWITCHING
INPUT CONDITIONS	 PW Varied to Attain $I_C = 100mA$	Drive Circuit  Set $+V_{in}$ to Obtain a Forced $h_{FE} = 5$ and Adjust PW to Attain Specified Peak I_C. Duty Cycle ⩽ 3% f = 1kHz Q1 2N6408 Q3 2N5875 Q2 2N6406 Q4 2N5877 Diodes 1N4933	 PW Varied to Attain I_C	 $I_C = 10A$ PW ⩽ 100μs t_r ⩽ 5ns t_f ⩽ 50ns Duty Cycle ⩽ 2%
CIRCUIT VALUES	$L_{coil} = 80mH$ $V_{CC} = 10V$ $R_{coil} = 0.7Ω$ V_{clamp} (Unclamped)	$L_{coil} = 180μH$ $R_{coil} = 0.05Ω$ $V_{CC} = 20V$ $f_o = 500kHz$ V_{clamp} = Rated V_{CEX} Value	$L_{coil} = 40μH$ $V_{CC} = 10V$ $R_{coil} = 0.2Ω$ V_{clamp} (Unclamped)	$V_{CC} = 250V$ $R_L = 25Ω$ D1 = 1N5820 or Equiv. $R_B = 6Ω$
TEST CIRCUITS	INDUCTIVE TEST CIRCUIT See Above For Detailed Conditions 	OUTPUT WAVEFORMS 	t_1 Adjusted to Obtain I_C $t_1 \approx \frac{L_{coil}(I_{Cpk})}{V_{CC}}$ $t_2 \approx \frac{L_{coil}(I_{Cpk})}{V_{clamp}}$ Test Equipment Tektronix Scope 475 or Equivalent	RESISTIVE TEST CIRCUIT 

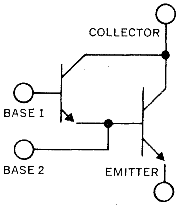
POWER DARLINGTONS

10 Amp, 150V, Planar NPN

U2T101
U2T105
U2T201
U2T205

FEATURES

- High Current Gain: up to 2000 min @ $I_C = 5A$
- Low Saturation Voltage: as low as 1.5V max @ $I_C = 5A$
- High Voltage: up to 150V min V_{CER}
- Monolithic Design Incorporating Multiple-Emitter Techniques
- Triple-Diffused Planar Construction



DESCRIPTION

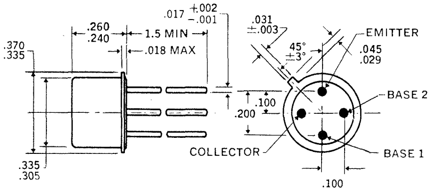
Unitrode NPN Darlingtons consist of a two transistor circuit on a single monolithic planar chip.

ABSOLUTE MAXIMUM RATINGS

	TO-33		3 PIN TO-66	
	U2T101	U2T105	U2T201	U2T205
Collector-Emitter Voltage	80V	150V	80V	150V
Emitter Base Voltages,				
V_{EB2}	6V	6V	6V	6V
V_{EB1}	12V	12V	12V	12V
D.C. Collector Current	5A	5A	5A	5A
Peak Collector Current	10A	10A	10A	10A
Base 1 Current	0.5A	0.5A	0.5A	0.5A
Power Dissipation				
25°C Ambient	1W	1W	2.5W	2.5W
100°C Case	5W	5W	25W	25W
Thermal Resistance, Junction to Case	20°C/W		4°C/W	
Operating and Storage Temperature Range	−65°C to 200°C		−65°C to 200°C	

MECHANICAL SPECIFICATIONS

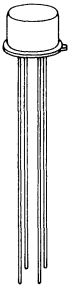
U2T101 U2T105



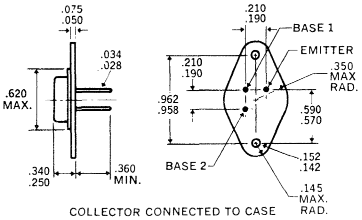
COLLECTOR CONNECTED TO CASE

Dimensions in inches.

TO33



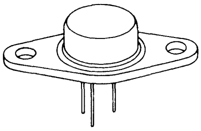
U2T201 U2T205



COLLECTOR CONNECTED TO CASE

Dimensions in inches.

3 Pin TO-66



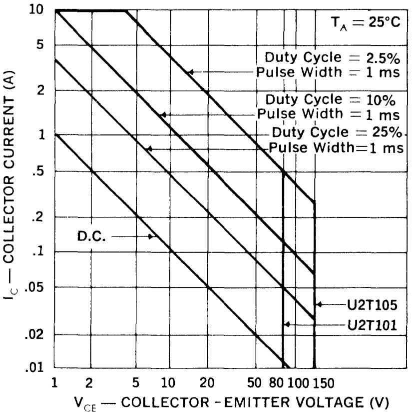
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

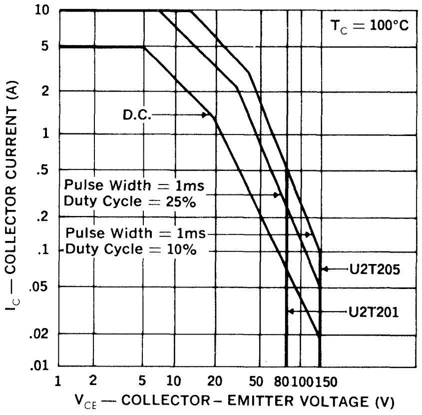
Test	Symbol	U2T101 & U2T201 Min.	Max.	U2T105 & U2T205 Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	2000	—	1000	—	—	$I_C = 1.0A, V_{CE} = 2V, R_{B2E} = 1K$
D.C. Current Gain (Note 1)	h_{FE}	2000	—	1000	—	—	$I_C = 5A, V_{CE} = 5V, R_{B2E} = 100$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.5	—	2.5	V	$I_C = 5A, R_{B2E} = 100$ U2T101, 201: $I_{B1} = 5mA$ U2T105, 205: $I_{B1} = 10mA$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}	80	—	150	—	V	$I_C = 25mA, R_{B1E} = 2.2K, R_{B2E} = 100$
Collector Cutoff Current	I_{CER}	—	1.0	—	1.0	µA	$R_{B1E} = 2.2K, R_{B2E} = 100$ U2T101, 201: $V_{CE} = 80V$ U2T105, 205: $V_{CE} = 150V$
Collector Cutoff Current	I_{CER}	—	1.0	—	1.0	mA	$R_{B1E} = 2.2K, R_{B2E} = 100, T = 150°C$ U2T101, 201: $V_{CE} = 80V$ U2T105, 205: $V_{CE} = 150V$
Collector Capacitance	C_{obo}	—	100	—	100	pf	$V_{CB1} = 10, I_E = 0, f = 1MHz$
A.C. Current Gain	h_{fe}	5	—	5	—	—	$I_C = 1.0A, V_{CE} = 10V, f = 10MHz, R_{B2E} = 100$
Switching Speeds Delay Time	t_d	100 Typ.		100 Typ.		ns	$V_{CC} = 30V$, $I_C = 5A$, U2T101, 201: I_B (on) $= I_B$ (off) $= 5mA$, U2T105, 205: I_B (on) $= I_B$ (off) $= 10mA$, $R_{B2E} = 100$
Rise Time	t_r	300 Typ.		400 Typ.		ns	
Storage Time	t_s	600 Typ.		500 Typ.		ns	
Fall Time	t_f	500 Typ.		500 Typ.		ns	

Note: 1. Pulse width = 300 µs; duty cycle ≤2%.

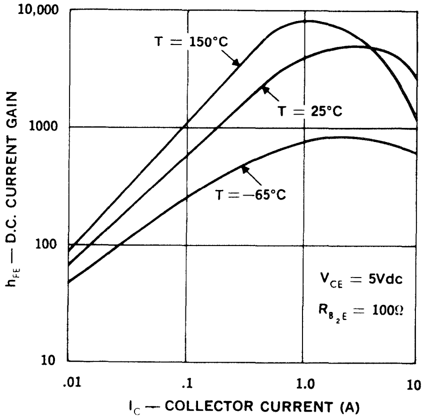
Maximum Safe Operating Area U2T101 & 105



Maximum Safe Operating Area U2T201 & 205



D.C. Current Gain vs. Collector Current U2T101, U2T105, U2T201, U2T205



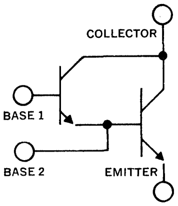
POWER DARLINGTONS

5 Amp, 150V, Planar NPN

U2T301 U2T401
U2T305 U2T405

FEATURES

- High Current Gain: 1000 min. @ $I_C = 2A$
- Low Saturation Voltage: as low as 1.5V max. @ $I_C = 2A$
- High Voltage: up to 150V min. V_{CER}
- Monolithic Design Incorporating Multiple-Emitter Techniques
- Triple-Diffused Planar Construction



DESCRIPTION

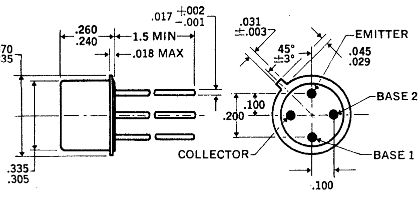
Unitrode NPN Darlingtons consist of a two transistor circuit on a single monolithic planar chip.

ABSOLUTE MAXIMUM RATINGS

	TO-33		3 PIN TO-66	
	U2T301	U2T305	U2T401	U2T405
Collector-Emitter Voltage	60V	150V	60V	150V
Emitter Base Voltages,				
V_{EB2}	6V	6V	6V	6V
V_{EB1}	12V	12V	12V	12V
D.C. Collector Current	2A	2A	2A	2A
Peak Collector Current	5A	5A	5A	5A
Base 1 Current	0.5A	0.5A	0.5A	0.5A
Power Dissipation				
25°C Ambient	1W	1W	2W	2W
100°C Case	4W	4W	16W	16W
Thermal Resistance				
Junction to Case	25°C/W		6°C/W	
Operating and Storage Temperature Range	—65°C to 200°C		—65°C to 200°C	

MECHANICAL SPECIFICATIONS

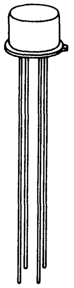
U2T301 U2T305



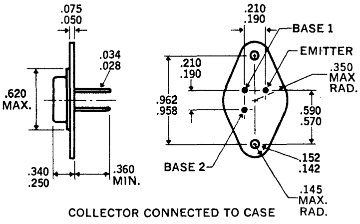
COLLECTOR CONNECTED TO CASE

Dimensions in inches.

TO-33



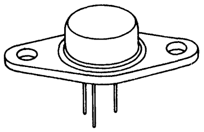
U2T401 U2T405



COLLECTOR CONNECTED TO CASE

Dimensions in inches.

3 Pin TO-66



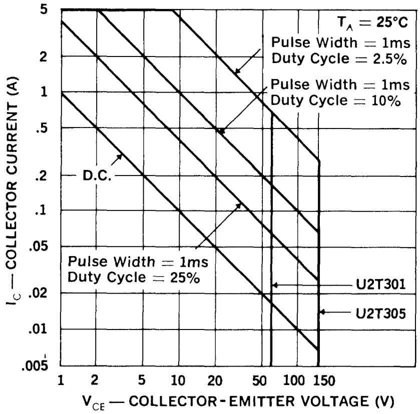
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

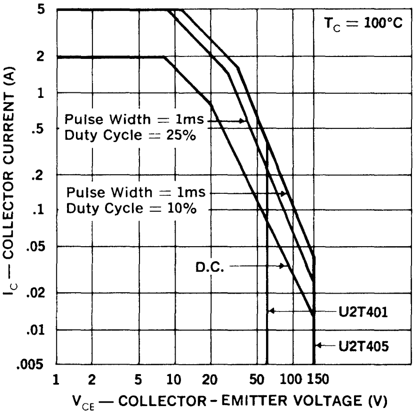
Test		Symbol	U2T301 & U2T401 Min.	Max.	U2T305 & U2T405 Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)		h_{FE}	1000	—	1000	—	—	$I_C = 1A, V_{CE} = 2V, R_{B2E} = 1K$
D.C. Current Gain (Note 1)		h_{FE}	1000	—	1000	—	—	$I_C = 2A, V_{CE} = 5V, R_{B2E} = 100$
Collector Saturation Voltage (Note 1)		V_{CE} (sat)	—	1.5	—	2.5	V	$I_C = 2A, R_{B2E} = 100, I_{B1} = 4mA$
Collector-Emitter Breakdown Voltage (Note 1)		BV_{CER}	60	—	150	—	V	$I_C = 25mA, R_{B1E} = 2.2K, R_{B2E} = 100$
Collector Cutoff Current		I_{CER}	—	1.0	—	1.0	μA	$R_{B1E} = 2.2K, R_{B2E} = 100$ U2T301, 401: $V_{CE} = 60V$ U2T305, 405: $V_{CE} = 150V$
Collector Cutoff Current		I_{CER}	—	1.0	—	1.0	mA	$R_{B1E} = 2.2K, R_{B2E} = 100, T = 150°C$ U2T301, 401: $V_{CE} = 60V$ U2T305, 405: $V_{CE} = 150V$
Collector Capacitance		C_{obo}	—	60	—	60	pf	$V_{CB1} = 10V, I_E = 0, f = 1MHz$
A.C. Current Gain		h_{fe}	5	—	5	—	—	$I_C = 0.5A, V_{CE} = 10V, f = 10MHz, R_{B2E} = 100$
Switching Speeds	Delay Time	t_d	100 Typ.		100 Typ.		ns	
	Rise Time	t_r	200 Typ.		300 Typ.		ns	$V_{CC} = 30V, I_C = 2A, I_B (on) = I_B (off) = 4mA$
	Storage Time	t_s	800 Typ.		800 Typ.		ns	
	Fall Time	t_f	300 Typ.		300 Typ.		ns	$R_{B2E} = 100$

Note: 1. Pulse width = 300 μs; duty cycle ≤2%.

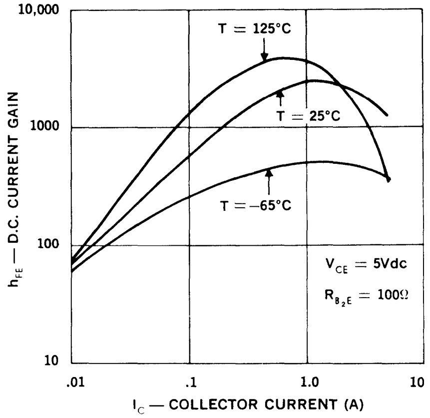
Maximum Safe Operating Area
U2T301 & 305



Maximum Safe Operating Area
U2T401 & 405



D.C. Current Gain vs. Collector Current
U2T301, U2T305, U2T401, U2T405

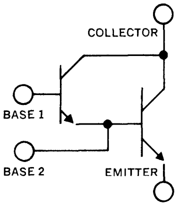


POWER DARLINGTONS
2 Amp, 300V, Planar NPN

U2T712
U2T713
U2T722
U2T723

FEATURES

- High Current Gain: up to 1000 min. @ $I_C = 1A$
- Low Saturation Voltage: as low as 1.5V max. @ $I_C = 2A$
- High Voltage: up to 300V. min. V_{CEO}
- Peak Current: to 5A
- Monolithic Planar Chip Construction



DESCRIPTION

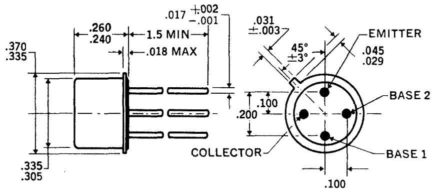
Unitrode NPN Darlingtons consist of a two transistor circuit on a single monolithic planar chip.

ABSOLUTE MAXIMUM RATINGS

	TO-33		3 PIN TO-66	
	U2T712	U2T713	U2T722	U2T723
Collector — Emitter Voltage	200V	300V	200V	300V
Emitter — Base Voltages				
V_{EB2}	6V	6V	6V	6V
V_{EB1}	12V	12V	12V	12V
D.C. Collector Current	2A	2A	2A	2A
Peak Collector Current	5A	5A	5A	5A
Base 1 Current	0.5A	0.5A	0.5A	0.5A
Power Dissipation				
25°C Ambient	1W	1W	2W	2W
100°C Case	5W	5W	20W	20W
Thermal Resistance				
Junction-to-Case	20°C/W		5°C/W	
Operating and Storage Temperature Range	−65°C to 200°C		−65°C to 200°C	

MECHANICAL SPECIFICATIONS

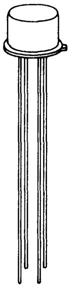
U2T712 U2T713



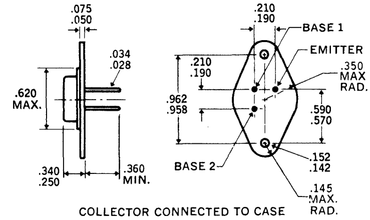
COLLECTOR CONNECTED TO CASE

Dimensions in inches.

TO-33



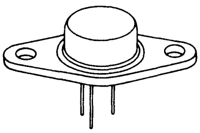
U2T722 U2T723



COLLECTOR CONNECTED TO CASE

Dimensions in inches.

3 PIN TO-66



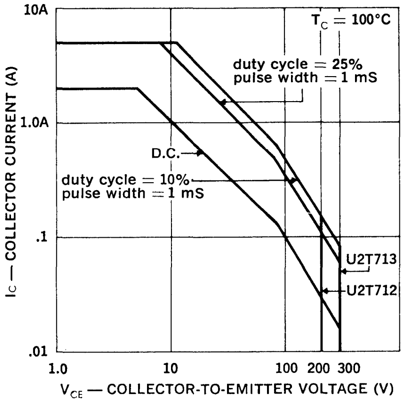
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

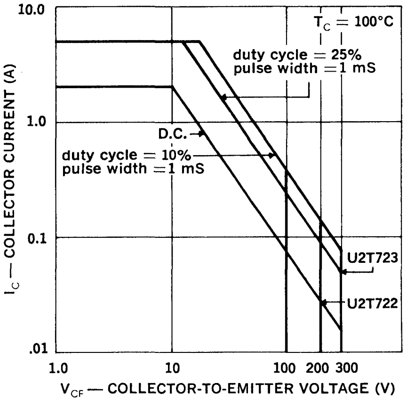
Test	Symbol	U2T712 & 722 Min.	U2T712 & 722 Max.	U2T713 & 723 Min.	U2T713 & 723 Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	1000	—	1000	—	—	$I_C = 1A$, $V_{CE} = 5V$, $R_{B2E} = 1K$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.5	—	1.5	V	$I_C = 2A$, $R_{B2E} = 100$, $I_{BI} = 20mA$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}	200	—	300	—	V	$I_C = 10mA$
	BV_{CER}	250 Typ.	—	350 Typ.	—	V	$I_C = 10mA$, $R_{BIE} = 2.2K$, $R_{B2E} = 100$
Collector Cutoff Current	I_{CER}	—	10.0	—	10.0	μA	$R_{BIE} = 2.2K$, $R_{B2E} = 100$ U2T712 & 722: $V_{CE} = 200$ U2T713 & 723: $V_{CE} = 300$
Collector Capacitance	C_{obo}	—	100	—	100	pf	$V_{CBI} = 10V$, $I_E = 0$, f = 1mHz
A.C. Current Gain	h_{fe}	4.0 Typ.	—	4.0 Typ.	—	—	$I_C = 0.5A$, $V_{CE} = 10V$, f = 20mHz, $R_{B2E} = 100$
Rise Time Storage Time Fall Time	t_r t_s t_f	0.6 Typ. 1.5 Typ. 1.0 Typ.		0.6 Typ. 1.5 Typ. 1.0 Typ.		μS μS μS	$V_{CC} = 100V$, I_B (on) $= I_B$ (off) $= 25mA$, $I_C = 2A$, $R_{B2E} = 100$

Note 1. Pulse width = 300 μS; duty cycle ⩽ 2%

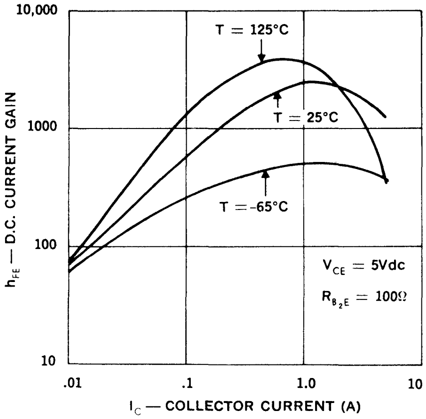
Maximum Safe Operating Area
U2T712 & 713



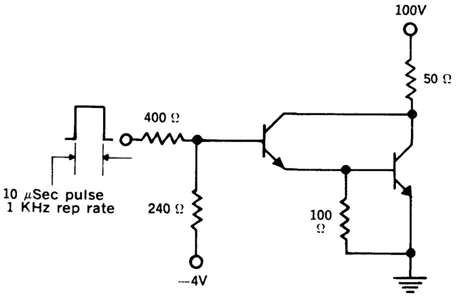
Maximum Safe Operating Area
U2T722 & 723



D.C. Current Gain vs. Collector Current
U2T712, U2T713, U2T722, U2T723



Switching Speed Circuit



$I_C = 2A$, $I_{B1} = -I_{B2} = 25mA$

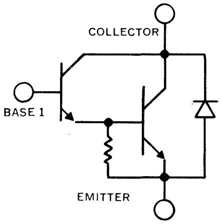
POWER DARLINGTONS

3 Amp, 100V, Planar NPN, Plastic

U2TA506
U2TA508
U2TA510

FEATURES

- High Current Gain: 500 min. @ $I_C = 3A$
- Low Saturation Voltage: as low as 1.5V max. @ $I_C = 3A$
- Economic Plastic Molded Construction



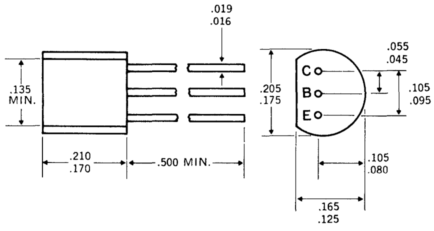
DESCRIPTION

Unitrode NPN Darlingtons consist of a two transistor circuit on a single monolithic planar chip, including integral bias resistance and protective diode. It is ideally suited for pulse power applications in power supplies, printers, solid state relays and displays.

ABSOLUTE MAXIMUM RATINGS

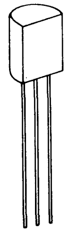
		TO-92	
	U2TA506	U2TA508	U2TA510
Collector-Base Voltage, V_{CBO}	80V	100V	100V
Collector-Emitter Voltage, V_{CEO}	60V	80V	120V
Emitter-Base Voltage, V_{EBO}		5V	
D.C. Collector Current, I_C		.75A	
Peak Collector Current, I_C		5A	
Base Current, I_B		.6A	
Power Dissipation			
25°C Case		2.4W	
25°C Ambient		970mW	
Thermal Resistance, Θ_{J-C}		62.5°C/W	
Thermal Resistance, Θ_{J-A}		155°C/W	
Storage Temperature Range		−55 to +150°C	
Maximum Junction Temperature		+175°C	

U2TA506 U2TA508 U2TA510



Dimensions in inches.

TO-92

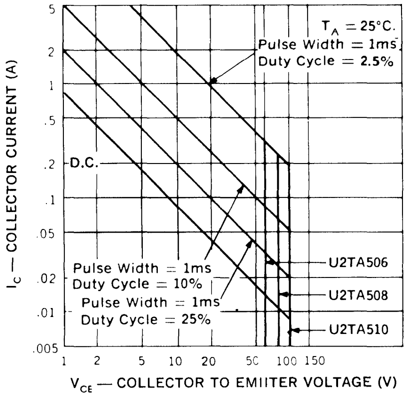


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

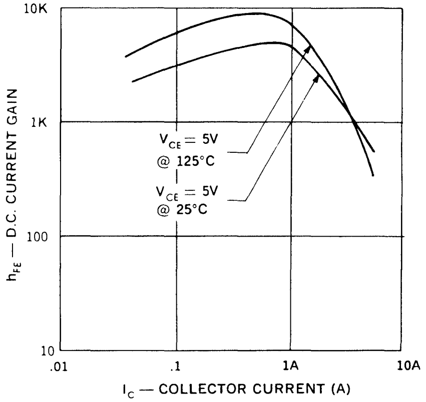
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	1000	—	—	$I_C = 1A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	500	—	—	$I_C = 3A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	300 Typ.		—	$I_C = 5A, V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.5	Vdc	$I_C = 3A, I_B = 30mA$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 10mAdc$
U2TA506		60	—		
U2TA508		80	—		
U2TA510		100	—		
Collector-Emitter Cutoff Current	I_{CER}	—	10	μAdc	V_{CE} = rating, R = 100Ω
Collector-Emitter Cutoff Current	I_{CER}	—	1	mAdc	V_{CE} = rating, R = 100Ω, T = 125°C
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	50	pf	$V_{CB} = 10Vdc, I_E = 0, f = 1MHz$
A.C. Current Gain	h_{fe}	4.0 Typ.		—	$I_C = 1Adc, V_{CE} = 5Vdc, f = 10MHz$
Rise Time	t_r	600 Typ.		ns	$I_C = 2A$
Storage Time	t_s	1500 Typ.		ns	V_{CC} = rating, $I_{B\,(on)} = I_{B\,(off)} = 4mA$
Fall Time	t_f	800 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ≤ 2%.

Maximum Safe Operating Area U2TA506, 508 & 510



D.C. Current Gain vs. Collector Current



POWER TRANSISTORS

5A, 500V, Fast Switching, High $E_{S/b}$
Silicon NPN Mesa

UMT1006
UMT1007

FEATURES

- Rise Time: 0.4μS } $I_C = 3A$
- Fall Time: 0.4μS }
- High Second Breakdown Energy: 540μJ
- Collector Emitter Voltage: up to 500V
- Peak Collector Current: 10A
- Key Parameters characterized at 100°C

DESCRIPTION

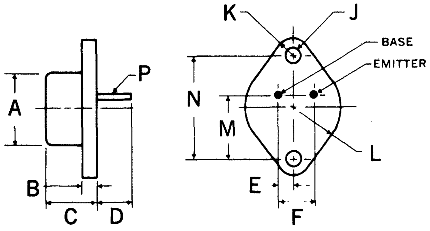
These high voltage glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

ABSOLUTE MAXIMUM RATINGS

	UMT1006	UMT1007
Collector Emitter Voltage, V_{CEV}	400V	500V
Collector Emitter Voltage, $V_{CEO\,(SUS)}$	300V	400V
Emitter Base Voltage, V_{EBO}	7V	7V
Collector Current, I_C continuous	5A	5A
Collector Current, I_C peak	10A	10A
Base Current, I_B continuous	5A	5A
Power Dissipation, 25°C Case	100W	100W
Derating Factor	.571W/°C	.571W/°C
Operating and Storage Temperature Range	—65 to 200°C	

MECHANICAL SPECIFICATIONS

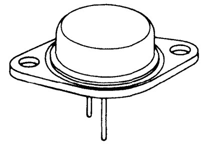
NOTE:
Leads may be soldered to within 1/16" of base provided temperature-time exposure is less than 260°C for 10 seconds.



UMT1006 UMT1007

	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.205-.225	5.21-5.72
F	.420-.440	10.67-11.18
J	.151-.161 DIA.	3.84-4.09 DIA.
K	.188 MAX. RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.655-.675	16.64-17.15
N	1.177-1.197	29.90-30.40
P	.038-.043 DIA.	9.65-10.92 DIA.

TO-3



UNITRODE

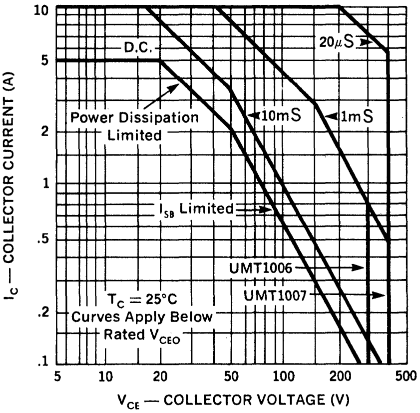
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

		UMT1006		UMT1007			
Test	Symbol	MIN.	MAX.	MIN.	MAX.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	12	60	12	60		$I_C = 1.5A, V_{CE} = 2V$
D.C. Current Gain (Note 1)	h_{FE}	7	35	7	35		$I_C = 3.0A, V_{CE} = 2V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.0	—	1.0	V	$I_C = 3.0A, I_B = 0.6A$
Collector Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{CE\,(sat)}$	—	2.0	—	2.0	V	$I_C = 3.0A, I_B = 0.6A$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	5.0	—	5.0	V	$I_C = 5.0A, I_B = 1.0A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.4	—	1.4	V	$I_C = 3.0A, I_B = 0.6A$
Base Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{BE\,(sat)}$	—	1.4	—	1.4	V	$I_C = 3.0A, I_B = 0.6A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	300	—	400	—	V	$I_C = 0.1A, I_B = 0$
Collector-Emitter Sustaining Voltage $T_C = 100°C$ (Note 2)	$V_{CEX\,(sus)}$	350	—	450	—	V	$I_C = 3.0A, L = 180\mu H$ $I_{B1} = I_{B2} = 0.6A$ V_{CE} clamp = rated $V_{CEX\,(sus)}$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	— —	0.5 —	— —	— 0.5	mA	$V_{CE} = 400V, V_{BE} = -1.5V$ $V_{CE} = 500V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	— —	2.5 —	— —	— 2.5	mA	$V_{CE} = 400V, V_{BE} = -1.5V$ $V_{CE} = 500V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CER}	— —	3.0 —	— —	— 3.0	mA	$V_{CE} = 400V, R_{BE} = 50\Omega$ $V_{CE} = 500V, R_{BE} = 50\Omega$
Output Capacitance, Common Base	C_{obo}	50	150	50	150	pF	$V_{CB} = 10V, f = 1\ MHz$
Gain-Bandwidth Product	F_T	6	24	6	24	MHz	$V_{CE} = 10V, I_C = 0.2A, f = 1\ MHz$
Energy Second Breakdown (unclamped)	$E_{s/b}$	540	—	540	—	μJ	$I_C = 3.0A, V_{BE\,(off)} = 4V$ $L = 120\mu H$ unclamped
Resistive Switching Speeds Delay Time Rise Time Storage Time Fall Time	 t_d t_r t_s t_f	 — — — —	 .05 0.4 4.0 0.4	 — — — —	 .05 0.4 4.0 0.4	μS	$I_C = 3.0A$ $V_{CC} = 200V$ $I_{B1} = I_{B2} = 0.6A$ $V_{BE\,(off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$ Storage Time Fall Time	 t_s t_f	 — —	 4.0 0.4	 — —	 4.0 0.4	μS	$I_C = 3.0A, L = 180\mu H$ $I_{B1} = I_{B2} = 0.6A$ V_{CE} clamp = rated $V_{CEX\,(sus)}$
Thermal Resistance, Junction-to-Case	$R\theta_{JC}$	—	1.75	—	1.75	°C/W	

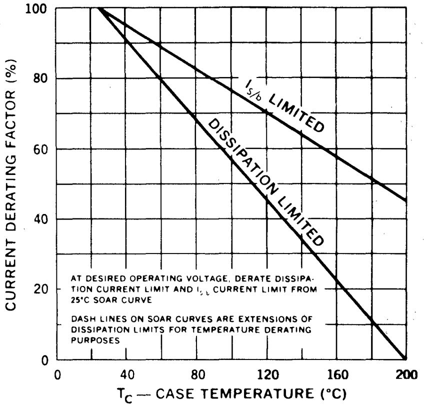
Notes

1. Pulse length = 250μS; duty cycle $\leqslant$1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50μS; duty cycle $\leqslant$1%. Voltage clamped at maximum collector-emitter voltage.

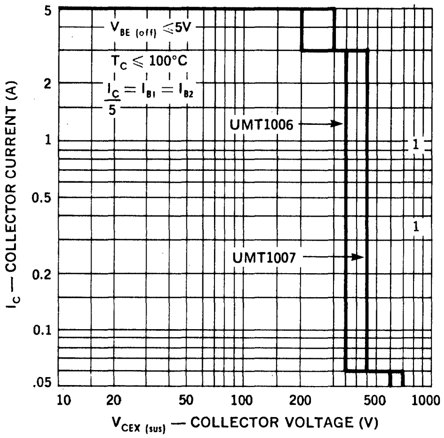
Forward Bias Safe Operating Area



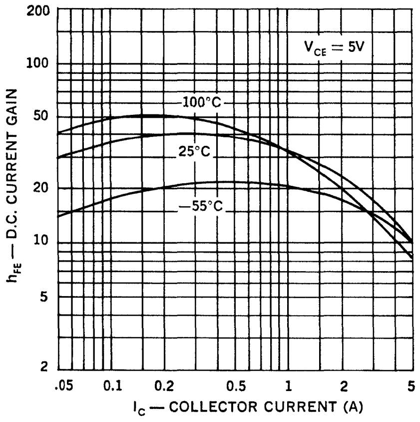
Power Derating



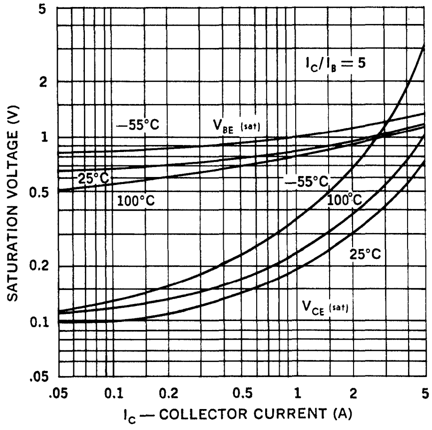
Reverse Biased Safe Operating Area

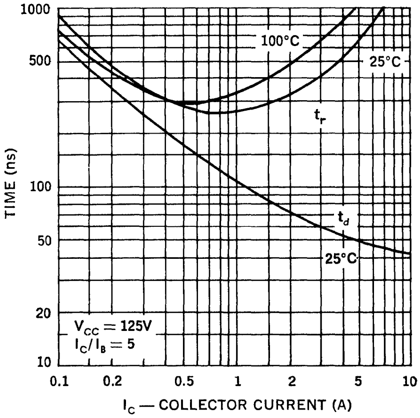


D.C. Current Gain

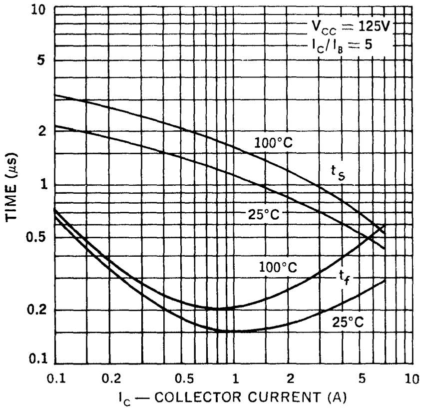


Saturation Voltages

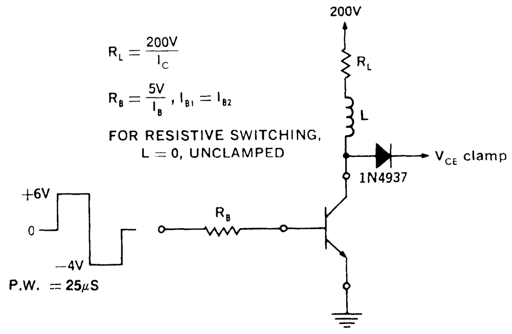




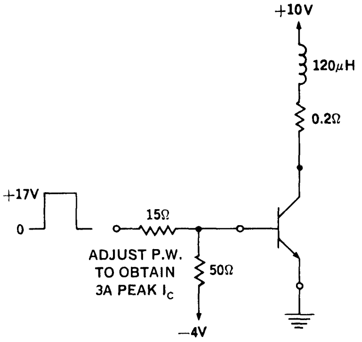
Resistive Turn-On Time



Resistive Turn-Off Time



Switching Time, $V_{CEX(sus)}$ Test Circuit



$E_s/_b$ Test Circuit

POWER TRANSISTORS

8 Amp, 500V Fast Switching, High $E_{S/b}$ Silicon NPN Mesa

UMT1008
UMT1009

FEATURES

- Rise Time: 0.4μs } $I_C = 5A$
- Fall Time: 0.4μs } $I_C = 5A$
- High Second Breakdown Energy: 1500μJ
- Collector Emitter Voltage: up to 500V
- Peak Collector Current: 16A
- Key Parameters characterized at 100°C

DESCRIPTION

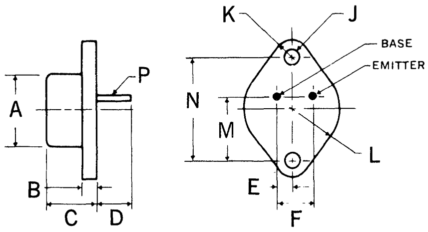
These high voltage triple diffused glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

ABSOLUTE MAXIMUM RATINGS

	UMT1008	UMT1009
Collector Emitter Voltage, V_{CEV}	400V	500V
Collector Emitter Voltage, $V_{CEO(SUS)}$	300V	400V
Emitter Base Voltage, V_{EBO}	7V	7V
Collector Current, I_C continuous	8A	8A
Collector Current, I_C peak	16A	16A
Base Current, I_B continuous	8A	8A
Power Dissipation, 25°C Case	125W	125W
Derating Factor	.714W/°C	.714W/°C
Operating and Storage Temperature Range	—65 to 200°C	

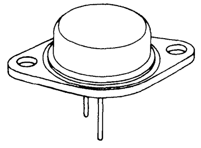
MECHANICAL SPECIFICATIONS

NOTE:
Loads may be soldered to within 1/16" of base provided temperature-time exposure is less than 260°C for 10 seconds.



	ins.	mm
A	.875 MAX.	2.22 MAX.
B	.135 MAX.	0.34 MAX.
C	.250—.450	0.64—1.14
D	.312 MIN.	0.79 MIN.
E	.205—.225	0.52—0.57
F	.420—.440	1.07—1.12
J	.151—.161 DIA.	0.38—0.41
K	.188 MAX. RAD.	0.48 MAX. RAD.
L	.525 MAX. RAD.	1.33 MAX. RAD.
M	.655—.675	1.66—1.71
N	1.177—1.197	2.99—3.04
P	.038—.043 DIA.	0.10—0.11 DIA.

TO-3



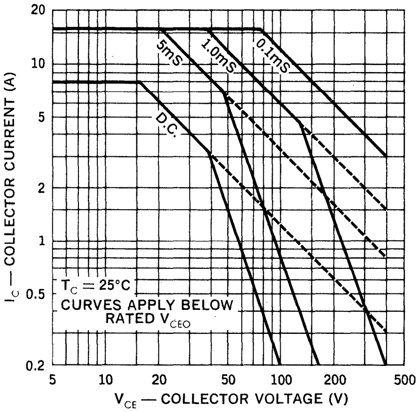
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	UMT1008		UMT1009		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	12	60	12	60		$I_C = 2.5A, V_{CE} = 3V$
D.C. Current Gain (Note 1)	h_{FE}	7	35	7	35		$I_C = 5.0A, V_{CE} = 3V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.5	—	1.5	V	$I_C = 5.0A, I_B = 1.0A$
Collector Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{CE\,(sat)}$	—	2.5	—	2.5	V	$I_C = 5.0A, I_B = 1.0A$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	5.0	—	5.0	V	$I_C = 8.0A, I_B = 2.0A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.6	—	1.6	V	$I_C = 5.0A, I_B = 1.0A$
Base Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{BE\,(sat)}$	—	1.6	—	1.6	V	$I_C = 5.0A, I_B = 1.0A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	300	—	400	—	V	$I_C = 0.1A$
Collector-Emitter Sustaining Voltage $T_C = 100°C$ (Note 2)	$V_{CEX\,(sus)}$	350	—	450	—	V	$I_C = 5.0A, L = 180\mu H$ $I_{B1} = I_{B2} = 1A$ V_{CE} clamp = rated $V_{CEX\,(SUS)}$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	—	0.5	—	—	mA	$V_{CE} = 400V, V_{BE} = -1.5V$
		—	—	—	0.5		$V_{CE} = 500V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	—	2.5	—	—	mA	$V_{CE} = 400V, V_{BE} = -1.5V$
		—	—	—	2.5		$V_{CE} = 500V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CER}	—	3.0	—	—	mA	$V_{CE} = 400V, R_{BE} = 50\Omega$
		—	—	—	3.0		$V_{CE} = 500V, R_{BE} = 50\Omega$
Output Capacitance, Common Base	C_{obo}	100	200	100	200	pF	$V_{CB} = 10V, f = 1$ MHz
Gain-Bandwidth Product	F_T	6	30	6	30	MHz	$V_{CE} = 10V, I_C = 0.3A, f = 1$ MHz
Energy Second Breakdown (unclamped)	$E_{S/b}$	1500	—	1500	—	μJ	$I_C = 5.0A$ $I_{B1} = 1A$ $L = 120\mu H$ unclamped
Resistive Switching Speeds							
Delay Time	t_d	—	0.1	—	0.1	μs	$I_C = 5.0A$
Rise Time	t_r	—	0.4	—	0.4		$V_{CC} = 200V$
Storage Time	t_s	—	4.0	—	4.0		$I_{B1} = I_{B2} = 1.0A$
Fall Time	t_f	—	0.4	—	0.4		$V_{BE\,(off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$							$I_C = 5.0A, L = 180\mu H$
Storage Time	t_s	—	4.0	—	4.0	μs	$I_{B1} = I_{B2} = 1A$
Fall Time	t_f	—	0.4	—	0.4		V_{CE} clamp = rated $V_{CEX\,(SUS)}$
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	—	1.4	—	1.4	°C/W	

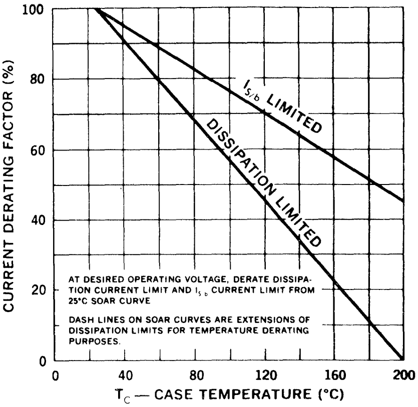
Notes

1. Pulse length = 250 μs; duty cycle $\leqslant 1\%$.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\cong$ 50 μs; duty cycle $\leqslant 1\%$. Voltage clamped at maximum collector-emitter voltage.

Forward Bias Safe Operating Area



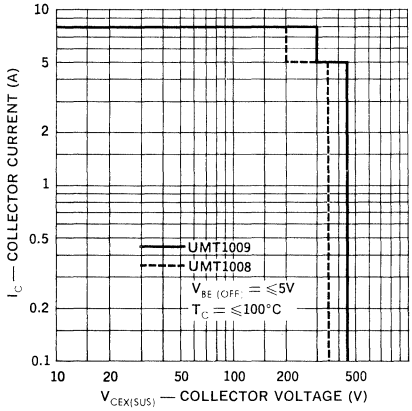
Power Derating



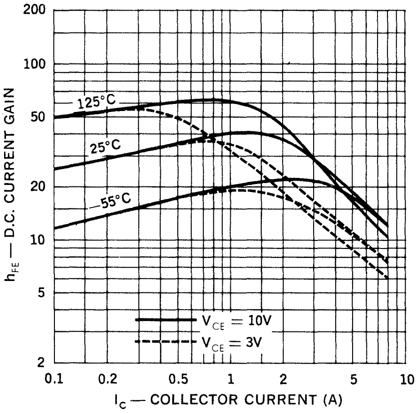
AT DESIRED OPERATING VOLTAGE, DERATE DISSIPATION CURRENT LIMIT AND $I_{S/b}$ CURRENT LIMIT FROM 25°C SOAR CURVE

DASH LINES ON SOAR CURVES ARE EXTENSIONS OF DISSIPATION LIMITS FOR TEMPERATURE DERATING PURPOSES.

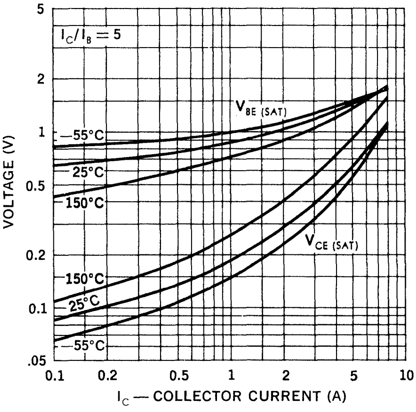
Reverse Biased Safe Operating Area



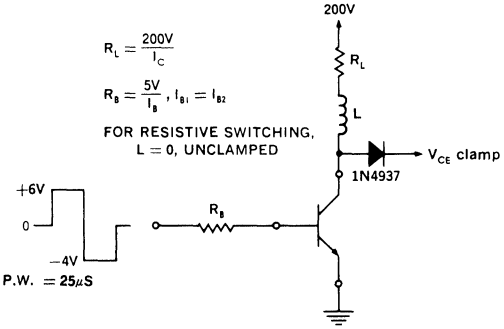
D.C. Current Gain



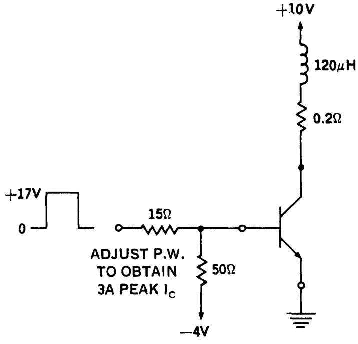
Saturation Voltages



Switching Time, $V_{CEX(sus)}$ Test Circuit

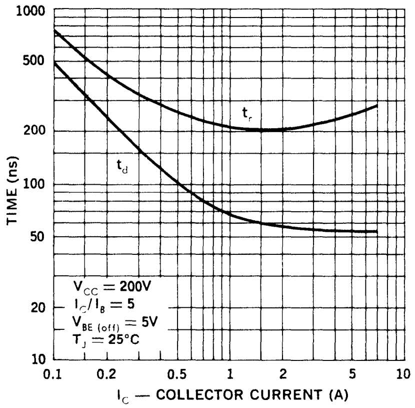


$E_{s/b}$ Test Circuit

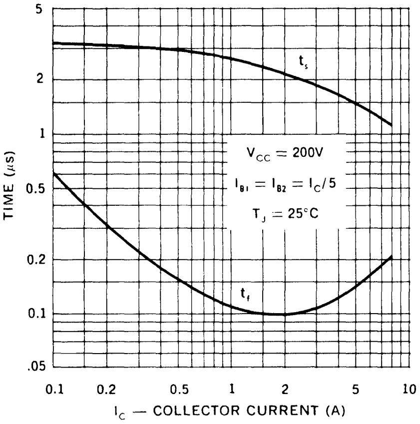


IV

Turn-On Time



Turn-Off Time



POWER TRANSISTORS

UMT1011
UMT1012

15A, 500V, Fast Switching, High $E_{S/b}$
Silicon NPN Mesa

FEATURES

- Rise Time: 0.4μS } $I_C = 10A$
- Fall Time: 0.4μS }
- High Second Breakdown Energy: 6000μJ
- Low Saturation Voltage
- Collector Emitter Voltage: up to 500V
- Peak Collector Current: 30A
- Key Parameters characterized at 100°C

DESCRIPTION

These high voltage glass passivated power transistors combine fast switching, low saturation voltage and rugged $E_S/_b$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, ignition systems and deflection circuits.

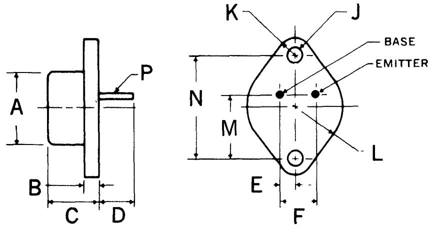
ABSOLUTE MAXIMUM RATINGS

	UMT1011	UMT1012
Collector Emitter Voltage, V_{CEV}	400V	500V
Collector Emitter Voltage, $V_{CEO\ (SUS)}$	300V	400V
Emitter Base Voltage, V_{EBO}	9V	9V
Collector Current, I_C continuous	15A	15A
Collector Current, I_C peak	30A	30A
Base Current, I_B continuous	10A	10A
Power Dissipation, 25°C Case	175W	175W
Derating Factor	1.0W/°C	1.0W/°C
Operating and Storage Temperature Range	−65 to 200°C	

MECHANICAL SPECIFICATIONS

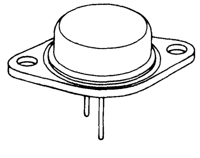
NOTE:
Leads may be soldered to within 1/16" of base provided temperature-time exposure is less than 260°C for 10 seconds.

UMT1011 UMT1012



	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.205-.225	5.21-5.72
F	.420-.440	10.67-11.18
J	.151-.161 DIA.	3.84-4.09 DIA.
K	.188 MAX. RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.655-.675	16.64-17.15
N	1.177-1.197	29.90-30.40
P	.038-.043 DIA.	9.65-10.92 DIA.

TO-3



UNITRODE

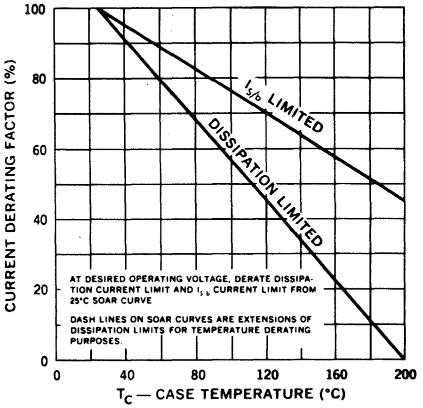
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	UMT1011		UMT1012		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	12	60	12	60		$I_C = 5.0A$, $V_{CE} = 2.0V$
D.C. Current Gain (Note 1)	h_{FE}	6	30	6	30		$I_C = 10A$, $V_{CE} = 2.0V$
Collector Saturation Voltage (Note 1)	$V_{CE\ (sat)}$	—	1.0	—	1.0	V	$I_C = 10A$, $I_B = 2.0A$
Collector Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{CE\ (sat)}$	—	2.0	—	2.0	V	$I_C = 10A$, $I_B = 2.0A$
Collector Saturation Voltage (Note 1)	$V_{CE\ (sat)}$	—	5.0	—	5.0	V	$I_C = 15A$, $I_B = 3.0A$
Base Saturation Voltage (Note 1)	$V_{BE\ (sat)}$	—	1.6	—	1.6	V	$I_C = 10A$, $I_B = 2.0A$
Base Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{BE\ (sat)}$	—	1.6	—	1.6	V	$I_C = 10A$, $I_B = 2.0A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\ (sus)}$	300	—	400	—	V	$I_C = 0.1A$, $I_B = 0$
Collector-Emitter Sustaining Voltage $T_C = 100°C$ (Note 2)	$V_{CEX\ (sus)}$	350	—	450	—	V	$I_C = 8.0A$, $L = 180\mu H$ $I_{B1} = I_{B2} = 2.0A$ V_{CE} clamp = rated $V_{CEX\ (sus)}$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	— —	1.0 —	— —	— 1.0	mA	$V_{CE} = 400V$, $V_{BE} = -1.5V$ $V_{CE} = 500V$, $V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	— —	3.0 —	— —	— 3.0	mA	$V_{CE} = 400V$, $V_{BE} = -1.5V$ $V_{CE} = 500V$, $V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CER}	— —	3.0 —	— —	— 3.0	mA	$V_{CE} = 400V$, $R_{BE} = 50\Omega$ $V_{CE} = 500V$, $R_{BE} = 50\Omega$
Output Capacitance, Common Base	C_{obo}	180	360	180	360	pF	$V_{CB} = 10V$, $f = 1$ MHz
Gain-Bandwidth Product	F_T	6	24	6	24	MHz	$V_{CE} = 10V$, $I_C = 0.5A$, $f = 1$ MHz
Energy Second Breakdown (unclamped)	$E_{s/b}$	6000	—	6000	—	μJ	$I_C = 10A$, $V_{BE\ (off)} = -4V$ $L = 120\mu H$ unclamped
Resistive Switching Speeds Delay Time Rise Time Storage Time Fall Time	 t_d t_r t_s t_f	 — — — —	 .05 0.4 4.0 0.4	 — — — —	 .05 0.4 4.0 0.4	μS	$I_C = 10A$ $V_{CC} = 200V$ $I_{B1} = I_{B2} = 2.0A$ $V_{BE\ (off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$ Storage Time Fall Time	 t_s t_f	 — —	 4.0 0.4	 — —	 4.0 0.4	μS	$I_C = 10A$, $L = 180\mu H$ $I_{B1} = I_{B2} = 2.0A$ V_{CE} clamp = rated $V_{CEX\ (sus)}$
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	—	1.0	—	1.0	°C/W	

Notes

1. Pulse length $= 250\mu S$; duty cycle $\leqslant 1\%$.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\cong 50\mu S$; duty cycle $\leqslant 1\%$. Voltage clamped at maximum collector-emitter voltage.

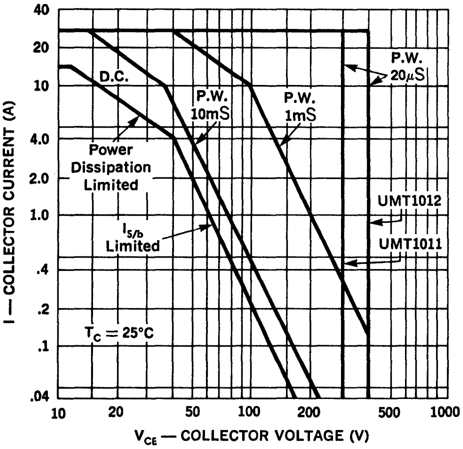
Power Derating



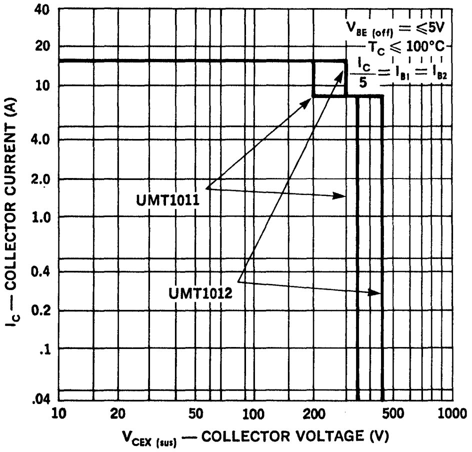
AT DESIRED OPERATING VOLTAGE, DERATE DISSIPATION CURRENT LIMIT AND $I_{S/b}$ CURRENT LIMIT FROM 25°C SOAR CURVE

DASH LINES ON SOAR CURVES ARE EXTENSIONS OF DISSIPATION LIMITS FOR TEMPERATURE DERATING PURPOSES.

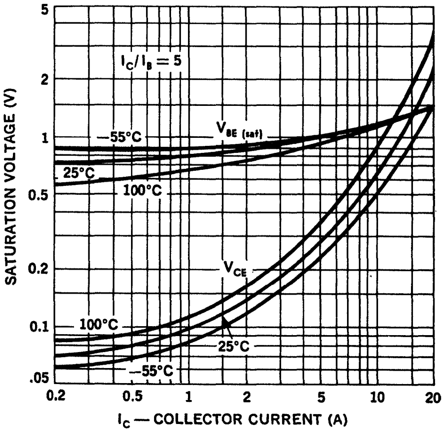
Forward Bias Safe Operating Area



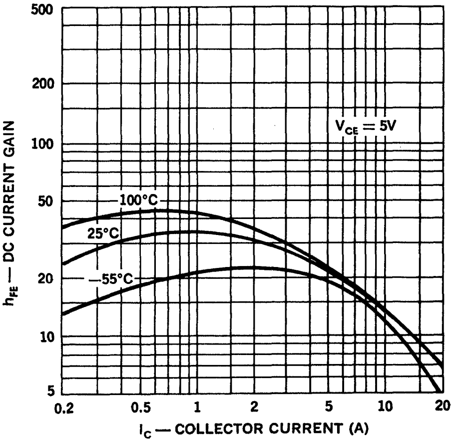
Reverse Biased Safe Operating Area



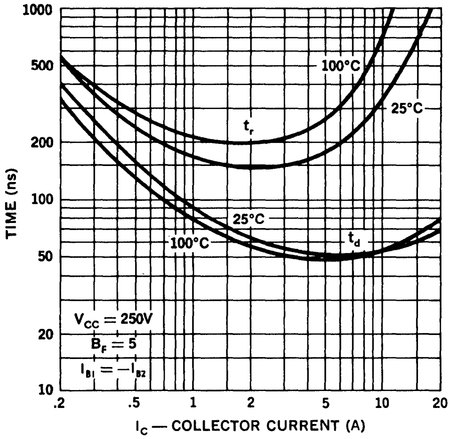
DC Current Gain



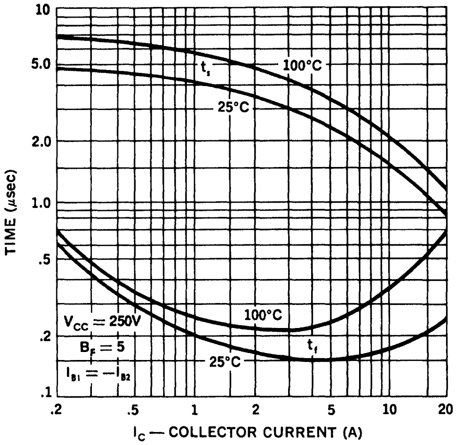
Saturation Voltages



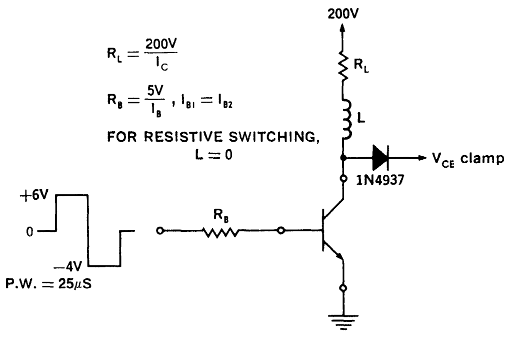
Resistive Turn-On Time



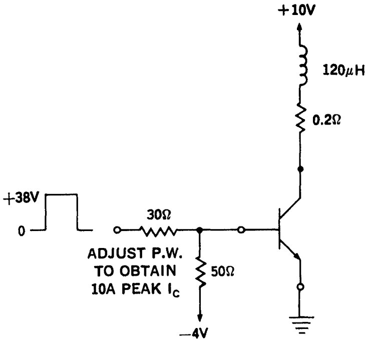
Resistive Turn-Off Time



Switching Time, $V_{CEX\,(sus)}$ Test Circuit



$E_s/_b$ Test Circuit



POWER TRANSISTORS

3 Amp, 500V, Fast Switching Silicon NPN Mesa

UMT1203
UMT1204

FEATURES

- Collector Emitter Voltage: up to 500V
- Peak Collector Current: 5A
- Rise Time: $\leqslant 1.0\mu s$ } at $I_C = 2A$
- Fall Time: $\leqslant 0.7\mu s$
- Key Parameters characterized at 100°C
- Economical Plastic Molded Construction

DESCRIPTION

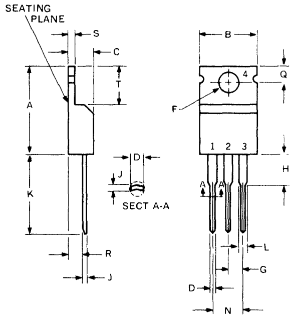
These high voltage triple diffused glass passivated power transistors, in a plastic TO-220 package, combine fast switching, low saturation voltage and rugged $E_{s/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, deflection circuits, motor controls and solenoid/relay drivers.

ABSOLUTE MAXIMUM RATINGS

	UMT1203	UMT1204
Collector Emitter Voltage, V_{CEV}	400V	500V
Collector Emitter Voltage, $V_{CEO\,(SUS)}$	300V	400V
Emitter Base Voltage, V_{EBO}	7V	7V
Collector Current, I_C continuous	3A	3A
Collector Current, I_{CM} peak	5A	5A
Base Current, I_B continuous	1A	1A
Power Dissipation, 25°C Case	40W	40W
Derating Factor	0.32W/°C	0.32W/°C
Operating and Storage Temperature Range	—65 to 150°C	

MECHANICAL SPECIFICATIONS

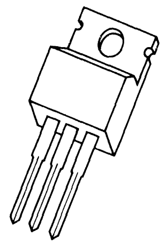
UMT1203, UMT1204



PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H		6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

TO-220



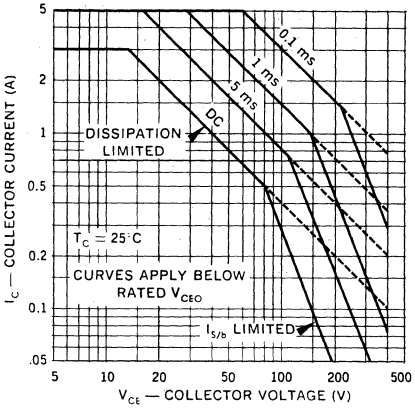
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

		UMT1203		UMT1204			
Test	Symbol	MIN.	MAX.	MIN.	MAX.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	12	60	12	60		$I_C = 1.0A$, $V_{CE} = 3V$
D.C. Current Gain (Note 1)	h_{FE}	7	35	7	35		$I_C = 2.0A$, $V_{CE} = 3V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.2	—	1.2	V	$I_C = 2.0A$, $I_B = 0.4A$
Collector Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{CE\,(sat)}$	—	1.5	—	1.5	V	$I_C = 2.0A$, $I_B = 0.4A$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	3.0	—	3.0	V	$I_C = 3.0A$, $I_B = 0.75A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.3	—	1.3	V	$I_C = 2.0A$, $I_B = 0.4A$
Base Saturation Voltage, $T_C = 100°C$ (Note 1)	$V_{BE\,(sat)}$	—	1.5	—	1.5	V	$I_C = 2.0A$, $I_B = 0.4A$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	300	—	400	—	V	$I_C = 0.1A$
Collector-Emitter Sustaining Voltage $T_C = 100°C$ (Note 2)	$V_{CEX\,(sus)}$	350	—	450	—	V	$I_C = 2.0A$, $L = 500\mu H$ $I_{B1} = I_{B2} = 0.4A$ V_{CE} clamp = rated $V_{CEX\,(sus)}$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 7V$
Collector Cutoff Current	I_{CEV}	—	0.5	—	—	mA	$V_{CE} = 400V$, $V_{BE} = -1.5V$
		—	—	—	0.5		$V_{CE} = 500V$, $V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	—	2.5	—	—	mA	$V_{CE} = 400V$, $V_{BE} = -1.5V$
		—	—	—	2.5		$V_{CE} = 500V$, $V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CER}	—	3.0	—	—	mA	$V_{CE} = 400V$, $R = 50\Omega$
		—	—	—	3.0		$V_{CE} = 500V$, $R = 50\Omega$
Output Capacitance, Common Base	C_{obo}	35	100	35	100	pF	$V_{CB} = 10V$, $f = 1$ MHz
Gain-Bandwidth Product	F_T	6	30	6	30	MHz	$V_{CE} = 10V$, $I_C = 0.3A$, $f = 1$ MHz
Energy Second Breakdown (unclamped)	$E_{s/b}$	80	—	80	—	μJ	$I_C = 2.0A$ $I_{B1} = 0.4A$ $L = 40\mu H$ unclamped
Resistive Switching Speeds							
Delay Time	t_d	—	0.1	—	0.1	μs	$I_C = 2.0A$
Rise Time	t_r	—	1.0	—	1.0		$V_{CC} = 200V$
Storage Time	t_s	—	4.0	—	4.0		$I_{B1} = I_{B2} = 0.4A$
Fall Time	t_f	—	0.7	—	0.7		$V_{BE\,(off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$							$I_C = 2.0A$, $L = 500\mu H$
Storage Time	t_s	—	4.0	—	4.0	μs	$I_{B1} = I_{B2} = 0.4A$
Fall Time	t_f	—	0.9	—	0.9		V_{CE} clamp = rated $V_{CEX\,(sus)}$
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	—	3.12	—	3.12	°C/W	

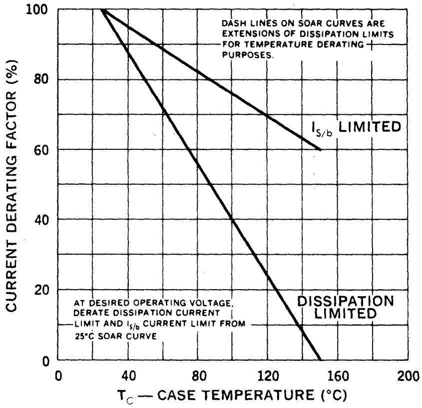
Notes

1. Pulse length = 250 μs; duty cycle $\leqslant 1\%$.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\cong$ 50 μs; duty cycle $\leqslant 1\%$. Voltage clamped at maximum collector-emitter voltage.

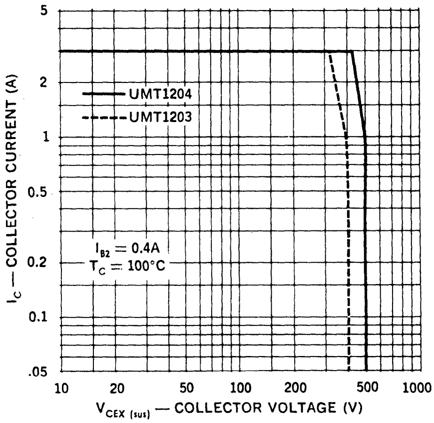
Forward Bias Safe Operating Area



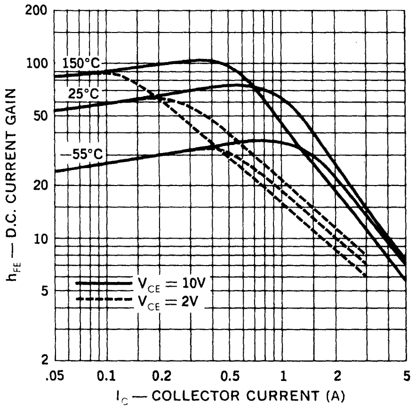
Power Derating



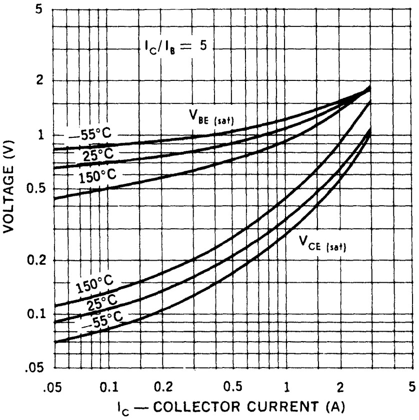
Reverse Biased Safe Operating Area



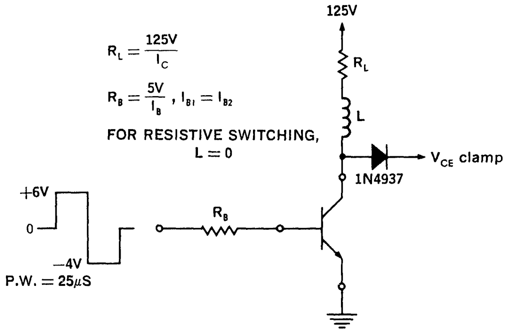
D.C. Current Gain



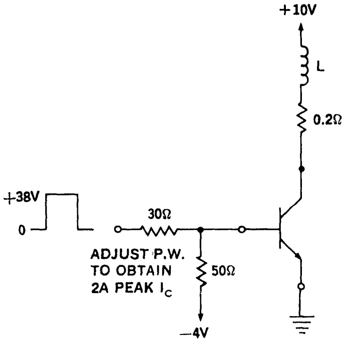
Saturation Voltages



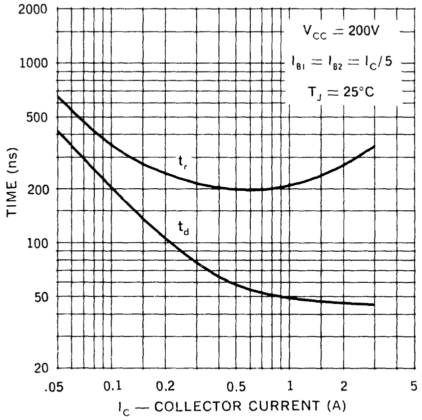
Switching Time Test Circuit



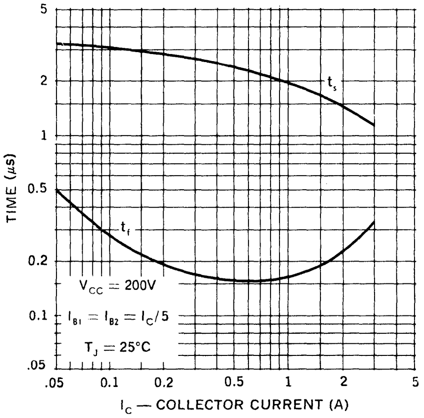
$E_{s/b}$ Test Circuit



Resistive Turn-On Time



Resistive Turn-Off Time



POWER TRANSISTORS

2 Amp, 500V, Fast Switching Silicon NPN Mesa

UMT3584
UMT3585

FEATURES

- Collector Base Voltage: up to 500V
- Peak Collector Current: 5A
- Rise Time ⩽ 3μs } $I_C = 1A$
- Fall Time ⩽ 3μs } $I_C = 1A$
- Economical Plastic Molded Construction

DESCRIPTION

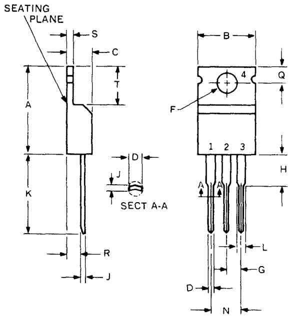
These high voltage triple diffused glass passivated power transistors in a plastic TO-220 package combine fast switching, low saturation voltage and rugged $E_{S/b}$ capability. They are designed for use in off-line switching regulators, converters, inverters and deflection circuitry.

ABSOLUTE MAXIMUM RATINGS

	UMT3584	UMT3585
Collector Base Voltage, V_{CBO}	375V	500V
Collector Emitter Voltage, $V_{CEO\,(SUS)}$	250V	300V
Emitter Base Voltage, V_{EBO}	6V	6V
Collector Current, I_C continuous	2A	2A
I_{CM} peak	5A	5A
D.C. Base Current, continuous	1A	1A
Power Dissipation, P_T 25°C Case	35W	35W
Operating and Storage Temperature Range	−65 to +150°C	

MECHANICAL SPECIFICATIONS

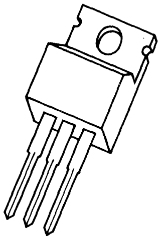
UMT3584, UMT3585



PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H		6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

TO-220



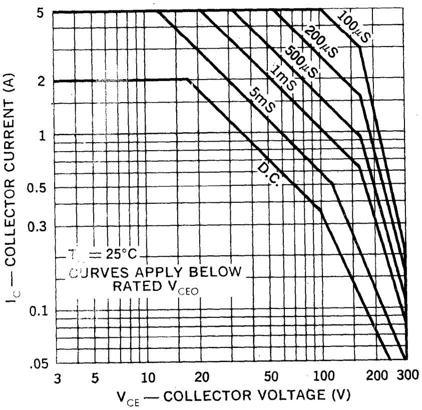
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	UMT3584		UMT3585		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	40	—	40	—		$I_C = 100mA, V_{CE} = 10V$
		8	80	8	80		$I_C = 1A, V_{CE} = 2V$
		25	100	25	100		$I_C = 1A, V_{CE} = 10V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	0.75	—	0.75	V	$I_C = 1A, I_B = 125mA$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.4	—	1.4	V	$I_C = 1A, I_B = 100mA$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	250	—	300	—	V	$I_C = 200mA$
Collector-Emitter Sustaining Voltage (See Note 2)	$V_{CER\,(sus)}$	300	—	400	—	V	$I_C = 200mA$ $R_{BE} = 200\Omega$
Emitter Cutoff Current	I_{EBO}	—	0.5	—	0.5	mA	$V_{BE} = -6V$
Collector-Cutoff Current	I_{CEO}	—	5.0	—	5.0	mA	$V_{CE} = 150V$
Collector-Cutoff Current	I_{CEV}	—	1.0	—	—	mA	$V_{CE} = 340V, V_{BE} = -1.5V$
		—	—	—	1.0		$V_{CE} = 450V, V_{BE} = -1.5V$
Collector Cutoff Current, 150°C	I_{CEV}	—	3.0	—	3.0	mA	$V_{CE} = 300V, V_{BE} = -1.5V$
Small Signal Forward Transfer Ratio	h_{fe}	3	—	3	—	—	$I_C = 200mA, V_{CE} = 10V$ $f = 5$ MHz
Collector Capacitance	C_{ob}	—	120	—	120	pF	$V_{CB} = 10V, f = 1$ MHz
Second Breakdown Collector Current	$I_{S/b}$	350	—	350	—	mA	$V_{CE} = 100V$
Second Breakdown Energy	$E_{S/b}$	200	—	200	—	μJ	$I_C = 2A$ $R_{BE} = 20\Omega$ $L = 100\mu H$
Switching Speeds							
Rise Time	t_r	—	3.0	—	3.0	μs	$I_C = 1A$
Storage Time	t_s	—	4.0	—	4.0		$I_{B1} = I_{B2} = 100mA$
Fall Time	t_f	—	3.0	—	3.0		$V_{CC} = 200V$
Thermal Resistance: Junction-to-Case	$R_{\theta JC}$	—	3.57	—	3.57	°C/W	
Junction-to-Ambient	$R_{\theta JA}$	—	70	—	70	°C/W	

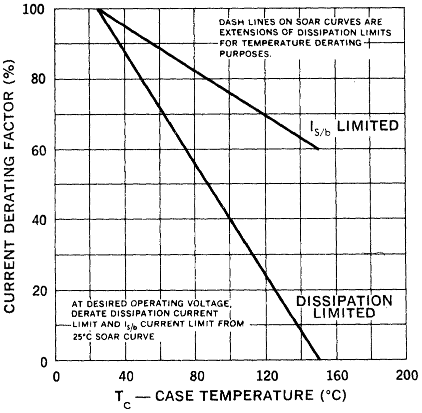
Notes

1. Pulse length = 250 μs; duty cycle $\leq$1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\cong$ 50 μs; duty cycle $\leq$1%. Voltage clamped at maximum collector-emitter voltage.

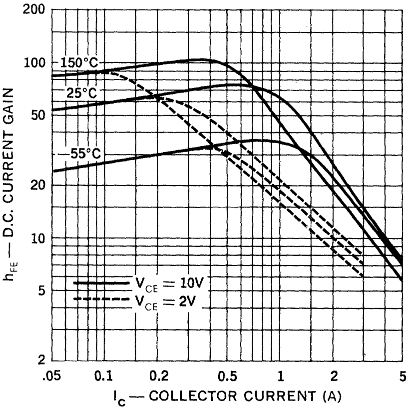
Forward Bias Safe Operating Area



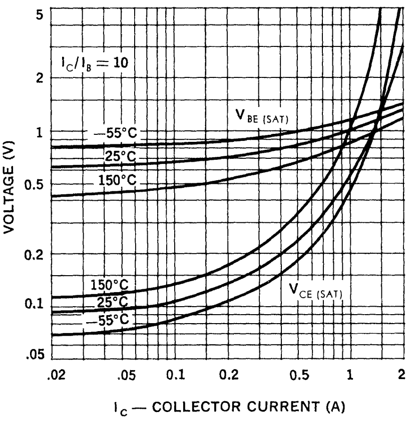
Power Derating



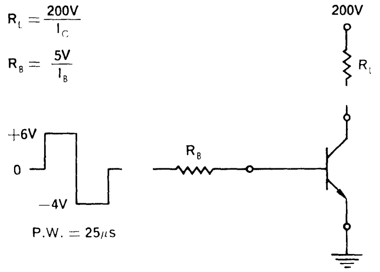
D.C. Current Gain



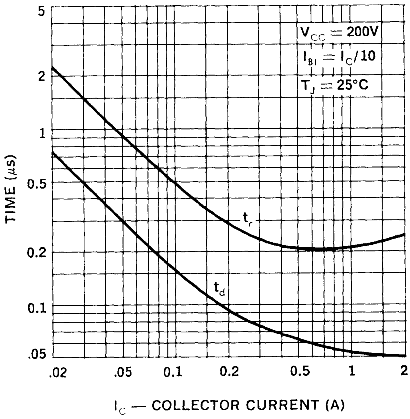
Saturation Voltages



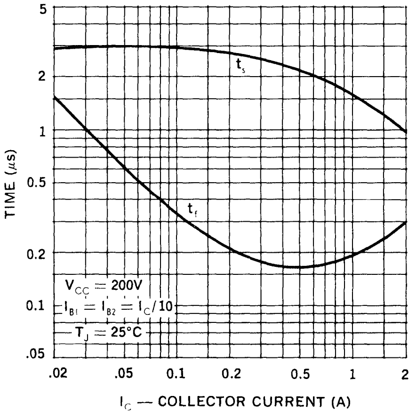
Switching Time Test Circuit



Turn-On Time



Turn-Off Time



POWER TRANSISTORS
4A, 700V, Fast Switching, Silicon NPN Mesa

UMT13004
UMT13005

FEATURES
- Collector Emitter Voltage: up to 700V
- Peak Collector Current: 8A
- Rise Time: $\leqslant .7\mu S$ } at $I_C = 2A$
- Fall Time: $\leqslant 0.9\mu S$ } at $I_C = 2A$
- Key Parameters characterized at 100°C
- Economical Plastic Molded Construction

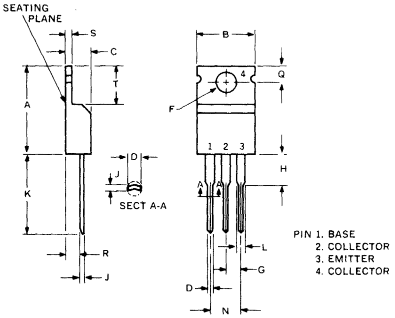
DESCRIPTION
These high voltage glass passivated power transistors, in a plastic TO-220 package, combine fast switching, low saturation voltage and rugged $E_{s/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, deflection circuits, motor controls and solenoid/relay drivers.

ABSOLUTE MAXIMUM RATINGS

	UMT13004	**UMT13005**
Collector Emitter Voltage, V_{CEV}	600V	700V
Collector Emitter Voltage, $V_{CEO\ (SUS)}$	300V	400V
Emitter Base Voltage, V_{EBO}	9V	9V
Collector Current, I_C continuous	4A	4A
Collector Current, I_{CM} peak	8A	8A
Base Current, I_B continuous	2A	2A
Power Dissipation, 25°C Case	75W	75W
Derating Factor	0.59W/°C	0.59W/°C
Operating and Storage Temperature Range	−65 to 150°C	

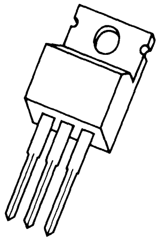
MECHANICAL SPECIFICATIONS

UMT13004, UMT13005



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H		6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

TO-220



UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	UMT13004		UMT13005		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	10	60	10	60		$I_C = 1.0A, V_{CE} = 5V$
D.C. Current Gain (Note 1)	h_{FE}	8	40	8	40		$I_C = 2.0A, V_{CE} = 5V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	.5	—	.5	V	$I_C = 1.0A, I_B = 0.2A$
Collector Saturation Voltage (Note 1) $T_C = 25°C$	$V_{CE\,(sat)}$	—	0.6	—	0.6	V	$I_C = 2.0A, I_B = 0.5A$
$T_C = 100°C$		—	1.0	—	1.0		
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.0	—	1.0	V	$I_C = 4.0A, I_B = 1.0A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.2	—	1.2	V	$I_C = 1.0A, I_B = 0.2A$
Base Saturation Voltage (Note 1) $T_C = 25°C$	$V_{BE\,(sat)}$	—	1.6	—	1.6	V	$I_C = 2.0A, I_B = 0.5A$
$T_C = 100°C$		—	1.5	—	1.5		
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	300	—	400	—	V	$I_C = 1\ mA$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	—	1	—	—	mA	$V_{CE} = 600V, V_{BE} = -1.5V$
		—	—	—	1		$V_{CE} = 700V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	—	5	—	—	mA	$V_{CE} = 600V, V_{BE} = -1.5V$
		—	—	—	5		$V_{CE} = 700V, V_{BE} = -1.5V$
Output Capacitance, Common Base	C_{obo}	65 typ.		65 typ.		pF	$V_{CB} = 10V, f = 1\ MHz$
Gain-Bandwidth Product	F_T	4	—	4	—	MHz	$V_{CE} = 10V, I_C = .5A, f = 1\ MHz$
Resistive Switching Speeds							
Delay Time	t_d	—	0.1	—	0.1	μS	$I_C = 2.0A$
Rise Time	t_r	—	0.7	—	0.7		$V_{CC} = 125V$
Storage Time	t_s	—	3.5	—	3.5		$I_{B1} = I_{B2} = 0.4A$
Fall Time	t_f	—	0.9	—	0.9		$V_{BE\,(off)} = 5V$, P.W. $= 25\mu S$
Inductive Switching Speeds $T_C = 100°C$							$I_C = 2.0A, L = 500\mu H$
Storage Time	t_s	—	4.0	—	4.0	μS	$I_{B1} = 0.4A, V_{BE\,(off)} = 5V$
Fall Time $(t_{fi} + t_{fv})$	t_f	—	0.9	—	0.9		V_{CE} clamp = rated $V_{CEX\,(sus)}$
Thermal Resistance, Junction-to-Case	$R_{\Theta JC}$	—	1.67	—	1.67	°C/W	
Thermal Resistance, Junction-to-Ambient	$R_{\Theta JA}$	—	62.5	—	62.5	°C/W	

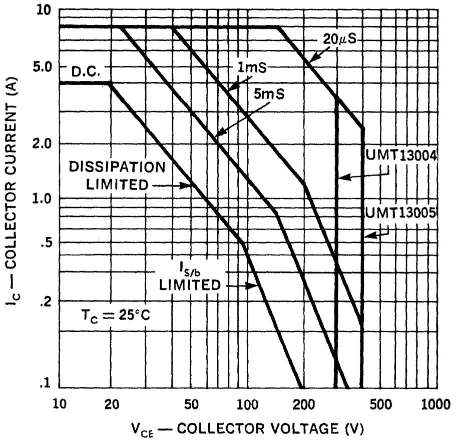
Notes

1. Pulse length $= 250\mu S$; duty cycle $\leqslant 1\%$.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\cong 50\mu S$; duty cycle $\leqslant 1\%$. Voltage clamped at maximum collector-emitter voltage.

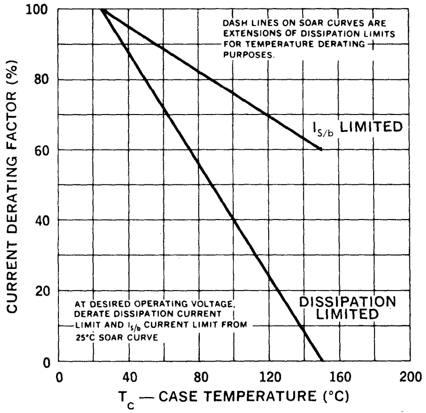
Typical Inductive Load Switching Performance

I_C Amps	T_J °C	t_s μS	t_{fv} nS	t_{fi} nS
0.5	25	1.8	180	20
	100	1.2	240	30
1.0	25	1.0	160	21
	100	1.5	220	30
2.0	25	1.2	180	25
	100	1.7	230	35

Forward Bias Safe Operating Area



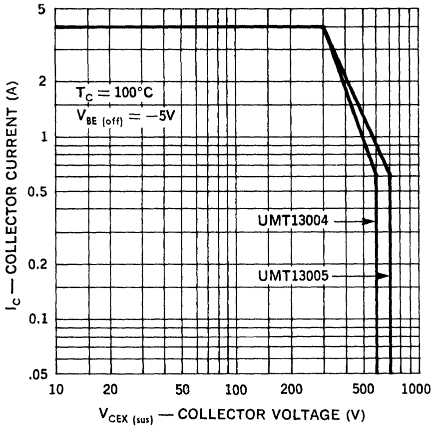
Power Derating



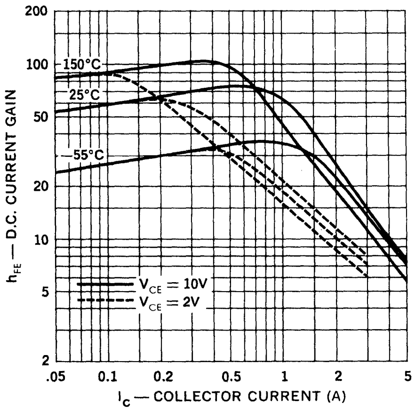
DASH LINES ON SOAR CURVES ARE EXTENSIONS OF DISSIPATION LIMITS FOR TEMPERATURE DERATING PURPOSES.

AT DESIRED OPERATING VOLTAGE, DERATE DISSIPATION CURRENT LIMIT AND $I_{S/b}$ CURRENT LIMIT FROM 25°C SOAR CURVE

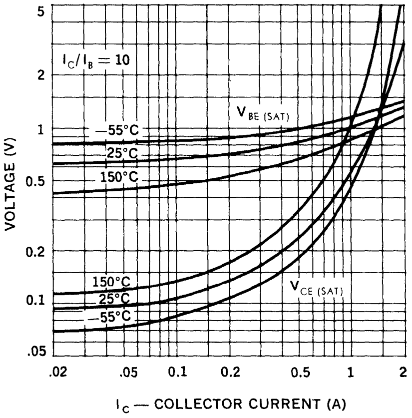
Reverse Biased Safe Operating Area

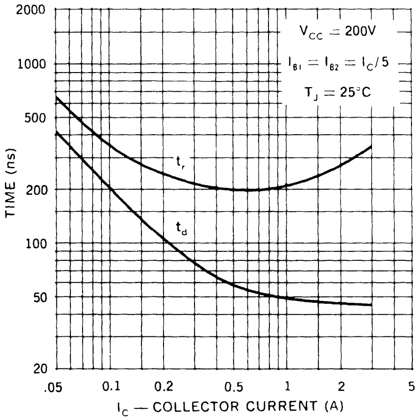


D.C. Current Gain

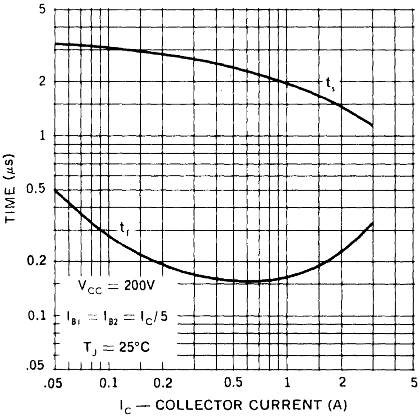


Saturation Voltages

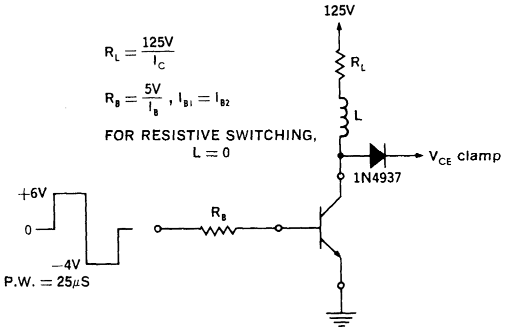




Resistive Turn-On Time



Resistive Turn-Off Time



Switching Time
Test Circuit

POWER TRANSISTORS

8A, 700V, Fast Switching, Silicon NPN Mesa

UMT13006
UMT13007

FEATURES

- Collector Emitter Voltage: up to 700V
- Peak Collector Current: 16A
- Rise Time: $\leqslant 1.0\mu S$ } at $I_C = 5A$
- Fall Time: $\leqslant 0.7\mu S$ }
- Key Parameters characterized at 100°C
- Economical Plastic Molded Construction

DESCRIPTION

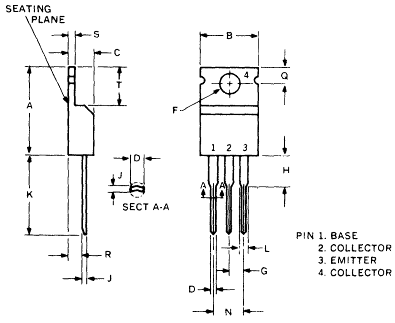
These high voltage glass passivated power transistors, in a plastic TO-220 package, combine fast switching, low saturation voltage and rugged $E_{s/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, deflection circuits, motor controls and solenoid/relay drivers.

ABSOLUTE MAXIMUM RATINGS

	UMT13006	**UMT13007**
Collector Emitter Voltage, V_{CEV}	600V	700V
Collector Emitter Voltage, $V_{CEO\ (SUS)}$	300V	400V
Emitter Base Voltage, V_{EBO}	8V	8V
Collector Current, I_C continuous	8A	8A
Collector Current, I_{CM} peak	16A	16A
Base Current, I_B continuous	4A	4A
Power Dissipation, 25°C Case	80W	80W
Derating Factor	0.641W/°C	0.641W/°C
Operating and Storage Temperature Range	−65 to 150°C	

MECHANICAL SPECIFICATIONS

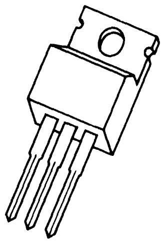
UMT13006, UMT13007



PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H		6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

TO-220



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	UMT13006		UMT13007		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	8	40	8	40		$I_C = 2.0A, V_{CE} = 5V$
D.C. Current Gain (Note 1)	h_{FE}	6	30	6	30		$I_C = 5.0A, V_{CE} = 5V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.0	—	1.0	V	$I_C = 2.0A, I_B = 0.4A$
Collector Saturation Voltage (Note 1) $T_C = 25°C$	$V_{CE\,(sat)}$	—	1.5	—	1.5	V	$I_C = 5.0A, I_B = 1.0A$
$T_C = 100°C$		—	2.0	—	2.0		
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	3.0	—	3.0	V	$I_C = 8.0A, I_B = 2.0A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.2	—	1.2	V	$I_C = 2.0A, I_B = 0.4A$
Base Saturation Voltage (Note 1) $T_C = 25°C$	$V_{BE\,(sat)}$	—	1.6	—	1.6	V	$I_C = 5.0A, I_B = 1.0A$
$T_C = 100°C$		—	1.5	—	1.5		
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	300	—	400	—	V	$I_C = 10mA$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	—	1.0	—	—	mA	$V_{CE} = 600V, V_{BE} = -1.5V$
		—	—	—	1.0		$V_{CE} = 700V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	—	5	—	—	mA	$V_{CE} = 600V, V_{BE} = -1.5V$
		—	—	—	5		$V_{CE} = 700V, V_{BE} = -1.5V$
Output Capacitance, Common Base	C_{obo}	110 typ.		110 typ.		pF	$V_{CB} = 10V, f = 1$ MHz
Gain-Bandwidth Product	F_T	4	—	4	—	MHz	$V_{CE} = 10V, I_C = 0.5A, f = 1$ MHz
Resistive Switching Speeds Delay Time Rise Time Storage Time Fall Time	t_d t_r t_s t_f	— — — —	0.1 1.0 3.0 0.7	— — — —	0.1 1.0 3.0 0.7	µS	$I_C = 5.0A$ $V_{CC} = 125V$ $I_{B1} = I_{B2} = 1A$ $V_{BE\,(off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$ Storage Time Fall Time ($t_{fi} + t_{fv}$)	t_s t_f	— —	2.3 0.7	— —	2.3 0.7	µS	$I_C = 5.0A, V_{BE\,(off)} = 5V$ $I_{B1} = 1A$ V_{CE} clamp = rated $V_{CEX\,(sus)}$
Thermal Resistance, Junction-to-Case	$R_{\Theta JC}$	—	1.56	—	1.56	°C/W	
Thermal Resistance, Junction-to-Ambient	$R_{\Theta JA}$	—	62.5	—	62.5	°C/W	

Notes

1. Pulse length = 250µS; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50µS; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.

Typical Inductive Load Switching Performance

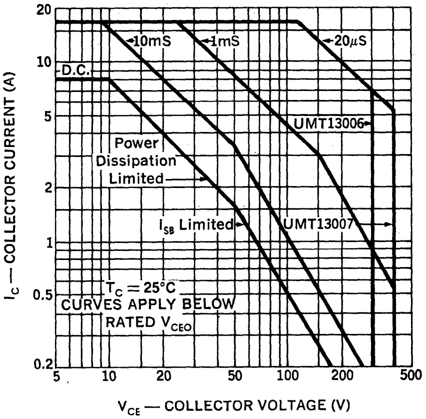
Conditions:

$$\frac{I_C}{I_{B1}} = 5$$

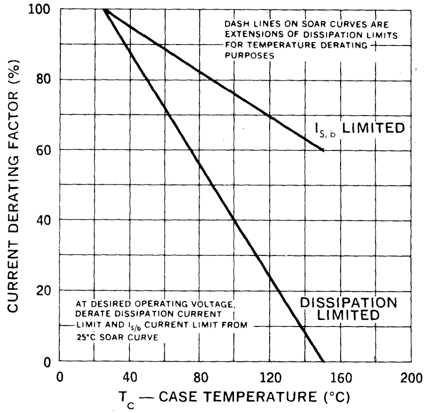
V clamp at rated $V_{CEX\,(sus)}$
(refer to RBSOA curve)
$V_{BE\,(off)} = -5V$

I_C Amps	T_J °C	t_s µS	t_{fv} nS	t_{fi} nS
3.0	25	.45	70	10
	100	.575	100	20
5.0	25	.475	25	4
	100	.60	45	10
8.0	25	.525	20	10
	100	.625	45	15

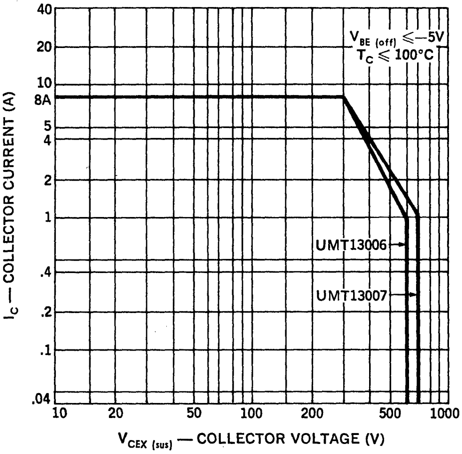
Forward Bias Safe Operating Area



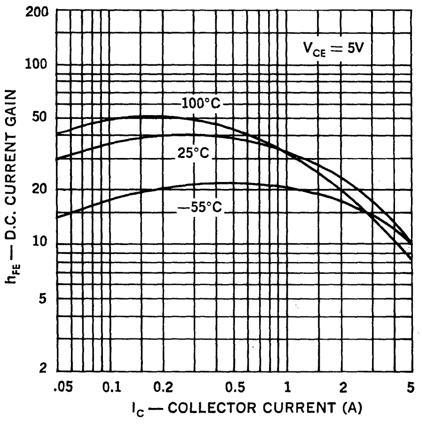
Power Derating



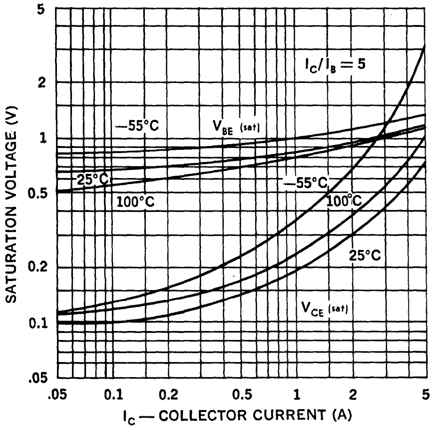
Reverse Biased Safe Operating Area



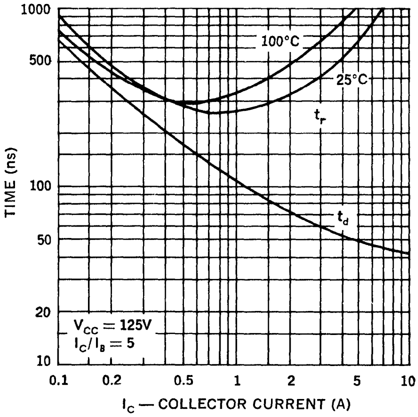
D.C. Current Gain



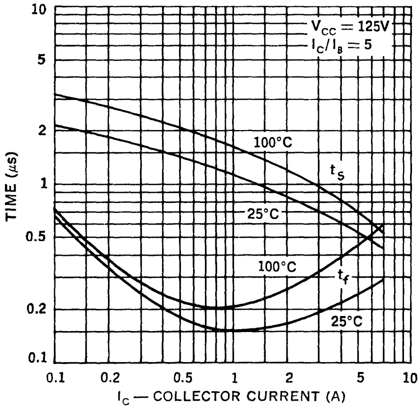
Saturation Voltages



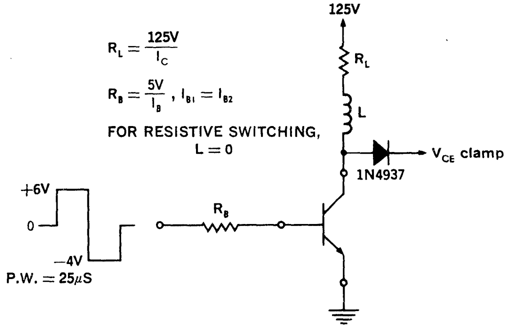
Resistive Turn-On Time



Resistive Turn-Off Time



Switching Time Test Circuit



POWER TRANSISTORS

12A, 700V, Fast Switching, Silicon NPN Mesa

UMT13008
UMT13009

FEATURES

- Collector Emitter Voltage: up to 700V
- Peak Collector Current: 24A
- Rise Time: $\leqslant 1.0\mu S$ } at $I_C = 8A$
- Fall Time: $\leqslant 0.7\mu S$ } at $I_C = 8A$
- Key Parameters characterized at 100°C
- Economical Plastic Molded Construction

DESCRIPTION

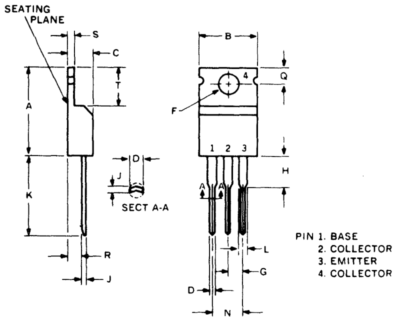
These high voltage glass passivated power transistors, in a plastic TO-220 package, combine fast switching, low saturation voltage and rugged $E_{s/b}$ capability. They are designed for use in off-line power supplies, high voltage inverters, switching regulators, deflection circuits, motor controls and solenoid/relay drivers.

ABSOLUTE MAXIMUM RATINGS

	UMT13008	UMT13009
Collector Emitter Voltage, V_{CEV}	600V	700V
Collector Emitter Voltage, $V_{CEO\ (SUS)}$	300V	400V
Emitter Base Voltage, V_{EBO}	9V	9V
Collector Current, I_C continuous	12A	12A
Collector Current, I_{CM} peak	24A	24A
Base Current, I_B continuous	6A	6A
Power Dissipation, 25°C Case	100W	100W
Derating Factor	0.80W/°C	0.80W/°C
Operating and Storage Temperature Range	−65 to 150°C	

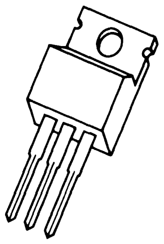
MECHANICAL SPECIFICATIONS

UMT13008 UMT13009



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H		6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

TO-220



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	UMT13008		UMT13009		Units	Test Conditions
		MIN.	MAX.	MIN.	MAX.		
D.C. Current Gain (Note 1)	h_{FE}	8	40	8	40		$I_C = 5.0A, V_{CE} = 5V$
D.C. Current Gain (Note 1)	h_{FE}	6	30	6	30		$I_C = 8.0A, V_{CE} = 5V$
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	1.0	—	1.0	V	$I_C = 5.0A, I_B = 1.0A$
Collector Saturation Voltage (Note 1) $T_C = 25°C$	$V_{CE\,(sat)}$	—	1.5	—	1.5	V	$I_C = 8.0A, I_B = 1.6A$
$T_C = 100°C$		—	2.0	—	2.0		
Collector Saturation Voltage (Note 1)	$V_{CE\,(sat)}$	—	3.0	—	3.0	V	$I_C = 12.0A, I_B = 3A$
Base Saturation Voltage (Note 1)	$V_{BE\,(sat)}$	—	1.2	—	1.2	V	$I_C = 5.0A, I_B = 1.0A$
Base Saturation Voltage (Note 1) $T_C = 25°C$	$V_{BE\,(sat)}$	—	1.6	—	1.6	V	$I_C = 8.0A, I_B = 1.6A$
$T_C = 100°C$		—	1.5	—	1.5		
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO\,(sus)}$	300	—	400	—	V	$I_C = 10mA$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	—	1.0	—	—	mA	$V_{CE} = 600V, V_{BE} = -1.5V$
		—	—	—	1.0		$V_{CE} = 700V, V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	—	5.0	—	—	mA	$V_{CE} = 600V, V_{BE} = -1.5V$
		—	—	—	5.0		$V_{CE} = 700V, V_{BE} = -1.5V$
Output Capacitance, Common Base	C_{obo}	180 typ.		180 typ.		pF	$V_{CB} = 10V, f = 1$ MHz
Gain-Bandwidth Product	F_T	4	—	4	—	MHz	$V_{CE} = 10V, I_C = 0.5A, f = 1$ MHz
Resistive Switching Speeds							
Delay Time	t_d	—	0.1	—	0.1	μS	$I_C = 8.0$
Rise Time	t_r	—	1.0	—	1.0		$V_{CC} = 125V$
Storage Time	t_s	—	3.0	—	3.0		$I_{B1} = I_{B2} = 1.6A$
Fall Time	t_f	—	0.7	—	0.7		$V_{BE\,(off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$							$I_C = 8A, V_{BE\,(off)} = 5V$
Storage Time	t_s	—	2.3	—	2.3	μS	$I_{B1} = 1.6A$
Fall Time ($t_{fi} + t_{fv}$)	t_f	—	0.7	—	0.7		V_{CE} clamp = rated $V_{CEX\,(sus)}$
Thermal Resistance, Junction-to-Case	$R_{\Theta JC}$	—	1.25	—	1.25	°C/W	
Thermal Resistance, Junction-to-Ambient	$R_{\Theta JA}$	—	62.5	—	62.5	°C/W	

Notes

1. Pulse length = 250μS; duty cycle ⩽1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50μS; duty cycle ⩽1%. Voltage clamped at maximum collector-emitter voltage.

Typical Inductive Load Switching Performance

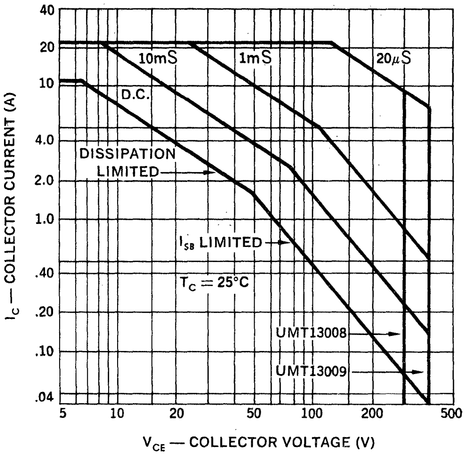
Conditions:

$$\frac{I_C}{I_{B1}} = 5$$

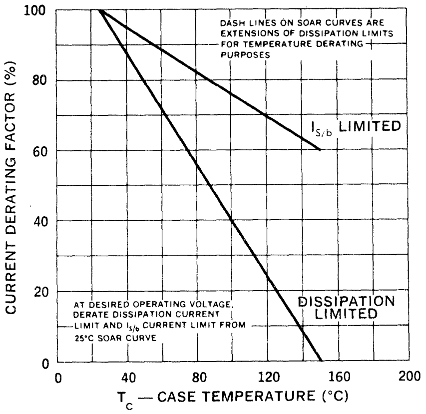
V clamp at rated $V_{CEX\,(sus)}$
(refer to RBSOA curve)
$V_{BE\,(off)} = -5V$

I_C Amps	T_J °C	t_s μS	t_{fv} nS	t_{fi} nS
3.0	25	0.5	100	10
	100	0.85	130	14
5.0	25	0.65	40	10
	100	0.90	50	12
8.0	25	0.72	60	12
	100	.092	65	28
12.0	25	.70	70	25
	100	.78	70	110

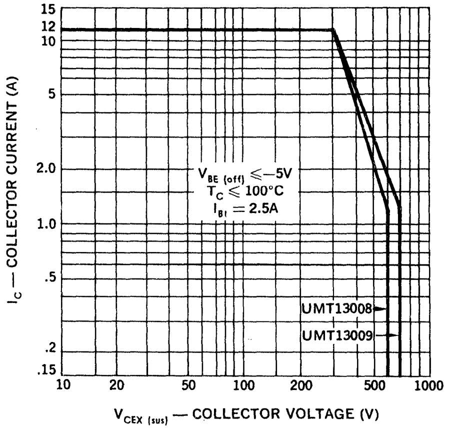
Forward Bias Safe Operating Area



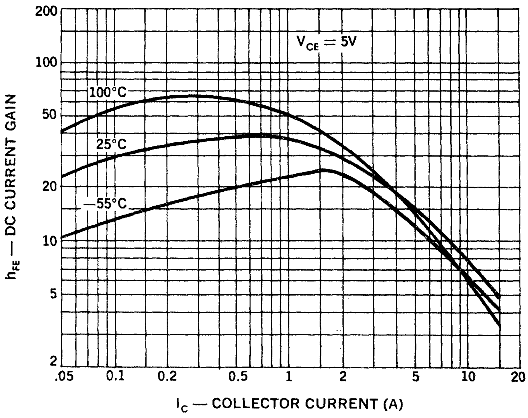
Power Derating



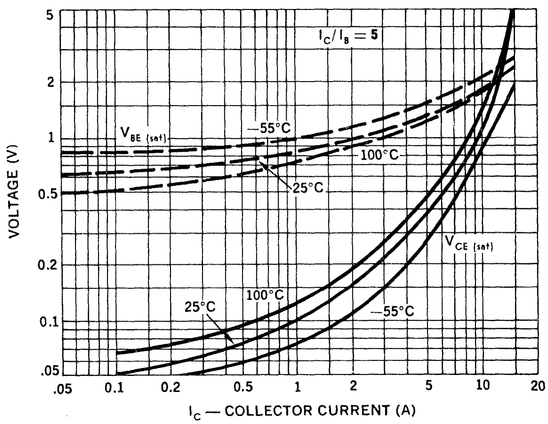
Reverse Biased Safe Operating Area



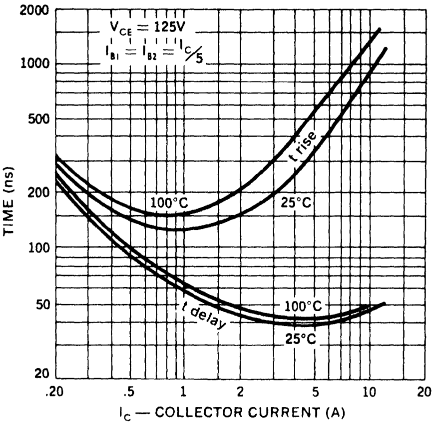
D.C. Current Gain



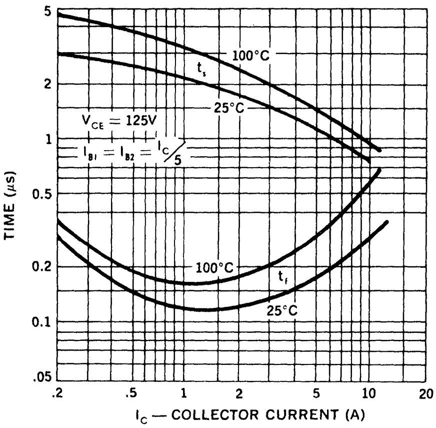
Saturation Voltages



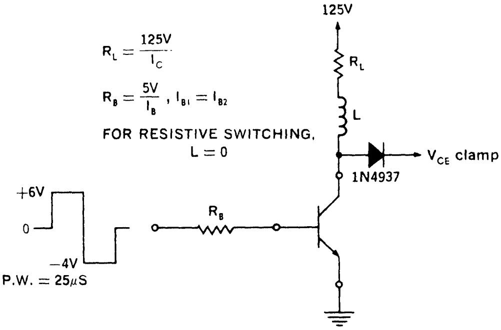
Resistive Turn-On Time



Resistive Turn-Off Time



Switching Time Test Circuit



POWER TRANSISTORS

1 Amp, 150V, Planar NPN

UPT111
UPT112
UPT113
UPT114
UPT115

FEATURES

- Collector-Base Voltage: up to 150V
- Peak Collector Current: 2A
- Turn-on Time: 100ns
- Turn-off Time: 250ns

DESCRIPTION

Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply pulse amplifier and similar high efficiency power switching applications.

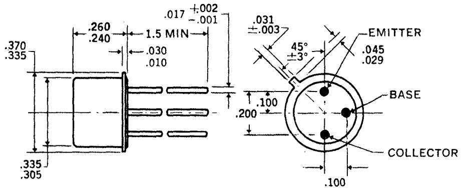
ABSOLUTE MAXIMUM RATINGS

	UPT111	UPT112	UPT113	UPT114	UPT115
Collector-Base Voltage, V_{CBO}	60V	80V	100V	120V	150V
Collector-Emitter Voltage, V_{CEO}	40V	60V	80V	100V	100V
Emitter-Base Voltage, V_{EBO}	5V	5V	5V	5V	5V
D.C. Collector Current, I_C	1A	1A	1A	1A	1A
Peak Collector Current, I_C	2A	2A	2A	2A	2A
Base Current, I_B	0.5A	0.5A	0.5A	0.5A	0.5A

Power Dissipation	UPT111-115	UPT121-125
25°C Ambient	.85W	1.6W
100°C Case	4W	16W
Thermal Resistance, θ_{J-C}	25°C/W	6.7°C/W
Operating and Storage Temperature Range	—65°C to 200°C	—65°C to 200°C

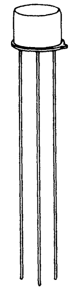
MECHANICAL SPECIFICATIONS

UPT111 UPT112 UPT113 UPT114 UPT115



Dimensions in inches.

TO-5



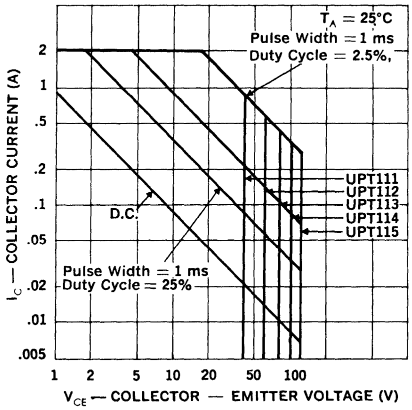
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

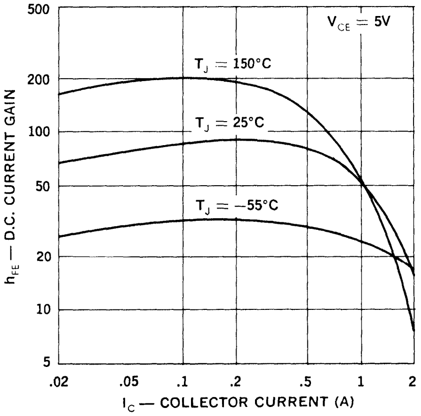
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	30	—	—	$I_C = 0.5A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	20	—	—	$I_C = 1A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	15 Typ.		—	$I_C = 2A, V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.0	Vdc	$I_C = 1A, I_B = 0.1A$
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.2	Vdc	$I_C = 1A, I_B = 0.1A$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}			Vdc	$I_C = 10mAdc; R_{BE} = 100\Omega$
UPT111		60	—		
UPT112		80	—		
UPT113		100	—		
UPT114		120	—		
UPT115		150	—		
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 10mAdc$
UPT111		40	—		
UPT112		60	—		
UPT113		80	—		
UPT114-5		100	—		
Collector-Emitter Cutoff Current	I_{CER}	—	10	μAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$
Collector-Emitter Cutoff Current, 150°C	I_{CER}	—	1.0	mAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$, $T = 150°C$
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	40	pf	$V_{CB} = 10Vdc, I_E = 0, f = 1MHz$
Gain-Bandwidth Product	f_T	50 Typ.		MHz	$I_C = 0.1Adc, V_{CE} = 5Vdc, f = 10MHz$
Switching Speeds Turn-on Time	t_{on}	100 Typ.		ns	$I_C = 1A$
Switching Speeds Turn-off Time	t_{off}	250 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ≤2%.

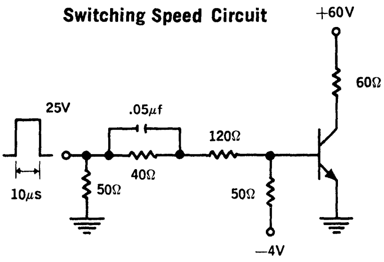
Maximum Safe Operating Area
UPT111 - 115



D.C. Current Gain vs. Collector Current



Switching Speed Circuit



POWER TRANSISTORS

2 Amp, 150V, Planar NPN

UPT211
UPT212
UPT213
UPT214
UPT215

FEATURES

- Collector-Base Voltage: up to 150V
- Peak Collector Current: 5A
- Turn-on Time: 130ns
- Turn-off Time: 300ns

DESCRIPTION

Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply, pulse amplifier and similar high efficiency power switching applications.

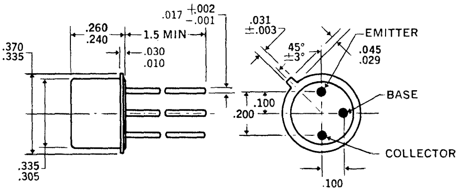
ABSOLUTE MAXIMUM RATINGS

	UPT211	UPT212	UPT213	UPT214	UPT215
Collector-Base Voltage, V_{CBO}	60V	80V	100V	120V	150V
Collector-Emitter Voltage, V_{CEO}	40V	60V	80V	100V	100V
Emitter-Base Voltage, V_{EBO}	5V	5V	5V	5V	5V
D.C. Collector Current, I_C	2A	2A	2A	2A	2A
Peak Collector Current, I_C	5A	5A	5A	5A	5A
Base Current, I_B	1A	1A	1A	1A	1A

	UPT211-215
Power Dissipation	
25°C Ambient	.85W
100°C Case	4W
Thermal Resistance, θ_{J-C}	25°C/W
Operating and Storage Temperature Range	—65°C to 200°C

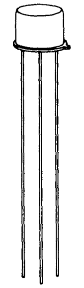
MECHANICAL SPECIFICATIONS

UPT211 UPT212 UPT213 UPT214 UPT215



Dimensions in inches.

TO-5



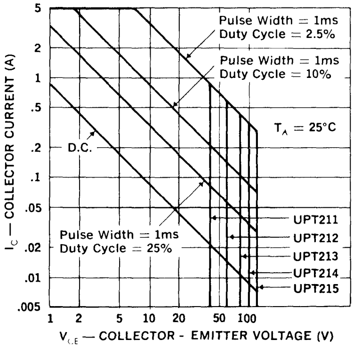
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

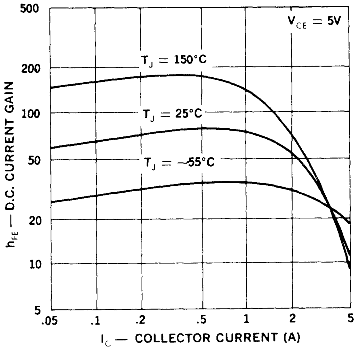
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	30	—	—	$I_C = 0.5A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	20	—	—	$I_C = 2A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	10 Typ.		—	$I_C = 5A, V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.0	Vdc	$I_C = 2A, I_B = 0.2A$
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.2	Vdc	$I_C = 2A, I_B = 0.2A$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}			Vdc	$I_C = 10mAdc; R_{BE} = 100\Omega$
UPT211		60	—		
UPT212		80	—		
UPT213		100	—		
UPT214		120	—		
UPT215		150	—		
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 10mAdc$
UPT211		40	—		
UPT212		60	—		
UPT213		80	—		
UPT214-5		100	—		
Collector-Emitter Cutoff Current	I_{CER}	—	10	μAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$
Collector-Emitter Cutoff Current, 150°C	I_{CER}	—	1.0	mAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$, $T = 150°C$
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	40	pf	$V_{CB} = 10Vdc, I_E = 0, f = 1MHz$
Gain-Bandwidth Product	f_T	70 Typ.		MHz	$I_C = 0.1Adc, V_{CE} = 5Vdc, f = 10MHz$
Switching Speeds — Turn-on Time	t_{on}	130 Typ.		ns	$I_C = 2A$
Switching Speeds — Turn-off Time	t_{off}	300 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ≤2%.

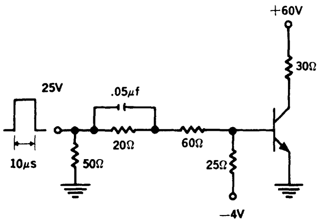
Maximum Safe Operating Area UPT211-215



D.C. Current Gain vs. Collector Current



Switching Speed Circuit



POWER TRANSISTORS
2 Amp, 400V, Planar NPN

UPT311 UPT321
UPT312 UPT322
UPT313 UPT323
UPT314 UPT324
UPT315 UPT325

FEATURES
- Collector-Base Voltage: up to 400V
- Peak Collector Current: 3A
- Turn-on Time: 200 ns
- Turn-off Time: 800 ns

DESCRIPTION
Unitrode high voltage transistors provide a unique combination of low saturation voltage, fast switching, and excellent gain. They are ideally suited for off-line power supply designs and other applications where the increased voltage rating adds to system reliability.

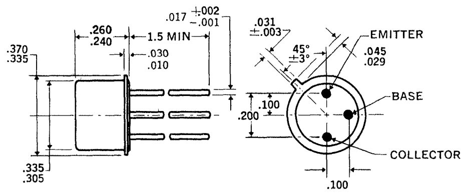
ABSOLUTE MAXIMUM RATINGS

	UPT311 UPT321	UPT312 UPT322	UPT313 UPT323	UPT314 UPT324	UPT315 UPT325
Collector-Base Voltage, V_{CBO}	200V	250V	300V	350V	400V
Collector-Emitter Voltage, V_{CEO}	150V	200V	250V	300V	300V
Emitter-Base Voltage, V_{EBO}	5V	5V	5V	5V	5V
D.C. Collector Current, I_C	2A	2A	2A	2A	2A
Peak Collector Current, I_C	3A	3A	3A	3A	3A
Base Current, I_B	1A	1A	1A	1A	1A

	UPT311-315	UPT321-325
Power Dissipation		
25°C Ambient	1W	2W
100°C Case	10W	16W
Thermal Resistance, Θ_{J-C}	10°C/W	6.7°C/W
Operating and Storage Temperature Range	−65°C to 200°C	−65°C to 200°C

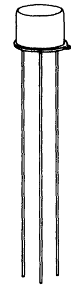
MECHANICAL SPECIFICATIONS

UPT311 UPT312 UPT313 UPT314 UPT315

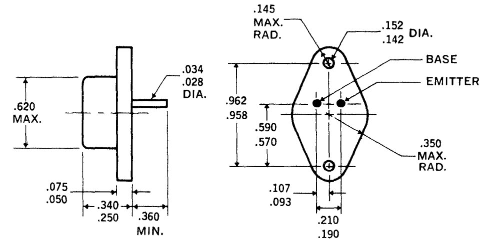


Dimensions in inches.

TO-5

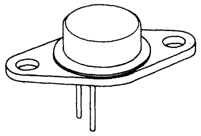


UPT321 UPT322 UPT323 UPT324 UPT325



Dimensions in inches.

TO-66



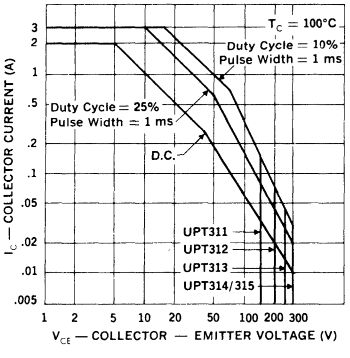
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

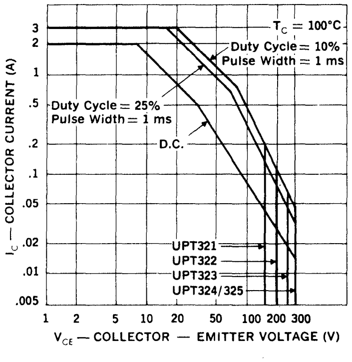
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	30	—	—	$I_C = 0.5A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	10	—	—	$I_C = 2A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	10 Typ.		—	$I_C = 3A, V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.0	Vdc	$I_C = 2A, I_B = 0.4A$
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.5	Vdc	$I_C = 2A, I_B = 0.4A$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}			Vdc	$I_C = 10mAdc; R_{BE} = 100\Omega$
UPT311, UPT321		200	—		
UPT312, UPT322		250	—		
UPT313, UPT323		300	—		
UPT314, UPT324		350	—		
UPT315, UPT325		400	—		
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 10mAdc$
UPT311, UPT321		150	—		
UPT312, UPT322		200	—		
UPT313, UPT323		250	—		
UPT314-5, UPT324-5		300	—		
Collector-Emitter Cutoff Current	I_{CER}	—	10	μAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$
Collector-Emitter Cutoff Current, 150°C	I_{CER}	—	1.0	mAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$, $T = 150°C$
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	50	pf	$V_{CB} = 10Vdc, I_E = 0, f = 1MHz$
Gain-Bandwidth Product	f_T	40 Typ.		MHz	$I_C = 0.5Adc, V_{CE} = 5Vdc, f = 10MHz$
Switching Speeds Turn-on Time	t_{on}	200 Typ.		ns	$I_C = 1A$
Switching Speeds Turn-off Time	t_{off}	800 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ⩽2%.

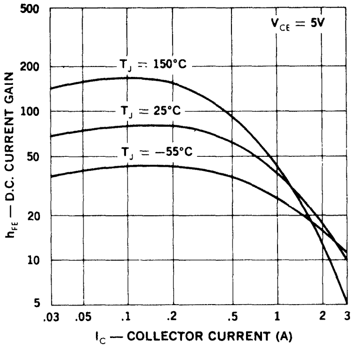
Maximum Safe Operating Area
UPT311 — 315



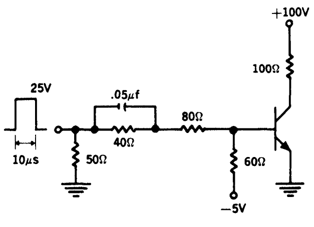
Maximum Safe Operating Area
UPT321 - 325



D.C. Current Gain vs. Collector Current



Switching Speed Circuit



POWER TRANSISTORS

3 Amp, 400V, Planar NPN

UPT521
UPT522
UPT523
UPT524
UPT525

FEATURES

- Collector-Base Voltage: up to 400V
- Peak Collector Current: 5A
- Turn-on Time: 200ns
- Turn-off Time: 900ns

DESCRIPTION

Unitrode high voltage transistors provide a unique combination of low saturation voltage, fast switching, and excellent gain. They are ideally suited for off-line power supply designs and other applications where the increased voltage rating adds to system reliability.

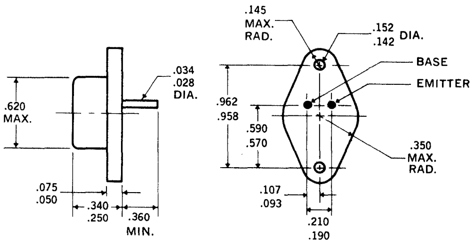
ABSOLUTE MAXIMUM RATINGS

	UPT521	UPT522	UPT523	UPT524	UPT525
Collector-Base Voltage, V_{CBO}	200V	250V	300V	350V	400V
Collector-Emitter Voltage, V_{CEO}	150V	200V	250V	300V	300V
Emitter-Base Voltage, V_{EBO}	5V	5V	5V	5V	5V
D.C. Collector Current, I_C	3A	3A	3A	3A	3A
Peak Collector Current, I_C	5A	5A	5A	5A	5A
Base Current, I_B	2A	2A	2A	2A	2A

Power Dissipation	
25°C Ambient	2W
100°C Case	25W
Thermal Resistance, θ_{J-C}	4°C/W
Operating and Storage Temperature Range	—65°C to 200°C

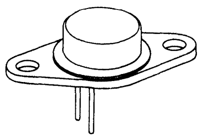
MECHANICAL SPECIFICATIONS

UPT521 UPT522 UPT523 UPT524 UPT525



Dimensions in inches.

TO-66



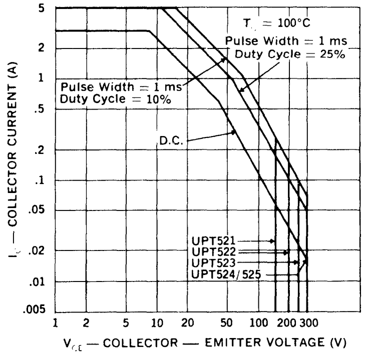
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

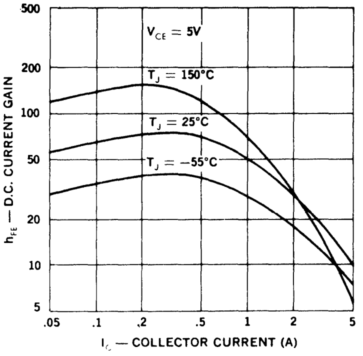
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	25	—	—	$I_C = 1.0A$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	10	—	—	$I_C = 3A$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	10 Typ.		—	$I_C = 5A$, $V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.0	Vdc	$I_C = 3A$, $I_B = 0.6A$
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.5	Vdc	$I_C = 3A$, $I_B = 0.6A$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}			Vdc	$I_C = 10mAdc$; $R_{BE} = 100\Omega$
UPT521		200	—		
UPT522		250	—		
UPT523		300	—		
UPT524		350	—		
UPT525		400	—		
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 10mAdc$
UPT521		150	—		
UPT522		200	—		
UPT523		250	—		
UPT524-5		300	—		
Collector-Emitter Cutoff Current	I_{CER}	—	10	μAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$
Collector-Emitter Cutoff Current, 150°C	I_{CER}	—	1.0	mAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$, $T = 150°C$
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	120	pf	$V_{CB} = 10Vdc$, $I_E = 0$, $f = 1MHz$
Gain-Bandwidth Product	f_T	30 Typ.		MHz	$I_C = 0.5Adc$, $V_{CE} = 5Vdc$, $f = 10MHz$
Switching Speeds Turn-on Time	t_{on}	200 Typ.		ns	$I_C = 3A$
Switching Speeds Turn-off Time	t_{off}	900 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ≤2%.

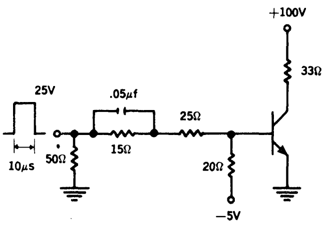
Maximum Safe Operating Area



D.C. Current Gain vs. Collector Current



Switching Speed Circuit



POWER TRANSISTORS
5 Amp, 150V, Planar NPN

UPT611
UPT612
UPT613
UPT614
UPT615

FEATURES
- Collector-Base Voltage: up to 150V
- Peak Collector Current: 10A
- Turn-on Time: 250ns
- Turn-off Time: 550ns

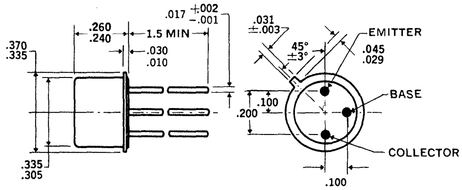
DESCRIPTION
Unitrode power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for power supply, pulse amplifier and similar high efficiency power switching applications.

ABSOLUTE MAXIMUM RATINGS

	UPT611	UPT612	UPT613	UPT614	UPT615
Collector-Base Voltage, V_{CBO}	60V	80V	100V	120V	150V
Collector-Emitter Voltage, V_{CEO}	40V	60V	80V	100V	100V
Emitter-Base Voltage, V_{EBO}	5V	5V	5V	5V	5V
D.C. Collector Current, I_C	5A	5A	5A	5A	5A
Peak Collector Current, I_C	10A	10A	10A	10A	10A
Base Current, I_B	2A	2A	2A	2A	2A
Power Dissipation					
25°C Ambient	1W				
100°C Case	5W				
Thermal Resistance, θ_{J-C}	20°C/W				
Operating and Storage Temperature Range	—65°C to 200°C				

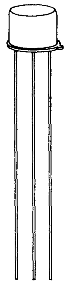
MECHANICAL SPECIFICATIONS

UPT611 UPT612 UPT613 UPT614 UPT615



Dimensions in inches.

TO-5



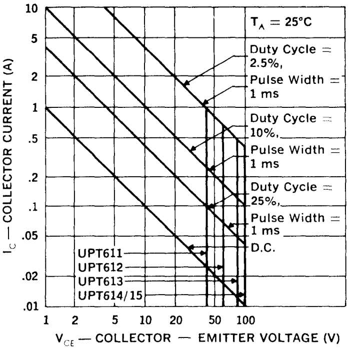
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

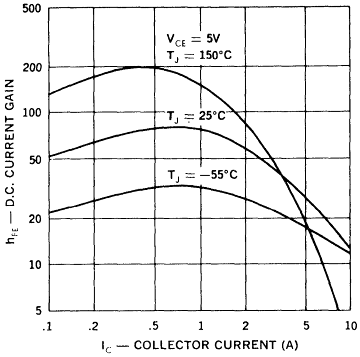
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	30	—	—	$I_C = 1A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	15	—	—	$I_C = 5A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	12 Typ.		—	$I_C = 10A, V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—			$I_C = 5A, I_B = 0.5A$
UPT611-3		—	1.0	Vdc	
UPT614-5		—	1.5	Vdc	
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—			$I_C = 5A, I_B = 0.5A$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}		1.5	Vdc	$I_C = 10mAdc; R_{BE} = 100\Omega$
UPT611		60	—	Vdc	
UPT612		80	—		
UPT613		100	—		
UPT614		120	—		
UPT615		150	—		
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 10mAdc$
UPT611		40	—		
UPT612		60	—		
UPT613		80	—		
UPT614-5		100	—		
Collector-Emitter Cutoff Current	I_{CER}	—	10	μAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$
Collector-Emitter Cutoff Current, 150°C	I_{CER}	—	1.0	mAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$, $T = 150°C$
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	120	pf	$V_{CB} = 10Vdc, I_E = 0, f = 1MHz$
Gain-Bandwidth Product	f_T	40 Typ.		MHz	$I_C = 0.5Adc, V_{CE} = 5Vdc, f = 10MHz$
Switching Speeds Turn-on Time	t_{on}	250 Typ.		ns	$I_C = 5A$
Turn-off Time	t_{off}	500 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ⩽2%.

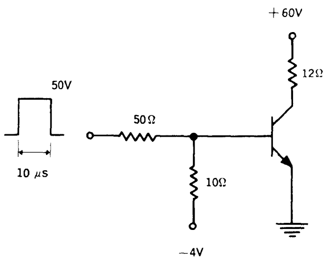
Maximum Safe Operating Area



D.C. Current Gain vs. Collector Current



Switching Speed Circuit



POWER TRANSISTORS

5 Amp, 400V, Planar NPN

UPT721
UPT722
UPT723
UPT724
UPT725

FEATURES

- Collector-Base Voltage: up to 400V
- Peak Collector Current: 10A
- Turn-on Time: 250ns
- Turn-off Time: 800ns

DESCRIPTION

Unitrode high voltage transistors provide a unique combination of low saturation voltage, fast switching, and excellent gain. They are ideally suited for off-line power supply designs and other applications where the increased voltage rating adds to system reliability.

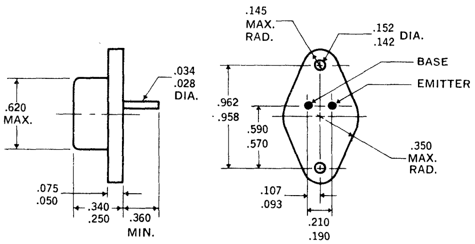
ABSOLUTE MAXIMUM RATINGS

	UPT721	UPT722	UPT723	UPT724	UPT725
Collector-Base Voltage, V_{CBO}	200V	250V	300V	350V	400V
Collector-Emitter Voltage, V_{CEO}	150V	200V	250V	300V	300V
Emitter-Base Voltage, V_{EBO}	5V	5V	5V	5V	5V
D.C. Collector Current, I_C	5A	5A	5A	5A	5A
Peak Collector Current, I_C	10A	10A	10A	10A	10A
Base Current, I_B	3A	3A	3A	3A	3A

Power Dissipation
25°C Ambient 2W
100°C Case 25W
Thermal Resistance, θ_{J-C} .... 4°C/W
Operating and Storage Temperature Range .... –65°C to 200°C

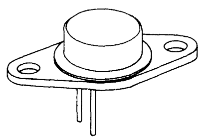
MECHANICAL SPECIFICATIONS

UPT721 UPT722 UPT723 UPT724 UPT725



Dimensions in inches.

TO-66



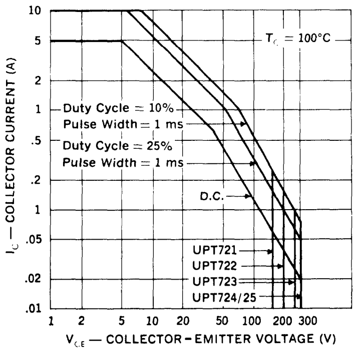
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

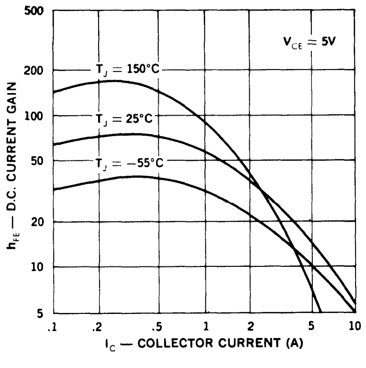
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	25	—	—	$I_C = 1A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	10	—	—	$I_C = 5A, V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	5 Typ.		—	$I_C = 10A, V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.0	Vdc	$I_C = 5A, I_B = 1A$
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.8	Vdc	$I_C = 5A, I_B = 1A$
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CER}			Vdc	$I_C = 10mAdc; R_{BE} = 100\Omega$
UPT721		200	—		
UPT722		250	—		
UPT723		300	—		
UPT724		350	—		
UPT725		400	—		
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 10mAdc$
UPT721		150	—		
UPT722		200	—		
UPT723		250	—		
UPT724-5		300	—		
Collector-Emitter Cutoff Current	I_{CER}	—	10	μAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$
Collector-Emitter Cutoff Current, 150°C	I_{CER}	—	1.0	mAdc	V_{CE} = rated BV_{CEO}, $R_{BE} = 100\Omega$, $T = 150°C$
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	120	pf	$V_{CB} = 10Vdc, I_E = 0, f = 1MHz$
Gain-Bandwidth Product	f_T	30 Typ.		MHz	$I_C = 0.5Adc, V_{CE} = 5Vdc, f = 10MHz$
Switching Speeds Turn-on Time	t_{on}	250 Typ.		ns	$I_C = 5A$
Switching Speeds Turn-off Time	t_{off}	800 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ⩽2%.

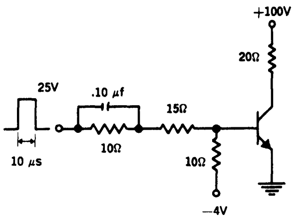
Maximum Safe Operating Area



D.C. Current Gain vs. Collector Current



Switching Speed Circuit



POWER TRANSISTORS
0.5 Amp, 300V, Planar NPN, Plastic

UPTA510
UPTA520
UPTA530

FEATURES
- Designed for High Speed Switching Applications
- Collector-Emitter Voltage: up to 300V
- Peak Collector Current: 1A
- Economical Plastic Molded Construction

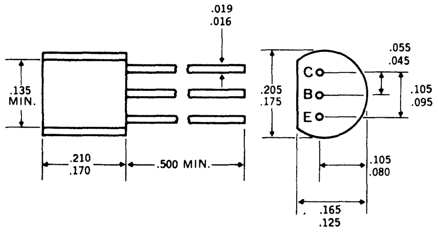
DESCRIPTION
Unitrode high voltage transistors provide a unique combination of low saturation voltage, fast switching, and excellent gain. They are ideally suited for off-line power supply designs and other applications where the increased voltage rating adds to system reliability.

ABSOLUTE MAXIMUM RATINGS

	UPTA510	UPTA520	UPTA530
Collector-Base Voltage, V_{CBO}	150V	250V	350V
Collector-Emitter Voltage, V_{CEO}	100V	200V	300V
Emitter-Base Voltage, V_{EBO}	5V	5V	5V
D.C. Collector Current, I_C	.5A	.5A	.5A
Peak Collector Current, I_C	1A	1A	1A
Base Current, I_B	.5A	.5A	.5A
Power Dissipation			
25°C Case	2.4W		
25°C Ambient	750mW		
Thermal Resistance, θ_{J-C}	62.5°C/W		
Thermal Resistance, θ_{J-A}	200°C/W		
Storage Temperature Range	−55°C to +150°C		
Maximum Junction Temperature	+175°C		

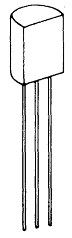
MECHANICAL SPECIFICATIONS

UPTA510 UPTA520 UPTA530



Dimensions in inches.

TO-92

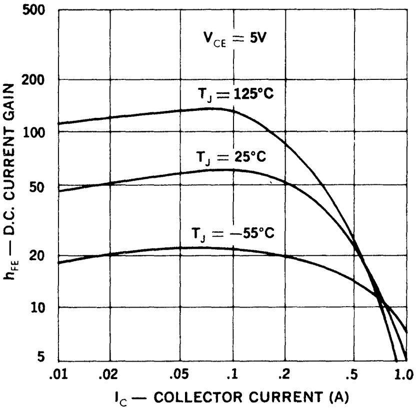


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

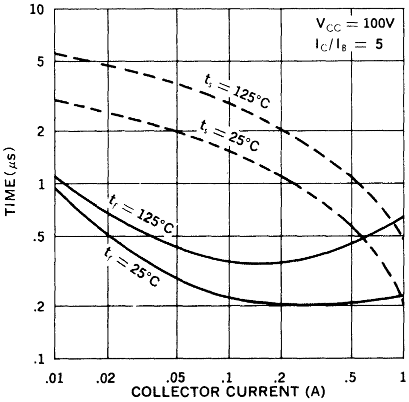
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	20	—	—	$I_C = .1A$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	8	—	—	$I_C = .5A$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	5 Typ.		—	$I_C = 1A$, $V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.0	Vdc	$I_C = .5A$, $I_B = .1A$
	V_{CE} (sat)		.5	Vdc	$I_C = .2A$, $I_B = .02A$
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.5	Vdc	$I_C = .5A$, $I_B = .1A$
Collector-Base Breakdown Voltage (Note 1)	BV_{CBO}			Vdc	$I_C = 10\mu Adc$
UPTA510		150	—		
UPTA520		250	—		
UPTA530		350	—		
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 10mAdc$
UPTA510		100	—		
UPTA520		200	—		
UPTA530		300	—		
Collector-Emitter Cutoff Current	I_{CES}	—	10	μAdc	V_{CE} = rated BV_{CEO}, $V_{BE} = 0$
Collector-Emitter Cutoff Current	I_{CES}	—	1	mAdc	V_{CE} = rated BV_{CEO}, $T = 125°C$, $V_{BE} = 0$
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	50	pf	$V_{CB} = 10Vdc$, $I_E = 0$, $f = 1MHz$
Gain-Bandwidth Product	f_T	15	—	MHz	$I_C = 1Adc$, $V_{CE} = 5Vdc$, $f = 10MHz$
Rise Time	t_r	100 Typ.		ns	$I_C = .5A$
Delay Time	t_d	50 Typ.		ns	
Storage Time	t_s	500 Typ.		ns	
Fall Time	t_f	200 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ⩽ 2%.

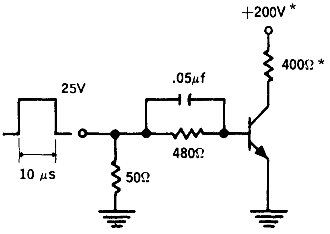
D.C. Current Gain vs. Collector Current



Switching Speeds



Switching Speed Circuit



*Note: For UPTA 410/510, $V_{CC} = 100V$, $R_L = 200Ω$

POWER TRANSISTORS

0.1 Amp, 500V, Planar NPN, Plastic

UPTB520
UPTB530
UPTB540
UPTB550

FEATURES

- Designed for High Speed Switching Applications
- Collector-Emitter Voltage: up to 500V
- Peak Collector Current: to .2A
- Economical Plastic Molded Construction

DESCRIPTION

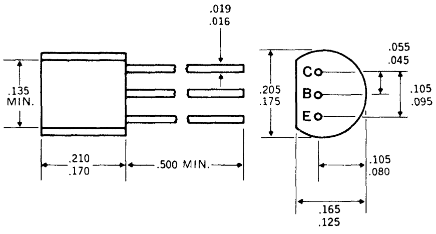
Unitrode high voltage power transistors provide a unique combination of low saturation voltage, high gain and fast switching. They are ideally suited for pulse power applications in power supplies, thermal printers, solid state relays and pulse amplifiers.

ABSOLUTE MAXIMUM RATINGS

	UPTB520	UPTB530	UPTB540	UPTB550
Collector-Base Voltage, V_{CBO}	250V	350V	450V	550V
Collector-Emitter Voltage, V_{CEO}	200V	300V	400V	500V
Emitter-Base Voltage, V_{EBO}	5V	5V	5V	5V
D.C. Collector Current, I_C	.1A	.1A	.1A	.1A
Peak Collector Current, I_C	.2A	.2A	.2A	.2A
Base Current, I_B	.1A	.1A	.1A	.1A
Power Dissipation				
25°C Case	2.4W			
25°C Ambient	750mW			
Thermal Resistance, Θ_{J-C}	62.5°C/W			
Thermal Resistance, Θ_{J-A}	200°C/W			
Storage Temperature Range	−55°C to +150°C			
Maximum Junction Temperature	+175°C			

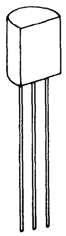
MECHANICAL SPECIFICATIONS

UPTB520 UPTB530 UPTB540 UPTB550



Dimensions in inches.

TO-92

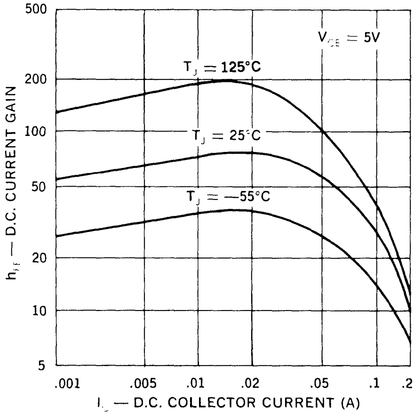


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

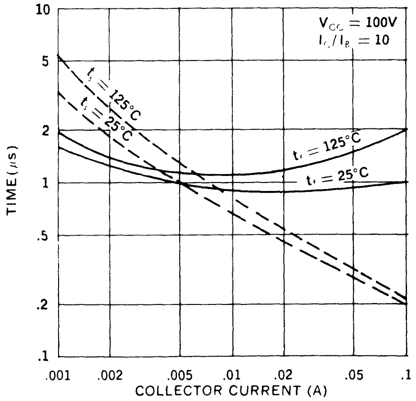
Test	Symbol	Min.	Max.	Units	Test Conditions
D.C. Current Gain (Note 1)	h_{FE}	20	—	—	$I_C = 25mA$, $V_{CE} = 5Vdc$
D.C. Current Gain (Note 1)	h_{FE}	5	—	—	$I_C = 100mA$, $V_{CE} = 5Vdc$
Collector Saturation Voltage (Note 1)	V_{CE} (sat)	—	1.2	Vdc	$I_C = 50mA$, $I_B = 10mA$
	V_{CE} (sat)		.5	Vdc	$I_C = 20mA$, $I_B = 2mA$
Base Saturation Voltage (Note 1)	V_{BE} (sat)	—	1.5	Vdc	$I_C = 50mA$, $I_B = 10mA$
Collector-Base Breakdown Voltage (Note 1)	BV_{CBO}			Vdc	$I_C = 10\mu Adc$
UPTB520		250	—		
UPTB530		350	—		
UPTB540		450	—		
UPTB550		550	—		
Collector-Emitter Breakdown Voltage (Note 1)	BV_{CEO}			Vdc	$I_C = 1mAdc$
UPTB520		200	—		
UPTB530		300	—		
UPTB540		400	—		
UPTB550		500	—		
Collector-Emitter Cutoff Current	I_{CES}	—	10	μAdc	V_{CE} = rated BV_{CEO}, $V_{BE} = 0$
Collector-Emitter Cutoff Current	I_{CES}	—	1	mAdc	V_{CE} = rated BV_{CEO}, T = 125°C, $V_{BE} = 0$
Emitter-Base Cutoff Current	I_{EBO}	—	50	μAdc	$V_{EB} = 5Vdc$
Output Capacitance	C_{ob}	—	50	pf	$V_{CB} = 10Vdc$, $I_E = 0$, f = 1MHz
Gain-Bandwidth Product	f_T	15	—	MHz	$I_C = 1Adc$, $V_{CE} = 5Vdc$, f = 10MHz
Rise Time	t_r	100 Typ.		ns	$I_C = 100mA$
Delay Time	t_d	50 Typ.		ns	
Storage Time	t_s	200 Typ.		ns	
Fall Time	t_f	1000 Typ.		ns	

Note: 1. Pulse width = 300 μs; duty cycle ≤ 2%.

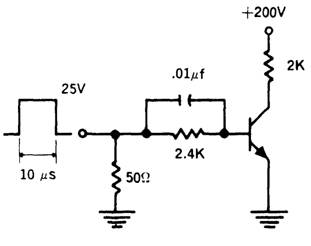
D.C. Current Gain vs. Collector Current



Switching Speeds



Switching Speed Circuit



PAGE	PART NUMBER	DESCRIPTION
		POWER TRANSISTOR
*	2N1647	NPN; 3.0A; 60V; TO-59
*	2N1648	NPN; 3.0A; 80V; TO-59
*	2N1649	NPN; 3.0A; 60V; TO-59
*	2N1650	NPN; 3.0A; 80V; TO-59
*	2N1714	NPN; 0.75A; 60V; TO-5
*	2N1715	NPN; 0.75A; 100V; TO-5
*	2N1716	NPN; 0.75A; 60V; TO-5
*	2N1717	NPN; 0.75A; 100V; TO-5
*	2N1718	NPN: 0.75A; 60V; TO-5 Stud Mount
*	2N1719	NPN; 0.75A; 100V; TO-5 Stud Mount
*	2N1720	NPN; 0.75A; 60V; TO-5 Stud Mount
*	2N1721	NPN; 0.75A; 100V; TO-5 Stud Mount
*	2N2150	NPN; 2.0A; 80V; TO-59
54	2N2151, J, JTX	NPN; 2.0A; 80V; TO-59
*	2N2657	NPN; 5.0A; 60V; TO-5
*	2N2658	NPN; 5.0A; 80V; TO-5
*	2N2858	NPN: 3A; 80V; TO-5
*	2N2859	NPN; 3A; 100V; TO-5
*	2N2877, 2N2878	NPN; 5A; 80V; TO-111
*	2N2879	NPN; 5A; 100V; TO-111
58	2N2880, J, JTX, JTXV	NPN; 5A; 80V; TO-59
*	2N2890, 2N2891	NPN; 5A; 80V; TO-5
*	2N2892, 2N2893	NPN; 5A; 80V; TO-59
*	2N2983	NPN; 3A; 80V; TO-5
*	2N2984	NPN; 3A; 120V; TO-5
*	2N2985	NPN; 3A; 80V; TO-5
*	2N2986	NPN; 3A; 120V; TO-5
*	2N2987	NPN; 1A; 80V; TO-5
*	2N2988	NPN; 1A; 100V; TO-5
*	2N2989	NPN; 1A; 80V; TO-5
*	2N2990	NPN; 1A; 100V; TO-5
*	2N2991	NPN; 1A; 80V; TO-5 Stud
*	2N2992	NPN; 1A; 100V; TO-5 Stud
*	2N2993	NPN; 1A; 80V; TO-5 Stud
*	2N2994, 2N2995	NPN; 1A; 100V; TO-5 Stud
62	2N3418, J, JTX, JTXV	NPN; 3.0A; 60V; TO-5
62	2N3419, J, JTX, JTXV	NPN; 3.0A; 80V; TO-5
62	2N3420, J, JTX, JTXV	NPN; 3.0A; 60V; TO-5
*	2N3421,J, JTX, JTXV	NPN; 3.0A; 80V; TO-5
*	2N3445	NPN; 7.5A; 60V; TO-3
*	2N3446	NPN; 7.5A; 80V; TO-3
*	2N3447	NPN; 7.5A; 60V; TO-3
*	2N3448	NPN; 7.5A; 80V; TO-3
*	2N3469	NPN; 5.0A; 25V; TO-5
*	2N3744	NPN; 5.0A; 40V; TO-111
*	2N3745	NPN; 5.0A; 60V; TO-111
*	2N3746	NPN; 5.0A; 80V; TO-111
*	2N3747	NPN; 5.0A; 40V; TO-111
*	2N3748	NPN; 5.0A; 60V; TO-111
58	2N3749, J, JTX, JTXV	NPN; 5.0A; 80V; TO-111
*	2N3750	NPN; 5.0A; 40V; TO-111
*	2N3751	NPN; 5.0A; 60V; TO-111
*	2N3752	NPN; 5.0A; 80V; TO-111
*	2N3850	NPN; 5.0A; 80V; TO-59
*	2N3851	NPN; 5.0A; 80V; TO-59
*	2N3852	NPN; 5.0A; 40V; TO-59
*	2N3853	NPN; 5.0A; 40V; TO-59
66	2N3996, J, JTX, JTXV	NPN; 5.0A; 80V; TO-111
66	2N3997, J, JTX, JTXV	NPN; 5.0A; 80V; TO-111
66	2N3998, J, JTX, JTXV	NPN; 5.0A; 80V; TO-59
66	2N3999, J, JTX, JTXV	NPN; 5.0A; 80V; TO-59
*	2N4000	NPN; 1.0A; 80V; TO-5

PAGE	PART NUMBER	DESCRIPTION
		POWER TRANSISTOR
*	2N4001	NPN; 1.0A; 100V; TO-5
*	2N4070	NPN; 10.0A; 100V; TO-3
*	2N4075	NPN; 3.0A; 80V; TO-111
*	2N4076	NPN; 3.0A; 80V; TO-111
70	2N4150, J, JTX, JTXV	NPN; 10.0A; 70V; TO-5
		TRANSISTOR
*	2N4237-2N4239	NPN; 1.0A
*	2N4300	NPN; 2.0A
74	2N5038, J, JTX, JTXV	NPN; 20.0A; 150V; TO-3
74	2N5039, J, JTX, JTXV	NPN; 20.0A; 120V; TO-3
*	2N5074-2N5075	NPN; 3A; 200V; TO-59
*	2N5076-2N5077	NPN; 3A; 250V; TO-59
*	2N5334	NPN; 3A; 60V; TO-39
*	2N5335	NPN; 3A; 80V; TO-39
*	2N5336-2N5337	NPN; 5A; 80V; TO-39
*	2N5338, 2N5339	NPN; 5A; 100V; TO-39
*	2N5346, 2N5347	NPN; 7A; 80V; TO-59
*	2N5348, 2N5349	NPN; 7A; 100V; TO-59
*	2N5477, 2N5478	NPN; 7A; 80V; TO-59
*	2N5479, 2N5480	NPN; 7A; 100V; TO-59
78	2N5487	NPN; 5A; 80V; TO-5 Low Profile
78	2N5487-1	NPN; 5A; 80V; TO-5
78	2N5487-3	NPN; 5A; 80V; TO-5 Stud
78	2N5488	NPN; 5A; 100V; TO-5 Low Profile
78	2N5488-1	NPN; 5A; 100V; TO-5
78	2N5488-3	NPN; 5A; 100V; TO-5 Stud
81	2N5552	NPN; 10A; 80V; TO-5
81	2N5552-4	NPN; 10A; 80V; TO-5 Stud
83	2N5658	NPN; 20A; 80V; TO-59
83	2N5659	NPN; 20A; 80V; TO-111
85	2N5660, J, JTX, JTXV	NPN; 3A; 200V; TO-66
85	2N5661, J, JTX, JTXV	NPN; 3A; 300V; TO-66
85	2N5662, J, JTX, JTXV	NPN; 3A; 200V; TO-5
85	2N5663, J, JTX, JTXV	NPN; 3A; 300V; TO-5
90	2N5664, J, JTX, JTXV	NPN; 5A; 200V; TO-66
90	2N5665, J, JTX, JTXV	NPN; 5A; 300V; TO-66
90	2N5666, J, JTX, JTXV	NPN; 5A; 200V; TO-5
90	2N5667, J, JTX, JTXV	NPN; 5A; 300V; TO-5
95	2N5671	NPN; 30A; 120V; TO-3
95	2N5672	NPN; 30A; 150V; TO-3
99	2N5838	NPN; 3A; 275V; TO-3
99	2N5839	NPN; 3A; 300V; TO-3
99	2N5840	NPN; 3A; 375V; TO-3
*	2N6077	NPN; 7A; 300V; TO-66
*	2N6078	NPN; 7A; 275V; TO-66
103	2N6232	NPN; 10A; 100V; TO-5
103	2N6232-4	NPN; 10A; 100V; TO-5 Stud
*	2N6233	NPN; 5A; 225V; TO-66
*	2N6234	NPN; 5A; 275V; TO-66
*	2N6235	NPN; 5A; 325V; TO-66
105	2N6249	NPN; 10A; 300V; TO-3
105	2N6250	NPN; 10A; 375V; TO-3
105	2N6251	NPN; 10A; 450V; TO-3
109	2N6306	NPN; 8.0A; 500V; TO-3
109	2N6307	NPN; 8.0A; 600V; TO-3
109	2N6308	NPN; 8.0A; 700V; TO-3
		POWER DARLINGTON
113	2N6350, J, JTX	NPN; 10.0A; 80V; TO-33
113	2N6351, J, JTX	NPN; 10.0A; 150V; TO-33
113	2N6352, J, JTX	NPN; 10.0A; 80V; TO-66
113	2N6353, J, JTX	NPN; 10.0A; 150V; TO-66
		POWER TRANSISTOR
118	2N6354	NPN; 10.0A; 150V; TO-3
118	2N6496	NPN; 15.0A; 150V; TO-3

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

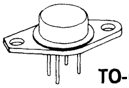
PAGE	PART NUMBER	DESCRIPTION
		POWER TRANSISTOR
122	2N6510	NPN; 7.0A; 250V; TO-3
122	2N6511	NPN; 7.0A; 300V; TO-3
122	2N6512	NPN; 7.0A; 350V; TO-3
122	2N6513	NPN; 7.0A; 400V; TO-3
122	2N6514	NPN; 7.0A; 350V; TO-3
126	2N6542	NPN; 5A; 650V; TO-3
126	2N6543	NPN; 5A; 850V; TO-3
130	2N6544	NPN; 8.0A; 650V; TO-3
130	2N6545	NPN; 8.0A; 850V; TO-3
134	2N6546	NPN; 15A; 650V; TO-3
134	2N6547	NPN; 15A; 850V; TO-3
		POWER DARLINGTON
138	U2T101	NPN; 10.0A; 80V; TO-33
138	U2T105	NPN; 10.0A; 150V; TO-33
138	U2T201	NPN; 10.0A; 80V; TO-66
138	U2T205	NPN; 10.0A; 150V; TO-66
140	U2T301	NPN; 5.0A; 60V; TO-33
140	U2T305	NPN; 5.0A; 150V; TO-33
140	U2T401	NPN; 5.0A; 60V; TO-66
140	U2T405	NPN; 5.0A; 150V; TO-66
144	U2TA506	NPN; 3.0A; 60V; TO-92
144	U2TA508	NPN; 3.0A; 80V; TO-92
144	U2TA510	NPN; 3.0A; 100V; TO-92
		POWER TRANSISTOR
146	UMT1006	NPN; 5A; 400V; TO-3
146	UMT1007	NPN; 5A; 500V; TO-3
150	UMT1008	NPN; 8A; 300V; TO-3
150	UMT1009	NPN; 8A; 400V; TO-3
154	UMT1011	NPN; 15A; 400V; TO-3
154	UMT1012	NPN; 15A; 500V; TO-3
158	UMT1203	NPN; 3.0A; 300V; TO-220
158	UMT1204	NPN; 3.0A; 400V; TO-220
162	UMT3584	NPN; 2.0A; 250V; TO-220
162	UMT3585	NPN; 2.0A; 300V; TO-220
166	UMT13004	NPN; 4A; 600V; TO-220
166	UMT13005	NPN; 4A; 700V; TO-220
170	UMT13006	NPN; 8A; 600V; TO-220
170	UMT13007	NPN; 8A; 700V; TO-220
174	UMT13008	NPN; 12A; 600V; TO-220
174	UMT13009	NPN; 12A; 700V; TO-220
178	UPT111	NPN; 1.0A; 40V; TO-5
178	UPT112	NPN; 1.0A; 60V; TO-5
178	UPT113	NPN; 1.0A; 80V; TO-5
178	UPT114	NPN; 1.0A; 100V; TO-5
178	UPT115	NPN; 1.0A; 100V; TO-5
180	UPT211	NPN; 2.0A; 40V; TO-5
180	UPT212	NPN; 2.0A; 60V; TO-5
180	UPT213	NPN; 2.0A; 80V; TO-5
180	UPT214	NPN; 2.0A; 100V; TO-5
180	UPT215	NPN; 2.0A; 100V; TO-5
182	UPT311	NPN; 2.0A; 150V; TO-5
182	UPT312	NPN; 2.0A; 200V; TO-5
182	UPT313	NPN; 2.0A; 250V; TO-5
182	UPT314	NPN; 2.0A; 300V; TO-5
182	UPT315	NPN; 2.0A; 300V; TO-5
182	UPT321	NPN; 2.0A; 150V; TO-66
182	UPT322	NPN; 2.0A; 200V; TO-66
182	UPT323	NPN; 2.0A; 250V; TO-66
182	UPT324	NPN; 2.0A; 300V; TO-66
182	UPT325	NPN; 2.0A; 300V; TO-66
184	UPT521	NPN; 3.5A; 150V; TO-66
184	UPT522	NPN; 3.5A; 200V; TO-66
184	UPT523	NPN; 3.5A; 250V; TO-66
184	UPT524	NPN; 3.5A; 300V; TO-66
184	UPT525	NPN; 3.5A; 300V; TO-66
		POWER TRANSISTOR
186	UPT611	NPN; 5.0A; 40V; TO-5
186	UPT612	NPN; 5.0A; 60V; TO-5
186	UPT613	NPN; 5.0A; 80V; TO-5
186	UPT614	NPN; 5.0A; 100V; TO-5
186	UPT615	NPN; 5.0A; 100V; TO-5
188	UPT721	NPN; 5.0A; 150V; TO-66
188	UPT722	NPN; 5.0A; 200V; TO-66
188	UPT723	NPN; 5.0A; 250V; TO-66
188	UPT724	NPN; 5.0A; 300V; TO-66
188	UPT725	NPN; 5.0A; 300V; TO-66
190	UPTA510	NPN; 0.5A; 100V; TO-92
190	UPTA520	NPN; 0.5A; 200V; TO-92
190	UPTA530	NPN; 0.5A; 300V; TO-92
192	UPTB520	NPN; 0.1A; 200V; TO-92
192	UPTB530	NPN; 0.1A; 300V; TO-92
192	UPTB540	NPN; 0.1A; 400V; TO-92
192	UPTB550	NPN; 0.1A; 500V; TO-92

*Contact Unitrode for specifications and ratings.

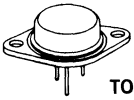
Legend: J — JAN JTX — JANTX JTXV — JANTXV

SWITCHING REGULATOR POWER CIRCUITS

The PIC600 through PIC657 series of devices consist of a driver transistor, a fast switching output transistor, a suitably matched fast recovery catch diode and thick film resistors in a hybrid circuit, designed, constructed and specified for use in high current switching regulator applications. Specific ratings for each type is summarized in this table.



TO-66



TO-3

Type	Output Current, Pk.	Input/Output Voltage	Polarity	Fall Time		On-State Voltage (V) @ (A)	Pkg.
				Volt. (nS)	Cur. (nS)		
PIC600	5A	60	Pos.	75	150	1.5 @ 2	**4 PIN** **TO-66** **(Isolated)**
PIC601		80	Pos.				
PIC602		100	Pos.				
PIC610		60	Neg.				
PIC611		80	Neg.				
PIC612		100	Neg.				
PIC625	15A	60	Pos.	175	300	1.5 @ 7	**4 PIN** **TO-66** **(Isolated)**
PIC626		80	Pos.				
PIC627		100	Pos.				
PIC635		60	Neg.	300	300		
PIC636		80	Neg.				
PIC637		100	Neg.				
PIC645	20A	60	Pos.	150	300	1.5 @ 7	**3 PIN** **TO-3**
PIC646		80	Pos.				
PIC647		100	Pos.				
PIC655		60	Neg.	300	300		
PIC656		80	Neg.				
PIC657		100	Neg.				

The PIC730 and 740 series offer a Schottky diode in place of the fast recovery PN catch diode, to permit higher operating efficiencies in switching regulator designs.

PIC730 PIC740	30A	30 40	Pos. Pos.	350	300	1 @ 20	**3 PIN** **TO-3**

The PIC800 through 811 series are high voltage (up to 400V) versions of the PIC600 series. Applications include high voltage buck or flyback regulators, and, in combination, half bridge or full bridges, as well as deflection circuits and DC motor drives.

PIC800 PIC801	8A	350 400	Pos.	200	200	1.5 @ 5	**4 PIN** **TO-66** **(Isolated)**
PIC810 PIC811	8A	350 400	Neg.	200	200	1.5 @ 5	**4 PIN** **TO-66** **(Isolated)**

POWER INTEGRATED CIRCUIT

Switching Regulator 5 Amp Positive and Negative Power Output Stages

PIC600
PIC601
PIC602
PIC610
PIC611
PIC612

FEATURES

- Designed and characterized for switching regulator applications
- Cost saving design reduces size, improves efficiency, reduces noise and RFI (See note 4.)
- High operating frequency (to > 100kHz) results in smaller inductor-capacitor filter and improved power supply response time
- High operating efficiency: Typical 2A circuit performance —
  Rise and Fall time <75ns
  Efficiency >85%
- No reverse recovery spike generated by commutating diode (See note 4. and Fig. 2.)
- Electrically isolated, 4-Pin, TO-66 hermetic case

DESCRIPTION

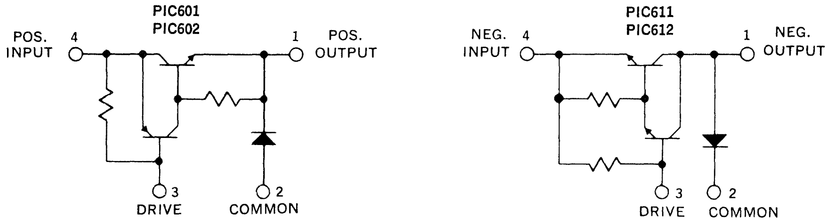
The Unitrode ESP Switching Regulator is a unique hybrid transistor circuit, specifically designed, constructed and specified for use in high current switching regulator applications. The designer is thus relieved of one of the most time consuming, tedious and critical aspects of switching regulator design: choosing the appropriate switching transistors and commutating diode, and empirically determining the optimum drive and bias conditions.

Switching regulators, when compared to conventional regulators, result in significant reductions in size, weight, and internal power losses and a major decrease in overall cost. Using the Unitrode PIC600 series, the designer can achieve further improvements in size, weight, efficiency, and costs. At the same time, because of the PIC600 series design and packaging, the designer is aided in overcoming two of the most significant drawbacks to switching regulators: noise generation and slow response time; there is, in fact, no diode reverse recovery spike (see note 4.).

The PIC600 series switching regulators are designed and characterized to be driven with standard integrated circuit voltage regulators. They are completely characterized over their entire operating range of —55°C to +125°C. The devices are enclosed in a special 4-pin TO-66 package, hermetically sealed for high reliability. The hybrid circuit construction utilizes thick film resistors on a beryllia substrate for maximum thermal conductivity and resultant low thermal impedance. All of the active elements in the hybrid are fully passivated.

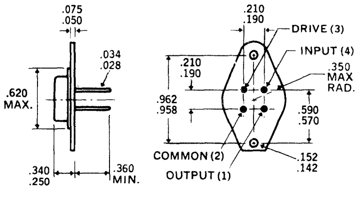
Application Notes U-68 and U-76 provide a detailed description of the hybrid circuit and design guidance for specific circuit applications.

SCHEMATIC



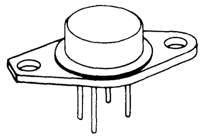
MECHANICAL SPECIFICATIONS

PIC600 PIC601 PIC602 PIC610 PIC611 PIC612



NOTES:
1. Case is electrically isolated.
2. Loads may be soldered to within $^1/_{16}$" of base provided temperature-time exposure is less than 260°C for 10 seconds.

4-Pin TO-66



ABSOLUTE MAXIMUM RATINGS

	PIC600	PIC601	PIC602	PIC610	PIC611	PIC612
Input Voltage, V_{4-2}	60V	80V	100V	—60V	—80V	—100V
Output Voltage, V_{1-2}	60V	80V	100V	—60V	—80V	—100V
Drive-Input Reverse Voltage, V_{3-4}	5V	5V	5V	—5V	—5V	—5V
Output Current, I_1	5A	5A	5A	—5A	—5A	—5A
Drive Current, I_3	—0.2A	—0.2A	—0.2A	0.2A	0.2A	0.2A

Thermal Resistance

Junction to Case, θ_{J-C}

Power Switch .... 4.0°C/W

Commutating Diode .... 4.0°C/W

Case to Ambient, θ_{C-A} .... 60.0°C/W

Operating Temperature Range, T_C .... —55°C to +125°C

Maximum Junction Temperature, T_J .... +150°C

Storage Temperature Range .... —65°C to +150°C

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	PIC600, 601, 602 Min.	Typ.	Max.	PIC610, 611, 612 Min.	Typ.	Max.	Units	Conditions
Current Delay Time	t_{di}	—	20	40	—	20	40	ns	$V_{in} = 25V(—25V)$
Current Rise Time	t_{ri}	—	50	75	—	50	75	ns	$V_{out} = 5V(—5V)$
Voltage Rise Time	t_{rv}	—	30	50	—	30	50	ns	$I_{out} = 2A(—2A)$
Voltage Storage Time	t_{sv}	—	700	—	—	700	—	ns	$I_3 = —20mA(20mA)$
Voltage Fall Time	t_{fv}	—	50	75	—	50	75	ns	See Figure 2.
Current Fall Time	t_{fi}	—	70	150	—	70	150	ns	See notes 1., 2., 4.
Efficiency (Notes 2. & 4.)	η	—	85	—	—	85	—	%	
On-State Voltage (Note 3.)	$V_{4-1(on)}$	—	1.0	1.5	—	—1.0	—1.5	V	$I_4 = 2A(—2A)$, $I_3 = —.02A(.02A)$
On-State Voltage (Note 3.)	$V_{4-1(on)}$	—	2.5	3.5	—	—2.5	—3.5	V	$I_4 = 5A(—5A)$, $I_3 = —.02A(.02A)$
Diode Forward Voltage (Note 3.)	$V_{2-1(on)}$	—	.8	1.0	—	—.8	—1.0	V	$I_2 = 2A(—2A)$
Diode Forward Voltage (Note 3.)	$V_{2-1(on)}$	—	1.0	1.5	—	—1.0	—1.5	V	$I_2 = 5A(—5A)$
Off-State Current	I_{4-1}	—	0.1	10	—	—0.1	—10	μA	V_4 = Rated input voltage
Off-State Current	I_{4-1}	—	10	—	—	—10	—	μA	V_4 = Rated input voltage, $T_A = 100°C$
Diode Reverse Current	I_{1-2}	—	1.0	10	—	—1.0	—10	μA	V_1 = Rated output voltage
Diode Reverse Current	I_{1-2}	—	500	—	—	500	—	μA	V_1 = Rated output voltage, $T_A = 100°C$

Notes:

1. In switching an inductive load, the current will lead the voltage on turn-on and lag the voltage on turn-off (see Figure 2). Therefore, Voltage Delay Time (t_{DV}) $\cong t_{di} + t_{ri}$ and Current Storage Time (t_{si}) $\cong t_{sv} + t_{fv}$.
2. The efficiency is a measure of internal power losses and is equal to Output Power divided by Input Power. The switching speed circuit of Figure 1 , in which the efficiency is measured, is representative of typical operating conditions for the PIC600 series switching regulators.
3. Pulse test: Duration = 300ms, Duty Cycle ≤2%.
4. As can be seen from the switching waveforms shown in Figure 2 , no reverse or forward recovery spike is generated by the commutating diode during switching! This reduces self-generated noise, since no current spike is fed through the switching regulator. It also improves efficiency and reliability, since the power switch only carries current during turn-on.

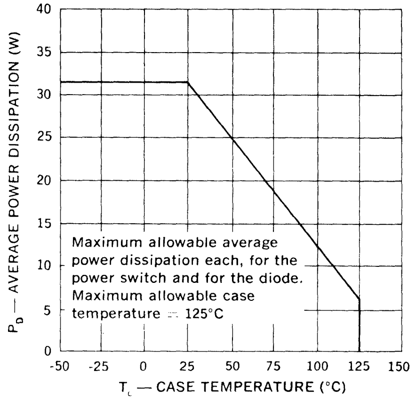
POWER DISSIPATION CONSIDERATIONS

The total power losses in the switching regulator is the sum of the switching losses, and the power switch and diode D.C. losses. Once total power dissipation has been determined, the Power Dissipation curve, or thermal resistance data may be used to determine the allowable case or ambient temperature for any operating condition.

The switching losses curve presents data for a frequency of 20KHz. To find losses at any other frequency, multiply by f/20KHz.

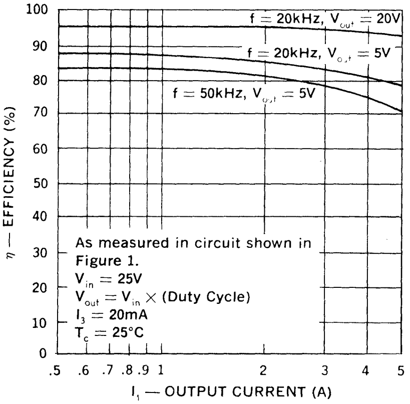
The D.C. losses curves present data for a duty cycle of .2. To find D.C. losses at any other duty cycle, multiply by D/.2 for the power switch and by (1-D)/.8 for the diode.

At frequencies much below 10KHz the above method for determining the allowable case or ambient temperature becomes invalid and a detailed transient thermal analysis must be performed. Please request Design Note 6 (DN-6) for further information.



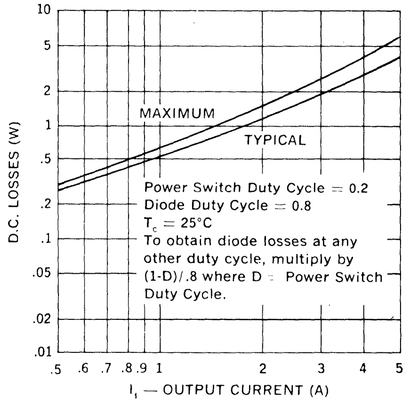
Power Dissipation

Maximum allowable average power dissipation each, for the power switch and for the diode. Maximum allowable case temperature = 125°C



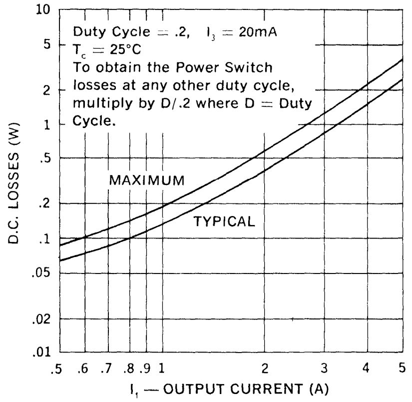
Efficiency

As measured in circuit shown in Figure 1.
V_{in} = 25V
$V_{out} = V_{in} \times$ (Duty Cycle)
I_3 = 20mA
T_c = 25°C



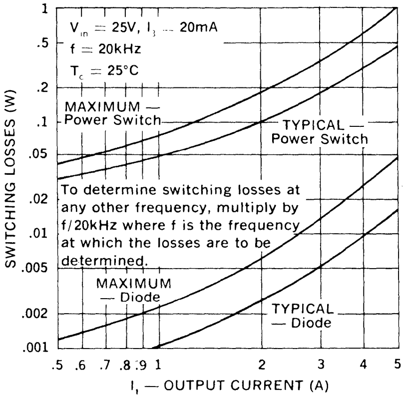
Diode D.C. Losses

Power Switch Duty Cycle = 0.2
Diode Duty Cycle = 0.8
T_c = 25°C
To obtain diode losses at any other duty cycle, multiply by (1-D)/.8 where D = Power Switch Duty Cycle.



Power Switch D.C. Losses

Duty Cycle = .2, I_3 = 20mA
T_c = 25°C
To obtain the Power Switch losses at any other duty cycle, multiply by D/.2 where D = Duty Cycle.



Switching Losses

V_{in} = 25V, I_3 = 20mA
f = 20kHz
T_c = 25°C

To determine switching losses at any other frequency, multiply by f/20kHz where f is the frequency at which the losses are to be determined.

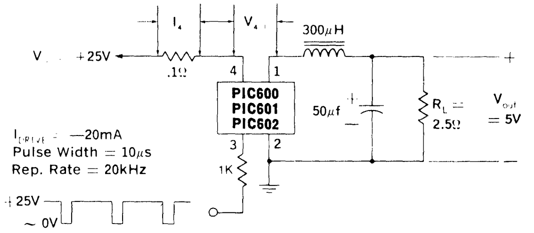


Figure 1. PIC600, 601, 602 Switching Speed Circuit

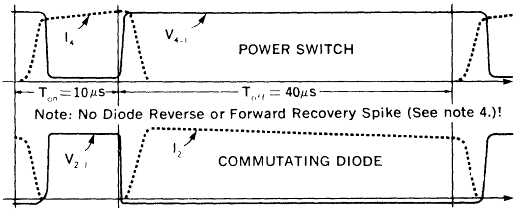
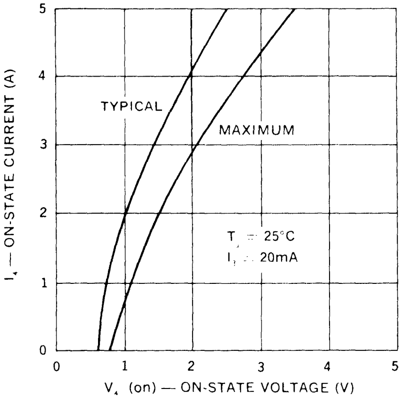


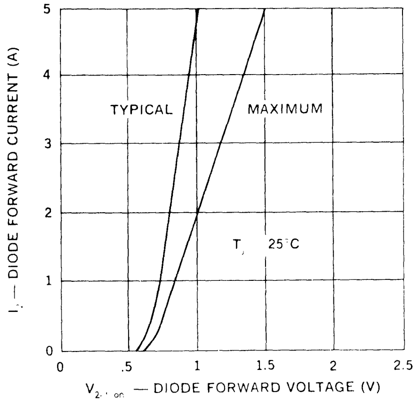
Figure 2. PIC600, PIC601, PIC602 Switching Waveforms

Note: PIC610, PIC611, PIC612 Test Circuit and waveforms are identical but of opposite polarity ($V_{in} = -25V$, $V_{out} = -5V$, $I_{DRIVE} = +20mA$).

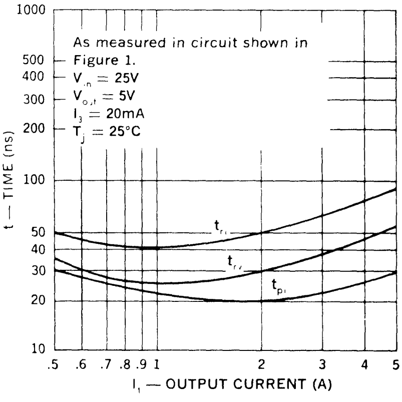
On-State Characteristics



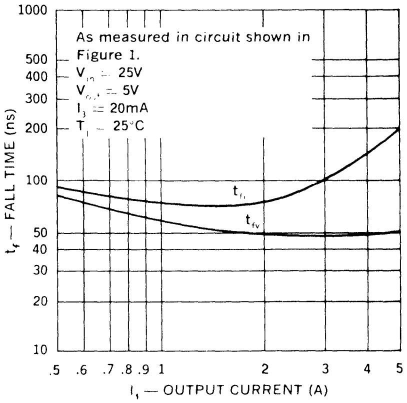
Diode Forward Characteristics



Turn-On Time



Fall Time



POWER INTEGRATED CIRCUIT

Switching Regulator 15 Amp Positive and Negative Power Output Stages

PIC625
PIC626
PIC627
PIC635
PIC636
PIC637

FEATURES

- Designed and characterized for switching regulator applications
- Cost saving design reduces size, improves efficiency, reduces noise and RFI (See note 4.)
- High operating frequency (to >100kHz) results in smaller inductor-capacitor filter and improved power supply response time
- High operating efficiency: Typical 7A circuit performance —
  Rise and Fall time <300 ns
  Efficiency >85%
- No reverse recovery spike generated by commutating diode (See note 4. and Fig. 2.)
- Electrically isolated, 4-Pin, TO66 hermetic case

DESCRIPTION

The Unitrode ESP Switching Regulator is a unique hybrid transistor circuit, specifically designed, constructed and specified for use in high current switching regulator applications. The designer is thus relieved of one of the most time consuming, tedious and critical aspects of switching regulator design: choosing the appropriate switching transistors and commutating diode, and empirically determining the optimum drive and bias conditions.

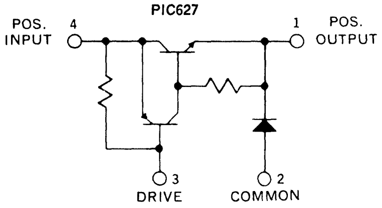
Switching regulators, when compared to conventional regulators, result in significant reductions in size, weight, and internal power losses and a major decrease in overall cost. Using the Unitrode PIC600 series the designer can achieve further improvements in size, weight, efficiency, and costs. At the same time, because of the PIC600 series design and packaging, the designer is aided in overcoming two of the most significant drawbacks to switching regulators: noise generation and slow response time; there is, in fact, no diode reverse recovery spike (See note 4.).

The PIC600 series switching regulators are designed and characterized to be driven wih standard integrated circuit voltage regulators. They are completely characterized over their entire operating range of —55°C to +125°C. The devices are enclosed in a special 4-pin TO66 package, hermetically sealed for high reliability. The hybrid circuit construction utilizes thick film resistors on a beryllia substrate for maximum thermal conductivity and resultant low thermal impedance. All of the active elements in the hybrid are fully passivated.

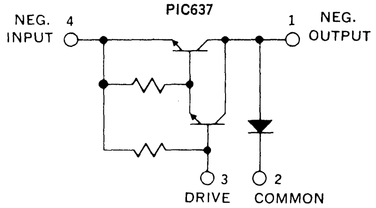
Application Notes U-68 and U-76 provide a detailed description of the hybrid circuit and design guidance for specific circuit applications.

SCHEMATIC

PIC625
PIC626
PIC627

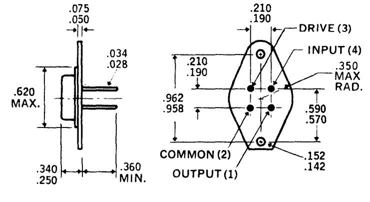


PIC635
PIC636
PIC637



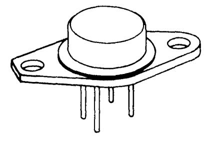
MECHANICAL SPECIFICATIONS

PIC625 PIC626 PIC627 PIC635 PIC636 PIC637



NOTES:
1. Case is electrically isolated.
2. Loads may be soldered to within 1/16" of base provided temperature-time exposure is less than 260°C for 10 seconds.

4-Pin TO-66



ABSOLUTE MAXIMUM RATINGS

	PIC625	PIC626	PIC627	PIC635	PIC636	PIC637
Input Voltage, V_{4-2}	60V	80V	100V	—60V	—80V	—100V
Output Voltage, V_{1-2}	60V	80V	100V	—60V	—80V	—100V
Drive-Input Reverse Voltage, V_{3-4}	5V	5V	5V	—5V	—5V	—5A
Output Current, I_1	15A	15A	15A	—15A	—15A	—15A
Drive Current, I_3	—0.4A	—0.4A	—0.4A	0.4A	0.4A	0.4A

Thermal Resistance	
Junction to Case, θ_{J-C}	
Power Switch	4.0°C/W
Commutating Diode	4.0°C/W
Case to Ambient, θ_{C-A}	60.0°C/W
Operating Temperature Range, T_C	—55°C to +125°C
Maximum Junction Temperature, T_j	+150°C
Storage Temperature Range	—65°C to +150°C

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

		PIC625/626/627			PIC635/636/637				
Test	Symbol	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Conditions
Current Delay Time	t_{di}	—	35	60	—	35	60	ns	$V_{in} = 25V(-25V)$
Current Rise Time	t_{ri}	—	65	150	—	65	175	ns	$V_{out} = 5V(-5V)$
Voltage Rise Time	t_{rv}	—	40	60	—	40	60	ns	$I_{out} = 7A(-7A)$
Voltage Storage Time	t_{sv}	—	900	—	—	900	—	ns	$I_3 = -30mA(30mA)$
Voltage Fall Time	t_{fv}	—	70	175	—	100	300	ns	See Figure 2
Current Fall Time	t_{fi}	—	175	300	—	175	300	ns	See notes 1, 2, 4
Efficiency (Notes 2 and 4)	η	—	85	—	—	85	—	%	
On-State Voltage (Note 3)	$V_{4-1(on)}$	—	1.0	1.5	—	—1.0	—1.5	V	$I_4 = 7A(-7A)$, $I_3 = -.03A(.03A)$
On-State Voltage (Note 3)	$V_{4-1(on)}$	—	2.5	3.5	—	—2.5	—3.5	V	$I_4 = 15A(-15A)$, $I_3 = -.03A(.03A)$
Diode Fwd. Voltage (Note 3)	$V_{2-1(on)}$	—	.85	1.25	—	—.85	—1.25	V	$I_2 = 7A(-7A)$
Diode Fwd. Voltage (Note 3)	$V_{2-1(on)}$	—	.95	1.75	—	—.95	—1.75	V	$I_2 = 15A(-15A)$
Off-State Current	I_{4-1}	—	0.1	10	—	—0.1	—10	μA	V_4 = Rated input voltage
Off-State Current	I_{4-1}	—	10	—	—	—10	—	μA	V_4 = Rated input voltage, $T_A = 100°C$
Diode Reverse Current	I_{1-2}	—	1.0	10	—	—1.0	—10	μA	V_1 = Rated output voltage
Diode Reverse Current	I_{1-2}	—	500	—	—	500	—	μA	V_1 = Rated output voltage, $T_A = 100°C$

Notes:

1. In switching an inductive load, the current will lead the voltage on turn-on and lag the voltage on turn-off (see Figure 2.). Therefore, Voltage Delay Time (t_{DV}) $\cong t_{di} + t_{ri}$ and Current Storage Time (t_{si}) $\cong t_{sv} + t_{fv}$.
2. The efficiency is a measure of internal power losses and is equal to Output Power divided by Input Power. The switching speed circuit of Figure 1., in which the efficiency is measured, is representative of typical operating conditions for the PIC600 series switching regulators.
3. Pulse test: Duration = 300ms, Duty Cycle ≤2%.
4. As can be seen from the switching waveforms shown in Figure 2., no reverse or forward recovery spike is generated by the commutating diode during switching! This reduces self-generated noise, since no current spike is fed through the switching regulator. It also improves efficiency and reliability, since the power switch only carries current during turn-on.

POWER DISSIPATION CONSIDERATIONS

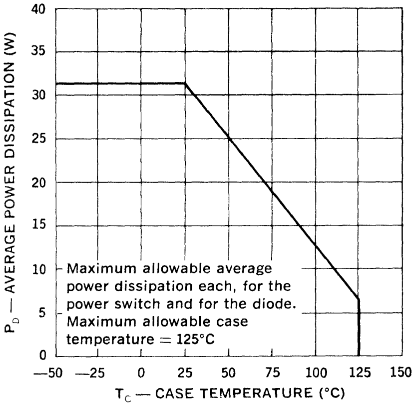
The total power losses in the switching regulator is the sum of the switching losses, and the power switch and diode D.C. losses. Once total power dissipation has been determined, the Power Dissipation curve, or thermal resistance data may be used to determine the allowable case or ambient temperature for any operating condition.

The switching losses curve presents data for a frequency of 20KHz. To find losses at any other frequency, multiply by f/20KHz.

The D.C. losses curves present data for a duty cycle of .2. To find D.C. losses at any other duty cycle, multiply by D/.2 for the power switch and by (1-D)/.8 for the diode.

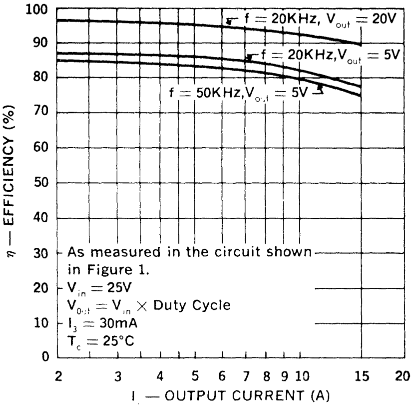
At frequencies much below 10KHz the above method for determining the allowable case or ambient temperature becomes invalid and a detailed transient thermal analysis must be performed. Please request Design Note 6 (DN-6) for further information.

Power Dissipation



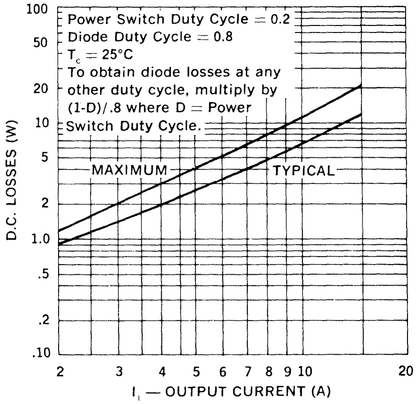
Maximum allowable average power dissipation each, for the power switch and for the diode. Maximum allowable case temperature = 125°C

Efficiency



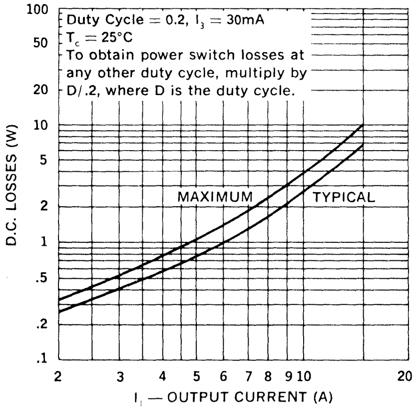
As measured in the circuit shown in Figure 1.
V_{in} = 25V
V_{out} = V_{in} × Duty Cycle
I_3 = 30mA
T_c = 25°C

Diode D.C. Losses



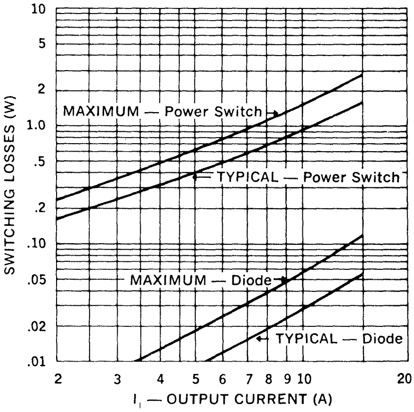
Power Switch Duty Cycle = 0.2
Diode Duty Cycle = 0.8
T_c = 25°C
To obtain diode losses at any other duty cycle, multiply by (1-D)/.8 where D = Power Switch Duty Cycle.

Power Switch D.C. Losses



Duty Cycle = 0.2, I_3 = 30mA
T_c = 25°C
To obtain power switch losses at any other duty cycle, multiply by D/.2, where D is the duty cycle.

Switching Losses



V_{in} = 25V, I_3 = 30mA
f = 20KHz
T_C = 25°C
To determine switching losses at any other frequency, multiply by f/20KHz where f is the frequency at which the losses are to be determined.

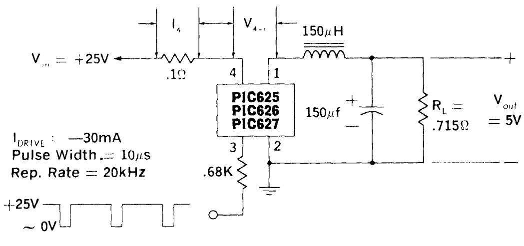


Figure 1. PIC625, 626, 627 Switching Speed Circuit

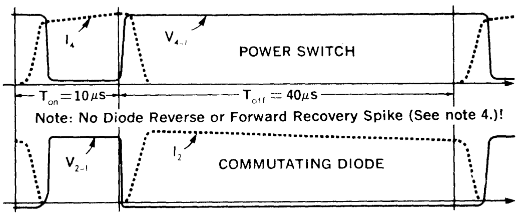
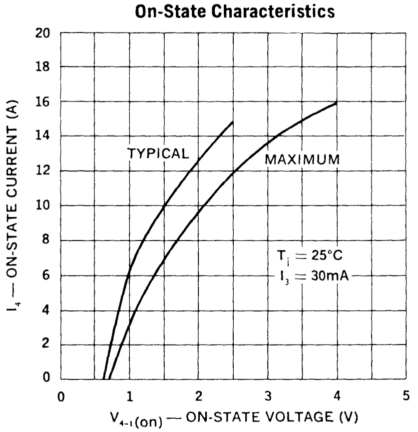
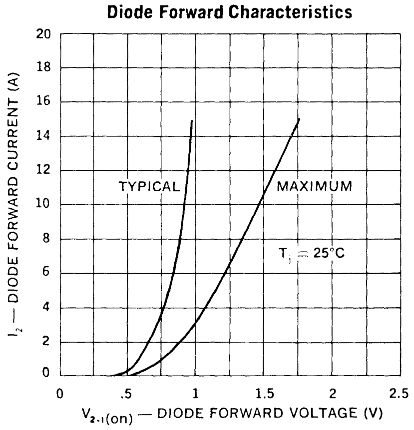
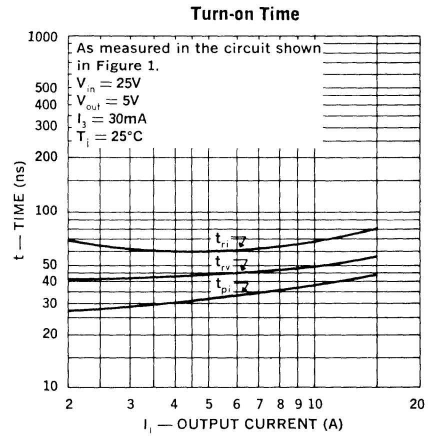


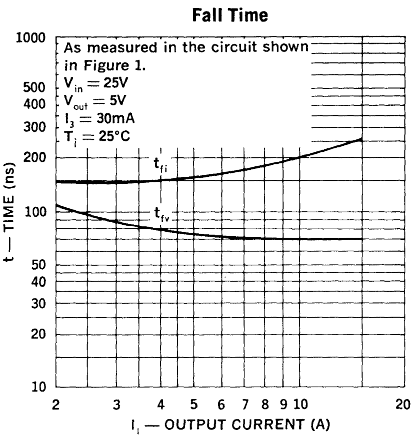
Figure 2. PIC625, 626, 627 Switching Waveforms

Note: PIC635, PIC636, PIC637 Circuit and waveforms are identical but of opposite polarity ($V_{in} = -25V$, $V_{out} = -5V$, $I_{DRIVE} = +30mA$.)









POWER INTEGRATED CIRCUIT

Switching Regulator 15 Amp Positive and Negative Power Output Stages

PIC645
PIC646
PIC647
PIC655
PIC656
PIC657

FEATURES

- Designed and characterized for switching regulator applications
- Cost saving design reduces size, improves efficiency, reduces noise and RFI (See note 4.)
- High operating frequency (to >100kHz) results in smaller inductor-capacitor filter and improved power supply response time
- High operating efficiency: Typical 7A circuit performance —
  Rise and Fall time <300 ns
  Efficiency >85%
- No reverse recovery spike generated by commutating diode (See note 4. and Fig. 2.)

DESCRIPTION

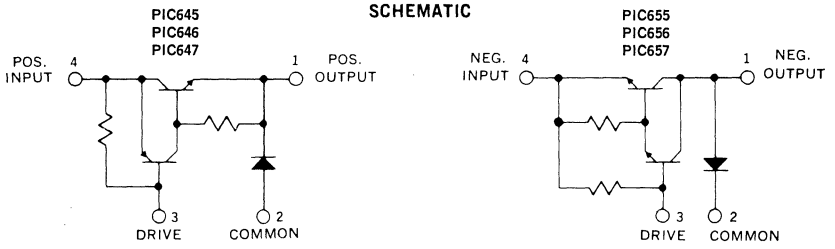
The Unitrode ESP Switching Regulator is a unique hybrid transistor circuit, specifically designed, constructed and specified for use in high current switching regulator applications. The designer is thus relieved of one of the most time consuming, tedious and critical aspects of switching regulator design: choosing the appropriate switching transistors and commutating diode, and empirically determining the optimum drive and bias conditions.

Switching regulators, when compared to conventional regulators, result in significant reductions in size, weight, and internal power losses and a major decrease in overall cost. Using the Unitrode PIC600 series the designer can achieve further improvements in size, weight, efficiency, and costs. At the same time, because of the PIC600 series design and packaging, the designer is aided in overcoming two of the most significant drawbacks to switching regulators: noise generation and slow response time; there is, in fact, no diode reverse recovery spike (See note 4.).

The PIC600 series switching regulators are designed and characterized to be driven with standard integrated circuit voltage regulators. They are completely characterized over their entire operating range of −55°C to +125°C. The devices are enclosed in a special 3 pin TO-3 package, hermetically sealed for high reliability. The hybrid circuit construction utilizes thick film resistors on a beryllia substrate for maximum thermal conductivity and resultant low thermal impedance. All of the active elements in the hybrid are fully passivated.

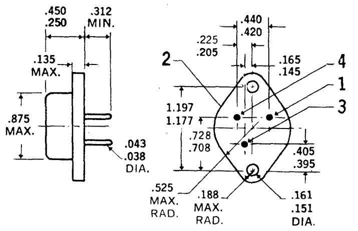
Application Notes U-68 and U-76 provide a detailed description of the hybrid circuit and design guidance for specific circuit applications.

SCHEMATIC



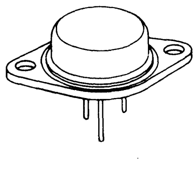
MECHANICAL SPECIFICATIONS

PIC645 PIC646 PIC647 PIC655 PIC656 PIC657



NOTE:
Loads may be soldered to within 1/16" of base provided temperature-time exposure is less than 260°C for 10 seconds.

3 Pin TO-3



ABSOLUTE MAXIMUM RATINGS

	PIC645	PIC646	PIC647	PIC655	PIC656	PIC657
Input Voltage, V_{4-2}	60V	80V	100V	—60V	—80V	—100V
Output Voltage, V_{1-2}	60V	80V	100V	—60V	—80V	—100V
Drive-Input Reverse Voltage, V_{3-4}	5V	5V	5V	—5V	—5V	—5V
Continuous Output Current, I_1	15A	15A	15A	—15A	—15A	—15A
Peak Output Current	20A	20A	20A	—20A	—20A	—20A
Drive Current, I_3	—0.4A	—0.4A	—0.4A	0.4A	0.4A	0.4A

Thermal Resistance

Junction to Case, θ_{J-C}

Power Switch .... 2°C/W

Commutating Diode .... 2°C/W

Case to Ambient, θ_{C-A} .... 30.0°C/W

Operating Temperature Range, T_C .... —55°C to +125°C

Maximum Junction Temperature, T_j .... +150°C

Storage Temperature Range .... —65°C to +150°C

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	PIC645/646/647 Min.	PIC645/646/647 Typ.	PIC645/646/647 Max.	PIC655/656/657 Min.	PIC655/656/657 Typ.	PIC655/656/657 Max.	Units	Conditions
Current Delay Time	t_{di}	—	35	60	—	35	60	ns	$V_{in} = 25V(-25V)$
Current Rise Time	t_{ri}	—	65	150	—	65	175	ns	$V_{out} = 5V(-5V)$
Voltage Rise Time	t_{rv}	—	40	60	—	40	60	ns	$I_{out} = 7A(-7A)$
Voltage Storage Time	t_{sv}	—	900	—	—	900	—	ns	$I_3 = -30mA(30mA)$
Voltage Fall Time	t_{fv}	—	70	175	—	100	300	ns	See Figure 2
Current Fall Time	t_{fi}	—	175	300	—	175	300	ns	See notes 1, 2, 4
Efficiency (Notes 2 and 4)	η	—	85	—	—	85	—	%	
On-State Voltage (Note 3)	$V_{4-1(on)}$	—	1.0	1.5	—	−1.0	−1.5	V	$I_4 = 7A(-7A)$, $I_3 = -.03A(.03A)$
On-State Voltage (Note 3)	$V_{4-1(on)}$	—	2.5	3.5	—	−2.5	−3.5	V	$I_4 = 15A(-15A)$, $I_3 = -.03A(.03A)$
Diode Fwd. Voltage (Note 3)	$V_{2-1(on)}$	—	.85	1.25	—	−.85	−1.25	V	$I_2 = 7A(-7A)$
Diode Fwd. Voltage (Note 3)	$V_{2-1(on)}$	—	.95	1.75	—	−.95	−1.75	V	$I_2 = 15A(-15A)$
Off-State Current	I_{4-1}	—	0.1	10	—	−0.1	−10	μA	V_4 = Rated input voltage
Off-State Current	I_{4-1}	—	10	—	—	−10	—	μA	V_4 = Rated input voltage, $T_A = 100°C$
Diode Reverse Current	I_{1-2}	—	1.0	10	—	−1.0	−10	μA	V_1 = Rated output voltage
Diode Reverse Current	I_{1-2}	—	500	—	—	500	—	μA	V_1 = Rated output voltage, $T_A = 100°C$

Notes:

1. In switching an inductive load, the current will lead the voltage on turn-on and lag the voltage on turn-off (see Figure 2.). Therefore, Voltage Delay Time (t_{DV}) $\cong t_{di} + t_{ri}$ and Current Storage Time (t_s) $\cong t_{sv} + t_{fv}$.
2. The efficiency is a measure of internal power losses and is equal to Output Power divided by Input Power. The switching speed circuit of Figure 1., in which the efficiency is measured, is representative of typical operating conditions for the PIC600 series switching regulators.
3. Pulse test: Duration = 300ms, Duty Cycle $\leqslant$2%.
4. As can be seen from the switching waveforms shown in Figure 2., no reverse or forward recovery spike is generated by the commutating diode during switching! This reduces self-generated noise, since no current spike is fed through the switching regulator. It also improves efficiency and reliability, since the power switch only carries current during turn-on.

POWER DISSIPATION CONSIDERATIONS

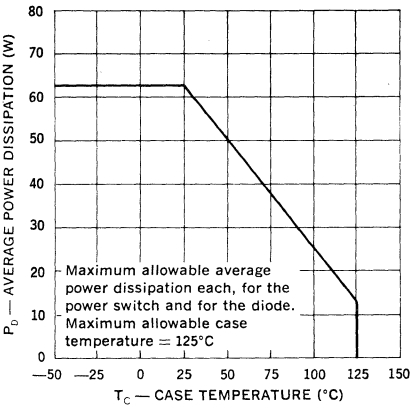
The total power losses in the switching regulator is the sum of the switching losses, and the power switch and diode D.C. losses. Once total power dissipation has been determined, the Power Dissipation curve, or thermal resistance data may be used to determine the allowable case or ambient temperature for any operating condition.

The switching losses curve presents data for a frequency of 20KHz. To find losses at any other frequency, multiply by f/20KHz.

The D.C. losses curves present data for a duty cycle of .2. To find D.C. losses at any other duty cycle, multiply by D/.2 for the power switch and by (1-D)/.8 for the diode.

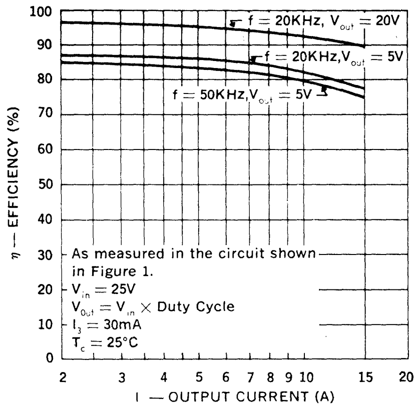
At frequencies much below 10KHz the above method for determining the allowable case or ambient temperature becomes invalid and a detailed transient thermal analysis must be performed. Please request Design Note 6 (DN-6) for further information.

Power Dissipation



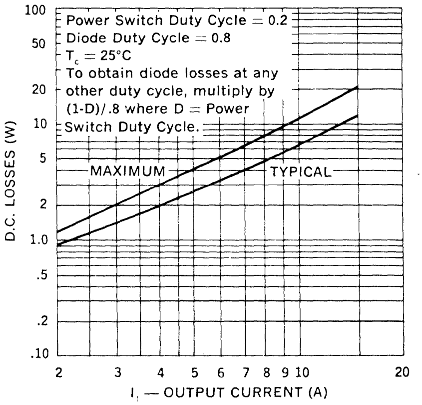
Maximum allowable average power dissipation each, for the power switch and for the diode. Maximum allowable case temperature = 125°C

Efficiency



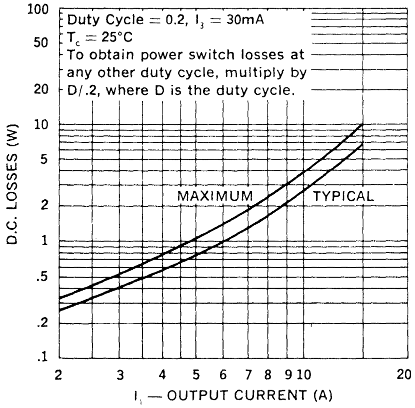
As measured in the circuit shown in Figure 1.
$V_{in} = 25V$
$V_{out} = V_{in} \times$ Duty Cycle
$I_3 = 30mA$
$T_c = 25°C$

Diode D.C. Losses



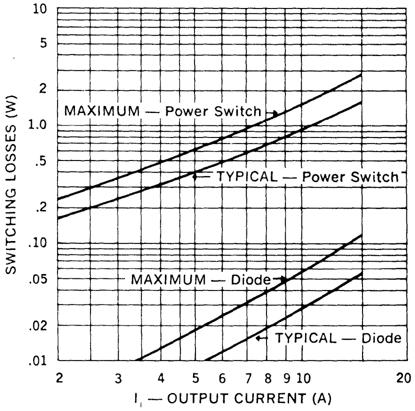
Power Switch Duty Cycle = 0.2
Diode Duty Cycle = 0.8
$T_c = 25°C$
To obtain diode losses at any other duty cycle, multiply by (1-D)/.8 where D = Power Switch Duty Cycle.

Power Switch D.C. Losses



Duty Cycle = 0.2, $I_3 = 30mA$
$T_c = 25°C$
To obtain power switch losses at any other duty cycle, multiply by D/.2, where D is the duty cycle.

Switching Losses



$V_{in} = 25V$, $I_3 = 30mA$
f = 20KHz
$T_C = 25°C$
To determine switching losses at any other frequency, multiply by f/20KHz where f is the frequency at which the losses are to be determined.

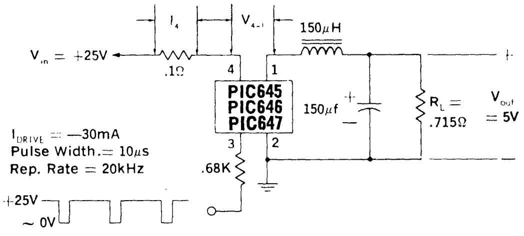


Figure 1. PIC645, 646, 647 Switching Speed Circuit

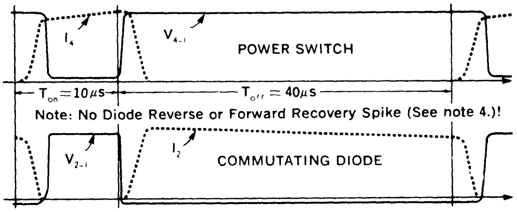
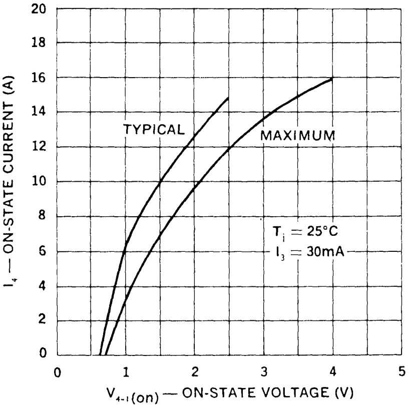
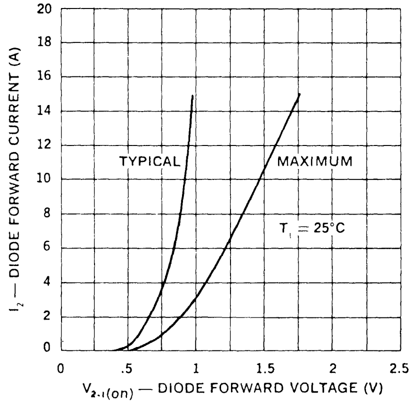
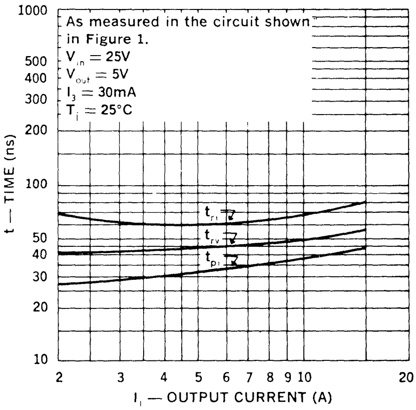


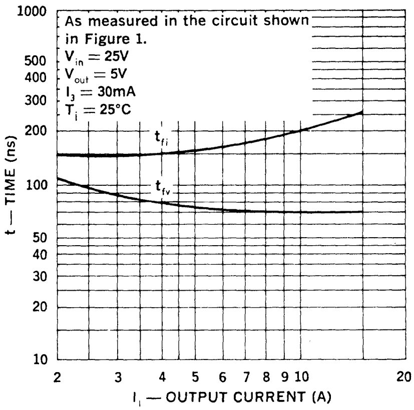
Figure 2. PIC645, 646, 647 Switching Waveforms

Note: PIC655, PIC656, PIC657 Circuit and waveforms are identical but of opposite polarity (V_{in} = −25V, V_{out} = −5V, I_{DRIVE} = +30mA.)


On-State Characteristics


Diode Forward Characteristics


Turn-on Time


Fall Time

POWER INTEGRATED CIRCUIT

Schottky Switching Regulator 30A, 40V Power Output Stages

PIC730
PIC740

FEATURES

- Designed and characterized for switching regulator applications
- Cost saving design reduces size, improves efficiency, reduces noise and RFI
- High operating frequency (to 100kHz) results in smaller inductor-capacitor filter and improved power supply response time
- Low forward drop of Schottky Rectifier: $V_F = .6V$ at 20 A
- High Efficiency: 90% typ. @ 15A (see last page)

APPLICATIONS:

High efficiency and high current Buck or Flyback type switching regulator.

DESCRIPTION

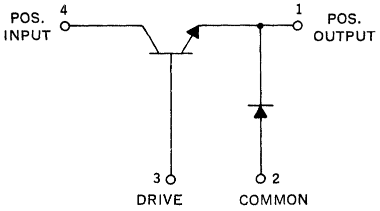
The Unitrode PIC700 series are unique hybrid circuits, specifically designed, constructed and specified for use in high current switching regulator applications. The designer is thus relieved of one of the most time consuming, tedious and critical aspects of switching regulator design: choosing the appropriate switching transistors and commutating diode.

Switching regulators, when compared to conventional regulators, result in significant reductions in size, weight, and internal power losses and a major decrease in overall cost. Using the Unitrode PIC700 series the designer can achieve further improvements in size, weight, efficiency, and costs. At the same time, because of the PIC700 series design and packaging, the designer is aided in overcoming two of the most significant drawbacks to switching regulators: noise generation and slow response time.

The PIC700 series switching regulators are completely characterized over their entire operating range of −55°C to +125°C. The devices are enclosed in a special 3 pin TO-3 package, hermetically sealed for high reliability. The hybrid circuit construction utilizes a beryllia substrate for maximum thermal conductivity and resultant low thermal impedance. All of the active elements in the hybrid are fully passivated.

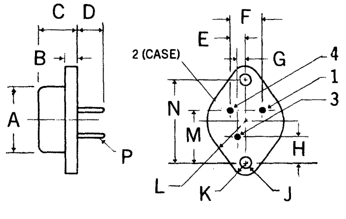
SCHEMATIC

PIC730
PIC740



MECHANICAL SPECIFICATIONS

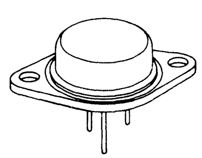
NOTE:
Leads may be soldered to within $^1/_{16}$" of base provided temperature-time exposure is less than 260°C for 10 seconds.



PIC730 PIC740

	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135	3.43
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.205-.225	5.21-5.72
F	.420-440	10.67-11.18
G	.145-.165	3.68-4.19
H	.395-.405	10.03-10.29
J	.151-.161 DIA.	3.84-4.09 DIA.
K	.188 MAX. RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.708-.728	17.98-18.49
N	1.177-1.197	29.90-30.40
P	.038-.043 DIA.	.97-1.09 DIA.

3 Pin TO-3



ABSOLUTE MAXIMUM RATINGS

	PIC730	PIC740
Input Voltage	30V	40V
Output Voltage	30V	40V
Drive-Input Reverse Voltage	8V	8V
Continuous Output Current	20A	20A
Peak Output Current	30A	30A
Drive Current	5A	5A

Thermal Resistance	
Junction to Case, $\theta_{J\text{-}C}$	
Power Switch	1.0°C/W
Commutating Diode	2.0°C/W
Case to Ambient, $\theta_{C\text{-}A}$	30°C/W
Operating Temperature Range, T_C	—55°C to +125°C
Maximum Junction Temperature, T_J	+150°C
Storage Temperature Range	—65°C to +150°C

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

SCHOTTKY RECTIFIER

Test	Symbol	PIC730		PIC740		Unit	Test Conditions
		Min.	Max.	Min.	Max.		
Maximum Instantaneous Reverse Current	i_R	—	50	—	50	mA	V_R = rated, $T_C = 125°C$ Pulse Width = 300μs, Duty Cycle = 1 percent
Maximum Instantaneous Forward Voltage	V_F	—	0.6	—	0.6	V	$i_F = 20A$ $T_C = 125°C$,

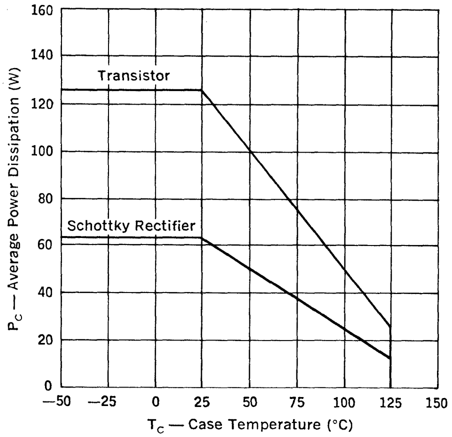
TRANSISTOR

Collector Saturation Voltage (Note 1)		$V_{CE\,(sat)}$	—	1.0	—	1.0	V	$I_C = 20A$ $I_B = 2.5A$
Base Saturation Voltage (Note 1)		$V_{BE\,(sat)}$	—	1.5	—	1.5	V	$I_C = 20A$ $I_B = 2.5A$
Collector-Emitter Sustaining Voltage (Note 2)		$V_{CEO\,(sus)}$	30	—	40	—	V	$I_C = 100mA$
Collector Cut-off Current		I_{CEO}	—	10	—	10	mA	$V_{CE} = 40V$ P.W. = 300μs
Emitter Cut-off Current		I_{EBO}	—	10	—	10	mA	$V_{EB} = 8V$ P.W. = 300μs
Resistive Switching Speed	Delay Rise Storage Fall	t_d t_r t_s t_f	—	20 500 1.5 250	—	20 500 1.5 250	nS nS μS nS	$V_{CC} = 30V$ $I_C = 20A$ $I_{B1} = I_{B2} = 2.5A$ $V_{BE\,(off)} = -4V$
Inductive Switching Speed	Current Fall	t_{fi}	—	300	—	300	nS	$T_J = 100°C$ $V_{CC} = 30V$ $I_C = 20A$ V clamp = 40V L = 175μH $I_{B1} = I_{B2} = 2.5A$
	Voltage Fall	t_{fv}	—	350	—	350	nS	

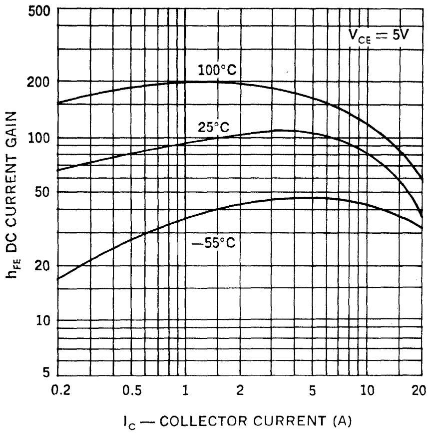
Notes

1. Pulse length=250 μs; duty cycle ≤1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length $\cong$ 50 μs; duty cycle ≤1%. Voltage clamped at maximum collector-emitter voltage.

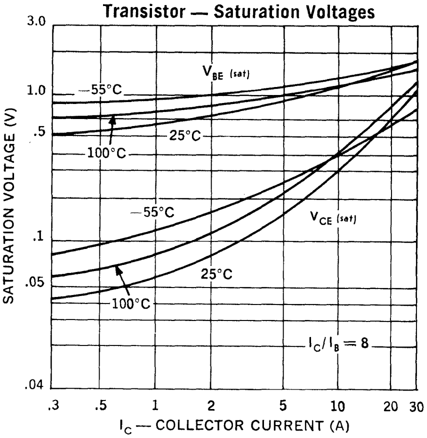
Power Dissipation



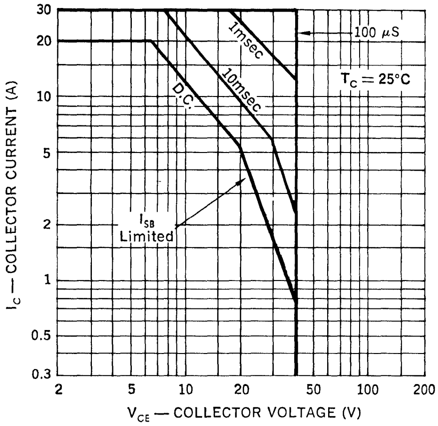
DC Current Gain



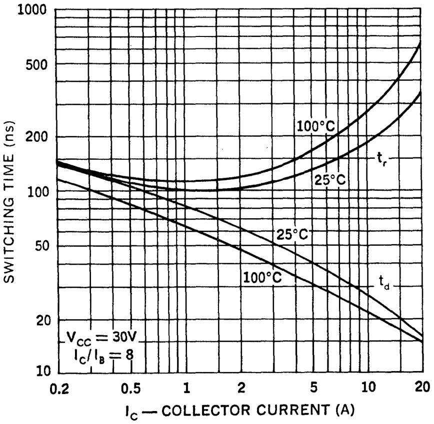
Transistor — Saturation Voltages



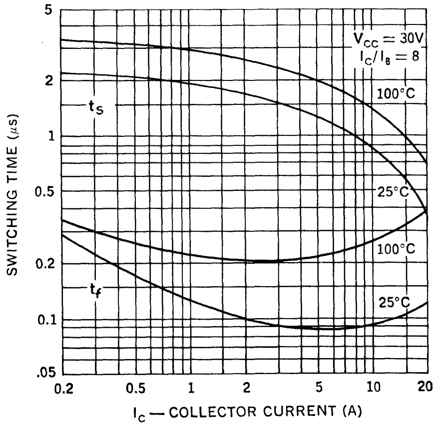
Forward Bias Safe Operating Area



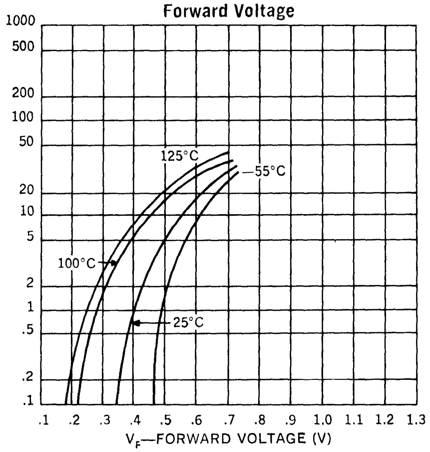
Resistive — Turn-On Time



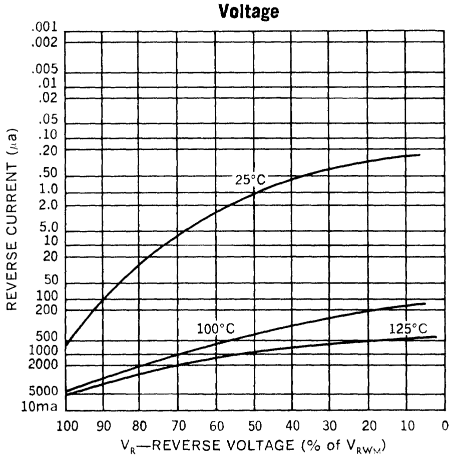
Resistive — Turn-Off Time



Rectifier — Forward Current vs Forward Voltage



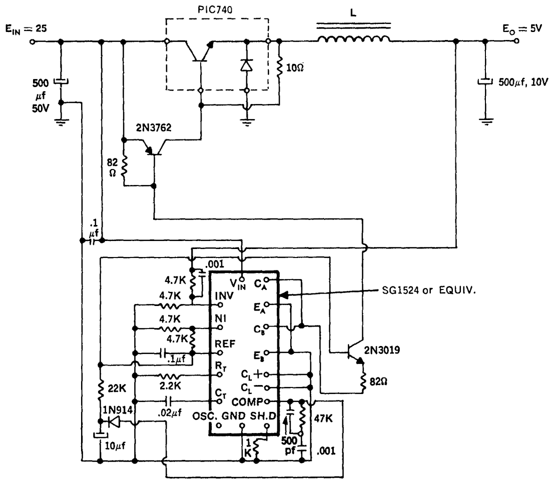
Rectifier — Typical Reverse Current vs Reverse Voltage



Possible Circuit Configurations

15 AMP SWITCHING REGULATOR

Pass Transistor — Unsaturated-Mode

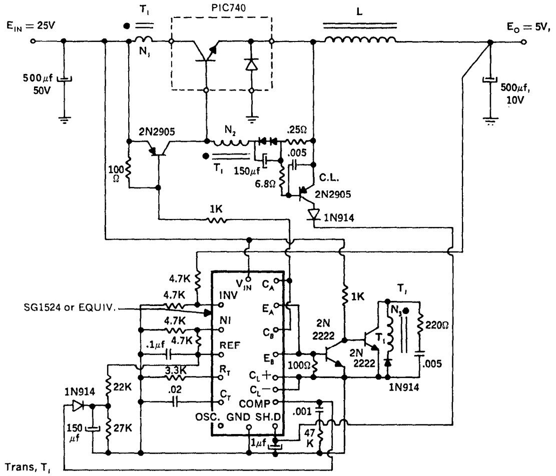


INDUCTOR L
N = 35 turns
Wire size #18
Arnold A4-17172

Regulation 18%
Typ. Efficiency at 15A 85%

15 AMP SWITCHING REGULATOR

Pass Transistor — Saturated-Mode



Trans, T₁
Ferroxcube
core, 2616P-3B7
$N_1 = 2.$
$N_2 = 16.$
$N_3 = 40,$

Inductor L
N = 35 turns.
Wire size #18
Arnold A4-17172

Regulation .... .18%
Typ. Efficiency at 15A 90%

Unitrode Corporation makes no representation that the use or interconnection of the circuits described herein will not infringe on existing or future patent rights, nor do the descriptions contained herein imply the granting of licenses to make, use or sell equipment constructed in accordance therewith.

POWER INTEGRATED CIRCUIT

Switching Regulator 8A, 400V
Power Output Stages

PIC800
PIC801
PIC810
PIC811

FEATURES

- Designed and characterized for switching regulator applications
- Cost saving design reduces size, improves efficiency, reduces noise and RFI
- High operating frequency (to 100kHz) results in smaller inductor-capacitor filter and improved power supply response time
- High operating efficiency
- Electrically isolated, 4 PIN, TO-66 hermetic case
- Fast reverse recovery time of commutating diode
- Low capacitance between active components and case (≈ 10pf)

APPLICATIONS:

PIC800/801 – High voltage Buck or Flyback regulator.
PIC810/811 – Single ended half bridge (2 required),
Full bridge (4 required),
Deflection circuits,
DC motor drive.

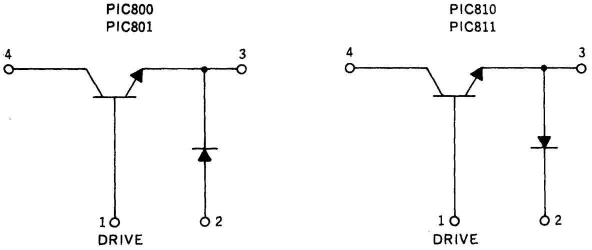
DESCRIPTION

The Unitrode PIC800 series are power hybrid circuits, specifically designed, constructed and specified for use in high voltage switching regulator applications. The designer is thus relieved of one of the most time consuming, tedious and critical aspects of switching regulator design: choosing the appropriate switching transistors and commutating diode.

Switching regulators, when compared to conventional regulators, result in significant reductions in size, weight, and internal power losses and a major decrease in overall cost. Using the Unitrode PIC800 series the designer can achieve further improvements in size, weight, efficiency, and costs. At the same time, because of the PIC800 series design and packaging, the designer is aided in overcoming two of the most significant drawbacks to switching regulators: noise generation and slow response time; the reverse recovery time of the commutating diode is less than 50 nanoseconds. The capacitance between the active components and the package is about 10 picofarads.

PIC800 series are completely characterized over their entire operating range of −55°C to +125°C. The devices are enclosed in a special 4-pin TO-66 package, hermetically sealed for high reliability. The hybrid circuit construction utilizes a beryllia substrate for maximum thermal conductivity and resultant low thermal impedance. All of the active elements in the hybrid are fully passivated.
Suggested circuit applications are listed on fourth page of this sheet.

SCHEMATIC

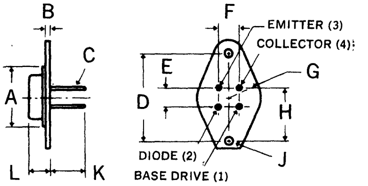

PIC800
PIC801

PIC810
PIC811

MECHANICAL SPECIFICATIONS

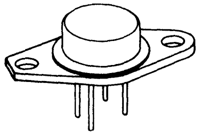
PIC800 PIC801 PIC810 PIC811

NOTES:
1. Case is electrically isolated.
2. Leads may be soldered to within $^1/_{16}$" of base provided temperature-time exposure is less than 260°C for 10 seconds.



	ins.	mm
A	.620 MAX.	15.75 MAX.
B	.050-.075	1.27-1.91
C	.028-.034	0.71-0.86
D	.958-.962	24.33-24.43
E	.190-.210	4.83-5.33
F	.190-.210	4.83-5.33
G	.350 MAX. RAD.	8.89 MAX. RAD.
H	.570-.590	14.48-14.99
J	.142-.152 DIA.	3.61-3.86 DIA.
K	.360 MIN.	9.14 MIN.
L	.250-.340	6.35-8.64

4-Pin TO-66



5/79

UNITRODE

ABSOLUTE MAXIMUM RATINGS

	PIC800-PIC810	PIC801-PIC811
Input Voltage	350V	400V
Output Voltage	350V	400V
Drive-Input Reverse Voltage	5V	5V
Peak Output Current	8A	8A
Continuous Output Current	5A	5A
Drive Current	2A	2A

Thermal Resistance
Junction to Case, $\theta_{J\text{-}C}$
Power Switch .... 2°C/W
Commutating Diode .... 3°C/W
Case to Ambient, $\theta_{C\text{-}A}$ .... 60.0°C/W
Operating Temperature Range, T_C .... −55°C to +125°C
Maximum Junction Temperature, T_J .... +150°C
Storage Temperature Range .... −65°C to +150°C

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

RECTIFIER

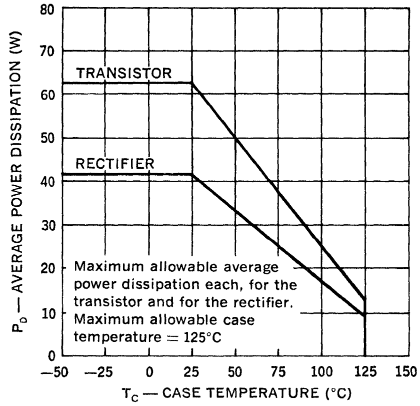
Test	Symbol	PIC800-PIC810 Min.	PIC800-PIC810 Max.	PIC801-PIC811 Min.	PIC801-PIC811 Max.	Unit	Test Conditions
Maximum Inst. Reverse Current $T_J = 25°C$	i_R	—	20	—	20	μA	V_R = rated, Pulse Width = 300μs, Duty Cycle = 1 percent
$T_J = 100°C$		—	500	—	500		
Maximum Forward Voltage $T_J = 25°C$	V_F	—	1.25	—	1.25	V	$i_F = 3A$
$T_J = 100°C$		—	1.15	—	1.15		
DC Blocking Voltage	V_R	350	—	400	—	V	Pulse Width = 300μs, $I_R = 20\mu A$
Maximum Reverse Recovery Time	t_{rr}	—	50	—	50	nS	$I_F = ½A$, $I_R = 1A$ $I_{REC} = .25A$

TRANSISTOR

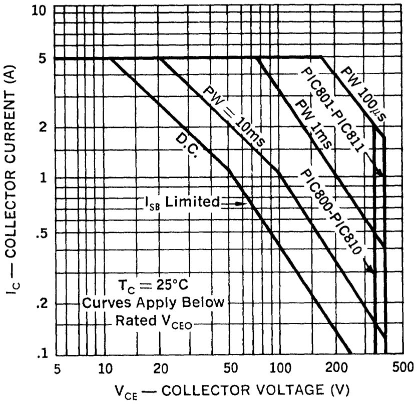
Test	Symbol	PIC800-PIC810 Min.	PIC800-PIC810 Max.	PIC801-PIC811 Min.	PIC801-PIC811 Max.	Unit	Test Conditions
Collector Saturation Voltage (Note 1)	$V_{CE(sat)}$	—	1.0	—	1.0	V	$I_C = 2.0A$, $I_B = 0.4A$
Collector Saturation Voltage (Note 1) $T_C = 25°C$	$V_{CE(sat)}$	—	1.5	—	1.5	V	$I_C = 5.0A$, $I_B = 1.0A$
$T_C = 100°C$		—	2.0	—	2.0		
Collector Saturation Voltage (Note 1)	$V_{CE(sat)}$	—	3.0	—	3.0	V	$I_C = 8.0A$, $I_B = 2.0A$
Base Saturation Voltage	$V_{BE(sat)}$	—	1.2	—	1.2	V	$I_C = 2.0A$, $I_B = 0.4A$
Base Saturation Voltage (Note 1) $T_C = 100°C$	$V_{BE(sat)}$	—	1.6	—	1.6	V	$I_C = 5.0A$, $I_B = 1.0A$
$T_C = 25°C$	$V_{BE(sat)}$	—	1.5	—	1.5		
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEO(sus)}$	350	—	400	—	V	$I_C = 10mA$
Collector-Emitter Sustaining Voltage (Note 2)	$V_{CEX(sus)}$	350	—	400	—	V	$I_C = 3.0A$, $L = 180\mu H$ $I_{B1} = I_{B2} = 0.6A$ V_{CE} clamp = rated $V_{CEX(sus)}$
Emitter-Base Cutoff Current	I_{EBO}	—	1	—	1	mA	$V_{EB} = 9V$
Collector Cutoff Current	I_{CEV}	— —	1.0 —	— —	— 1.0	mA	$V_{CE} = 350V$, $V_{BE} = -1.5V$ $V_{CE} = 400V$, $V_{BE} = -1.5V$
Collector Cutoff Current, $T_C = 100°C$	I_{CEV}	— —	5 —	— —	— 5	mA	$V_{CE} = 350V$, $V_{BE} = -1.5V$ $V_{CE} = 400V$, $V_{BE} = -1.5V$
Output Capacitance, Common Base	C_{obo}	110	Typ	110	Typ	pF	$V_{CB} = 10V$, f = 1 MHz
Gain-Bandwidth Product	F_T	4	—	4	—	MHz	$V_{CE} = 10V$, $I_C = 0.5A$, f = 1 MHz
Energy Second Breakdown (unclamped)	$E_{s/b}$	180	—	180	—	μJ	$I_C = 3.0A$, $V_{BE(off)} = 4V$ $I_{B1} = 0.6A$ $L = 40\mu H$ unclamped
Resistive Switching Speeds Delay Time Rise Time Storage Time Fall Time	 t_d t_r t_s t_f	 — — — —	 0.1 0.8 2.0 0.4	 — — — —	 0.1 0.8 2.0 0.4	μs	$I_C = 5.0A$ $V_{CC} = 125V$ $I_{B1} = I_{B2} = 1A$ $V_{BE(off)} = 5V$
Inductive Switching Speeds $T_C = 100°C$ Storage Time Fall Time	 t_s t_f	 — —	 2.3 0.4	 — —	 2.3 0.4	μs	$I_C = 5.0A$, $V_{BE(off)} = 5V$ $I_{B1} = I_{B2} = 1A$ V_{CE} clamp = rated $V_{CEX(sus)}$

Notes
1. Pulse length=250 μs; duty cycle ≤1%.
2. Sustaining Voltage. Measured at a high current point where collector-emitter voltage is lowest. Current pulse length ≅ 50 μs; duty cycle ≤1%. Voltage clamped at maximum collector-emitter voltage.

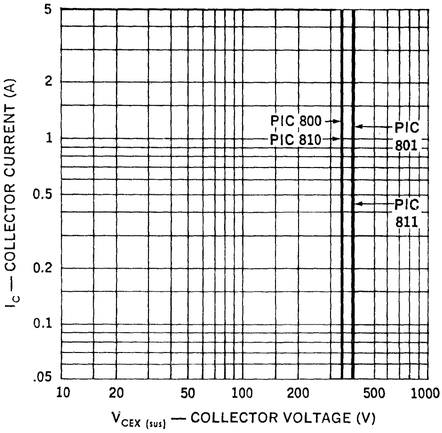
Power Dissipation



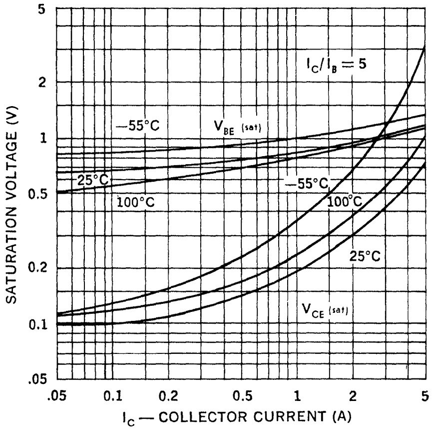
Forward Bias Safe Operating Area



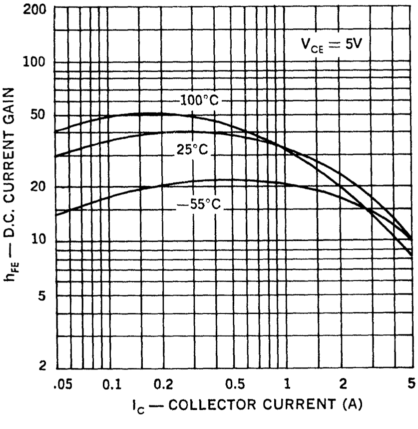
Reverse Biased Safe Operating Area



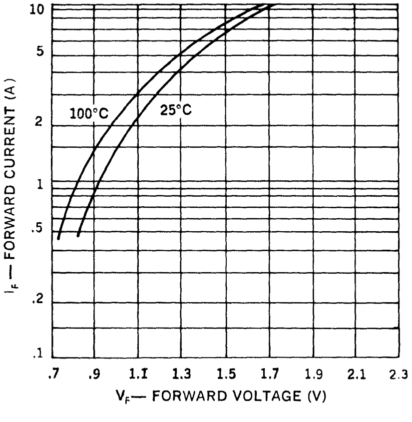
Saturation Voltages



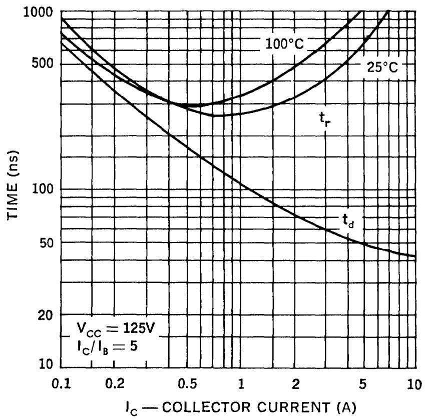
D.C. Current Gain



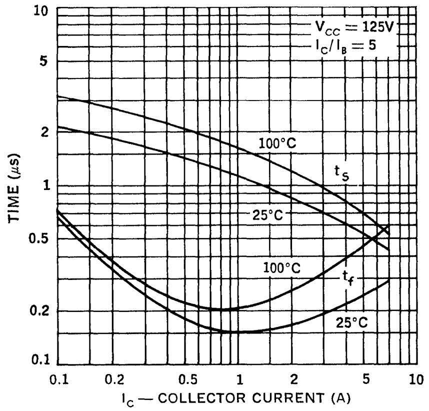
Rectifier — Forward Current vs Forward Voltage



Resistive — Turn-On Time



Resistive — Turn-Off Time



Typical Inductive Switching Times

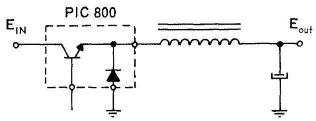
$$\frac{I_C}{5} = I_{B1} = -I_{B2}, \text{ V(clamp)} = 350V$$

$$V_{CC} = 125V$$

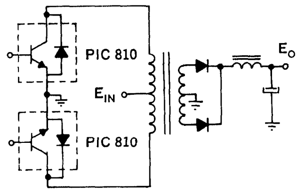
Current	Temp.	t_s μS	t_{fv} nS	t_{fi} nS
$I_C = 1A$	25°C	1.2	120	160
	100°C	1.76	140	185
$I_C = 3A$	25°C	.8	100	100
	100°C	1.1	170	130
$I_C = 5A$	25°C	.9	80	100
	100°C	1.0	190	140

APPLICATIONS:

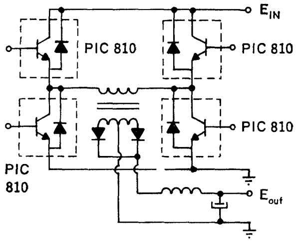
BUCK REGULATOR



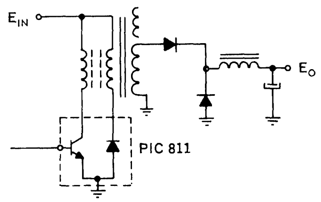
PUSH-PULL



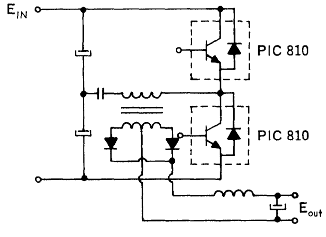
FULL BRIDGE



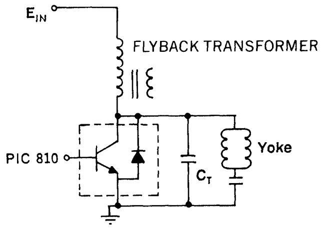
SINGLE ENDED



HALF BRIDGE



DEFLECTION CIRCUIT



SWITCHING REGULATOR POWER CIRCUITS

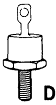
PAGE	PART NUMBER	DESCRIPTION
200	PIC600	5.0A; 60V (Pos.); TO-66
200	PIC601	5.0A; 80V (Pos.); TO-66
200	PIC602	5.0A; 100V (Pos.); TO-66
200	PIC610	5.0A; 60V (Neg.); TO-66
200	PIC611	5.0A; 80V (Neg.); TO-66
200	PIC612	5.0A; 100 V (Neg.); TO-66
204	PIC625	15.0A; 60V (Pos.); TO-66
204	PIC626	15.0A; 80V (Pos.); TO-66
204	PIC627	15.0A; 100V (Pos.); TO-66
204	PIC635	15.0A; 60V (Neg.); TO-66
204	PIC636	15.0A; 80V (Neg.); TO-66
204	PIC637	15.0A; 100V (Neg.); TO-66
208	PIC645	15.0A; 60V (Pos.); TO-3
208	PIC646	15.0A; 80V (Pos.); TO-3
208	PIC647	15.0A; 100V (Pos.); TO-66
208	PIC655	15.0A; 60V (Neg.); TO-3
208	PIC656	15.0A; 80V (Neg.); TO-3
208	PIC657	15.0A; 100V (Neg.); TO-66
212	PIC730	30A; 30V; (Pos.); TO-3
212	PIC740	30A; 30V; (Pos.); TO-3
216	PIC800	8A; 350V; (Pos.); TO-66
216	PIC801	8A; 400V; (Pos.); TO-66
216	PIC810	8A; 350V; (Neg.); TO-66
216	PIC811	8A; 400V; (Neg.); TO-66

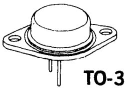
*Contact Unitrode for specifications and ratings.

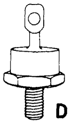
Legend: J — JAN JTX — JANTX JTXV — JANTXV

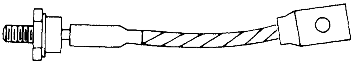
SCHOTTKY RECTIFIERS

PRODUCT SELECTION GUIDE


DO-4


TO-3


DO-5

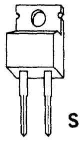

DO-5F

Average D.C. Output Current		25A	30A	30A*	50A	60A	75A
Package Style		**DO-4**	**DO-4**	**TO-3***	**DO-5**	**DO-5** **DO-5F**	**DO-5** **DO-5F**
PEAK INVERSE VOLTAGE	20V		USD420	USD320C			USD520
	30V	1N6095			1N6097		
	35V		USD435	USD335C			USD535
	40V	1N6096			1N6098		
	45V		USD445 SD41**	USD345C SD241		SD51**	USD545

*Center-tap 15A per leg.

**V_R at 25°C is 45V. V_R at 150°C is 35V.

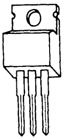
RECTIFIERS

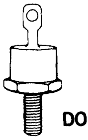


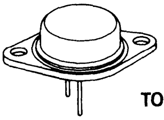
ULTRA-FAST RECOVERY (t_{rr} — 25 to 50nS)

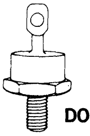
Average D.C. Output Current			1A	2A	2.5A	5A	6A	8A
Package Style			**A**	**A**	**A**	**B**	**B**	**sim to TO-220**
Peak Inverse Voltage	50V	V_F t_{rr}	UES1001 .975 @ 1A 25nS		1N5802* UES1101 .975 @ 2A 25nS		1N5807* UES1301 .925 @ 6A 30nS	UES1401 .975 @ 8A 35nS
	75V	V_F t_{rr}			1N5803 .875 @ 1A 25nS		1N5808 .925 @ 6A 30nS	
	100V	V_F t_{rr}	UES1002 .975 @ 1A 25nS		1N5804* UES1102 .975 @ 2A 25nS		1N5809* UES1302 .925 @ 6A 30nS	UES1402 .975 @ 8A 35nS
	125V	V_F t_{rr}			1N5805 .875 @ 1A 25nS		1N5810 .925 @ 6A 30nS	
	150V	V_F t_{rr}	UES1003 .975 @ 1A 25nS		1N5806* UES1103 .975 @ 2A 25nS		1N5811* UES1303 .925 @ 6A 30nS	UES1403 .975 @ 8A 35nS
	200V	V_F t_{rr}		UES1104 1.25 @ 1A 50nS		UES1304 1.25 @ 3A 50nS		
	300V	V_F t_{rr}		UES1105 1.25 @ 1A 50nS		UES1305 1.25 @ 3A 50nS		
	400V	V_F t_{rr}		UES1106 1.25 @ 1A 50nS		UES1306 1.25 @ 3A 50nS		

* Available as JAN, TANTX, JANTXV


TO-220


DO-4


TO-3

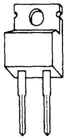

DO-5

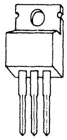
ULTRA-FAST RECOVERY (t_{rr} — 25 to 50nS)

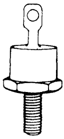
Average D.C. Output Current			16A(1)	20A	25A	30A(2)	50A	70A
Package Style			**TO-220**	**DO-4**	**DO-4**	**TO-3**	**DO-5**	**DO-5**
Peak Inverse Voltage	50V	V_F t_{rr}	UES2401 .975 @ 8A 35nS		1N5812* UES701 .825 @ 25A 35nS	UES2601 .825 @ 15A 35nS	UES501 .9 @ 50A 50nS	UES801 .84 @ 70A 50nS
	75V	V_F t_{rr}			1N5813 .825 @ 25A 30nS		UES502 .9 @ 50A 50nS	
	100V	V_F t_{rr}	UES2402 .975 @ 8A 35nS		1N5814* UES702 .825 @ 25A 35nS	UES2602 .825 @ 15A 35nS	UES503 .9 @ 50A 50nS	UES802 .84 @ 70A 50nS
	125V	V_F t_{rr}			1N5815 .825 @ 25A 35nS		UES504 .9 @ 50A 50nS	
	150V	V_F t_{rr}	UES2403 .975 @ 8A 35nS		1N5816* UES703 .825 @ 25A 35nS	UES2603 .825 @ 15A 35nS	UES505 .9 @ 50A 50nS	UES803 .84 @ 70A 50nS
	200V	V_F t_{rr}		UES704 1.15 @ 20A 50nS		UES2604 1.15 @ 15A 50nS	UES804 1.15 @ 50A 50nS	
	300V	V_F t_{rr}		UES705 1.15 @ 20A 50nS		UES2605 1.15 @ 15A 50nS	UES805 1.15 @ 50A 50nS	
	400V	V_F t_{rr}		UES706 1.15 @ 20A 50nS		UES2606 1.15 @ 15A 50nS	UES806 1.15 @ 50A 50nS	

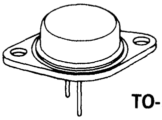
(1) Center-tap, 8A per leg
(2) Center-tap, 15A per leg
*Available as JAN, JANTX, JANTXV

RECTIFIERS


Sim. to TO-220


TO-220


DO-4

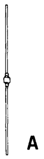

TO-3

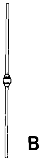
SUPER-FAST RECOVERY (t_{rr}—75 to 100nS)

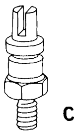
Average D.C. Output Current			1A	2A	2A	3A	4A
Package Style			**A**	**A**	**A**	**B**	**B**
Peak Inverse Voltage	50V	V_F t_{rr}	UTX105 1.00 @ .5A 75nS	UTX205 1.0V @ 1A 75nS	SES5001 .975 @ 1A 100nS	UTX3105 1V @ 2A 100nS	UTX4105 1V @ 3A 100nS
	100V	V_F t_{rr}	UTX110 1.0V @ .5A 75nS	UTX210 1.0V @ 1A 75nS	SES5002 .975 @ 1A 100nS	UTX3110 1.0V @ 2A 100nS	UTX4110 1.0V @ 3A 100nS
	150V	V_F t_{rr}	UTX115 1.00 @ .5A 75nS	UTX215 1.0V @ 1A 75nS	SES5003 .975 @ 1A 100nS	UTX3115 1.0V @ 2A 100nS	UTX4115 1.0V @ 3A 100nS
	200V	V_F t_{rr}	UTX120 1.00 @ 1A 75nS	UTX220 1.0V @ 1A 75nS		UTX3120 1.0V @ 2A 100nS	UTX4120 1.0V @ 3A 100nS
	250V	V_F t_{rr}	UTX125 1.00 @ .5A 75nS	UTX225 1.0V @ 1A 75nS			

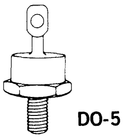
Average D.C. Output Current			5A	8A	16A(1)	20A	25A(2)	60A
Package Style			**B**	**sim to TO-220**	**TO-220**	**DO-4**	**TO-3**	**DO-5**
Peak Inverse Voltage	50V	V_F t_{rr}	SES5301 .975 @ 5A 100nS	SES5401 1.025 @ 8A 100nS	SES5401C 1.025 @ 8A 100nS	SES5701 .83 @ 20A 100nS	SES5601C .83 @ 12.5A 100nS	SES5801 .85 @ 60A 100nS
	100V	V_F t_{rr}	SES5302 .975 @ 5A 100nS	SES5402 1.025 @ 8A 100nS	SES5402C 1.025 @ 8A 100nS	SES5702C .83 @ 20A 100nS	SES5602C .83 @ 12.5A 100nS	SES5802 .85 @ 60A 100nS
	150V	V_F t_{rr}	SES5303 .975 @ 5A 100nS	SES5403 1.025 @ 8A 100nS	SES5403C 1.025 @ 8A 100nS	SES5703 .83 @ 20A 100nS	SES5603C .83 @ 12.5A 100nS	SES5803 .85 @ 60A 100nS

(1)Center-tap, 8A per leg
(2)Center-tap, 12.5A per leg





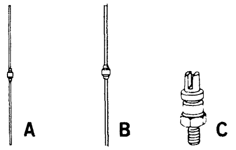




FAST RECOVERY (t_{rr} — 150 to 500nS)

Average D.C. Output Current			1A	1A	2A	3A	3A	4A	6-9A	30A
Package Style			**A**	**A**	**A**	**B**	**B**	**B**	**C**	**DO-5**
Peak Inverse Voltage	50V	V_F t_{rr}	UTR01 1.1V @ .5A 250nS		UTR02 1.1V @ 1A 250nS	UTR3305 1.1V @ 3A 250nS	1N5415* 1.5V @ 9A 150nS	UTR4305 1.1V @ 4A 250nS	UTR4405 UTR5405 UTR6405 1.1V @ 6A 300nS	1N3909** 1.4V @ 95A 200nS
	100V	V_F t_{rr}	UTR11 1.1V @ .5A 250nS		UTR12 1.1V @ 1A 250nS	UTR3310 1.1V @ 3A 250nS	1N5416* 1N5186** 1.5V @ 9A 150nS	UTR4310 1.1V @ 4A 250nS	UTR4410 UTR5410 UTR6410 1.1V @ 6A 300nS	1N3910** 1.4V @ 95A 200nS
	200V	V_F t_{rr}	UTR21 1.1V @ .5A 250nS	1N4942* 1N5615* 1.3V @ 1A 150ns	UTR22 1.1V @ 1A 250nS	UTR3320 1.1V @ 3A 250nS	1N5417* 1N5187** 1.5V @ 9A 150nS	UTR4320 1.1V @ 4A 250nS	UTR4420 UTR5420 UTR6420 1.1V @ 6A 400nS	1N3911** 1.4V @ 95A 300nS
	300V	V_F t_{rr}	UTR31 1.1V @ .5A 300nS		UTR32 1.1V @ 1A 300nS					1N3912** 1.4V @ 95A 200nS
	400V	V_F t_{rr}	UTR41 1.1V @ .5A 350nS	1N4944* 1N5617* 1.3V @ 1A 150nS	UTR42 1.1V @ 1A 350nS	UTR3340 1.1V @ 3A 300nS	1N5418* 1N5188** 1.5V @ 9A 150nS	UTR4340 1.1V @ 4A 400nS	UTR4440 UTR5400 UTR6440 1.1V @ 6A 500nS	1N3913* 1.4V @ 95A 200nS
	500V	V_F t_{rr}	UTR51 1.1V @ .5A 400nS		UTR52 1.1V @ 1A 400nS	UTR3350 1.1V @ 3A 350nS	1N5419* 1.5V @ 9A 250nS	UTR4350 1.1V @ 4A 400nS		
	600V	V_F t_{rr}	UTR61 1.1V @ .5A 400nS	1N4946* 1N5619* 1.3V @ 1A 250nS	UTR62 1.1V @ 1A 400nS	UTR3360 1.1V @ 3A 400nS	1N5420* 1N5190** 1.5V @ 9A 400nS	UTR4360 1.1V @ 4A 400nS		

*Available as JAN, JANTX, JANTXV
**Available as JAN, JANTX



STANDARD RECOVERY

Average D.C. Output Current		1A	2A	3A	4A	7.5A	9A	12A
Package Style		**A**	**A**	**B**	**B**	**C**	**C**	**C**
Peak Inverse Voltage	50V	UR105†	UR205	UT3005	UT4005	UT5105	UT6105	UT8105
	100V	UT236 UR110†	UT261 UR210†	UT3010	UT4010	UT5110	UT6110	UT8110
	150V	UR115†	UR215†					
	200V	UT234 UR120† 1N4245* 1N5614*	UT262 UR220† 1N3611**	UT3020	T4020 1N5550*	UT5120	UT6120	UT8120
	250V	UR125†	UR225†					
	400V	UT235 1N4246* 1N5616*	UT264 1N3612**	UT3040	UT4040 1N5551*	UT5140	UT6140	UT8140
	600V	UT238 1N4247* 1N5618*	UT267 1N3613**	UT3060	UT4060 1N5552*	UT5160	UT6160	UT8160
	800V	UT361 1N4248* 1N5620*	UT268 1N3614**		1N5553*			
	1000V	UT347 1N4249*	UT364					

*Available as JAN, JANTX, JANTXV.
**Available as JAN, JANTX.
†Radiation Tolerant

RECTIFIERS

Military Approved, 1 Amp, General Purpose

JAN & JANTX 1N3611-1N3614

FEATURES

- Qualified to MIL-S-19500/228
- Continuous Rating: 1A
- Surge Rating: 30A
- PIV: to 800V

DESCRIPTION

This series of MIL approved JAN and JANTX general purpose 1 amp rectifiers are useful in many high rel applications.

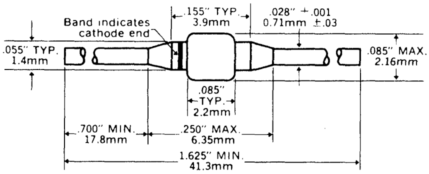
ABSOLUTE MAXIMUM RATINGS

Peak Reverse Voltage Min.	Reverse Working Voltage	Type
240V	200V	JAN & JANTX 1N3611
480V	400V	JAN & JANTX 1N3612
720V	600V	JAN & JANTX 1N3613
920V	800V	JAN & JANTX 1N3614

Maximum Average D.C. Output Current	
@ $T_A = 100°C$	1.0A
@ $T_A = 150°C$	0.3A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	30A
Operating Temperature Range	—65°C to +175°C
Storage Temperature Range	—65°C to +200°C
Thermal Resistance	See Lead Temperature Derating Curve

MECHANICAL SPECIFICATIONS

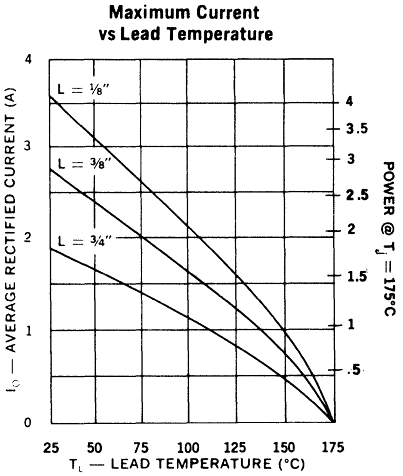
JAN & JANTX 1N3611-1N3614



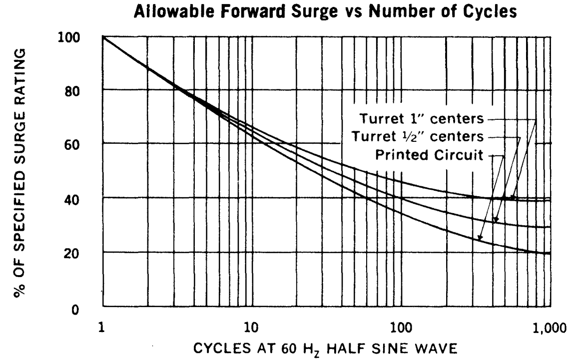
BODY A

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

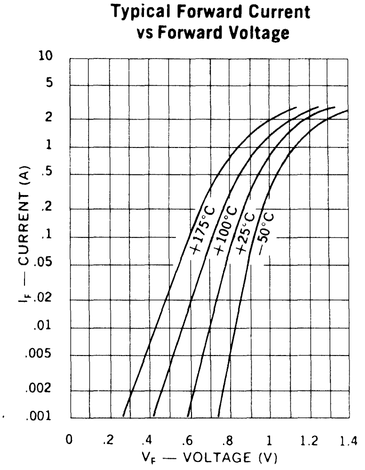
Type	Peak Reverse D.C. Voltage	Minimum Reverse Breakdown Voltage @ 100μA	Peak Forward Voltage		Maximum D.C. Reverse Current at D.C. Voltage	
			Min.	Max.	25°C	150°C
JAN & JANTX 1N3611	200V	240V	0.6V	1.1V(pk) @ 1.0A	1μA	300μA
JAN & JANTX 1N3612	400V	480V				
JAN & JANTX 1N3613	600V	720V				
JAN & JANTX 1N3614	800V	920V				



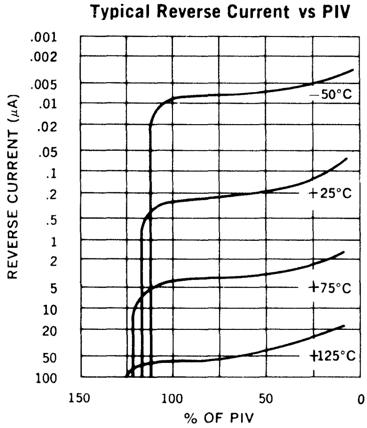
Maximum Current vs Lead Temperature



Allowable Forward Surge vs Number of Cycles



Typical Forward Current vs Forward Voltage



Typical Reverse Current vs PIV

RECTIFIERS
Military Approved, Fast Recovery, 30A

JAN, JANTX 1N3909
JAN, JANTX 1N3910
JAN, JANTX 1N3911
JAN, JANTX 1N3912
JAN, JANTX 1N3913

FEATURES
- Qualified to MIL-S-19500/308
- High Mechanical Integrity
- Low Thermal Resistance
- JAN and JANTX Available

DESCRIPTION
These devices feature unique mechanical ruggedness combined with fast switching electrical characteristics. Devices may be used in many power switching circuits.

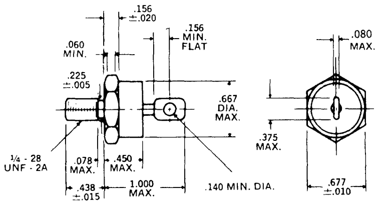
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	Type
50V	JAN, JANTX 1N3909
100V	JAN, JANTX 1N3910
200V	JAN, JANTX 1N3911
300V	JAN, JANTX 1N3912
400V	JAN, JANTX 1N3913

Maximum Average D.C. Output Current @ $T_C = 100°C$	30A
Non Repetitive Sinusoidal Surge Current @ $T_C = 100°C$	300A
Thermal Resistance, Junction-to-Case	1.2°C/W
Operating Temperature	$T_C = -65°C$ to $+150°C$
Storage Temperature	$T_C = -65°C$ to $+175°C$

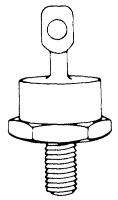
MECHANICAL SPECIFICATIONS

JAN, JANTX 1N3909, 1N3910, 1N3911, 1N3912, 1N3913



Dimensions in inches.

DO-5



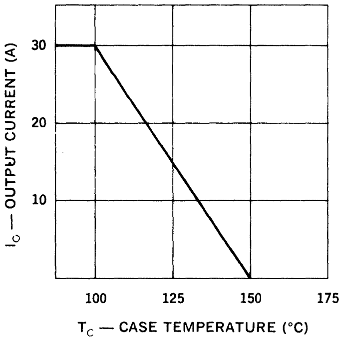
Notes:
1. Polarity is cathode-to-stud.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 30 inch pounds.
4. Angular orientation of terminal is undefined.

UNITRODE

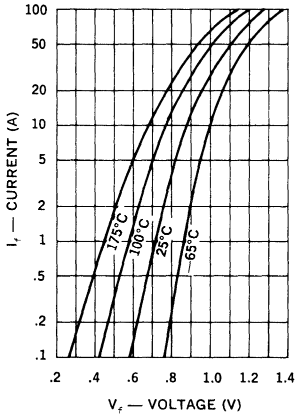
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)†

Type	Peak Inverse Voltage	Maximum Forward Voltage	Maximum Leakage Current @ PIV		Maximum Reverse Recovery Time $I_F = 1A, V_R = 30V$
			25°C	100°C	
J, JTX 1N3909 J, JTX 1N3910 J, JTX 1N3911 J, JTX 1N3912 J, JTX 1N3913	50V 100V 200V 300V 400V	1.4V(pk) @ $I_f = 95Apk$ $t_p \leqslant 8.3ms$ $d_C \leqslant 2\%$	80μA	10mA	200 nsec

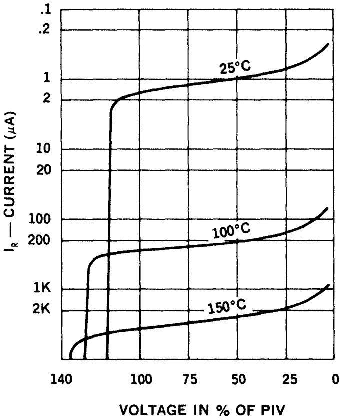
Output Current vs. Case Temperature



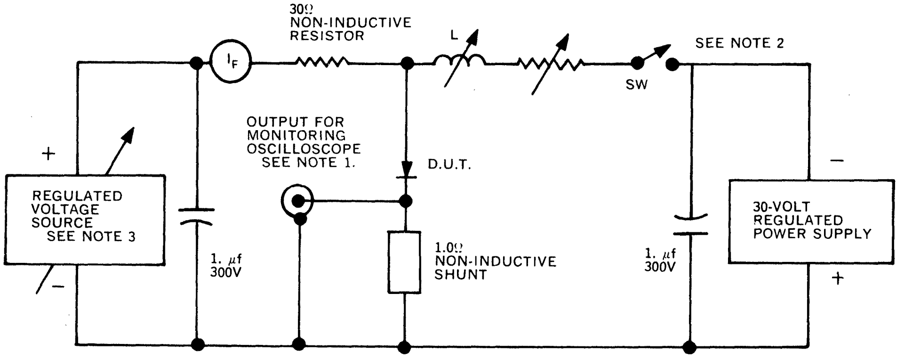
Typical Forward Current vs. Forward Voltage



Typical Reverse Current vs. Voltage



Reverse-Recovery Circuit



NOTES:

1. Monitoring oscilloscope requirements: $t_r \leqslant 14$ nsec, $R_{in} \geqslant 9M\Omega$, $C_{in} \leqslant 12$ pF, L_{in} (series) $\leqslant 0.5$ μH.
2. SW characteristics: Mercury-wetted make-before-break relay switches at a 60 Hz rate. The relay should conduct for approximately 640 μsec and be open for approximately 7.7 msec. (C.P. Clare HGP 1004 or equivalent).
3. Voltage source characteristics: Output impedance $\leqslant 0.5\Omega$ from 0 to 2 Hz.

RECTIFIERS
Military Approved, 1 Amp, General Purpose

1N4245-1N4249
JAN, JANTX & JANTXV

FEATURES
- Qualified to MIL-S-19500/286
- Surge Rating: 25A
- PIV: to 1000 V
- Controlled Avalanche
- No Plastic, Epoxy, Silicone, Oxides, Gases or Solder are used

DESCRIPTION
This series of general purpose power rectifiers are available as JAN, JANTX or JANTXV for many power supply applicatons.

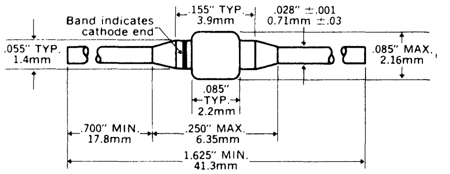
ABSOLUTE MAXIMUM RATINGS

Maximum Reverse Voltage	Type
200V	JAN, JANTX, JANTXV 1N4245
400V	JAN, JANTX, JANTXV 1N4246
600V	JAN, JANTX, JANTXV 1N4247
800V	JAN, JANTX, JANTXV 1N4248
1000V	JAN, JANTX, JANTXV 1N4249

Maximum Average D.C. Output Current	
@ $T_A = 100°C$	1.0A
@ $T_A = 150°C$	0.333A
Non-Repetitive Sinusoidal Surge Current	25A
Operating Temperature Range	—65°C to +175°C
Storage Temperature Range	—65°C to +175°C
Thermal Resistance	See Lead Temperature Derating Curve

MECHANICAL SPECIFICATIONS

J, JTX, JTXV 1N4245-1N4249



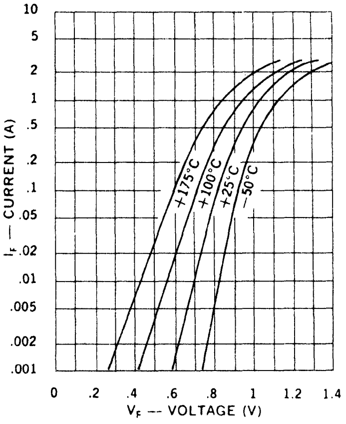
BODY A

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

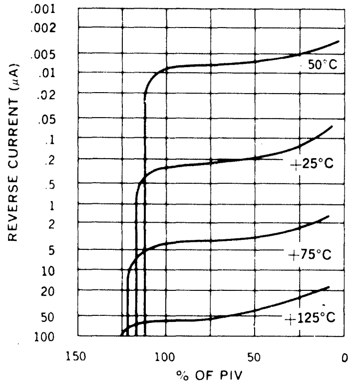
Type	PIV	Minimum Reverse Breakdown Voltage @ 100µA	Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*
			Min.	Max.	25°C	150°C	
J, JTX, JTXV 1N4245	200V	240V	0.6V	1.3V(pk) @ 3.0A(pk)	1.0µA	150µA	5.0µs
J, JTX, JTXV 1N4246	400V	480V					
J, JTX, JTXV 1N4247	600V	720V					
J, JTX, JTXV 1N4248	800V	960V					
J, JTX, JTXV 1N4249	1000V	1150V					

*Measured in circuit $I_F = ½A$, $I_R = 1.0A$, $I_{REC} = ¼A$

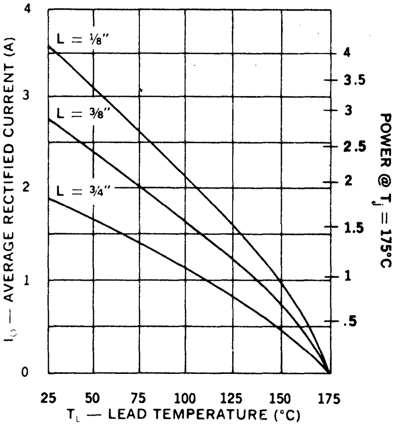
Typical Forward Current vs Forward Voltage



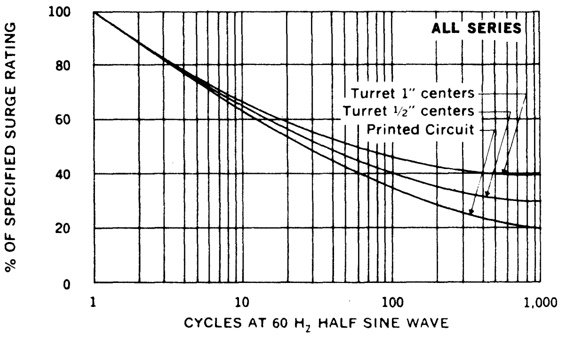
Typical Reverse Current vs PIV



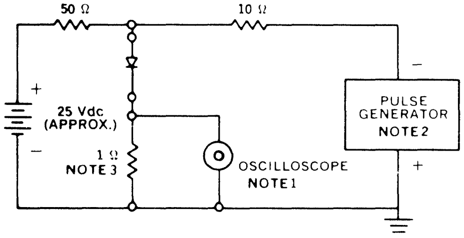
Maximum Current vs Lead Temperature



Allowable Forward Surge vs Number of Cycles



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time < 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time < 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
Military Approved, 1 Amp, Fast Recovery

JAN, JANTX, & JANTXV 1N4942
JAN, JANTX, & JANTXV 1N4944
JAN, JANTX, & JANTXV 1N4946

FEATURES

- Qualified to MIL-S-19500/359
- Surge Rating: 15A
- PIV: to 600V
- Controlled Avalanche

DESCRIPTION

These fast recovery rectifiers are suitable for use as power devices for many applications. Devices are available as JAN, JANTX or JANTXV.

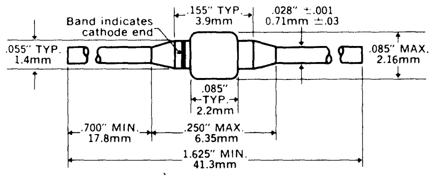
ABSOLUTE MAXIMUM RATINGS

Maximum Reverse Voltage	Type
200V	JAN, JANTX, & JANTXV 1N4942
400V	JAN, JANTX, & JANTXV 1N4944
600V	JAN, JANTX, & JANTXV 1N4946

Maximum Average D.C. Output Current	
@ $T_A = 55°C$	1.0A
@ $T_A = 100°C$	0.75A
Non-Repetitive Sinusoidal	
Surge Current (8.3ms)	15A
Operating Temperature Range	—65°C to +175°C
Storage Temperature Range	—65°C to +175°C
Thermal Resistance	See Lead Temperature Derating Curve

MECHANICAL SPECIFICATIONS

JAN, JANTX, & JANTXV 1N4942, 1N4944, 1N4946



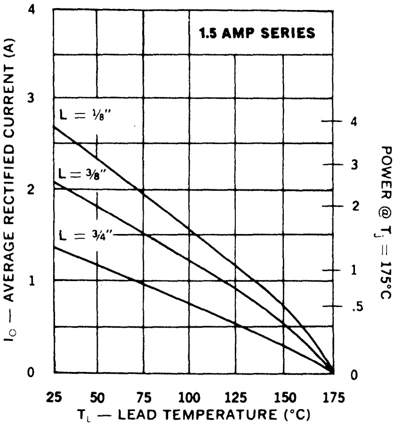
BODY A

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

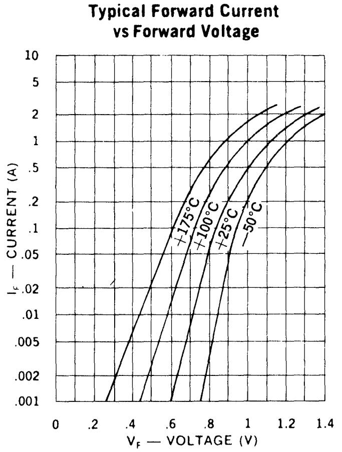
Type	Peak Inverse Voltage	Minimum Reverse Breakdown Voltage @ 50μA	Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*	Capacitance @ $V_R = 12V$ f = 1MHz
			Min.	Max.	25°C	150°C		
J, JTX, JTXV 1N4942	200V	220V	0.6V	1.3Vdc @ 1 Adc	1.0μA	200μA	150ns	45pf
J, JTX, JTXV 1N4944	400V	440V					150ns	35pf
J, JTX, JTXV 1N4946	600V	660V					250ns	25pf

*Measured in circuit $I_F = ½A$, $I_R = 1.0A$, $I_{REC} = ¼A$

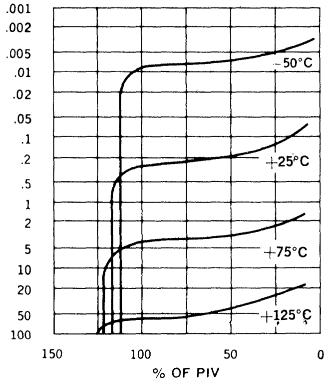
Maximum Current vs Lead Temperature



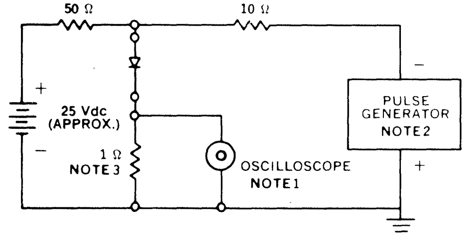
Typical Forward Current vs Forward Voltage



Typical Reverse Current vs PIV



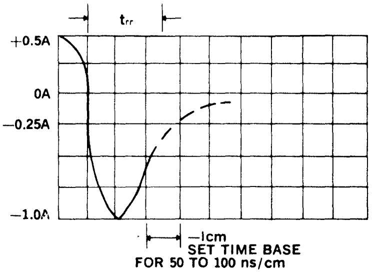
Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time $\leq$ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time $\leq$ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

Characteristic Waveform.



SET TIME BASE
FOR 50 TO 100 ns/cm

RECTIFIERS

Military Approved, 3 Amp, Fast Recovery

1N5186-1N5190 JAN & JANTX

FEATURES

- Continuous Rating: 3A
- Qualified to MIL-S-19500/424
- PIV : to 600V
- Recovery Time: 150ns
- Miniature Size
- Controlled Avalanche

DESCRIPTION

These miniature fast recovery rectifiers permit operation at full power at frequencies as high as 100kHz sine wave.
They are qualified to military specification and available as JAN, JANTX or JANTXV.

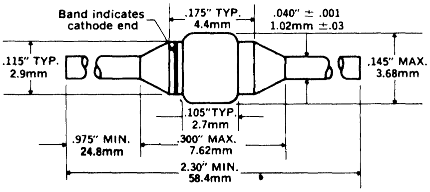
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	Type
100V	JAN & JANTX 1N5186
200V	JAN & JANTX 1N5187
400V	JAN & JANTX 1N5188
600V	JAN & JANTX 1N5190

Maximum Average D.C. Output Current	
@ $T_A = 25°C$	3.0A
@ $T_A = 150°C$	0.7A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	80A
Operating Temperature Range	—65°C to +175°C
Storage Temperature Range	—65°C to +200°C
Thermal Resistance	See Lead Temperature Derating Curve

MECHANICAL SPECIFICATIONS

JAN & JANTX 1N5186-1N5190



BODY B

UNITRODE

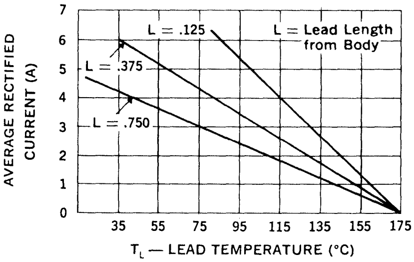
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	Peak Inverse Voltage	Minimum Reverse Breakdown Voltage @ 100μA	Peak Forward Voltage		Maximum Reverse D.C. Current @ PIV	
			Min.	Max.	25°C	100°C
J, JTX 1N5186	100V	120V	0.9V @ 9A(pk) (8.3ms)	1.5V	2μA	100μA
J, JTX 1N5187	200V	240V				
J, JTX 1N5188	400V	480V				
J, JTX 1N5190	600V	660V				

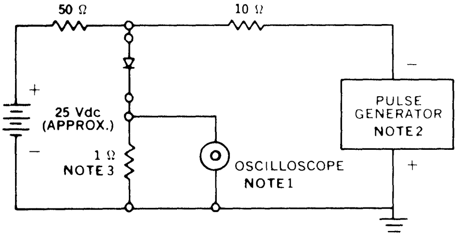
Type	Reverse Recovery Time*	Capacitance @ $V_R = 0V$ f = 1MHz	Capacitance @ $V_R = 4V$ f = 1MHz
J, JTX 1N5186	150ns	300pf	200pf
J, JTX 1N5187	200ns	300pf	170pf
J, JTX 1N5188	250ns	230pf	120pf
J, JTX 1N5190	400ns	180pf	90pf

*Recovery time measured from $I_F = 0.5A$ to $I_R = 1.0A$, $I_{REC} = 0.25A$

Maximum Current vs. Lead Temperature

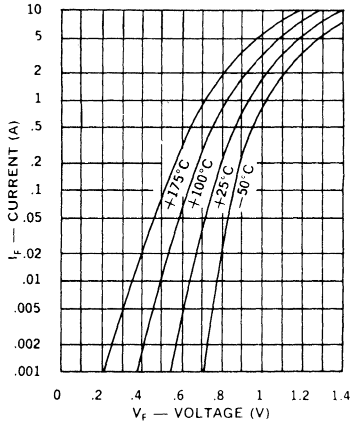


Reverse-Recovery Circuit

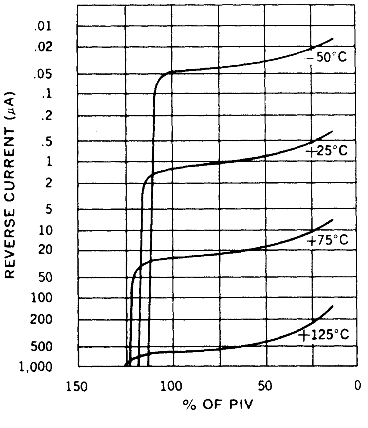


NOTES:
1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

Typical Forward Current vs Forward Voltage



Typical Reverse Current vs PIV



RECTIFIERS
Military Approved, Fast Recovery, 3 Amp

1N5415-1N5420
JAN, JANTX & JANTXV

FEATURES
- Qualified to MIL-S-19500/411
- PIV: to 600V
- Controlled Avalanche

DESCRIPTION
This series of devices as designed to meet the need for high speed, power rectifiers in military high-rel power supplies.

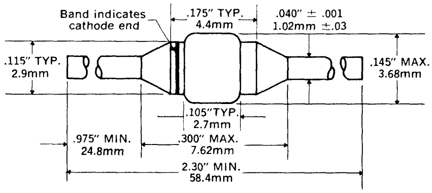
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	Type
50V	JAN, JANTX, JANTXV 1N5415
100V	JAN, JANTX, JANTXV 1N5416
200V	JAN, JANTX, JANTXV 1N5417
400V	JAN, JANTX, JANTXV 1N5418
500V	JAN, JANTX, JANTXV 1N5419
600V	JAN, JANTX, JANTXV 1N5420

Maximum Average D.C. Output Current	
@ $T_A = 55°C$	3.0A
@ $T_A = 100°C$	2.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	80A
Operating Temperature Range	—65°C to +175°C
Storage Temperature Range	—65°C to +200°C
Thermal Resistance θ_{JL} @ $L = 3/8''$	20°C/W See Lead Temperature Derating Curve

MECHANICAL SPECIFICATIONS

J, JTX, JTXV 1N5415-1N5420



Dimensions in inches.

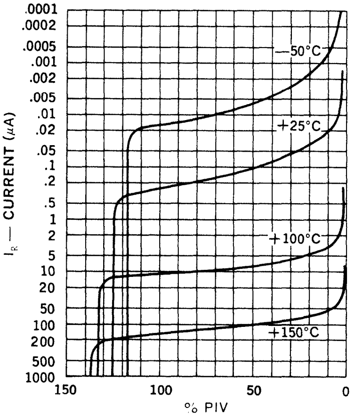
BODY B

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

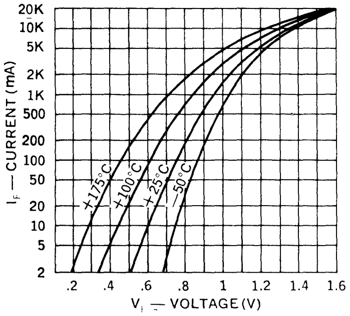
Type	PIV	Minimum Reverse Breakdown Voltage @ 50µA	Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*
			Min.	Max.	25°C	100°C	
J, JTX, JTXV 1N5415	50V	55V	0.6V @ 9Adc tp = 300µs	1.5V(pk)	1.0µA	20µA	150
J, JTX, JTXV 1N5416	100V	110V					150
J, JTX, JTXV 1N5417	200V	220V					150
J, JTX, JTXV 1N5418	400V	440V					150
J, JTX, JTXV 1N5419	500V	550V					250
J, JTX, JTXV 1N5420	600V	660V					400

*Measured in circuit $I_F = 0.5$ A, $I_R = 1$A, $I_{REC} = 0.25$ A.

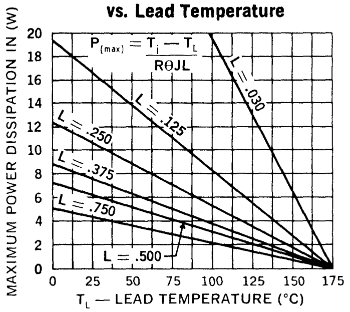
Typical Reverse Current vs. PIV



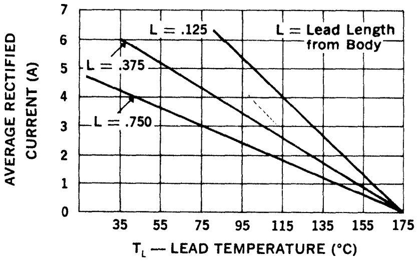
Typical Forward Current vs. Forward Voltage



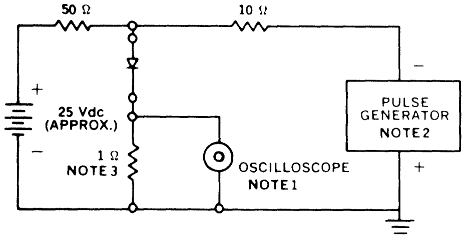
Maximum Power vs. Lead Temperature



Maximum Current vs. Lead Temperature



Reverse-Recovery Circuit



NOTES:
1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
Military Approved, 5 Amp, General Purpose

1N5550-1N5553
JAN, JANTX & JANTXV

FEATURES

- Qualified to MIL-S-19500/420A
- Continuous Rating: 5A
- PIV: to 800V
- TX Parts 100% Screened
- Miniature Size
- Controlled Avalanche

DESCRIPTION

This series of military approved rectifiers is useful in many military applications. The 100% screening requirements in the "TX" version combined with the unique Unitrode construction assures the highest degree of reliability.

ABSOLUTE MAXIMUM RATINGS

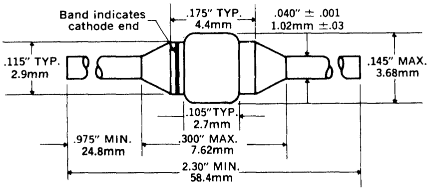
Peak Inverse Voltage	Type
200V	JAN, JANTX & JANTXV 1N5550
400V	JAN, JANTX & JANTXV 1N5551
600V	JAN, JANTX & JANTXV 1N5552
800V	JAN, JANTX & JANTXV 1N5553

Maximum Average D.C. Output Current

@ $T_A = 55°C$	3.0A
@ $T_L = 55°C$	5.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	100A
Operating Temperature Range	—65°C to +175°C
Storage Temperature Range	—65°C to +200°C
Thermal Resistance	See Lead Temperature Derating Curve

MECHANICAL SPECIFICATIONS

J, JTX, JTXV 1N5550-1N5553



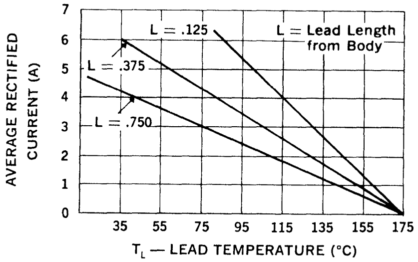
BODY B

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

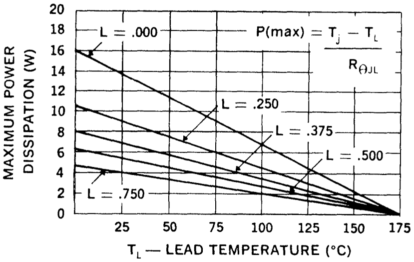
Type	Peak Inverse Voltage	Minimum Reverse Breakdown Voltage @ 50µA	Peak Forward Voltage		Maximum Leakage Current @ PIV		Maximum Reverse Recovery Time*
			Min.	Max.	25°C	100°C	
J, JTX, JTXV 1N5550	200V	240V	0.6V	1.2V @ I_F = 9A(pk) (8.3ms)	1.0µA	75µA	2.0µs
J, JTX, JTXV 1N5551	400V	460V					
J, JTX, JTXV 1N5552	600V	660V					
J, JTX, JTXV 1N5553	800V	880V					

*Measured in a test circuit I_F =0.5A, I_R = 1.0A, I_{REC} = 0.25A

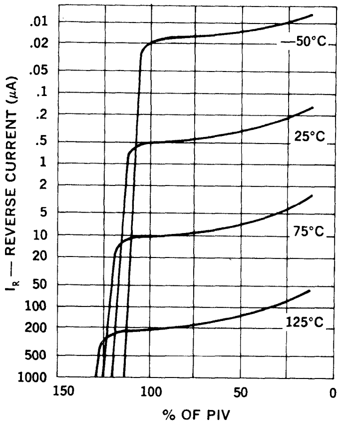
Maximum Current vs. Lead Temperature



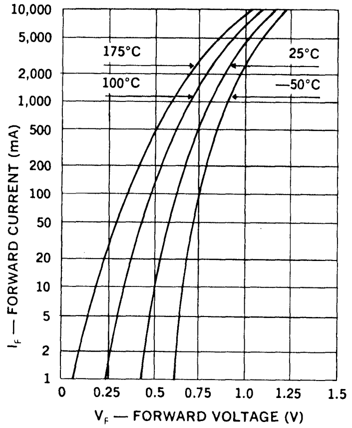
Maximum Power Dissipation vs. Lead Temperature



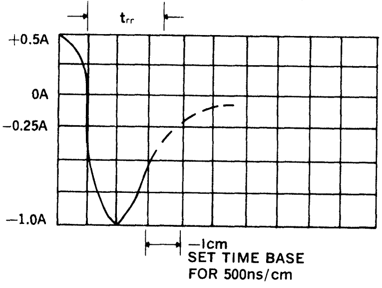
Reverse Current vs. PIV



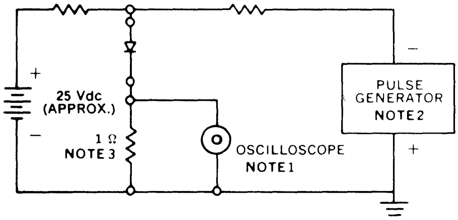
Forward Current vs. Forward Voltage



Characteristic Wave Form



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
Standard Recovery, 1 Amp
Military Approved

1N5614, 1N5616, 1N5618, 1N5620, JAN, JANTX & JANTXV

FEATURES
- Qualified to MIL-S-19500/427
- PIV: to 1000V
- Controlled Avalanche

DESCRIPTION
This series of medium power general purpose rectifiers can be used in the most demanding military supplies. Rugged mechanical integrity and tight electrical parameters make them particularly useful.

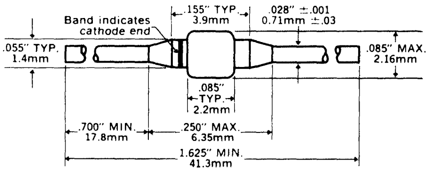
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	Type
200V	JAN, JANTX & JANTXV 1N5614
400V	JAN, JANTX & JANTXV 1N5616
600V	JAN, JANTX & JANTXV 1N5618
800V	JAN, JANTX & JANTXV 1N5620

Maximum Average D.C. Output Current	
@ $T_A = 55°C$	1.0A
@ $T_A = 100°C$	0.75A
Non-Repetitive Sinusoidal	
Surge Current (8.3ms)	30A
Operating Temperature Range	−65°C to +175°C
Storage Temperature Range	−65°C to +200°C
Thermal Resistance Θ_{JL} @ $L = 3/8''$	38°C/W See Lead Temperature Derating Curve

MECHANICAL SPECIFICATIONS

J, JTX, JTXV 1N5614, 1N5616, 1N5618, 1N5620

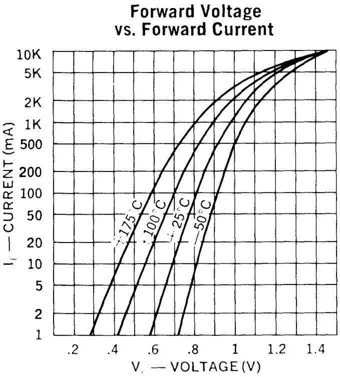


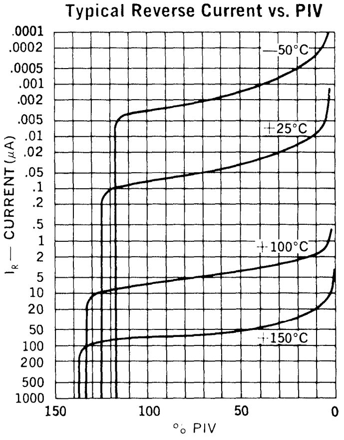
BODY A

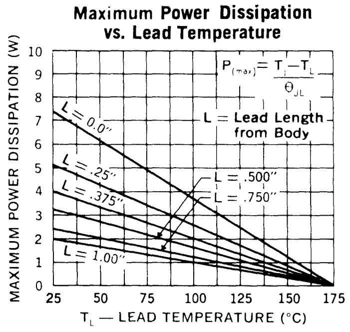
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

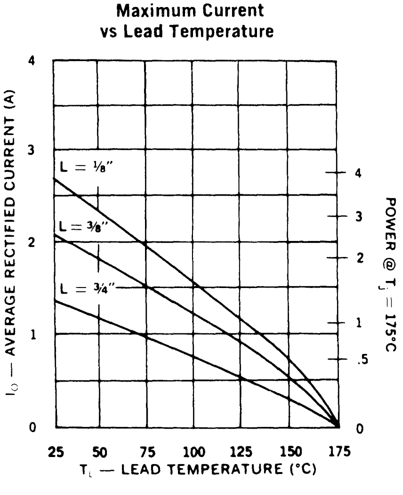
Type	PIV	Minimum Reverse Breakdown Voltage @ 50µA	Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*
			Min.	Max.	25°C	100°C	
J, JTX, JTXV 1N5614	200V	220V	0.8	1.3V(pk) @ 3.0A tp = 300µs	0.5µA	25µA	2.0µs
J, JTX, JTXV 1N5616	400V	440V					
J, JTX, JTXV 1N5618	600V	660V					
J, JTX, JTXV 1N5620	800V	880V					

*Measured in Circuit $I_F = \frac{1}{2}A$, $I_R = 1.0A$, $I_{REC} = \frac{1}{4}A$









RECTIFIERS
Military Approved, Fast Recovery, 1 Amp

1N5615, 1N5617, 1N5619
JAN, JANTX & JANTXV

FEATURES
- Qualified to MIL-S-19500/429
- PIV: to 600V
- Controlled Avalanche

DESCRIPTION
This series of military approved rectifiers is useful in many military applications where fast recovery and medium power are required. The 100% screening requirements in the "TX" version combined with the unique Unitrode construction assures the highest degree of reliability.

ABSOLUTE MAXIMUM RATINGS

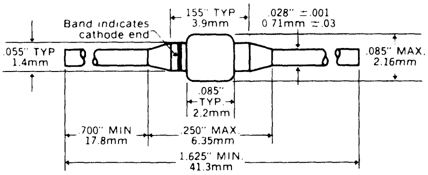
Peak Inverse Voltage	Type
200V	JAN, JANTX, JANTXV 1N5615
400V	JAN, JANTX, JANTXV 1N5617
600V	JAN, JANTX, JANTXV 1N5619

Maximum Average D.C. Output Current	
@ $T_A = 55°C$	1.0A
@ $T_A = 100°C$	0.75A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	25A
Operating Temperature Range	−65°C to +175°C
Storage Temperature Range	−65°C to +200°C
Thermal Resistance θ_{JL}	38°C/W

See Lead Temperature Derating Curve

MECHANICAL SPECIFICATIONS

J, JTX, JTXV 1N5615, 1N5617, 1N5619



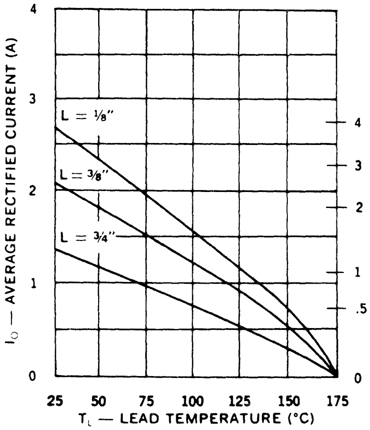
BODY A

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

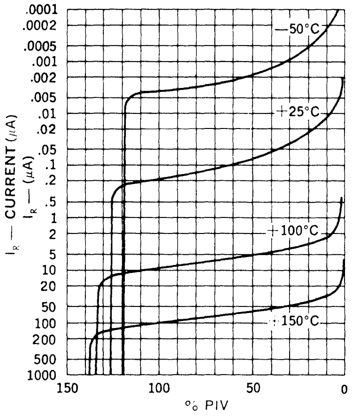
Type	PIV	Minimum Reverse Breakdown Voltage @ 50μA	Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*	Capacitance @ $V_R = 12V$ f = 1MHz
			Min.	Max.	25°C	100°C		
J, JTX, JTXV 1N5615	200V	220V	0.8V	1.6V (pk)	0.5μA	25μA	150ns	45pf
J, JTX, JTXV 1N5617	400V	440V	@ 3.0 Adc				150ns	35pf
J, JTX, JTXV 1N5619	600V	660V	tp = 300μs				250ns	25pf

*Measured in Circuit $I_F = ½A$, $I_R = 1A$, $I_{REC} = ¼A$

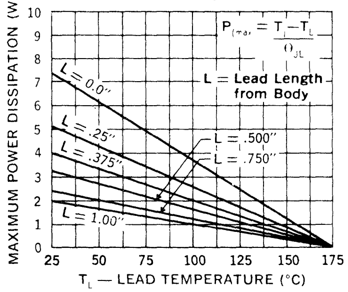
Maximum Current vs Lead Temperature



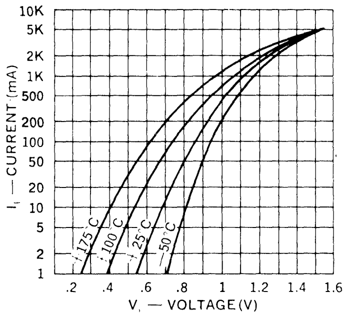
Typical Reverse Current vs. PIV



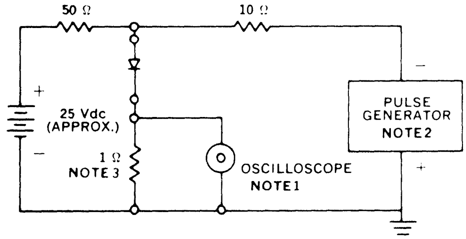
Maximum Power vs. Lead Temperature



Forward Voltage vs. Forward Current



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, ESP, 2.5 Amp to 20 Amp

1N5802-1N5806
1N5807-1N5811
1N5812-1N5816

FEATURES
- Exceptional Efficiency
- Low Forward Voltage
- Extremely Fast Reverse Recovery Time
- Extremely Fast Forward Recovery Time
- High Surge
- Small Size
- Rugged, High Current Termination
- Radiation Tolerant

DESCRIPTION
This series of High Efficiency Power Rectifiers allows circuit designers to design high current, high frequency supplies to 500 kHz with very low diode losses. The high forward surge capability makes these devices useful in protective circuits.

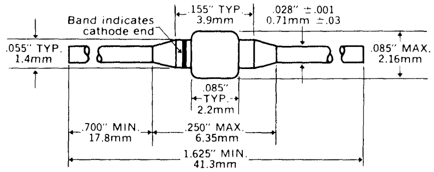
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5 Amp Series	6 Amp Series	20 Amp Series
50V	1N5802	1N5807	1N5812
75V	1N5803	1N5808	1N5813
100V	1N5804	1N5809	1N5814
125V	1N5805	1N5810	1N5815
150V	1N5806	1N5811	1N5816

	2.5 AMP SERIES	6.0 AMP SERIES	20 AMP SERIES
Maximum Average D.C. Output Current			
@ $T_L = 75°C$, L = ⅜"	2.5A	6.0A	—
@ $T_C = 100°C$			20.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	35A	125A	250A
Operating and Storage Temperature Range		—65°C to +175°C	
Thermal Resistance 2.5A and 6A Series		See Lead Temperature Derating Curve	
20A Series			3.0°C/W

MECHANICAL SPECIFICATIONS

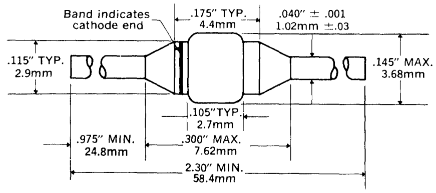
1N5802-1N5806



Typical Weight — 0.22 grams

BODY A

1N5807-1N5811



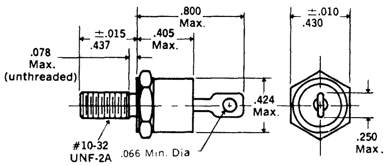
Typical Weight — 0.75 grams

BODY B

UNITRODE

MECHANICAL SPECIFICATIONS

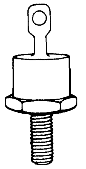
1N5812-1N5816



Part Identification: Type number printed on metal case.
Polarity: Cathode to stud end
Max. Weight: 7.0 Grams
Installation Precautions: Maximum unlubricated stud torque: 10 inch pounds
Thermal Resistance: 3.0°C/W

Dimensions in inches.

DO-4

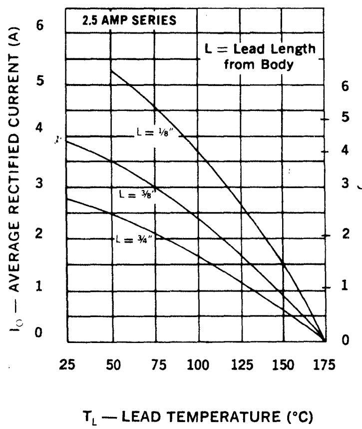


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

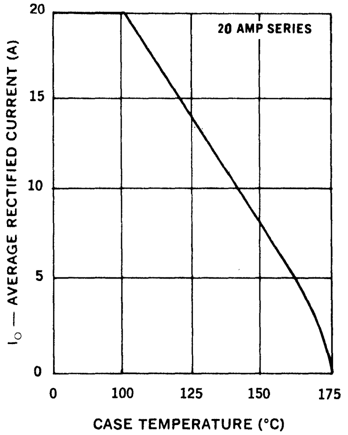
Type	PIV	Maximum Forward Voltage Drop*	Leakage Current @ PIV		Maximum Reverse Recovery Time I_F, I_R, I_{REC}	Typical Forward Recovery Time @ 1A Recover to 1V	Typical Forward Recovery Voltage @ 1A tr = 8ns	Typical Junction Capacitance @ —10V
			25°C	100°C				
1N5802 1N5803 1N5804 1N5805 1N5806	50V 75V 100V 125V 150V	.875 @ 1A	1μA	50μA	25ns, 0.5A-0.5A-0.05A	15ns	1.5V	15pf
1N5807 1N5808 1N5809 1N5810 1N5811	50V 75V 100V 125V 150V	.875 @ 4A	5μA	150μA	30ns, 1.0-1.0-0.1A	15ns	1.5V	45pf
1N5812 1N5813 1N5814 1N5815 1N5816	50V 75V 100V 125V 150V	.900 @ 10A	10μA	750μA	35ns, 1.0-1.0-0.1A	15ns	1.5V	200pf

*Pulse width = 250ms

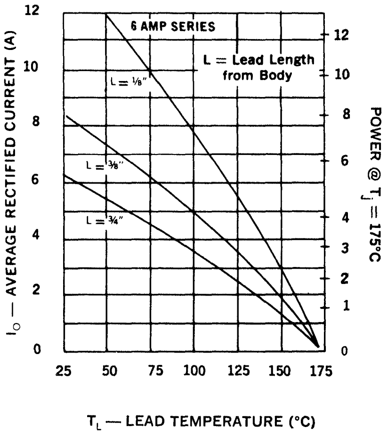
Output Current vs. Lead Temp.



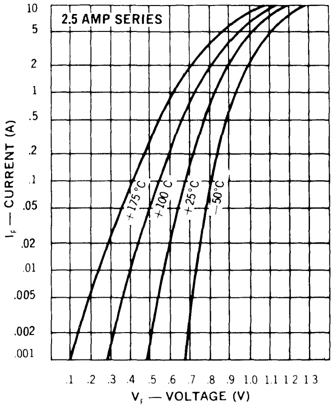
Output Current vs. Case Temp.



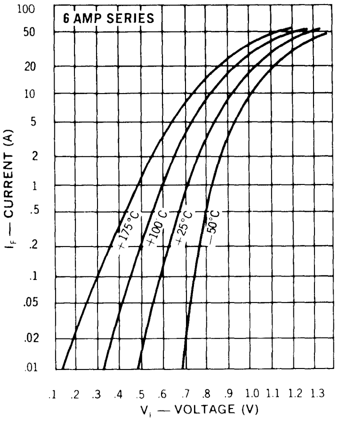
Output Current vs. Lead Temp.



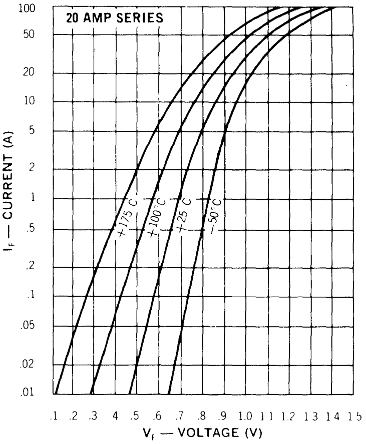
Typical Forward Current vs. Forward Voltage



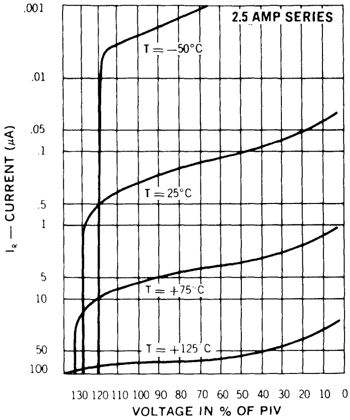
Typical Forward Current vs. Forward Voltage



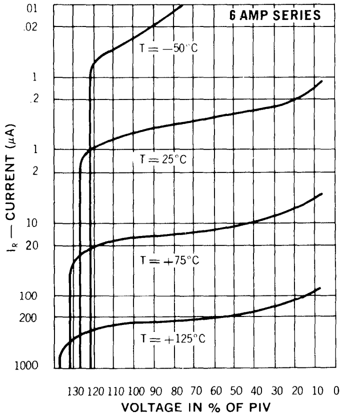
Typical Forward Current vs. Forward Voltage



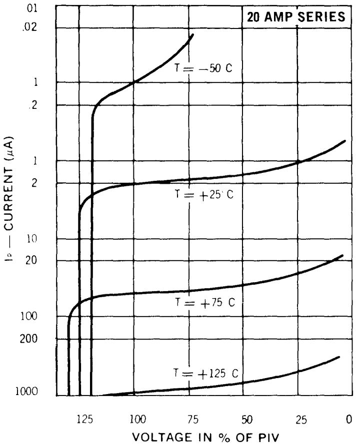
Typical Reverse Current vs. Voltage



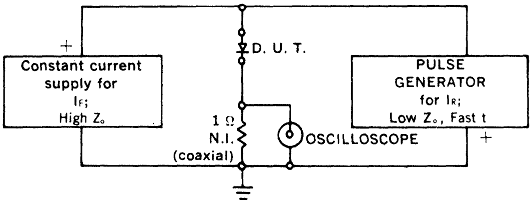
Typical Reverse Current vs. Voltage



Typical Reverse Current vs. Voltage



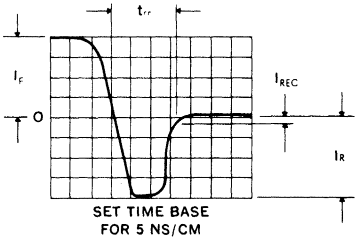
Reverse-Recovery Time Circuit



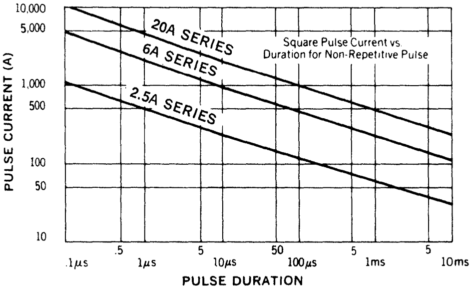
NOTES:

1. Oscilloscope: Rise time ⩽ 3 ns; input impedance = 50 Ω.
2. Pulse Generator: Rise time ⩽ 8 ns; source impedance 10 Ω.

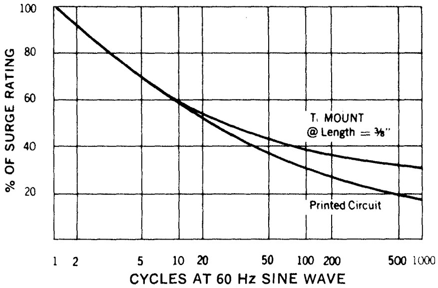
Characteristic Waveform



Forward Pulse Current vs. Duration



Multiple Surge Current vs. Duration



RECTIFIERS
Military Approved, High Efficiency, 2.5 Amp and 6.0 Amp

1N5802, 1N5804, 1N5806,
1N5807, 1N5809, 1N5811
JAN, JANTX & JANTXV

FEATURES
- Qualified to MIL-S-19500/477
- PIV: to 150V
- Low Forward Voltage

DESCRIPTION
This series of high efficiency power rectifiers are particularly applicable to switching regulator power supplies where extremely fast switching and low forward losses are most important.

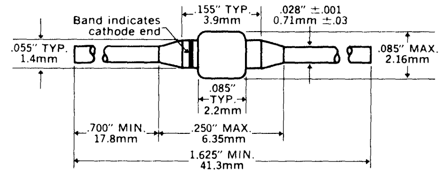
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5A Series	6.A Series
50V	JAN, JANTX & JANTXV 1N5802	JAN, JANTX & JANTXV 1N5807
100V	JAN, JANTX & JANTXV 1N5804	JAN, JANTX & JANTXV 1N5809
150V	JAN, JANTX & JANTXV 1N5806	JAN, JANTX & JANTXV 1N5811

	2.5A SERIES	6A SERIES
Maximum Average D.C. Output Current		
@ $T_L = 75°C$, $L = 3/8''$	2.5A	6.0A
@ $T_A = 55°C$	1.0A	3.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	35A	125A
Operating Temperature Range	−65°C to +175°C	
Storage Temperature Range	−65°C to +200°C	
Thermal Resistance, θ_{JL} @ $L = 3/4''$	59°C/W	35.5°C/W
	See lead temperature derating curve	

MECHANICAL SPECIFICATIONS

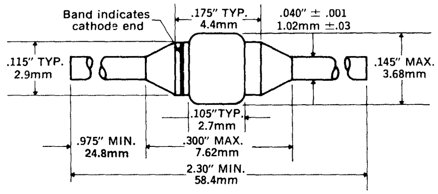
J, JTX, JTXV 1N5802-1N5806



Dimensions in inches.

BODY A

J, JTX, JTXV 1N5807-1N5811



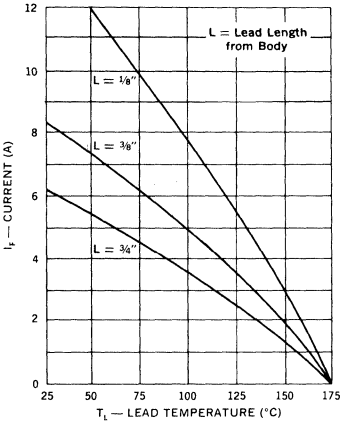
Dimensions in inches.

BODY B

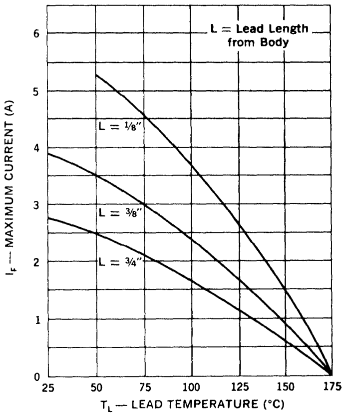
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

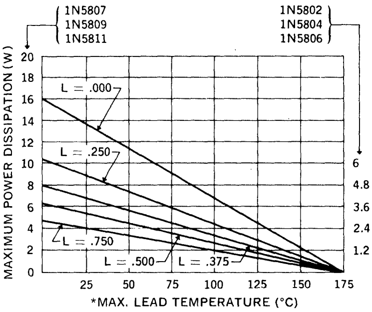
Type	PIV	Minimum Breakdown Voltage @ 100µA	Forward Voltage @ 25°C	Forward Voltage @ 100°C	Maximum Reverse Current @ PIV 25°C	Maximum Reverse Current @ PIV 100°C	Maximum Reverse Recovery Time
J, JTX, JTXV 1N5807	50V	60V	.875V Max. @ 4A (pk) .925V Max. @ 6A (pk)	.8V Max. @ 4A (pk)	5µA	150µA	30ns $I_F = I_R = 1.0A$ $I_{REC} = 0.1A$ di/dt = 100A/µs min.
J, JTX, JTXV 1N5809	100V	110V					
J, JTX, JTXV 1N5811	150V	160V					
J, JTX, JTXV 1N5802	50V	60V	.875V Max. @ 1A (pk) .975V Max. @ 2.5A (pk)	.8V Max. @ 1A (pk)	1µA	50µA	25ns $I_F = I_R = 0.5A$ $I_{REC} = 0.05A$ di/dt = 65A/µs min.
J, JTX, JTXV 1N5804	100V	110V					
J, JTX, JTXV 1N5806	150V	160V					

Output Current vs. Lead Temperature 1N5807-5811



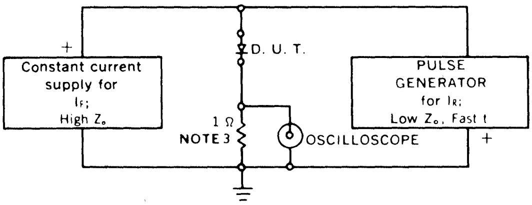
Output Current vs. Lead Temperature 1N5802-5806



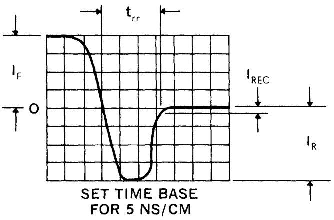


*Maximum lead temperature in °C (T_L) at point "L" from body. (For maximum operating junction temperature of 175°C with equal two-lead conditions.)

Reverse-Recovery Circuit

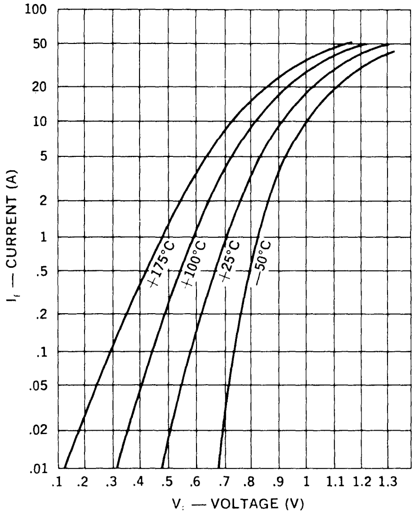


Characteristic Waveform

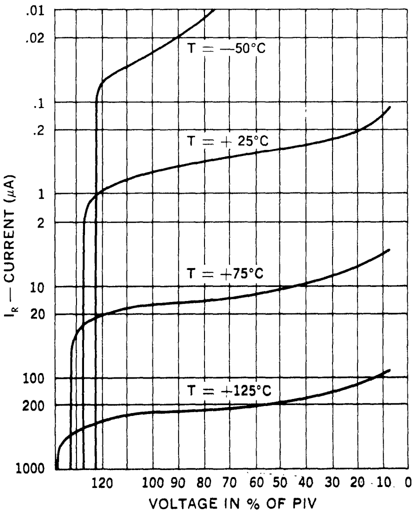


NOTES:
1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time < 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

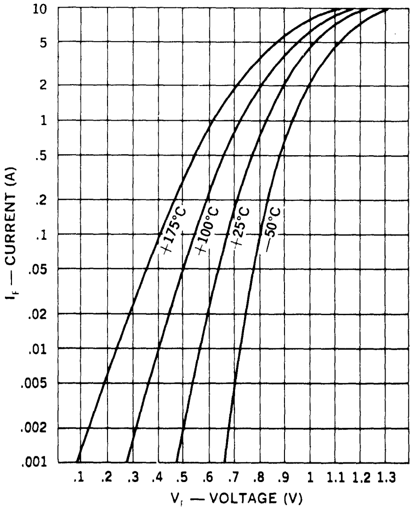
Typical Forward Current vs. Forward Voltage
JAN & JANTX 1N5807-5811



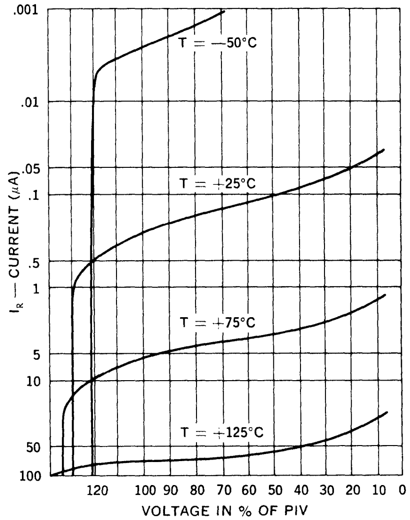
Typical Reverse Current vs. Voltage
JAN & JANTX 1N5807-5811



Typical Forward Current vs. Forward Voltage
JAN & JANTX 1N5802-5806



Typical Reverse Current vs. Voltage
JAN & JANTX 1N5802-5806



RECTIFIERS
Military Approved
High Efficiency, 20 Amp

1N5812, 1N5814, 1N5816
JAN, JANTX & JANTXV

FEATURES
- Qualified to MIL-S-19500/478
- Exceptional Efficiency
- Mechanically Rugged
- Low Thermal Resistance
- JAN, JANTX and JANTXV Available

DESCRIPTION
This series is suited for use as a power rectifier in switching regulator and high frequency inverter/converter and other appropriate equipment circuits where low voltage drop and fast recovery times are important.

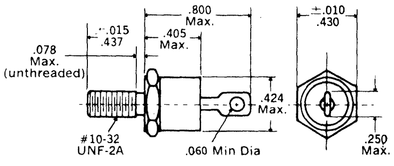
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	Type
50V	JAN, JANTX, JANTXV 1N5812
100V	JAN, JANTX, JANTXV, 1N5814
150V	JAN, JANTX, JANTXV 1N5816

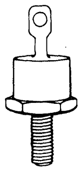
Maximum Average D.C. Output Current	
@ $T_C = 100°C$	20A
@ $T_A = 55°C$	5A
Non-Repetitive Sinusoidal Surge Current @ 8.3mSec	400A
Thermal Resistance, Junction to Case	1.5°C/W
Operating Junction Temperature	−65°C to +175°C
Storage Ambient Temperature	−65°C to +200°C

MECHANICAL SPECIFICATIONS

J, JTX, JTXV 1N5812, 1N5814, 1N5816



DO-4



Notes:
1. Polarity is cathode-to-stud.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 15 inch pounds.
4. Angular orientation of terminal is undefined.

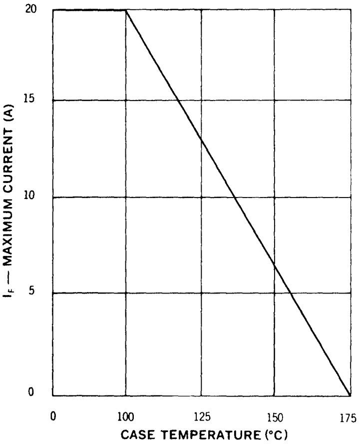
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

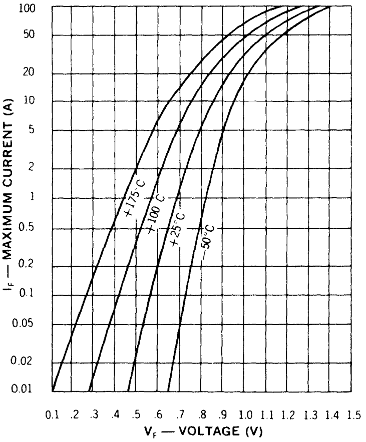
Type	Peak Inverse Voltage	Minimum Reverse Breakdown Voltage @ 100μA	Peak Forward Voltage		Maximum Leakage Current @ PIV	
			@ 10Apk	@ 20Apk	25°C	100°C
J, JTX, JTXV 1N5812	50V	60V	.86V MAX.	.95V MAX.	10μA	750μA
J, JTX, JTXV 1N5814	100V	110V				
J, JTX, JTXV 1N5816	150V	160V				

Maximum Reverse Recovery Time @ IF, IR, IREC	Maximum Forward Recovery Time @ 1A Recovery to 1V	Maximum Forward Recovery Voltage @ 1A tr = 8nsec	Maximum Junction Capacitance @ —10V
35nsec 1.0A —1.0A —0.1A	15nsec	2.2V	300pf

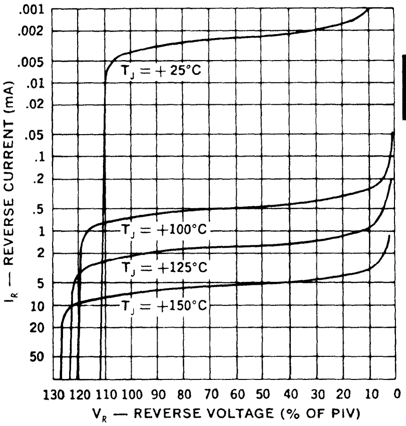
Output Current vs. Case Temperature



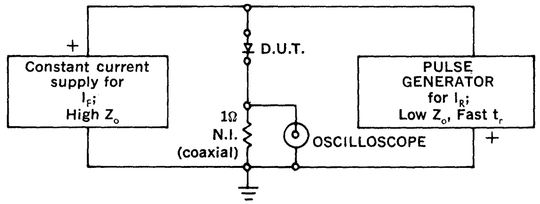
Typical Forward Current vs. Forward Voltage



Typical Reverse Current vs. Reverse Voltage



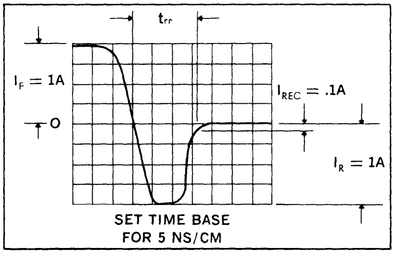
Reverse-Recovery Time Test Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3 ns; input impedance = 50 Ω.
2. Pulse Generator: Rise time ≤ 8 ns; source impedance 10 Ω.

Characteristic Waveform



POWER SCHOTTKY RECTIFIERS

25A, 30 and 40V

1N6095
1N6096

FEATURES

- Very Low Forward Drop
- Low Recovered Charge
- Rugged Package Design (DO-4)
- High Efficiency for Low Voltage Supplies

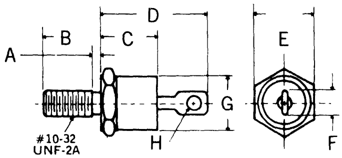
DESCRIPTION

Unitrode's series of Schottky barrier power rectifiers is ideally suited for output rectifiers and catch diodes in low voltage power supplies. The Unitrode high conductivity design, using a heavy copper top post and 4 point crimp, ensures cool thermal operation and low dynamic impedance. Rugged design absorbs stress that can damage glass-to-metal seal during installation and use.

ABSOLUTE MAXIMUM RATINGS (T_{CASE} = 25°C)	**1N6095**	**1N6096**
Working Peak Reverse Voltage, V_{RWM}	30V	40V
DC Blocking Voltage, V_R	30V	40V
Repetitive Peak Reverse Voltage, V_{RRM}	30V	40V
Non-repetitive Peak Reverse Voltage, V_{RSM}	36V	48V
Average Rectified Forward Current, I_O	25A (T_c = 70°C) 10A (T_c = 105°C)	
Non-repetitive Peak Surge Current (8.3 mS), I_{FSM}	400A	
Operating and Storage Temperature Range, T_j, T_{stg}	−65 to + 165°C	
Peak Operating Junction Temperature, $T_{j(pk)}$	+150°C	
Thermal Resistance Junction to Case, $R_{\theta JC}$	2°C/W Max.	

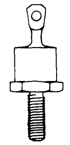
MECHANICAL SPECIFICATIONS

1N6095, 1N6096



	ins.	mm
A	.078 MAX.	1.98 MAX.
B	.437 ± .015	11.10 ±0.38
C	.405 MAX.	10.29 MAX.
D	.800 MAX.	20.32 MAX.
E	.430 ± .010	10.92 ± 0.25
F	.250 MAX.	6.35 MAX.
G	.424 MAX.	10.77 MAX.
H	.066 MIN. DIA.	1.68 MIN. DIA.

DO-4



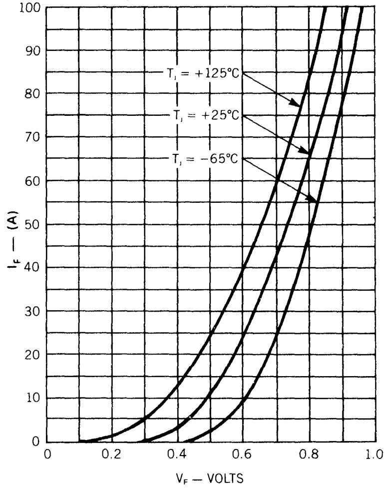
Notes:

1. Cathode is stud.
2. Maximum unlubricated stud torque: 10 inch pounds.
3. Angular Orientation of terminal is undefined.

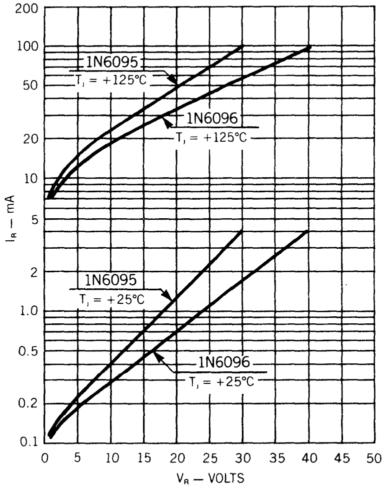
ELECTRICAL CHARACTERISTICS (T_{CASE}=25°C)

Characteristic	Symbol	Both Types	Units	Conditions
Maximum Instantaneous Reverse Current	i_R	250	mA	V_R = Rated T_C = 125°C Pulse Width = 300μS Duty Cycle ≤ 2 percent
Maximum Reverse Current	I_R	250	mA	V_R = Rated, T_C = 125°C
Maximum Instantaneous Forward Voltage	V_{FM}	0.86	V	I_F = 78.5A T_C = 70°C
	V_{FM}	0.60	V	I_F = 10A Pulse Width 300μS Duty Cycle ≤ 2 percent
Capacitance	C_t	6000	pF	V_R = 1.0V

Typical Instantaneous I_F vs V_F



Typical Instantaneous I_R vs V_R



POWER SCHOTTKY RECTIFIERS

1N6097
1N6098

50 Amp, 30 and 40 Volts

FEATURES

- Very Low Forward Drop
- Low Recovered Charge
- Rugged Package Design (DO-5)
- Low Thermal Resistance
- High Surge Current

DESCRIPTION

Unitrode's series of Schottky barrier power rectifiers is ideally suited for output rectifiers and catch diodes in low voltage power supplies. The Unitrode high conductivity design, using a heavy copper top post and 4 point crimp, ensures cool thermal operation and low dynamic impedance. Rugged design absorbs stress that can damage glass-to-metal seal during installation and use.

ABSOLUTE MAXIMUM RATINGS

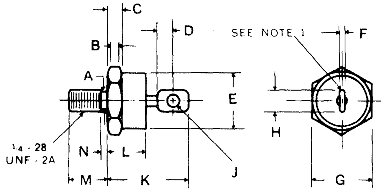
	1N6097	1N6098
Working Peak Reverse Voltage, V_{RWM}	30V	40V
DC Blocking Voltage, V_R	30V	40V
Repetitive Peak Reverse Voltage, V_{RRM}	30V	40V
Non-repetitive Peak Reverse Voltage, V_{RSM}	36V	48V
Average Rectified Forward Current, I_O	50A ($T_C = 70°C$) 20A ($T_C = 105°C$)	
Non-repetitive Peak Surge Current (8.3 mS), I_{FSM}	800A	
Operating and Storage Temperature Range, T_j, T_{stg}	−65 to +175°C	
Peak Operating Junction Temperature, $T_{j(pk)}$	+175°C	
Thermal Resistance Junction to Case, $R_{\theta JC}$	1°C/WMax.	

ELECTRICAL CHARACTERISTICS ($T_{CASE} = 25°C$)

Characteristic	Symbol	Both Types	Units	Conditions
Maximum Instantaneous Reverse Current	I_{RRM}	250	mA	V_R = Rated, $T_C = 125°C$ Pulse Width = 300μs, Duty Cycle ≤ 2 percent
Maximum Reverse Current	I_R	250	mA	V_R = Rated, $T_C = 105°C$
Maximum Instantaneous Forward Voltage	V_{FM}	0.86	V	$I_F = 157A$ $T_C = 70°C$
	V_{FM}	0.60	V	$I_F = 10A$ Pulse Width 300μs Duty Cycle ≤ 2 percent
Capacitance	C_t	7000	pF	$V_R = 1.0V$

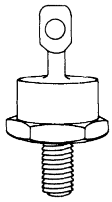
MECHANICAL SPECIFICATIONS

1N6097, 1N6098



	ins.	mm
A	.225 ± .005	5.72 ± 0.13
B	.060 MIN	1.52 MIN
C	.156 ± 020	3 96 ± 0 51
D	156 MIN FLAT	3 96 MIN. FLAT
E	.667 DIA MAX.	16.94 DIA. MAX.
F	.090 MAX.	2.29 MAX
G	677 ± 010	17.20 ± 0 25
H	.375 MAX	9.53 MAX
J	.140 MIN. DIA	3.56 MIN DIA
K	1 000 MAX	25 40 MAX
L	450 MAX	11 43 MAX
M	.438 ± 015	11 13 ± 0 38
N	.078 MAX	1 98 MAX

DO-5



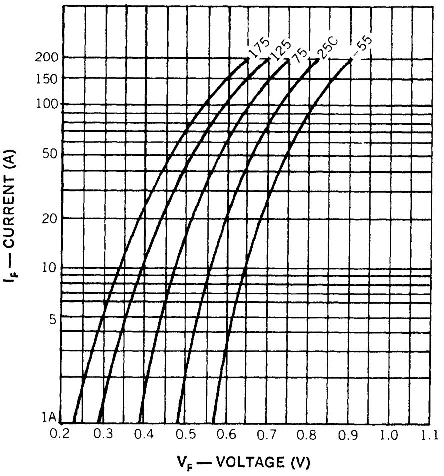
Notes:

1. Cathode is stud.
2. Maximum unlubricated stud torque: 30 inch pounds.
3. Angular orientation of terminal is undefined.
4. Maximum tension (90°) anode terminal 15 pounds for 30 seconds.

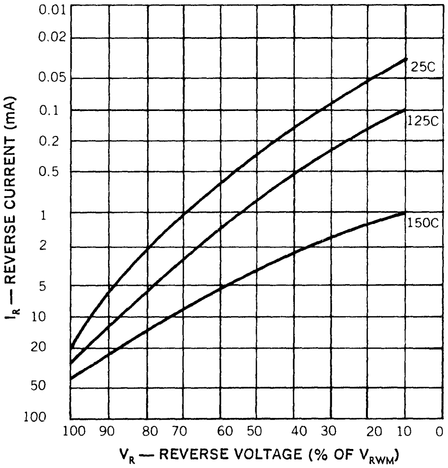
3/79

UNITRODE

Typical Forward Current vs Forward Voltage



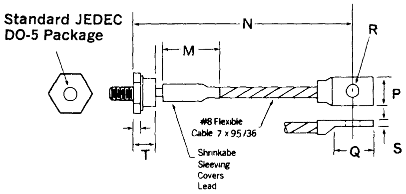
Typical Reverse Current vs Reverse Voltage



MECHANICAL SPECIFICATIONS

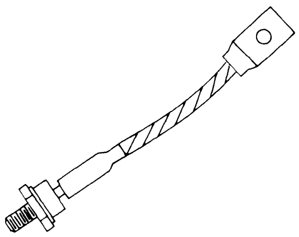
FLEXIBLE TOP LEAD (OPTIONAL)
Add an "F" Suffix to Part Number.

1N6097, 1N6098



	ins.	mm
M	1.500 ± .100	38.10 ± 2.54
N	.475 ± .250	12.07 ± 6.35
P	.425 ± .025	10.80 ± 0.64
Q	.678 ± .320	17.22 ± 8.13
R	.205 ± .005 DIA.	5.21 ± 0.13 DIA.
S	.075 ± .010	1.91 ± 0.25
T	.1 MIN.	2.54 MIN.

DO-5 with Flexible Lead



Note: Consult Factory for Non-standard Lead Lengths.

POWER SCHOTTKY RECTIFIERS

60A Pk, 45V

SD41

FEATURES

- Very Low Forward Drop
- Low Recovered Charge
- Rugged Package Design (DO-4)
- High Efficiency for Low Voltage Supplies

DESCRIPTION

The SD41 has a Schottky barrier junction and is ideally suited for output rectifiers and catch diodes in low voltage power supplies. The Unitrode high conductivity design, using a heavy copper top post and a 4 point crimp, ensures cool terminal operation and low dynamic impedance. Rugged design absorbs stress that can damage glass-to-metal seal during installation and use.

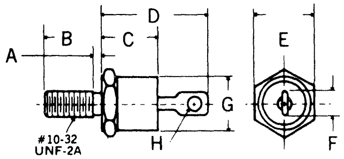
ABSOLUTE MAXIMUM RATINGS (T_{CASE} = 25°C)

Working Peak Reverse Voltage V_{RWM}	45V*
DC Blocking Voltage, V_R	45V*
Average Rectified Forward Current, I_O	30A
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 KHz, 50 percent Duty cycle), I_{FRM}	60A
Non-repetitive Peak Surge current (8.3 mS), I_{FSM}	600 A
Storage Temperature Range, T_{stg}	−55°C to +165°C
Junction Operating Temperature Range, T_j	−55°C to +150°C
Thermal Resistance, Junction to Case, $R\theta_{JC}$	2.0°C/W

*See curve of $V_{R(MAX)}$ Rating vs Case Temperature

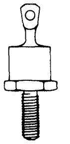
MECHANICAL SPECIFICATIONS

SD41



	ins.	mm
A	.078 MAX.	1.98 MAX.
B	.437 ± .015	11.10 ±0.38
C	.405 MAX.	10.29 MAX.
D	.800 MAX.	20.32 MAX.
E	.430 ± .010	10.92 ± 0.25
F	.250 MAX.	6.35 MAX.
G	.424 MAX.	10.77 MAX.
H	.066 MIN. DIA.	1.68 MIN. DIA.

DO-4

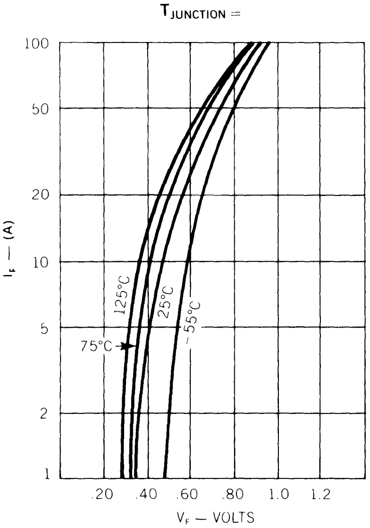


Notes:

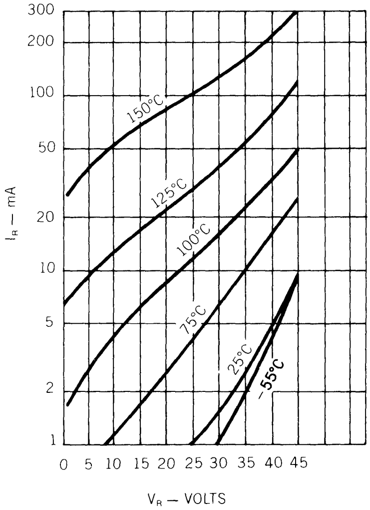
1. Cathode is stud.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 10 inch pounds.
4. Angular orientation of terminal is undefined.

ELECTRICAL CHARACTERISTICS (T_{CASE} = 25°C)

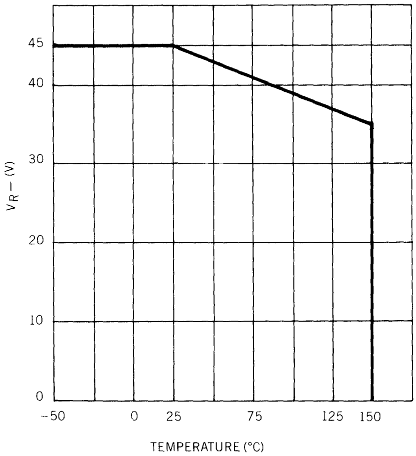
Characteristic	Symbol	Limit	Units	Conditions
Maximum Instantaneous Reverse Current	i_R	125	mA	v_R = 35V T_c = 125°C Pulse Width = 400µS Duty Cycle = 1 percent
Maximum Instantaneous Forward Voltage	v_F	0.55	V	i_F = 30A T_c = 125°C Pulse Width = 300µS Duty Cycle = 1 percent
Capacitance	C_t	2000	pF	V_R = 5.0V
Voltage Rate of Change	dv/dt	700	v/µS	v_R = 35V



Typical Reverse Characteristics



$V_{R\,(MAX)}$ Rating versus Case Temperature



POWER SCHOTTKY RECTIFIERS

SD51

120 Amp Pk, 45V

FEATURES

- Very Low Forward Drop
- Low Recovered Charge
- Rugged Package Design (DO-5)
- High Efficiency for Low Voltage Supplies
- Available with Flexible Top Lead

DESCRIPTION

The SD51 has a Schottky barrier junction and is ideally suited for output rectifiers and catch diodes in low voltage power supplies. The Unitrode high conductivity design, using a heavy copper top post and a 4 point crimp, ensures cool terminal operation and low dynamic impedance. Rugged design absorbs stress that can damage glass-to-metal seal during installation and use.

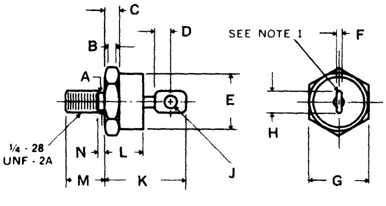
ABSOLUTE MAXIMUM RATINGS ($T_{CASE} = 25°C$)

Working Peak Reverse Voltage, V_{RWM}	45V*
DC Blocking Voltage, V_R	45V*
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 KHz, 50 percent Duty Cycle), I_{FRM}	120A
Non-repetitive Peak Surge Current (8.3 mS), I_{FSM}	800A
Storage Temperature Range, T_{stg}	−55°C to +165°C
Junction Operating Temperature Range, T_j	−55°C to +150°C
Thermal Resistance, Junction-to-Case, $R_{\theta JC}$	1.0°C/W

*See curve of $V_{R(MAX)}$ Rating vs Case Temperature

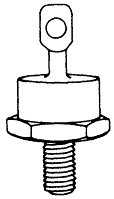
MECHANICAL SPECIFICATIONS

SD51



	ins.	mm
A	.225 ± .005	5.72 ± 0.13
B	.060 MIN.	1.52 MIN.
C	.156 ± .020	3.96 ± 0.51
D	.156 MIN. FLAT	3.96 MIN. FLAT
E	.667 DIA. MAX.	16.94 DIA. MAX.
F	.090 MAX.	2.29 MAX.
G	.677 ± .010	17.20 ± 0.25
H	.375 MAX.	9.53 MAX.
J	.140 MIN. DIA.	3.56 MIN. DIA.
K	1.000 MAX.	25.40 MAX.
L	.450 MAX.	11.43 MAX.
M	.438 ± .015	11.13 ± 0.38
N	.078 MAX.	1.98 MAX.

DO-5



Notes:

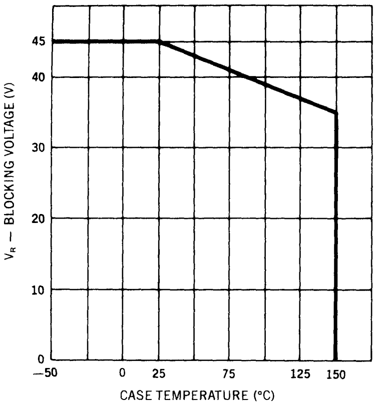
1. Cathode is stud.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 30 inch pounds (35 kg. cm).
4. Angular orientation of terminal is undefined.

UNITRODE

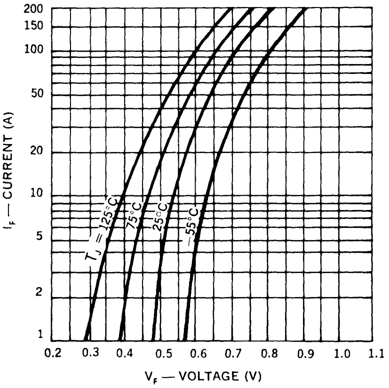
ELECTRICAL CHARACTERISTICS ($T_{CASE} = 25°C$)

Characteristic	Symbol	Limit	Units	Conditions
Maximum Instantaneous Reverse Current	i_R	200	mA	$v_R = 35V$ $T_c = 125°C$ Pulse Width $= 400\mu S$ Duty Cycle = 1 percent
Maximum Instantaneous Forward Voltage	v_F	0.60	V	$i_F = 60A$ $T_c = 125°C$ Pulse Width $= 300\mu S$ Duty Cycle = 1 percent
Flexible Top Lead Option	v_F	0.65	V	
Maximum Capacitance	C_t	4000	pF	$V_R = 5.0V$
Maximum Voltage Rate of Change	dv/dt	700	$V/\mu S$	$v_R = 35V$

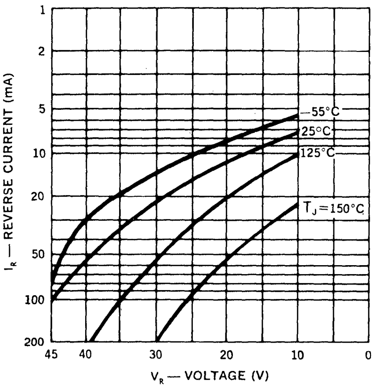
$V_{R(MAX)}$ Rating vs Case Temperature



Typical Forward Current vs Forward Voltage



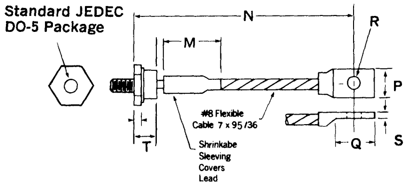
Typical Reverse Current vs Voltage



MECHANICAL SPECIFICATIONS

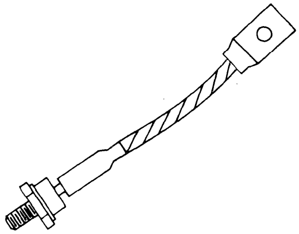
FLEXIBLE TOP LEAD (OPTIONAL) **SD51F**

Add an "F" Suffix to Part Number.



	ins.	mm
M	1.500 ± .100	38.10 ± 2.54
N	.475 ± .250	12.07 ± 6.35
P	.425 ± .025	10.80 ± 0.64
Q	.678 ± .320	17.22 ± 8.13
R	.205 ± .005 DIA.	5.21 ± 0.13 DIA.
S	.075 ± .010	1.91 ± 0.25
T	.1 MIN.	2.54 MIN.

DO-5 with Flexible Lead



Note: Consult Factory for Non-standard Lead Lengths.

DUAL POWER SCHOTTKY RECTIFIERS

SD241

30 Amp Pk per diode, 45V

FEATURES

- Very Low Forward Drop
- Low Recovered Charge
- Rugged Package Design (TO-3)
- High Efficiency for Low Voltage Supplies
- Dual Schottky Rectifiers in a Single Package

DESCRIPTION

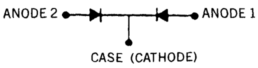
The SD241 has two Schottky barrier juntions arranged in a common cathode configuration and is ideally suited for output rectifiers and catch diodes in low voltage supplies.

ABSOLUTE MAXIMUM RATINGS (T_{CASE} = 25°C) Per Diode

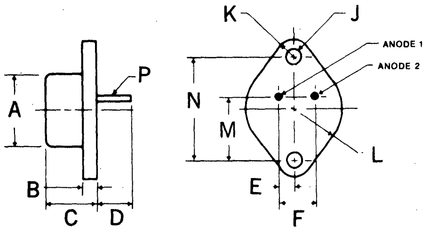
Working Peak Reverse Voltage V_{RWM}	45V
DC Blocking Voltage, V_R	45V
Average Rectified Forward Current, I_O	30A
Non-repetitive Peak Surge current (8.3 mS), I_{FSM}	400A
Storage Temperature Range, T_{stg}	−55°C to +175°C
Junction Operating Temperature Range, T_j	−55°C to +150°C
Package Thermal Resistance, Junction to Case, $R\theta_{JC}$	1.4°C/W

MECHANICAL SPECIFICATIONS

NOTE:
Leads may be soldered to within $^1/_{16}$" of base provided temperature-time exposure is less than 260°C for 10 seconds.

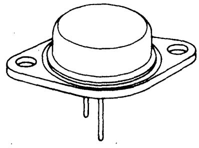


SD241



	ins.	mm
A	.875	22.23
B	.135 MAX.	3.43 MAX.
C	.350 ± .100	8.89 ± 2.54
D	.312 MIN.	7.92 MIN.
E	.215 ± .010	5.46 ± .254
F	.430 ± .010	10.92 ± .254
J	.156 ± .005	3.96 ± .127
K	.188 MAX RAD.	4.78 MAX. RAD.
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.665 ± .010	16.89 ± .254
N	1.187 ± .010	30.15 ± .254
P	.0405 ± .0025	1.03 ± .064

TO-3

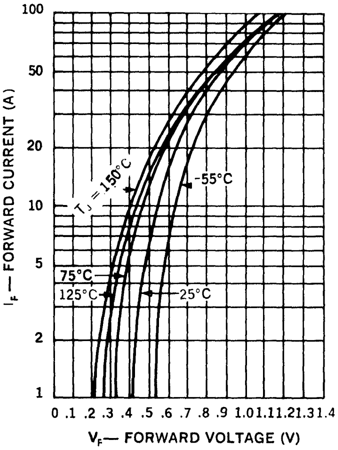


Notes: All metal surfaces tin plated.

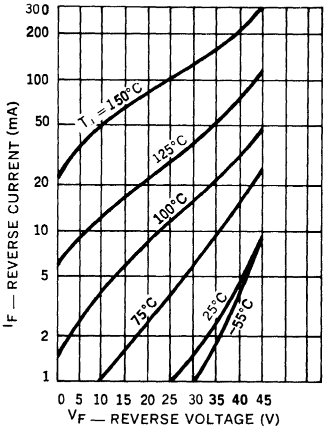
ELECTRICAL CHARACTERISTICS (T_{CASE} = 25°C) Per Diode

Characteristic	Symbol	Limit	Units	Conditions
Maximum Instantaneous Reverse Current	i_R	100	mA	$V_R = 35V$ $T_C = 125°C$ Pulse Width = 400μS Duty Cycle = 1 percent
Maximum Instantaneous Forward Voltage	v_F	.47	V	$i_F = 10A$ Pulse Width = 300μS Duty Cycle = 1 percent $T_c = 125°C$
		.60	V	$i_F = 20A$ Pulse Width = 300μS Duty Cycle = 1 percent $T_c = 125°C$
Maximum Capacitance	C_t	2000	pF	$V_R = 5.0V$
Maximum Voltage Rate of Change	dv/dt	1000	v/μS	$v_R = 35V$

Typical Forward Current vs Forward Voltage



Typical Reverse Current vs Reverse Voltage



RECTIFIERS

High Efficiency, 2A

SES5001-SES5003

FEATURES

- Fast Recovery Times
- Low Forward Voltage
- Small Size
- Convenient Package

DESCRIPTION

An axial leaded power rectifier useful in many switching applications. Particularly suited where very fast recovery and low forward voltage are required.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, SES5001	50V
Peak Inverse Voltage, SES5002	100V
Peak Inverse Voltage, SES5003	150V
Maximum Average D.C. Output Current at T_L = 75 °C, L = 3/8″	2A
Non-Repetitive Surge Current at 8.3mS	35A
Thermal Resistance, @ L = 3/8″	38 °C/W
Operating and Storage Temperature Range	− 55 °C + 175 °C

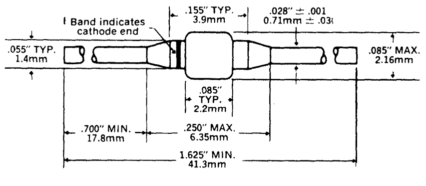
ELECTRICAL SPECIFICATIONS

Type	**PIV**	**Maximum Forward Voltage (V_F) @**		**Maximum Reverse Current (I_R) @PIV**		**Maximum Reverse Recovery Time***
		T_J = 25 °C	**T_J = 100 °C**	**@ T_J = 25 °C**	**@ T_J = 100 °C**	
SES5001	50V	.975V	.895V			
SES5002	100V	@	@	2μA	50μA	100nS
SES5003	150V	1A	1A			

*Measured in circuit I_F = .5A, I_R = 1.0A, I_{REC} = .25A

MECHANICAL SPECIFICATIONS

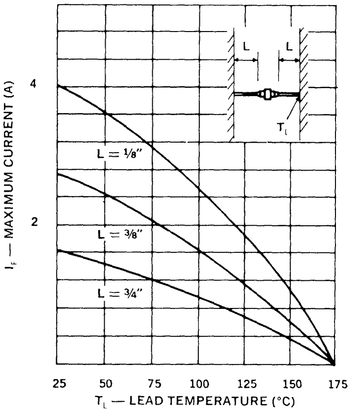
SES5001-SES5003



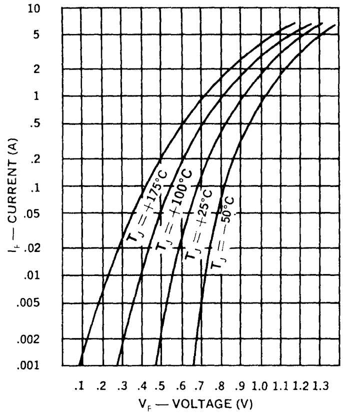
BODY A

UNITRODE

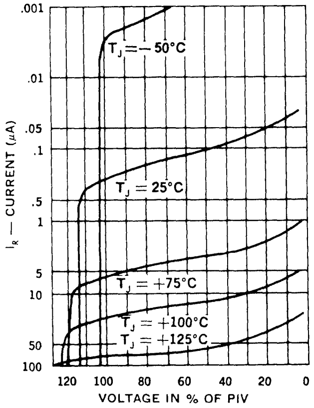
Output Current vs. Lead Temperature



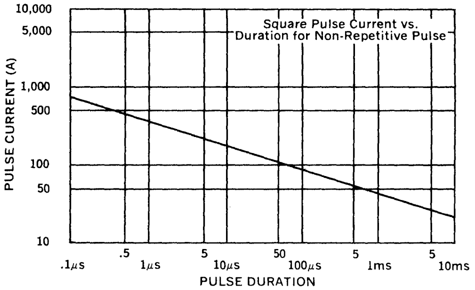
Typical Forward Current vs. Forward Voltage



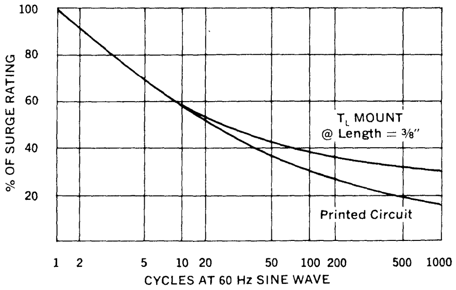
Typical Reverse Current vs. Voltage



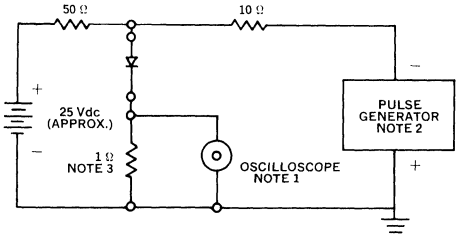
Forward Pulse Current vs. Duration



Multiple Surge Current vs. Duration



Reverse-Recovery Circuit



NOTES:
1. Oscilloscope: Rise time<3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time<8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 5A

SES5301-SES5303

FEATURES

- Low Forward Voltage
- Fast Recovery Times
- Small Size
- High Surge

DESCRIPTION

An axial leaded power rectifier useful in many switching applications. Particularly suited where very fast recovery and low forward voltage are required.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, SES5301	50V
Peak Inverse Voltage, SES5302	100V
Peak Inverse Voltage, SES5303	150V
Maximum Average D.C. Output Current at T_L = 75 °C, L = 3/8″	5A
Non-Repetitive Sinusoidal Surge Current at 8.3mS	110A
Thermal Resistance at L = 3/8″	20 °C/W
Operating and Storage Temperature Range	−55 °C to +170 °C

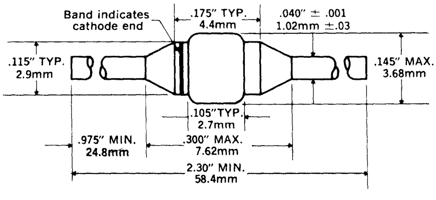
ELECTRICAL SPECIFICATIONS

Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*
		T_J = 25°C	T_J = 100°C	@T_J = 25°C	@T_J = 100°C	
SES5301	50V	0.975V @ 5A	0.895V @ 5A	5µA	150µA	100 ns
SES5302	100V					
SES5303	150V					

*Measured in circuit $I_F = 0.5A$, $I_R = 1.0A$, $I_{REC} = 0.25A$

MECHANICAL SPECIFICATIONS

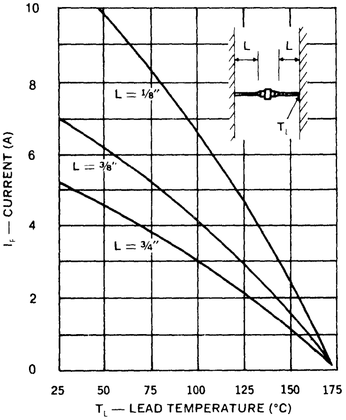
SES5301-SES5303



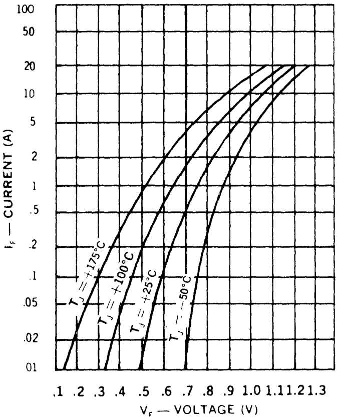
BODY B

UNITRODE

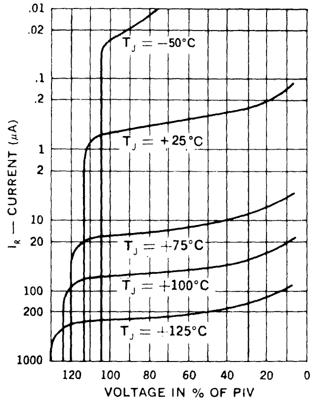
Output Current vs. Lead Temperature



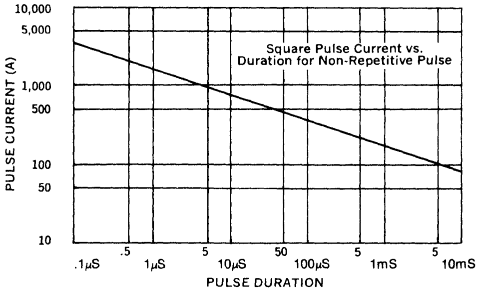
Typical Forward Current vs. Forward Voltage



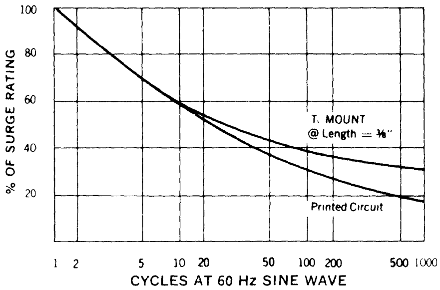
Typical Reverse Current vs. Voltage



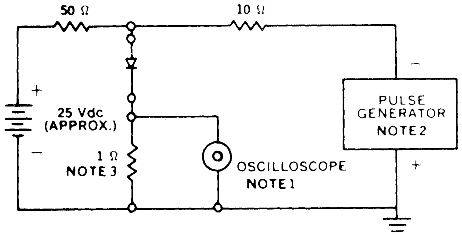
Forward Pulse Current vs. Duration



Multiple Surge Current vs. Duration



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 8A

SES5401-SES5403

FEATURES
- Low Forward Voltage
- Fast Recovery Times
- Economical, Convenient TO-220 Package
- Low Thermal Resistance
- Mechanically Rugged

DESCRIPTION
The SES5401 Series, in the economical, convenient TO-220 package, is specifically designed for operation in power switching circuits to frequencies in excess of 100KHz. The very low forward voltage and very fast recovery time make them particularly suited for switching type power supplies.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, SES5401	50V
Peak Inverse Voltage, SES5402	100V
Peak Inverse Voltage, SES5403	150V
Maximum Average D.C. Output Current	
@ T_C = 125°C	8.0A
@ T_A = 25°C	3.0A
@ T_A = 25°C (Note 1)	8.0A
Non-Repetitive Sinusoidal Surge Current, 8.3mS	70A
Thermal Resistance, Junction to Case, Θ_{J-C}	2.5°C/W
Thermal Resistance, Junction to Ambient, Θ_{J-A}	60°C/W
Operating and Storage Temperature Range	−55°C to +150°C

NOTE 1. Using Wakefield Type 295 heatsink with convection cooling. For more definitive data refer to the Output Current vs. Temperature Curves on this datasheet.

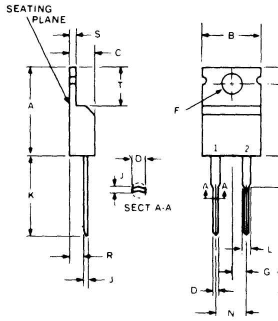
ELECTRICAL SPECIFICATIONS

Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*	Typical Forward Recovery Voltage @1A t_r = 8nS
		T_J = 25°C	T_J = 100°C	@ T_J = 25°C	@ T_J = 100°C		
SES5401 SES5402 SES5403	50V 100V 150V	1.025V @ 8A	0.945V @ 8A	5μA	150μA	100nS	1.4V

*Measured in circuit I_F = 0.50A, I_R = 1.0A, I_{REC} = 0.25A

MECHANICAL SPECIFICATIONS

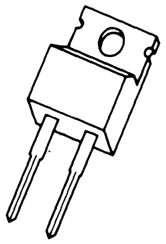
SES5401-SES5403



PIN 1. Cathode
2. Anode
Tab is connected to Cathode.

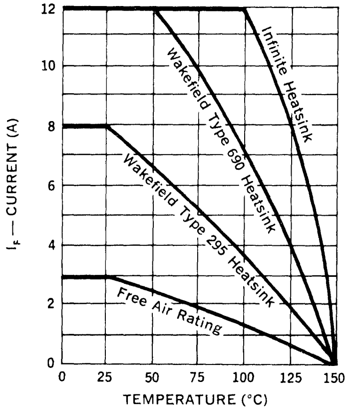
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H	—	6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

SIMILAR TO TO-220

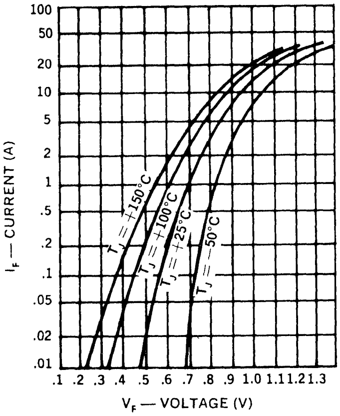


UNITRODE

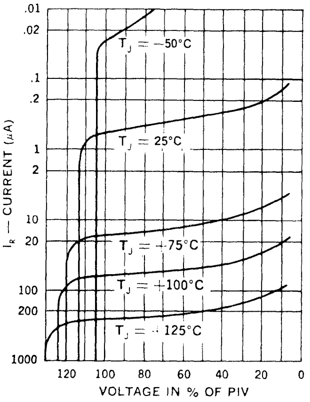
Output Current vs. Temperature



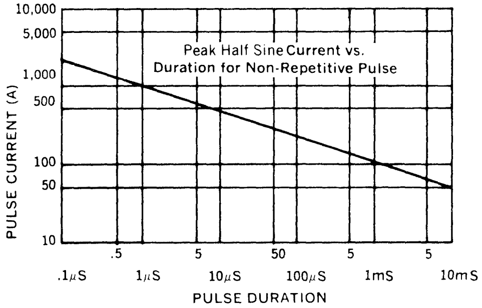
Typical Forward Current vs. Forward Voltage



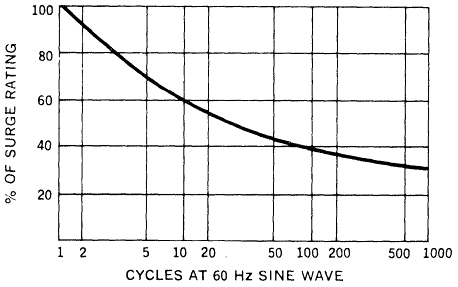
Typical Reverse Current vs. Voltage



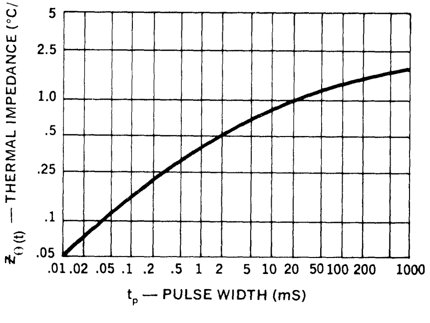
Forward Pulse Current vs. Duration



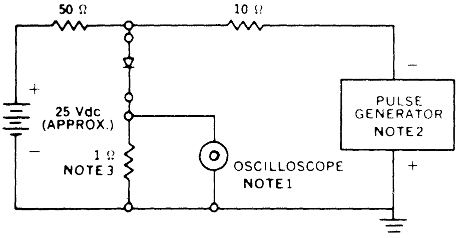
Multiple Surge Current vs. Duration



Thermal Impedance vs. Pulse Width



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 16A Center-Tap

SES5401C-SES5403C

FEATURES

- Low Forward Voltage
- Fast Recovery Times
- Economical, Convenient TO-220 Package
- Low Thermal Resistance
- Mechanically Rugged

DESCRIPTION

The SES5401C Series, in the economical, convenient TO-220 package, is specifically designed for operation in power switching circuits to frequencies in excess of 100KHz. The series combines two high efficiency devices into one package, simplifying installation, reducing heatsink requirements and the need to purchase matched components.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, SES5401C	50V
Peak Inverse Voltage, SES5402C	100V
Peak Inverse Voltage, SES5403C	150V
Maximum Average D.C. Output Current	
@ T_C = 125°C	16A
@ T_A = 25°C	3A
@ T_A = 25°C (Note 1)	10A
Non-Repetitive Sinusoidal Surge Current, 8.3mS	70A
Thermal Resistance, Junction to Case, $\Theta_{J\text{-}C}$	1.75°C/W
Thermal Resistance, Junction to Ambient, $\Theta_{J\text{-}A}$	60°C/W
Operating and Storage Temperature Range	−55°C to +150°C

NOTE 1. Using Wakefield Type 295 heatsink with convection cooling. For more definitive data refer to the Output Current vs. Temperature Curves on this datasheet.

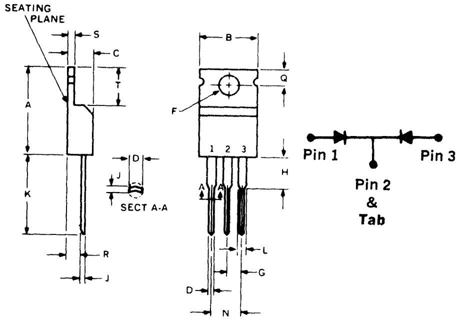
ELECTRICAL SPECIFICATIONS

Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*	Typical Forward Recovery Voltage @1A t_r = 8nS
		T_J = 25°C	T_J = 100°C	@ T_J = 25°C	@ T_J = 100°C		
SES5401C SES5402C SES5403C	50V 100V 150V	1.025V @ 8A	0.945V @ 8A	5μA	150μA	100nS	1.4V

*Measured in circuit I_F = 0.5A, I_R = 1.0A, I_{REC} = 0.25A

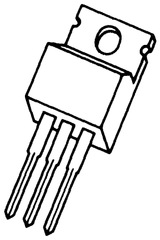
MECHANICAL SPECIFICATIONS

SES5401C-SES5403C



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H	—	6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

TO-220



UNITRODE

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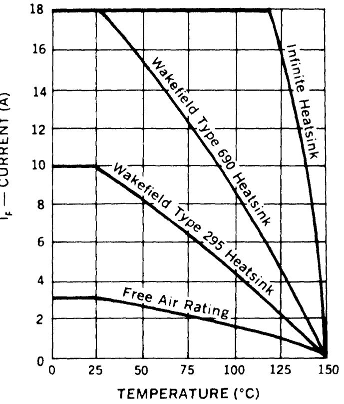
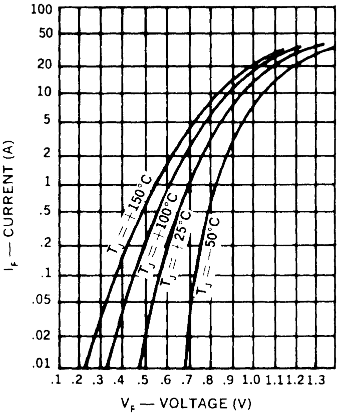
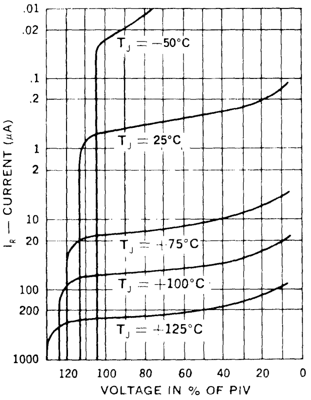
Output Current vs. Temperature



Typical Forward Current vs. Forward Voltage

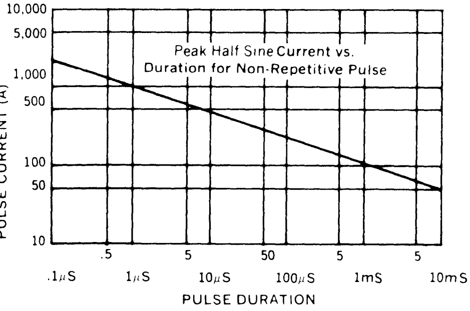


Typical Reverse Current vs. Voltage

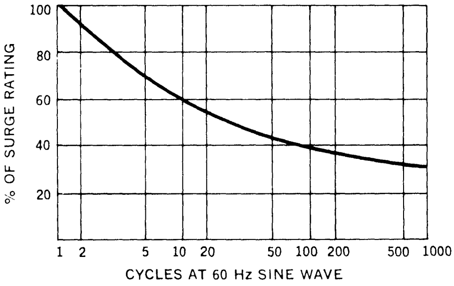


VI

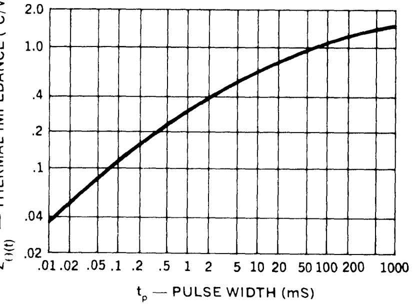
Forward Pulse Current vs. Duration



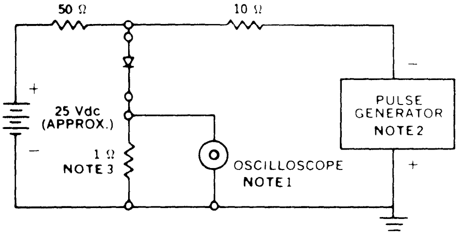
Multiple Surge Current vs. Duration



Thermal Impedance vs. Pulse Width



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 25A Center-Tap

SES5601C
SES5602C
SES5603C

FEATURES

- Low Forward Voltage Drop
- Fast Switching Speed
- Convenient Package
- High Surge Capability
- Low Thermal Resistance
- Mechanically Rugged TO-3 Package
- Available as Positive or Negative Center-Tap

DESCRIPTION

The SES, super-fast recovery, rectifiers are specifically designed for operation in power switching circuits. Their super-fast recovery time and very low forward voltage drop make them particularly efficient in most switching applications.

ABSOLUTE MAXIMUM RATINGS

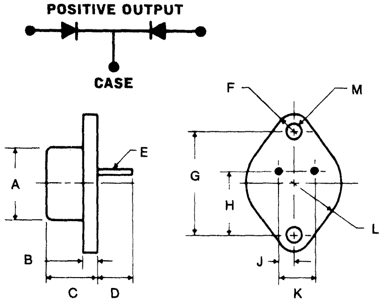
Peak Inverse Voltage, SES5601C	50V
Peak Inverse Voltage, SES5602C	100V
Peak Inverse Voltage, SES5603C	150V
Maximum Average D.C. Output Current at $T_c = 100°C$	25A
Non-Repetitive Sinusoidal Surge Current 8.3 mS	400A
Thermal Resistance, Junction to Case	1°C/W
Operating and Storage Temperature Range	−55°C to +175°C

ELECTRICAL SPECIFICATIONS PER DIODE

Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	@$T_C = 25°C$	@$T_C = 125°C$	
SES5601C SES5602C SES5603C	50V 100V 150V	0.990V @ 12.5A $t_p = 300\mu S$	0.830V @ 12.5A $t_p = 300\mu S$	20μA	4mA	100nS

*Measured in circuit $I_F = 0.5A$, $I_R = 1.0A$, $I_{REC} = 0.25A$

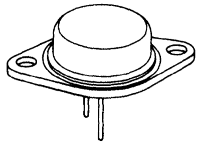
MECHANICAL SPECIFICATIONS



SES5601C-SES5603C

	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.038-.043 DIA.	0.97-1.09 DIA.
F	.188 MAX. RAD.	4.78 MAX. RAD.
G	1.177-1.197	29.00-30.40
H	.655-.675	16.64-17.15
J	.205-.225	5.21-5.72
K	.420-.440	10.67-11.18
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.151-.161	3.84-4.09 DIA.

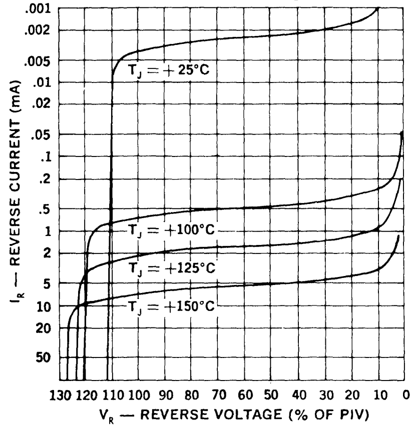
TO-3



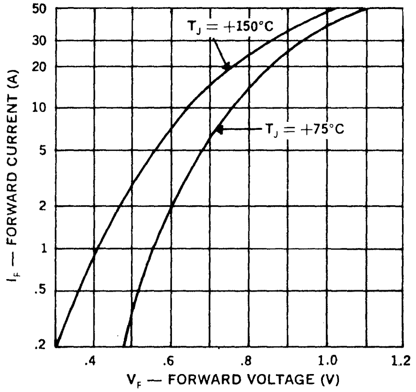
NOTES:

1. Standard polarity is positive output.
   For reverse polarity (negative output) add suffix "R", ie, SES5601CR.
2. All metal surfaces tin plated.

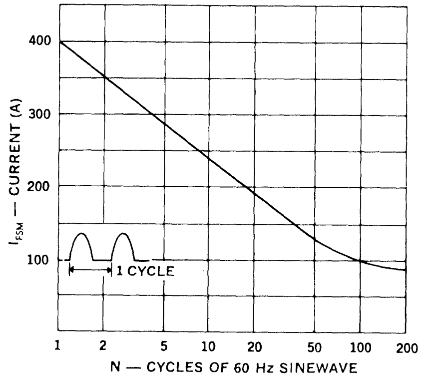
Typical Reverse Current vs. Reverse Voltage



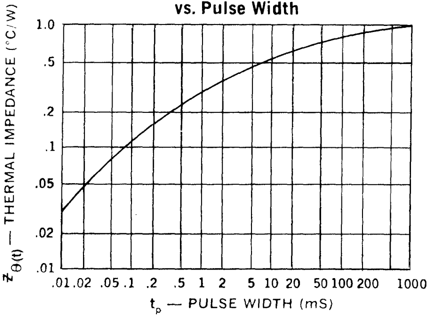
Typical Forward Current vs. Forward Voltage



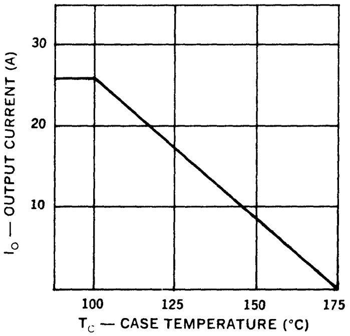
Maximum Forward Surge vs. Number of Cycles



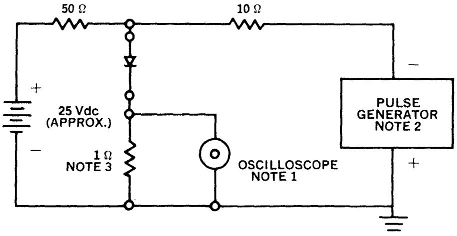
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 20A

SES5701
SES5702
SES5703

FEATURES
- Low Forward Voltage Drop
- Fast Switching
- Low Thermal Resistance
- High Surge Capability
- Mechanically Rugged DO-4 Package
- Reverse Polarity Available

DESCRIPTION
The SES, super-fast recovery, rectifiers are specifically designed for operation in power switching circuits. Their super-fast recovery time and very low forward voltage drop make them particularly efficient in most switching applications.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, SES5701	50V
Peak Inverse Voltage, SES5702	100V
Peak Inverse Voltage, SES5703	150V
Maximum Average D.C. Output Current at $T_c = 100°C$	20A
Non-Repetitive Sinusoidal Surge Current 8.3 mS	400A
Thermal Resistance, Junction to Case	1.5 °C/W
Operating and Storage Temperature Range	− 55 °C to + 175 °C

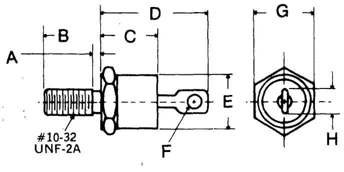
ELECTRICAL SPECIFICATIONS

Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	@ $T_C = 25°C$	@$T_C = 125°C$	
SES5701 SES5702 SES5703	50V 100V 150V	.990V @ 20A $t_p = 300\mu S$	.830 @ 20A $t_p = 300\mu S$	20μA	4mA	100nS

*Measured in circuit I_F = .5A, I_R = 1.0A, I_{REC} = .25A

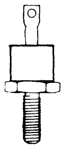
MECHANICAL SPECIFICATIONS

SES5701-SES5703



	ins.	mm
A	.078 MAX.	1.98 MAX.
B	±.437 ±.015	11.10 ±0.38
C	.405 MAX.	10.29 MAX.
D	.800 MAX.	20.32 MAX.
E	.424 MAX.	10.77 MAX.
F	.066 MIN. DIA.	1.68 MIN. DIA.
G	.430 ±.010	10.92 ±0.25
H	.250 MAX.	6.35 MAX.

DO-4



NOTES:
1. Standard polarity is cathode-to-stud.
   For reverse Polarity (anode-to-stud) add suffix "R", ie. SES5701R.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 10 inch pounds.
4. Angular orientation of terminal is undefined.

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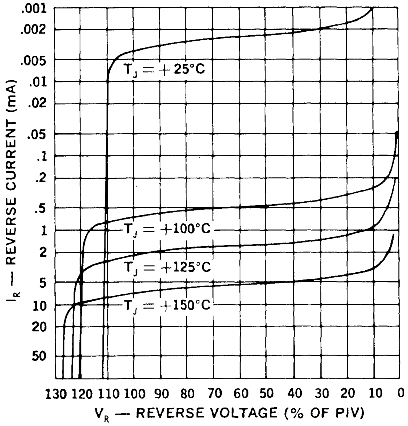
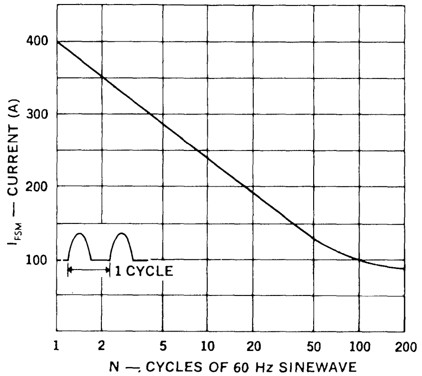
UNITRODE

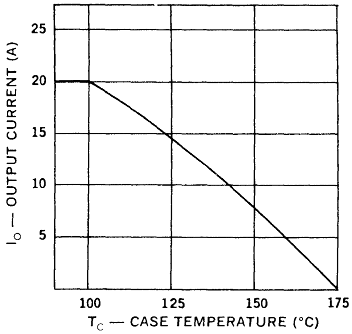
Typical Reverse Current vs. Reverse Voltage



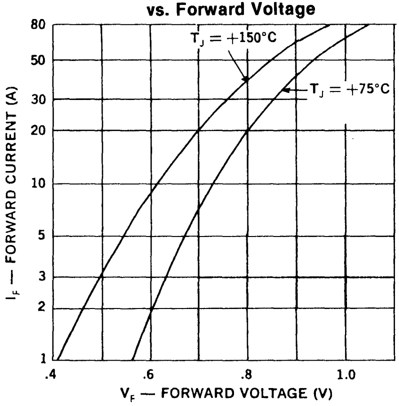
Maximum Forward Surge vs. Number of Cycles



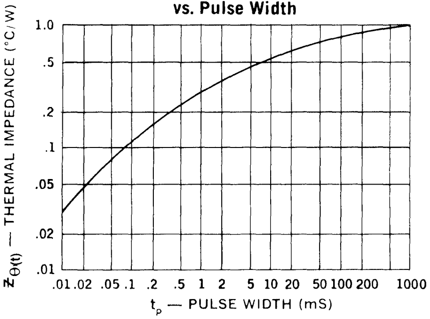
Output Current vs. Case Temperature



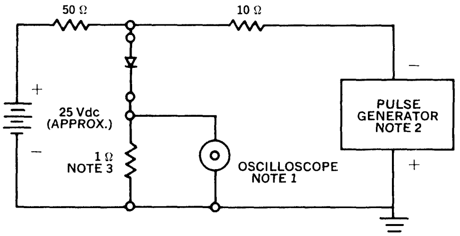
Typical Forward Current vs. Forward Voltage



Thermal Impedance vs. Pulse Width



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 60A

SES5801
SES5802
SES5803

FEATURES
- Low Forward Voltage Drop
- Fast Switching Speeds
- High Surge Capability
- Low Thermal Resistance
- Mechanically Rugged DO-5 Package
- Reverse Polarity Available

DESCRIPTION
The SES, super-fast recovery, rectifiers are specifically designed for operation in power switching circuits. Their super-fast recovery time and very low forward voltage drop make them particularly efficient in most switching applications.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, SES5801	50V
Peak Inverse Voltage, SES5802	100V
Peak Inverse Voltage, SES5803	150V
Maximum Average D.C. Output Current at $T_c = 100\,°C$	60A
Non-Repetitive Sinusoidal Surge Current 8.3 mS	800A
Thermal Resistance, Junction to Case	0.8 °C/W
Operating and Storage Temperature Range	−55 °C to +175 °C

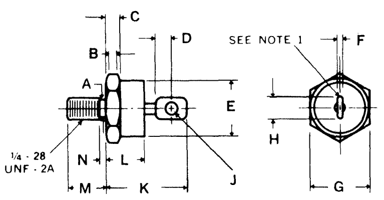
ELECTRICAL SPECIFICATIONS

Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*
		$T_C = 25\,°C$	$T_C = 150\,°C$	@$T_C = 25\,°C$	@$T_C = 150\,°C$	
SES5801 SES5802 SES5803	50V 100V 150V	0.990V @ 60A $t_p = 300\mu S$	0.850V @ 60A $t_p = 300\mu S$	25μA	30mA	100nS

*Measured in circuit $I_F = 0.5A$, $I_R = 1.0A$, $I_{REC} = 0.25A$

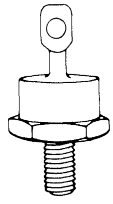
MECHANICAL SPECIFICATIONS

SES5801-SES5803



	ins.	mm
A	.225 ± .005	5.72 ± 0.13
B	.060 MIN.	1.52 MIN.
C	.156 ± .020	3.96 ± 0.51
D	.156 MIN. FLAT	3.96 MIN. FLAT
E	.667 DIA. MAX.	16.94 DIA. MAX.
F	.090 MAX.	2.29 MAX.
G	.667 ± .010	16.94 ± 0.25
H	.375	9.53
J	.140 MIN. DIA.	3.56 MIN. DIA.
K	1.000 MAX.	25.40 MAX.
L	.450 MAX.	11.43 MAX.
M	.438 ±.015	11.13 ± 0.38
N	.078 MAX	1.98 MAX.

DO-5



Notes:
1. Standard polarity is cathode-to-stud.
   For reverse polarity (anode-to-stud) add suffix "R", ie. SES5801R.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 20 inch pounds.
4. An angular orientation of terminal is undefined.

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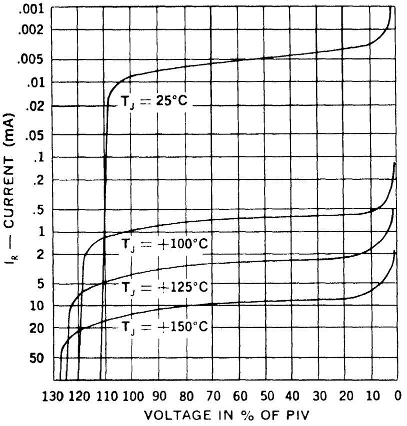
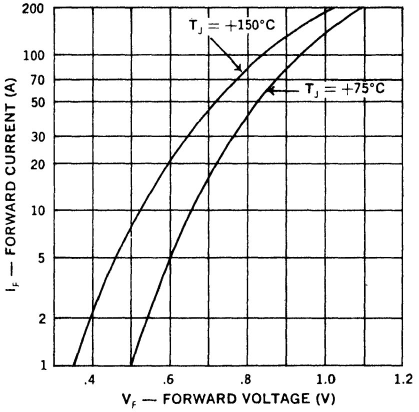
UNITRODE

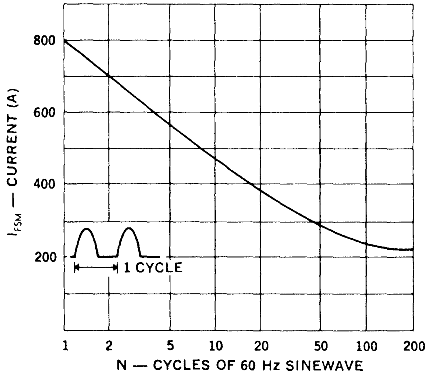
Typical Reverse Current vs. Reverse Voltage



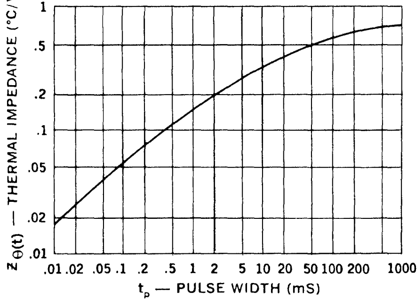
Forward Current vs. Forward Voltage



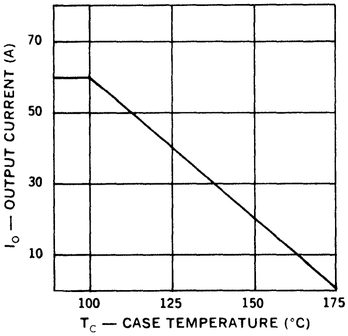
Maximum Forward Surge vs. Number of Cycles



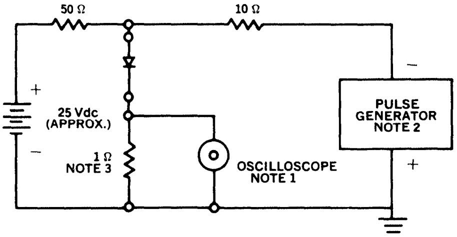
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

UES501-UES505

High Efficiency, 50 Amp

FEATURES

- 50A Continuous Rating at Case Temperature of 125°C
- Exceptional Efficiency
- Low Forward Voltage
- Extremely Fast Reverse Recovery Time
- Extremely Fast Forward Recovery Time
- High Surge
- Radiation Tolerant
- Rugged, High Current Termination

DESCRIPTION:

This series of High Efficiency Power Rectifiers allows circuit designers to design high current, high frequency supplies with very low diode losses. Reverse recovery time is typically 1/10 - 1/100th of equivalent power rectifiers, with even lower forward voltage.

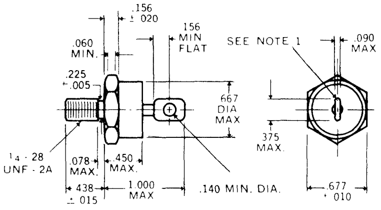
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	Type
50V	UES501
75V	UES502
100V	UES503
125V	UES504
150V	UES505

Maximum Average D.C. Output Current @ $T_C = 125°C$	50A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	600A
Operating Temperature Range	−65°C to +175°C
Storage Temperature Range	−65°C to +175°C
Thermal Resistance	1°C/W

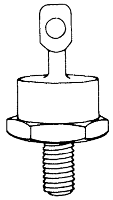
MECHANICAL SPECIFICATIONS

UES501-UES505



Dimensions in inches.

DO-5

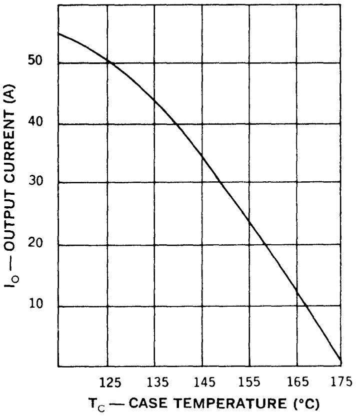


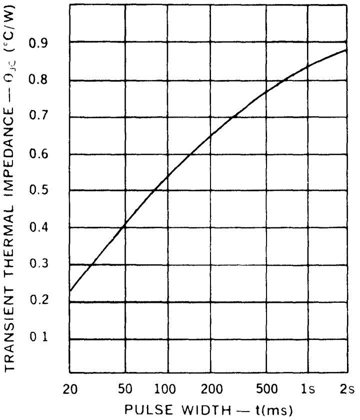
Notes:

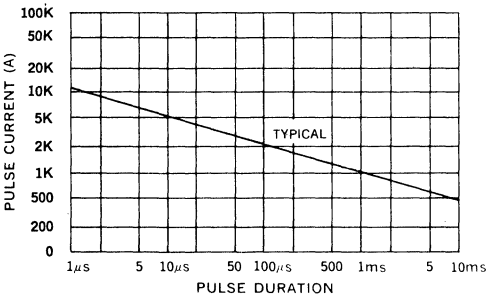
1. Angular orientation of terminal is undefined.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 30 inch pounds.
4. All dimensions in inches.
5. Polarity is cathode to stud; for anode to stud add suffix "R".

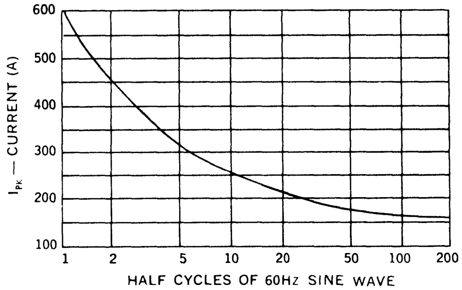
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	Peak Inverse Voltage	Maximum Forward Voltage Drop	Maximum Leakage Current		Maximum Reverse Recovery Time t_{rr} @ I_F-I_R-I_{REC}
			25°C	125°C	
UES501 UES502 UES503 UES504 UES505	50V 75V 100V 125V 150V	.95V @ 50A (pw = 250ms)	25µA	10mA	50ns. 1A-1A-0.5A

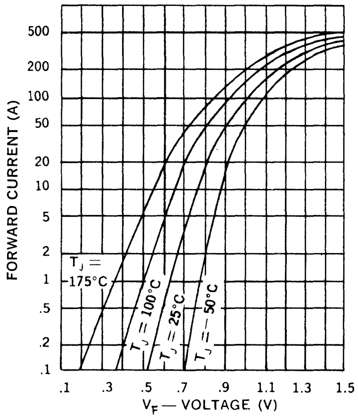

Output Current vs. Case Temp.


Pulse Thermal Impedance vs. Pulse Width

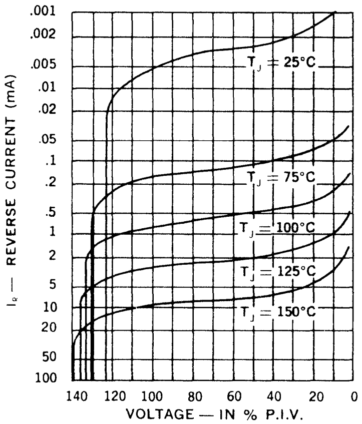

Square Pulse Current vs. Duration for Non-Repetition Square Wave


Multiple Surge Current vs. Duration

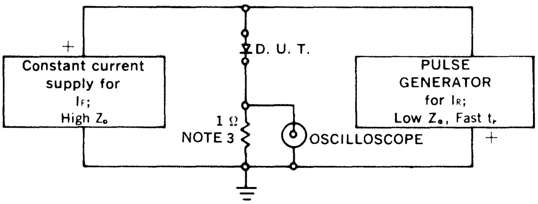
Typical Forward Current vs. Forward Voltage



Typical Reverse Current vs. Voltage



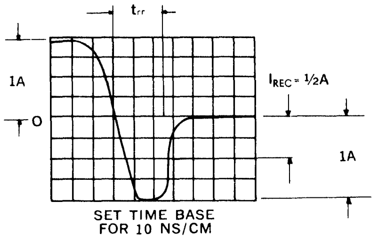
Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3 ns; input impedance = 50 Ω.
2. Pulse Generator: Rise time ≤ 8 ns; source impedance 10 Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

Characteristic Waveform



RECTIFIERS
High Efficiency, 30A

UES601-UES603

FEATURES

- Very Low Forward Voltage
- Very Fast Switching Speeds
- High Surge Capability
- Low Thermal Resistance
- Mechanically Rugged
- Both Polarities Available

DESCRIPTION

This series consists of a power switching rectifier in a convenient TO-3 package. Although designed as a component for switching type power supplies, these devices can be used in any circuit in which fast switching and/or high efficiency is required.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES601	50V
Peak Inverse Voltage, UES602	100V
Peak Inverse Voltage, UES603	150V
Maximum Average D.C. Output Current at $T_C = 100°C$	30A
Non-Repetitive Sinusoidal Surge Current 8.3 ms	800A
Thermal Resistance, Junction to Case	1°C/W
Operating and Storage Temperature Range	—55°C to +175°C

POWER CYCLING

These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

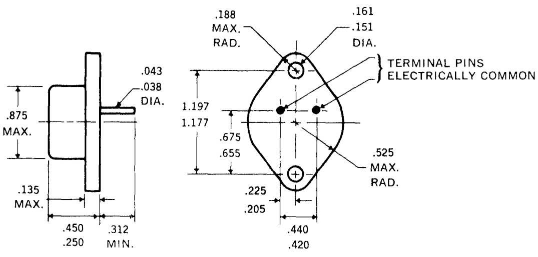
In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

SWITCHING CHARACTERISTICS

The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

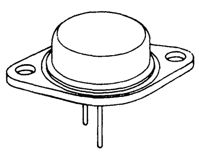
MECHANICAL SPECIFICATIONS

UES601-UES603



Dimensions in inches.

TO-3

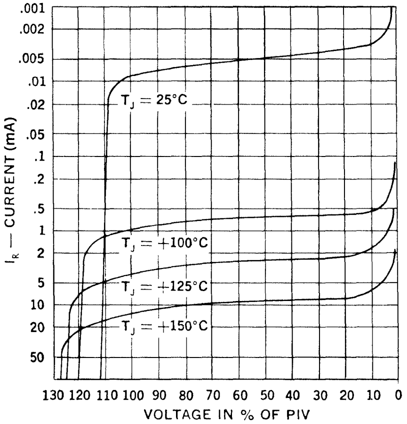


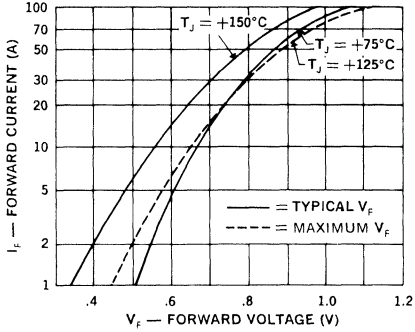
Note:
Standard polarity is cathode-to-case.
For reverse polarity (anode-to-case) add suffix "R", ie. UES601R.

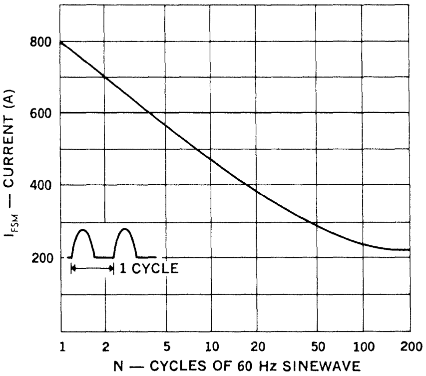
ELECTRICAL SPECIFICATIONS

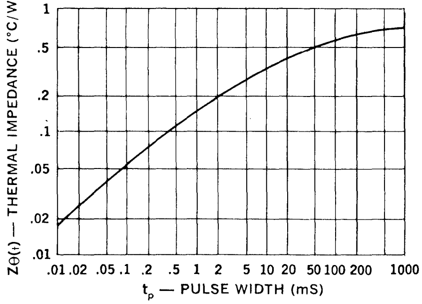
Type	PIV	Maximum Forward Voltage @		Maximum Reverse Current @		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	$T_C = 25°C$	$T_C = 125°C$	
UES601 UES602 UES603	50V 100V 150V	.915V @ 30A $t_p = 300\mu S$	.800V @ 30A $t_p = 300\mu S$	25μA	10mA	50nS

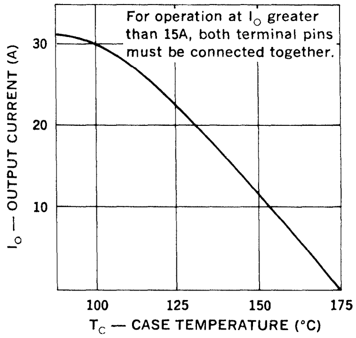
* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

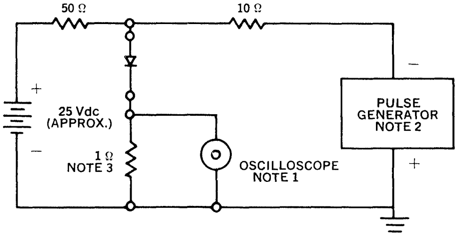

Typical Reverse Current vs. Reverse Voltage


Forward Current vs. Forward Voltage


Maximum Forward Surge vs. Number of Cycles


Thermal Impedance vs. Pulse Width


Output Current vs. Case Temperature


Reverse-Recovery Circuit

NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 25 A

UES701-UES703

FEATURES
- Low Forward Voltage
- Very Fast Switching
- Low Thermal Resistance
- High Surge Capability
- Mechanically Rugged
- Both Polarities Available

DESCRIPTION
Designed to meet the efficiency demand of switching type power supplies, these devices are useful in many switching applications.
The low thermal resistance and forward voltage drop of this series allows the user to replace DO-5 size devices in many applications.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES701	50V
Peak Inverse Voltage, UES702	100V
Peak Inverse Voltage, UES703	150V
Maximum Average D.C. Output Current at $T_C = 100°C$	25A
Non-Repetitive Sinusoidal Surge Current at 8.3ms	400A
Thermal Resistance, Junction to Case	1.5°C/W
Operating and Storage Temperature Range	−55°C to +175°C

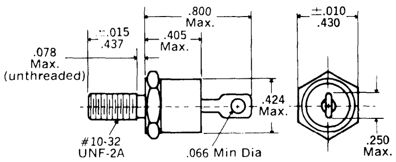
POWER CYCLING
These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

SWITCHING CHARACTERISTICS
The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

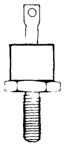
MECHANICAL SPECIFICATIONS

UES701-UES703



Dimension in inches.

DO-4



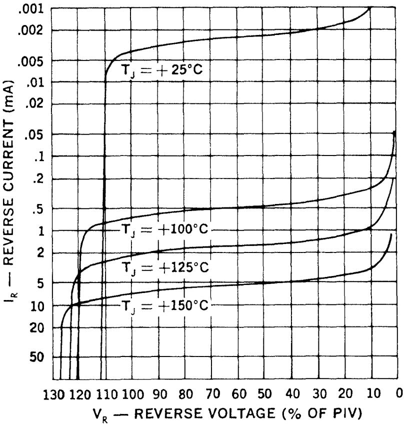
Notes:
1. Standard polarity is cathode-to-stud.
   For reverse Polarity (anode-to-stud) add suffix "R", ie. UES701R.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 15 inch pounds.
4. Angular orientation of terminal is undefined.

ELECTRICAL SPECIFICATIONS

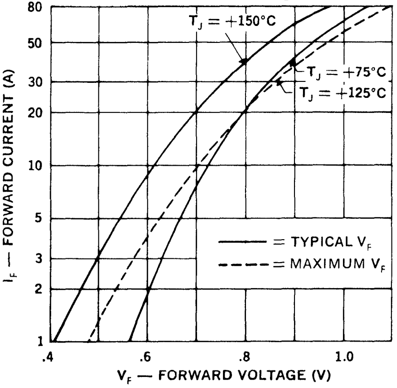
Type	PIV	Maximum Forward Voltage @		Maximum Reverse Current @		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	$T_C = 25°C$	$T_C = 125°C$	
UES701	50V	.950 @ 25A $t_p = 300\mu S$	.825 @ 25A $t_p = 300\mu S$	$20\mu A$	4mA	35nS
UES702	100V					
UES703	150V					

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

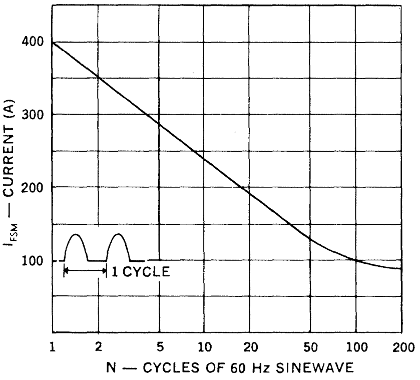
Typical Reverse Current vs. Reverse Voltage



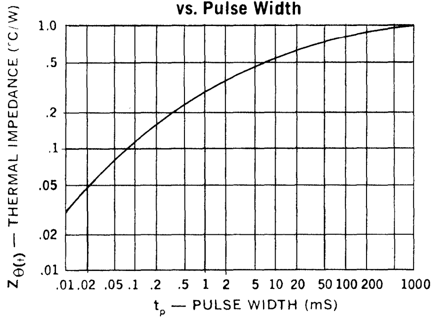
Forward Current vs. Forward Voltage



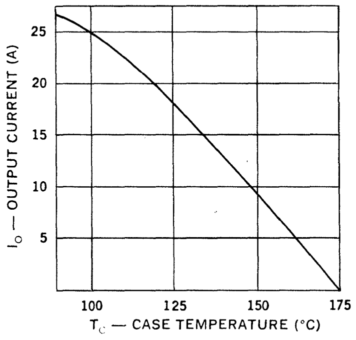
Maximum Forward Surge vs. Number of Cycles



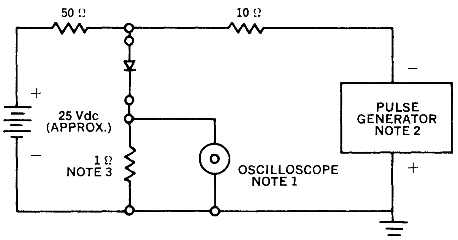
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 20A

UES704–UES706

FEATURES

- Very Low Forward Voltage (1.15V)
- Very Fast Recovery Times (50nSec)
- Low Thermal Resistance
- High Surge Capability
- Mechanically Rugged
- Both Polarities Available

DESCRIPTION

The UES704 series is specifically designed for operation in power switching circuits operating at frequencies of at least 20 KHz.

The low thermal resistance and forward voltage drop of this series allows the user to replace DO-5 size devices in many applications.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES704	200V
Peak Inverse Voltage, UES705	300V
Peak Inverse Voltage, UES706	400V
Ave. D.C. Output Current, I_O @ $T_C = 100°C$	20A
Surge Current, 8.3mSec	300A
Thermal Resistance, Junction to Case	1.5°C/W
Operating and Storage Temperature Range	–55°C to +150°C

POWER CYCLING

These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

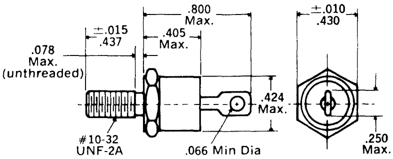
In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

SWITCHING CHARACTERISTICS

The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

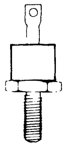
MECHANICAL SPECIFICATIONS

UES704-UES706



Dimension in inches.

DO-4



Notes:

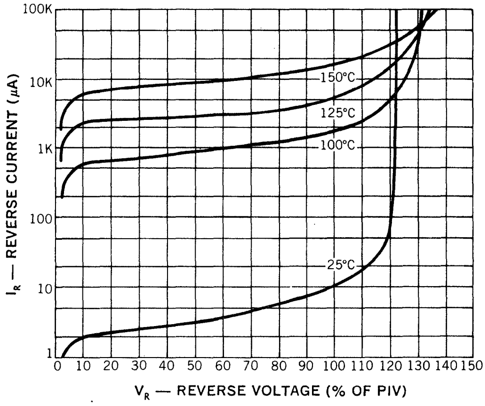
1. Standard polarity is cathode-to-stud.
   For reverse Polarity (anode-to-stud) add suffix "R", ie. UES704R.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 15 inch pounds.
4. Angular orientation of terminal is undefined.

ELECTRICAL SPECIFICATIONS

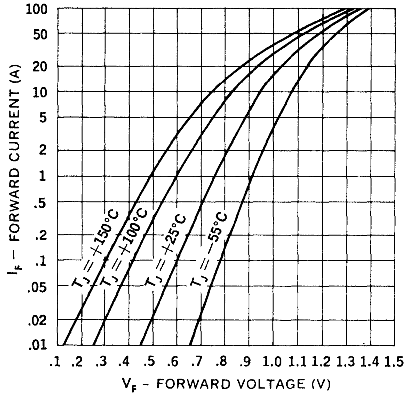
Type	PIV	Maximum Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	$T_C = 25°C$	$T_C = 125°C$	
UES704 UES705 UES706	200V 300V 400V	1.25V @ 20A $t_p = 300\mu S$	1.15V @ 20A $t_p = 300\mu S$	50µA	10mA	50nS

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

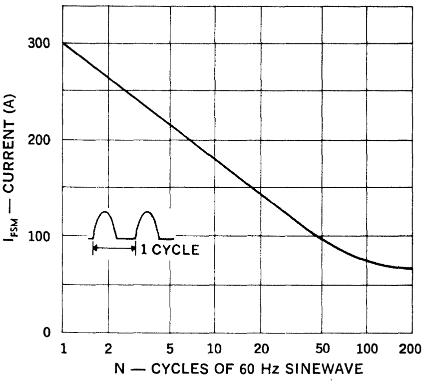
Typical Reverse Current vs. Reverse Voltage



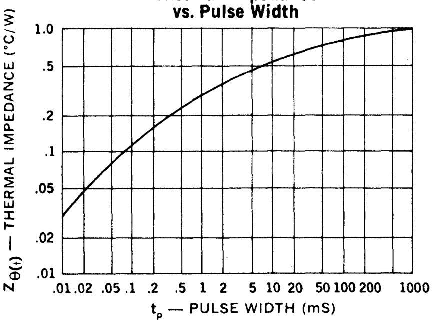
Forward Current vs. Forward Voltage



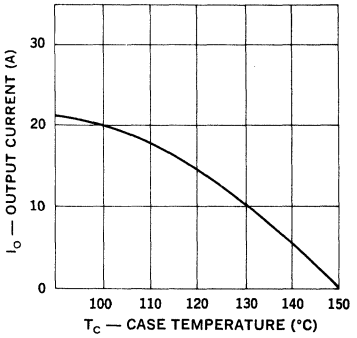
Maximum Forward Surge vs. Number of Cycles



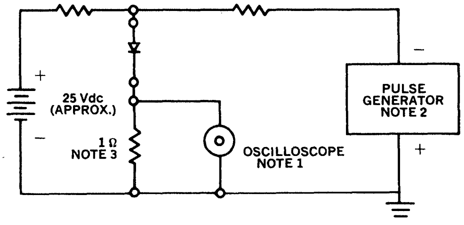
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 70 Amp

UES801-UES803

FEATURES

- High Continuous Current Rating
- Very Low Forward Voltage
- Very Fast Switching Speeds
- High Surge Capability
- Low Thermal Resistance
- Mechanically Rugged
- Both Polarities Available
- Available with Flexible Top Lead

DESCRIPTION

The UES801 Series is specifically designed for operation in power switching circuits operating at frequencies of at least 20 KHz. The very low forward voltage and very fast recovery time make them particularly suited for switching type power supplies.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES801	50V
Peak Inverse Voltage, UES802	100V
Peak Inverse Voltage, UES803	150V
Maximum Average D.C. Output Current at $T_C = 100°C$	70A
Non-Repetitive Sinusoidal Surge Current 8.3 ms	800A
Thermal Resistance, Junction to Case	0.8°C/W
Operating and Storage Temperature Range	−55°C to +175°C

POWER CYCLING

These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

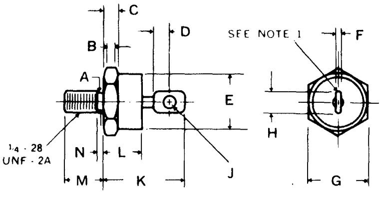
In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

SWITCHING CHARACTERISTICS

The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

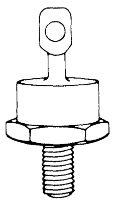
MECHANICAL SPECIFICATIONS

UES801-UES803



	ins.	mm
A	.225 ± 005	5.72 ± 0 13
B	.060 MIN.	1 52 MIN
C	156 ± 020	3.96 ± 0 51
D	156 MIN. FLAT	3.96 MIN. FLAT
E	.667 DIA. MAX.	16.94 DIA. MAX
F	.090 MAX.	2.29 MAX
G	677 ± .010	17.20 ± 0 25
H	375 MAX	9.53 MAX
J	140 MIN. DIA	3.56 MIN DIA
K	1.000 MAX.	25.40 MAX.
L	.450 MAX.	11 43 MAX.
M	438 ± .015	11 13 ± 0.38
N	078 MAX	1.98 MAX

DO-5



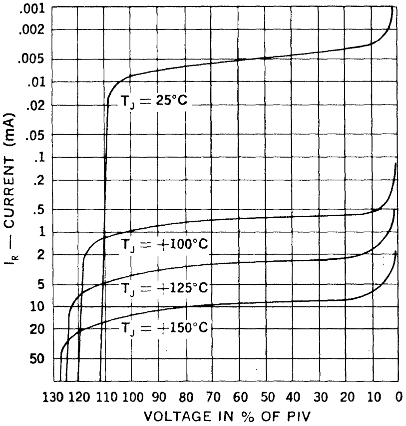
Notes:

1. Standard polarity is cathode-to-stud.
   For reverse polarity (anode-to-stud) add suffix "R", ie. UES801R.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 20 inch pounds (20 kg. cm).
4. Angular orientation of terminal is undefined.

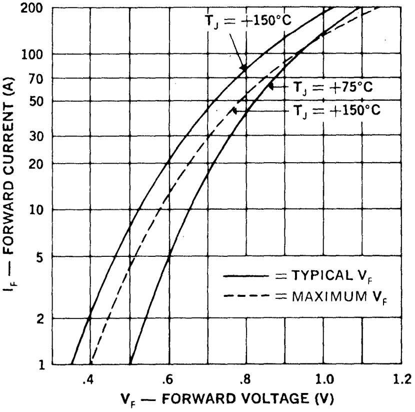
ELECTRICAL SPECIFICATIONS

Type	PIV	Maximum Forward Voltage @		Maximum Reverse Current @		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 150°C$	$T_C = 25°C$	$T_C = 150°C$	
UES801 UES802 UES803	50V 100V 150V	.975V @ 70A $t_p = 300\mu S$	.840V @ 70A $t_p = 300\mu S$	25μA	30mA	50nS

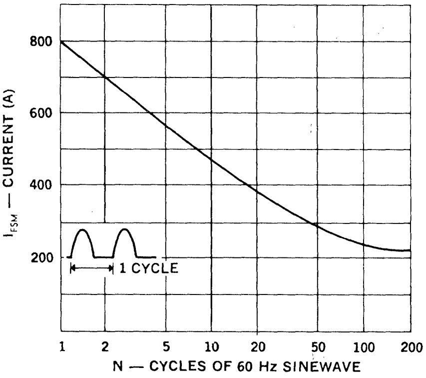
Note: Add 0.03 Volts to Max Forward Voltage for Flexible Top Lead Option. * Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$



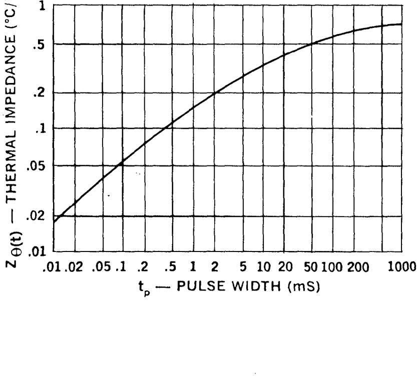
Typical Reverse Current vs. Reverse Voltage



Forward Current vs. Forward Voltage

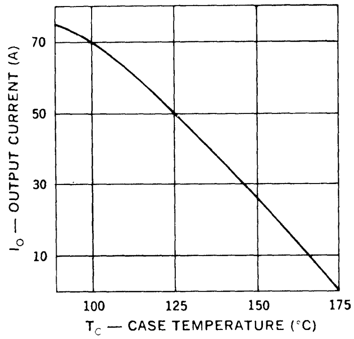


Maximum Forward Surge vs. Number of Cycles

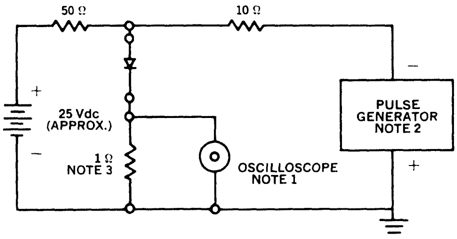


Thermal Impedance vs. Pulse Width

Output Current vs. Case Temperature



Reverse-Recovery Circuit

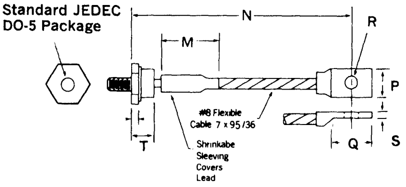


NOTES:
1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

MECHANICAL SPECIFICATIONS

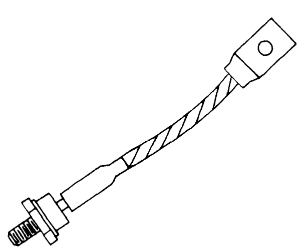
FLEXIBLE TOP LEAD (OPTIONAL)
Add an "F" Suffix to Part Number.

UES801-UES803



	ins.	mm
M	1.500 ± .100	38.10 ± 2 54
N	.475 ± .250	12.07 ± 6.35
P	425 ± .025	10.80 ± 0.64
Q	.678 ± .320	17.22 ± 8.13
R	.205 ± .005 DIA.	5.21 ± 0.13 DIA.
S	075 ± .010	1.91 ± 0.25
T	.1 MIN.	2.54 MIN.

DO-5 with Flexible Lead



Note: Consult Factory for Non-standard Lead Lengths.

RECTIFIERS
High Efficiency, 50A

UES804–UES806

FEATURES
- Very Low Forward Voltage (1.15V)
- Very Fast Recovery Times (50nSec)
- High Surge Capability
- Low Thermal Resistance
- Mechanically Rugged
- Both Polarities Available

DESCRIPTION
The UES804 is specifically designed for operation in power switching circuits operating at frequencies of at least 20 KHz.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES804	200V
Peak Inverse Voltage, UES805	300V
Peak Inverse Voltage, UES806	400V
Maximum Average D.C. Output Current @ $T_C = 100°C$	50A
Surge Current, 8.3mSec	600A
Thermal Resistance, Junction to Case	.8°C/W
Operating and Storage Temperature Range	–55°C to +150°C

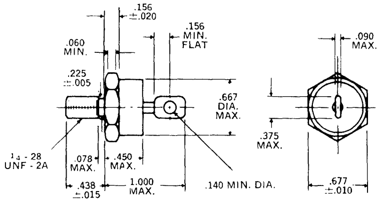
POWER CYCLING
These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

SWITCHING CHARACTERISTICS
The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

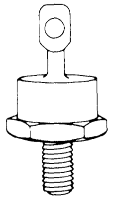
MECHANICAL SPECIFICATIONS

UES804-UES806



Dimensions in inches.

DO-5



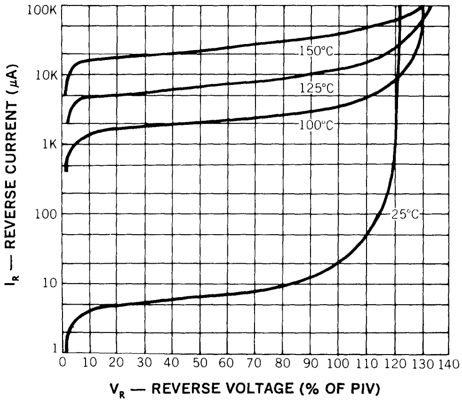
Notes:
1. Standard polarity is cathode-to-stud.
   For reverse polarity (anode-to-stud) add suffix "R", ie. UES804R.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 30 inch pounds.
4. Angular orientation of terminal is undefined.

ELECTRICAL SPECIFICATIONS

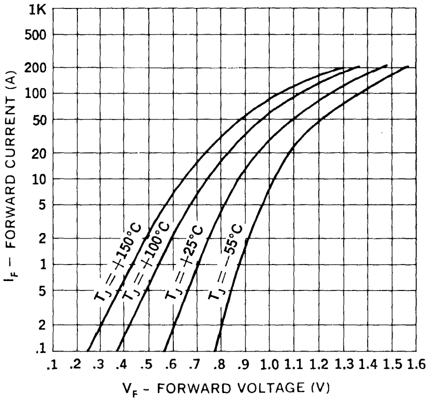
Type	PIV	Maximum Forward Voltage		Maximum Reverse Curent		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	$T_C = 25°C$	$T_C = 125°C$	
UES804 UES805 UES806	200V 300V 400V	1.25V @ $I_F = 50A$ $t_p = 300\mu S$	1.15V @ $I_F = 50A$ $t_p = 300\mu S$	70μA	30mA	50nS

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

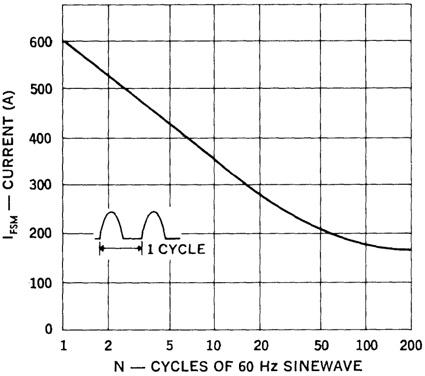
Typical Reverse Current vs. Reverse Voltage



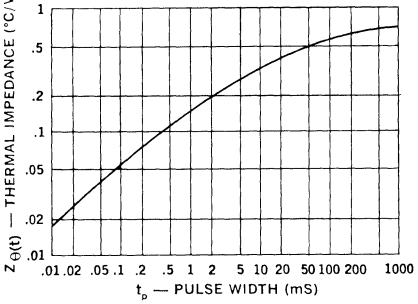
Forward Current vs. Forward Voltage



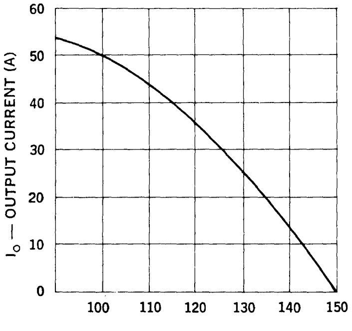
Maximum Forward Surge vs. Number of Cycles



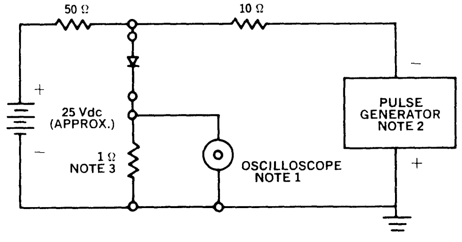
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 1A

UES1001-UES1003

FEATURES
- Very Fast Recovery Times
- Very Low Forward Voltage
- Small Size
- Convenient Package

DESCRIPTION
An axial leaded power rectifier useful in many switching applications. Particularly suited where very fast recovery and low forward voltage are required.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES1001	50V
Peak Inverse Voltage, UES1002	100V
Peak Inverse Voltage, UES1003	150V
Maximum Average D.C. Output Current at T_L = 75 °C, L = 3/8″	1A
Non-Repetitive Surge Current at 8.3mS	30A
Thermal Resistance at L = 3/8″	75 °C/W
Operating and Storage Temperature Range	−55 °C +175 °C

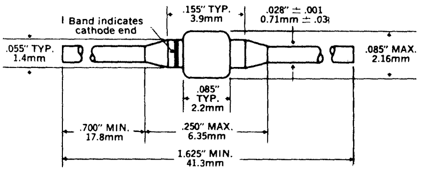
ELECTRICAL SPECIFICATIONS

Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*
		$T_J = 25$ °C	$T_J = 100$ °C	@ $T_J = 25$ °C	@ $T_J = 100$ °C	
UES1001 UES1002 UES1003	50V 100V 150V	.975V @ 1A	.895V @ 1A	2μA	50μA	25nS

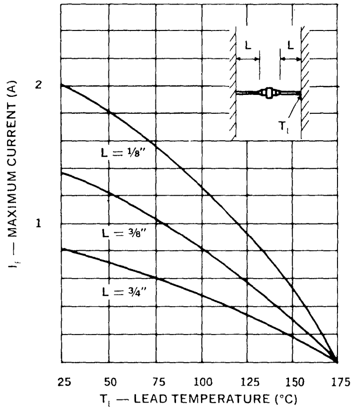
*Measured in circuit I_F = .5A, I_R = 1.0A, I_{REC} = .25A

MECHANICAL SPECIFICATIONS

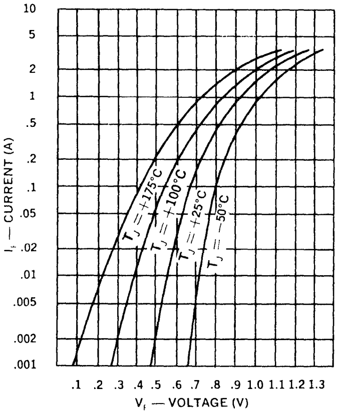
UES1001-UES1003



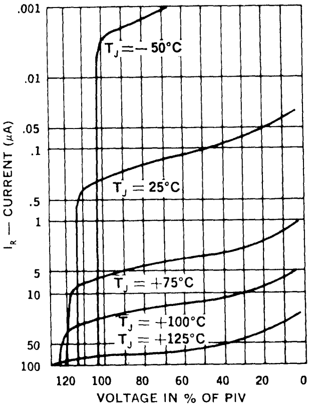
BODY A



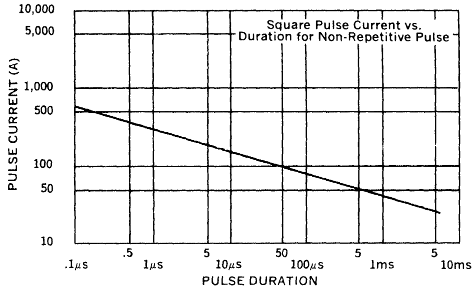
Output Current vs. Lead Temperature



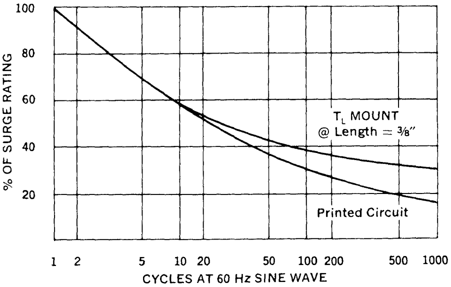
Typical Forward Current vs. Forward Voltage



Typical Reverse Current vs. Voltage

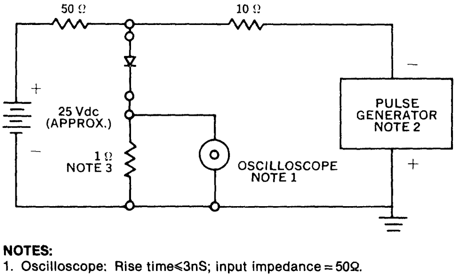


Forward Pulse Current vs. Duration



Multiple Surge Current vs. Duration

Reverse-Recovery Circuit



NOTES:
1. Oscilloscope: Rise time⩽3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time⩽8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 2.5A

FEATURES
- Very Fast Recovery Times
- Very Low Forward Voltage
- Small Size
- Convenient Package

DESCRIPTION

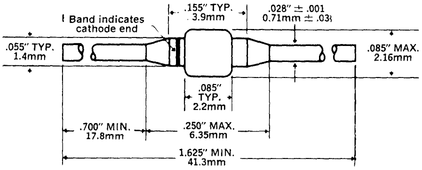
An axial leaded power rectifier useful in many switching applications. Particularly suited where very fast recovery and low forward voltage are required.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES1101	50V
Peak Inverse Voltage, UES1102	100V
Peak Inverse Voltage, UES1103	150V
Maximum Average D.C. Output Current at $T_L = 75°C$, L = 3/8"	2.5A
Non-Repetitive Surge Current at 8.3 ms	35A
Thermal Resistance at L = 3/8"	38°C/W
Operating and Storage Temperature Range	−55°C +175°C

MECHANICAL SPECIFICATIONS

UES1101-UES1103



BODY A

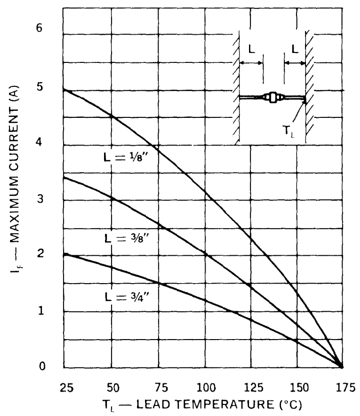
UNITRODE

ELECTRICAL SPECIFICATIONS

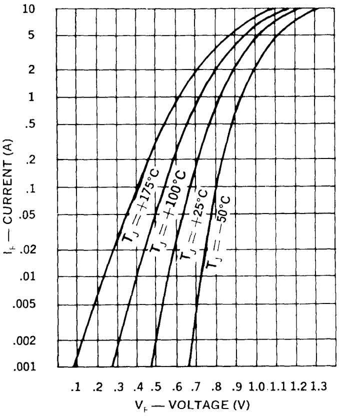
Type	PIV	Maximum Forward Voltage @		Maximum Reverse Current @		Maximum Reverse Recovery Time*
		$T_J = 25°C$	$T_J = 100°C$	$T_J = 25°C$	$T_J = 100°C$	
UES1101	50V	.975V @ 2A tp = 300μS	.895V @ 2A tp = 300μS	2μA	50μA	25nS
UES1102	100V					
UES1103	150V					

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

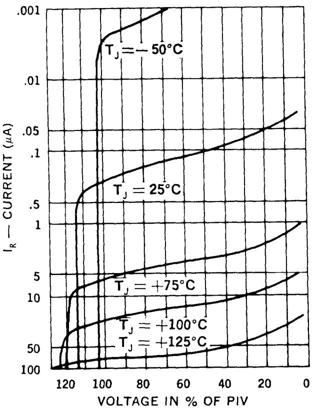
Output Current vs. Lead Temperature



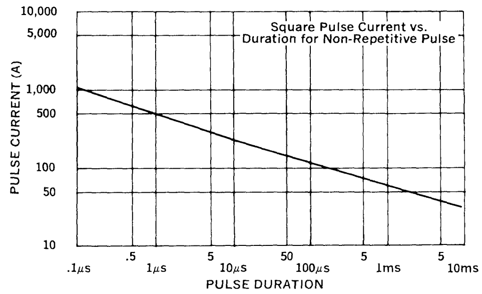
Typical Forward Current vs. Forward Voltage



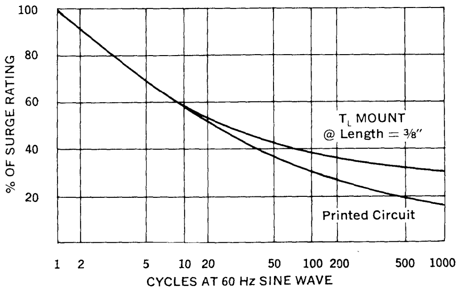
Typical Reverse Current vs. Voltage



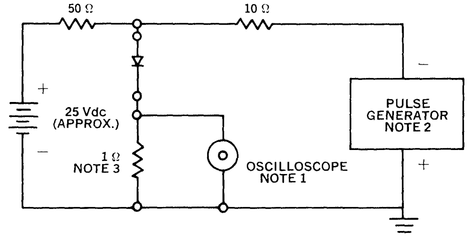
Forward Pulse Current vs. Duration



Multiple Surge Current vs. Duration



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 2A

UES1104–UES1106

FEATURES

- Very Low Forward Voltage (1.15V)
- Very Fast Recovery Times (50nSec)
- Small Size
- Convenient Package

DESCRIPTION

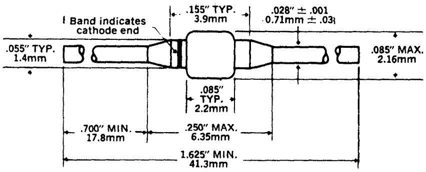
The UES1104 series is specifically designed for operation in power switching circuits operating at frequencies of at least 20 KHz.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES1104	200V
Peak Inverse Voltage, UES1105	300V
Peak Inverse Voltage, UES1106	400V
Maximum Average D.C. Output Current, I_O	
@ $T_A = 25°C$ (Free Air)	1A
@ $T_L = 50°C$, L—⅜″	2A
Surge Current, 8.3mSec	20A
Thermal Resistance @ L = ⅜″	38°C/W
Operating and Storage Temperature Range	—55°C to +150°C

MECHANICAL SPECIFICATIONS

UES1104-UES1106



BODY A

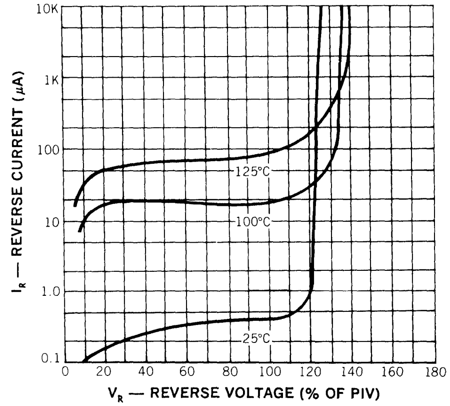
UNITRODE

ELECTRICAL SPECIFICATIONS

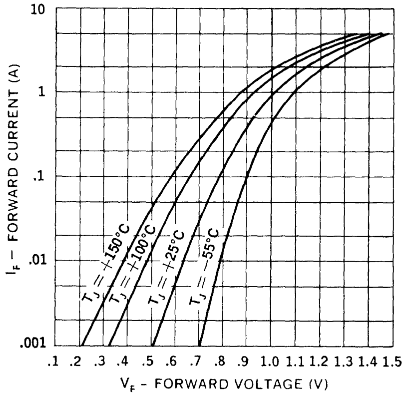
Type	PIV	Maximum Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*
		$T_J = 25°C$	$T_J = 100°C$	@ PIV, $T_J = 25°C$	$T_J = 100°C$	
UES1104 UES1105 UES1106	200V 300V 400V	1.25V @ 1A tp = 300μS	1.15V @ 1A tp = 300μS	10μA	200μA	50nS

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

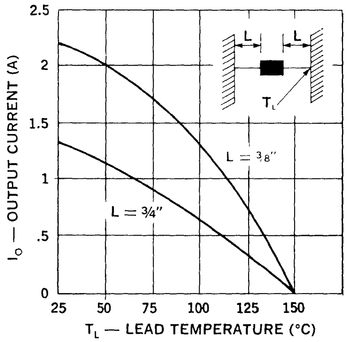
Typical Reverse Current vs. Reverse Voltage



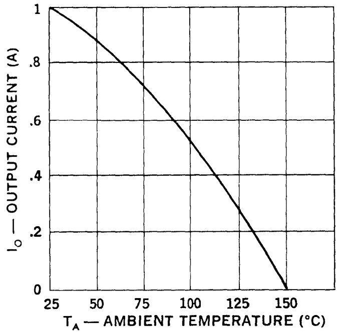
Forward Current vs. Forward Voltage



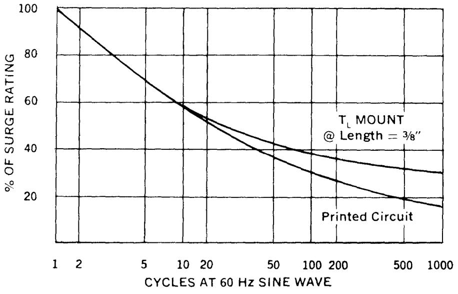
Output Current vs. Lead Temperature



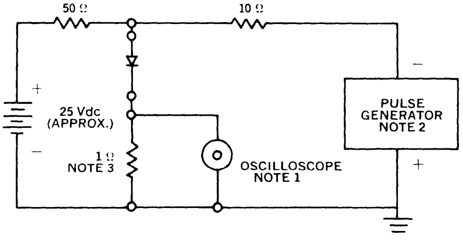
Output Current vs. Ambient Temperature



Multiple Surge Current vs. Duration



Reverse-Recovery Circuit



NOTES:
1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 6A

UES1301-UES1303

FEATURES
- Very Low Forward Voltage
- Very Fast Recovery Times
- Small Size
- High Surge

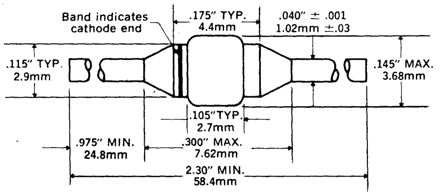
DESCRIPTION
Now power rectifiers in axial leaded package to meet the most demanding switching applications. An industrial product with military reliability.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES1301	50V
Peak Inverse Voltage, UES1302	100V
Peak Inverse Voltage, UES1303	150V
Maximum Average D.C. Output Current at $T_L = 75°C$, $L = 3/8''$	6.0A
Non-Repetitive Sinusoidal Surge Current at 8.3ms	125A
Thermal Resistance at $L = 3/8''$	20°C/W
Operating and Storage Temperature Range	−55°C to +175°C

MECHANICAL SPECIFICATIONS

UES1301-1303



BODY B

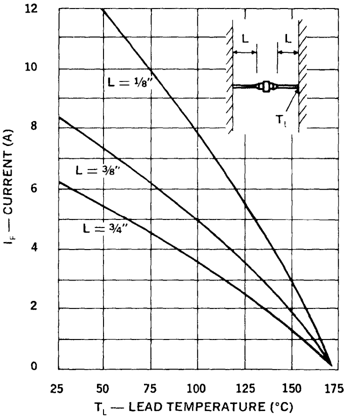
UNITRODE

ELECTRICAL SPECIFICATIONS

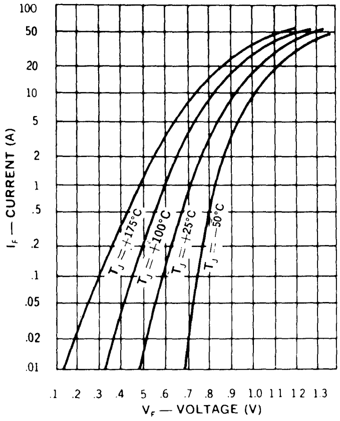
Type	PIV	Maximum Forward Voltage @		Maximum Reverse Current @		Maximum Reverse Recovery Time*
		$T_J = 25°C$	$T_J = 100°C$	$T_J = 25°C$	$T_J = 100°C$	
UES1301	50V	.925V @ 6A tp = 300μS	.850V @ 6A tp = 300μS	5μA	150μA	30nS
UES1302	100V					
UES1303	150V					

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

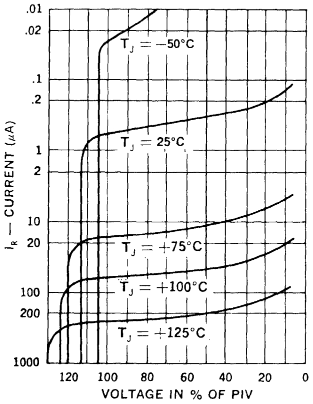
Output Current vs. Lead Temperature



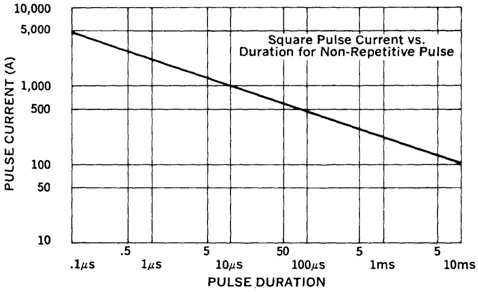
Typical Forward Current vs. Forward Voltage



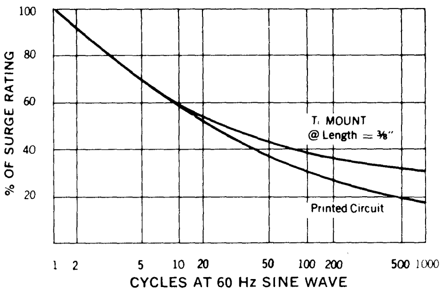
Typical Reverse Current vs. Voltage



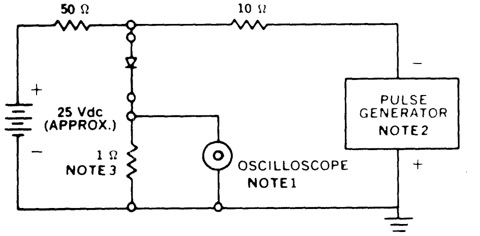
Forward Pulse Current vs. Duration



Multiple Surge Current vs. Duration



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 5A

UES1304–UES1306

FEATURES

- Very Low Forward Voltage (1.15V)
- Very Fast Recovery Times (50nSec)
- Small Size
- High Surge

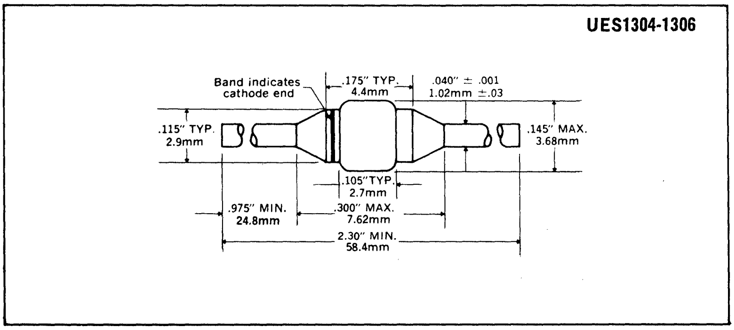
DESCRIPTION

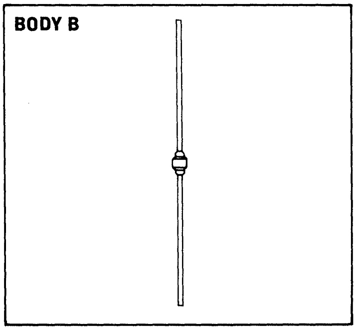
The UES1304 series is specifically designed for operation in power switching circuits operating at frequencies of at least 20 KHz.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES1304	200V
Peak Inverse Voltage, UES1305	300V
Peak Inverse Voltage, UES1306	400V
Maximum Average D.C. Output Current, I_O	
@ $T_A = 25°C$ (Free Air)	3A
@ $T_L = 50°C$, L = ⅜″	5A
Surge Current, 8.3mSec	70A
Thermal Resistance @ L — ⅜″	20°C/W
Operating and Storage Temperature Range	−55°C to +150°C

MECHANICAL SPECIFICATIONS





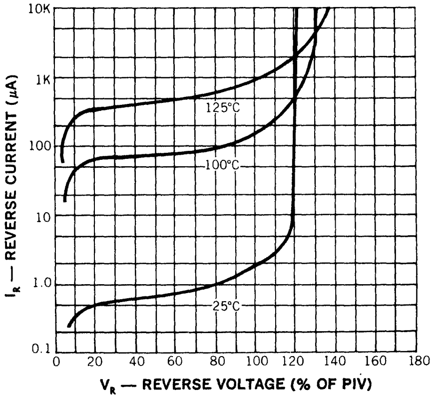
UNITRODE

ELECTRICAL SPECIFICATIONS

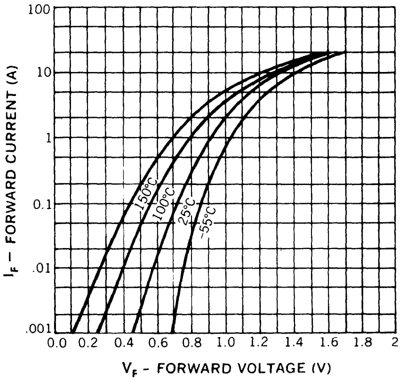
Type	PIV	Maximum Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*
		$T_J = 25°C$	$T_J = 100°C$	@ PIV, $T_J = 25°C$	$T_J = 100°C$	
UES1304 UES1305 UES1306	200V 300V 400V	1.25V @3A tp = 300μS	1.15V @3A tp = 300μS	20μA	500μA	50nS

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

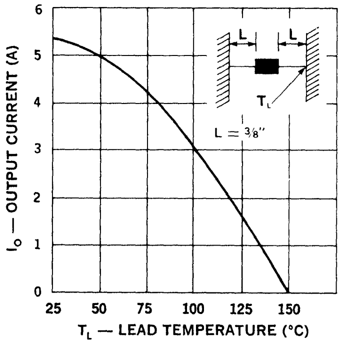
Typical Reverse Current vs. Reverse Voltage



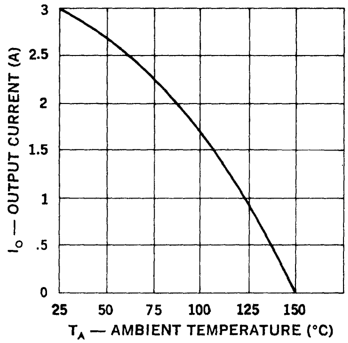
Forward Current vs. Forward Voltage



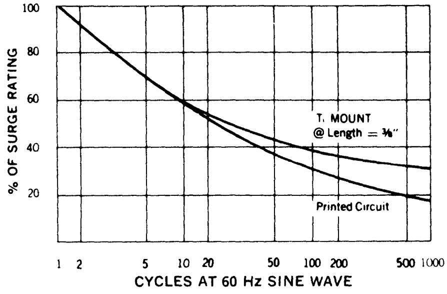
Output Current vs. Lead Temperature



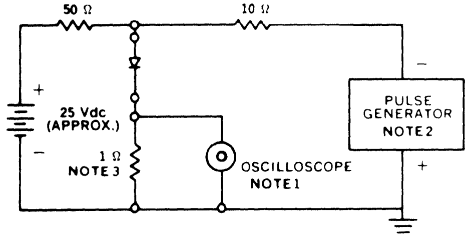
Output Current vs Ambient Temperature



Multiple Surge Current vs. Duration



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 8A

UES1401-UES1403

FEATURES

- Very Low Forward Voltage
- Very Fast Recovery Times
- Economical, Convenient Plastic Package
- Low Thermal Resistance
- Mechanically Rugged

DESCRIPTION

The UES1401 Series, in a plastic package similar to the TO-220, is specifically designed for operation in power switching circuits to frequencies in excess of 100KHz. The very low forward voltage and very fast recovery time make them particularly suited for switching type power supplies.

ABSOLUTE MAXIMUM RATINGS

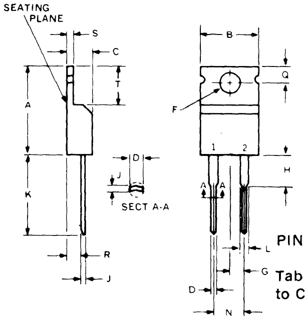
Peak Inverse Voltage, UES1401	50V
Peak Inverse Voltage, UES1402	100V
Peak Inverse Voltage, UES1403	150V
Maximum Average D.C. Output Current	
@ T_C =125°C (Note 1)	8.0A
@ T_A = 25°C	3.0A
@ T_A = 25°C (Note 2)	8.0A
Non-Repetitive Sinusoidal Surge Current, 8.3mS	80A
Thermal Resistance, Junction to Case, θ_{J-C}	2.5°C/W
Thermal Resistance, Junction to Ambient, θ_{J-A}	60°C/W
Operating and Storage Temperature Range	−55°C to +150°C

Note 1. Above 100°C use the tab for electrical connection.

Note 2. Using Wakefield Type 295 heatsink with convection cooling. For more definitive data refer to the Output Current vs. Temperature Curves on this datasheet.

MECHANICAL SPECIFICATIONS

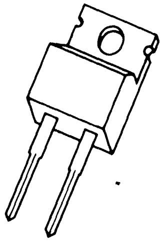
UES1401-1403



PIN 1. Cathode
2. Anode
Tab is connected
to Cathode.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H		6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

SIMILAR TO TO-220

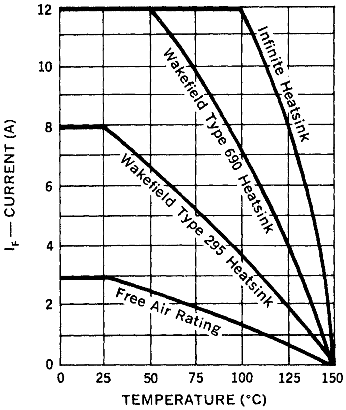


ELECTRICAL SPECIFICATIONS

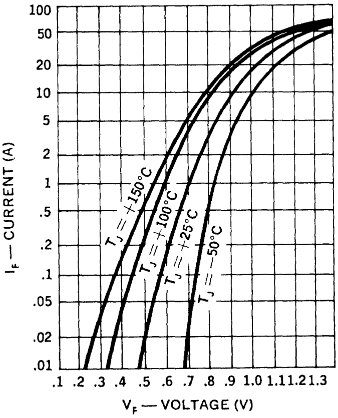
Type	PIV	Maximum Forward Voltage		Maximum Reverse Current @ PIV		Maximum Reverse Recovery Time*	Typical Forward Recovery Voltage @ 1A t_r = 8nS
		$T_J = 25°C$	$T_J = 100°C$	$T_J = 25°C$	$T_J = 100°C$		
UES1401 UES1402 UES1403	50V 100V 150V	0.9V @ 4A 0.975V @ 8A tp = 300μS	0.8V @ 4A 0.895V @ 8A	5μA	150μA	35nS	1.4V

*Measured in circuit I_F = 0.5A, I_R = 1.0A, I_{REC} = 0.25A

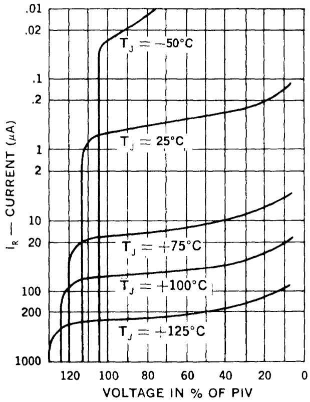
Output Current vs. Temperature



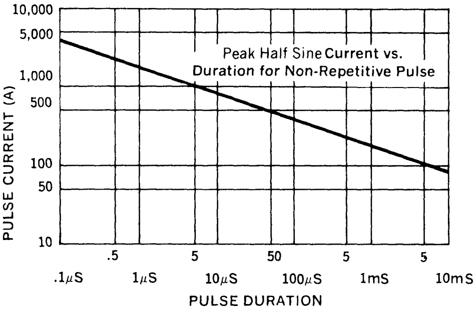
Typical Forward Current vs. Forward Voltage



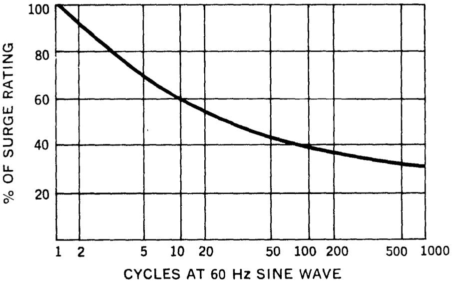
Typical Reverse Current vs. Voltage



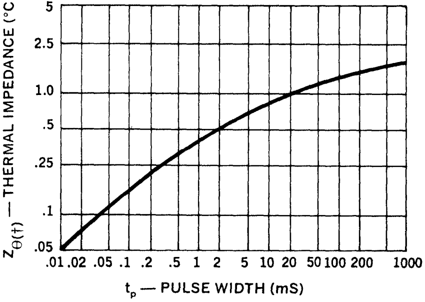
Forward Pulse Current vs. Duration



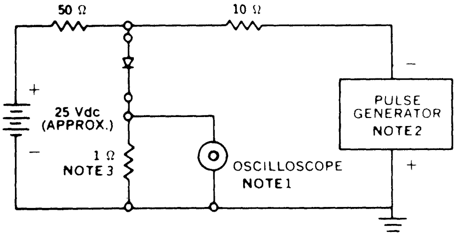
Multiple Surge Current vs. Duration



Thermal Impedance vs. Pulse Width



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 16A Center-Tap

UES2401-UES2403

FEATURES
- Very Low Forward Voltage
- Very Fast Recovery Times
- Economical, Convenient TO-220 Package
- Low Thermal Resistance
- Mechanically Rugged

DESCRIPTION
The UES2401 Series in the economical, convenient TO-220 package, is specifically designed for operation in power switching circuits to frequencies in excess of 100KHz. The series combines two high efficiency devices into one package, simplifying installation, reducing heatsink requirements and the need to purchase matched components.

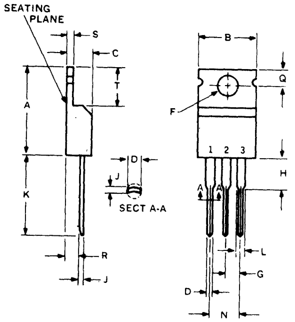
ABSOLUTE MAXIMUM RATINGS

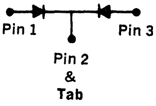
Peak Inverse Voltage, UES2401	50V
Peak Inverse Voltage, UES2402	100V
Peak Inverse Voltage, UES2403	150V
Maximum Average D.C. Output Current	
@ T_C = 125°C (Note 1)	16A
@ T_A = 25°C	3A
@ T_A = 25°C (Note 2)	10A
Non-Repetitive Sinusoidal Surge Current, 8.3mS	80A
Thermal Resistance, Junction to Case, $\theta_{J\text{-}C}$	1.75°C/W
Thermal Resistance, Junction to Ambient, $\theta_{J\text{-}A}$	60°C/W
Operating and Storage Temperature Range	−55°C to +150°C

Note 1. Above 8A use the tab for electrical connection.
Note 2. Using Wakefield Type 295 heatsink with convection cooling. For more definitive data refer to the Output Current vs. Temperature Curves on this datasheet.

MECHANICAL SPECIFICATIONS

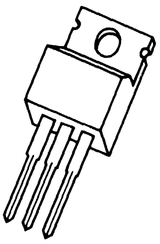
UES2401-2403





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H		6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

TO-220

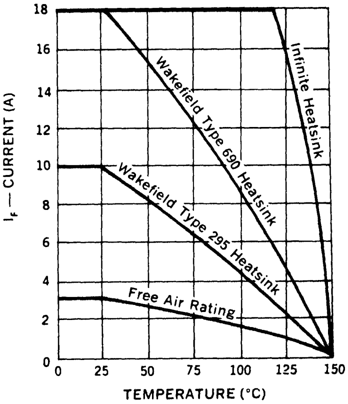


ELECTRICAL SPECIFICATIONS

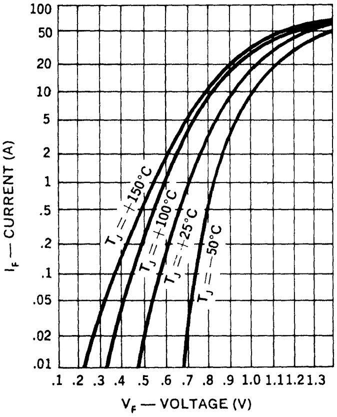
Type	PIV	Maximum Forward Voltage		Maximum Reverse Current @ PIV		Maximum Reverse Recovery Time*	Typical Forward Recovery Voltage @ 1A t_r = 8nS
		T_J = 25°C	T_J = 100°C	T_J = 25°C	T_J = 100°C		
UES2401 UES2402 UES2403	50V 100V 150V	0.9V @ 4A 0.975V @ 8A tp = 300μS	0.8V @ 4A 0.895V @ 8A	5μA	150μA	35nS	1.4V

*Measured in circuit I_F = 0.5A, I_R = 1.0A, I_{REC} = 0.25A

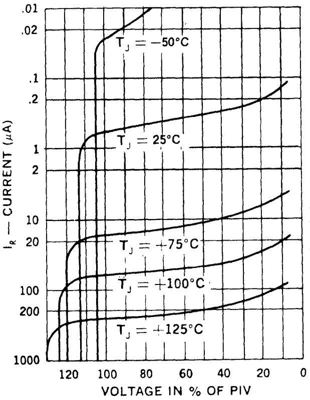
Output Current vs. Temperature



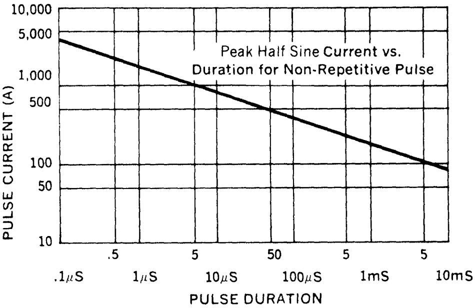
Typical Forward Current vs. Forward Voltage



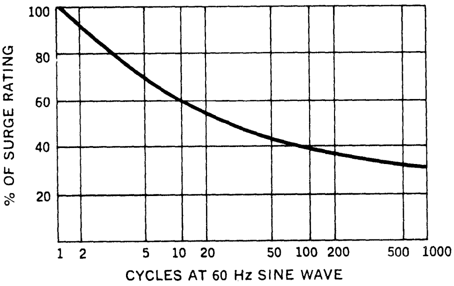
Typical Reverse Current vs. Voltage



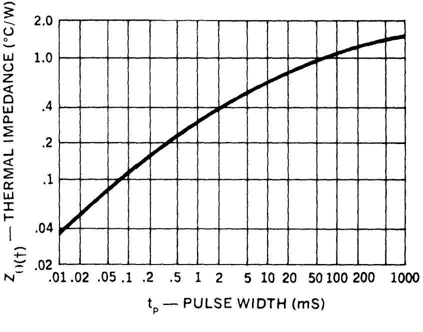
Forward Pulse Current vs. Duration



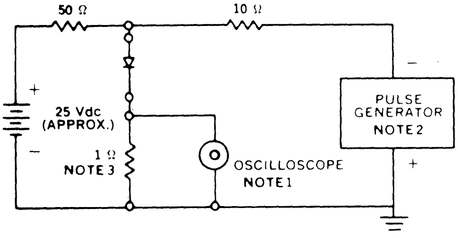
Multiple Surge Current vs. Duration



Thermal Impedance vs. Pulse Width



Reverse-Recovery Circuit



NOTES:
1. Oscilloscope: Rise time ≤ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 30A Center-Tap

UES-2601-UES2603

FEATURES

- Very Low Forward Voltage
- Very Fast Switching Speed
- Convenient Package
- High Surge
- Low Thermal Resistance
- Mechanically Rugged
- Both Polarities Available

DESCRIPTION

This series combines two high efficiency devices into one package, simplifying installation, reducing heat sink requirements and the need to purchase matched components.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES2601	50V
Peak Inverse Voltage, UES2602	100V
Peak Inverse Voltage, UES2603	150V
Maximum Average D.C. Output Current at $T_C = 100°C$	30A
Non-Repetitive Sinusoidal Surge Current 8.3 ms	400A
Thermal Resistance, Junction to Case	1°C/W
Operating and Storage Temperature Range	−55°C to +175°C

POWER CYCLING

These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

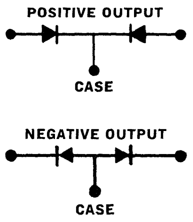
In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

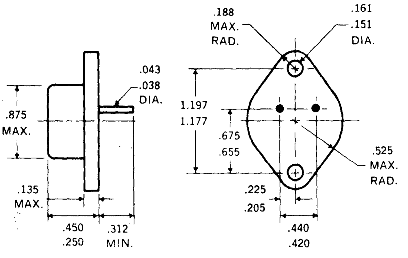
SWITCHING CHARACTERISTICS

The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

MECHANICAL SPECIFICATIONS

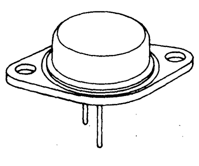
UES2601-UES2603





Dimensions in inches.

TO-3



Note:

Standard polarity is positive output.
For reverse polarity (negative output) add suffix "R", ie. UES2601R.

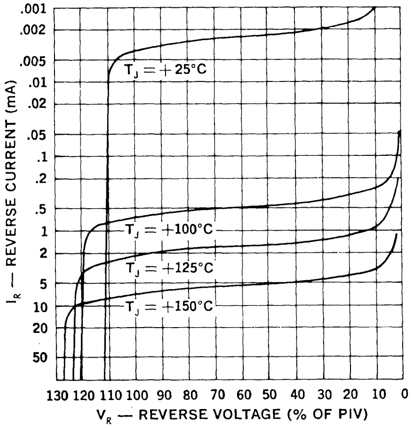
UNITRODE

ELECTRICAL SPECIFICATIONS

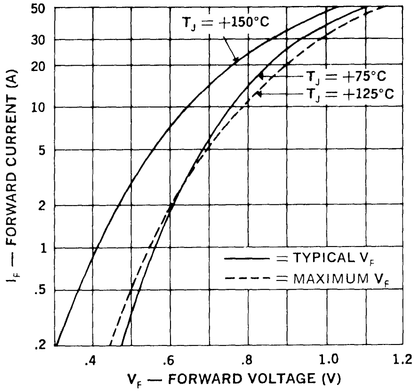
Type	PIV	Maximum Forward Voltage @		Maximum Reverse Current @		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	$T_C = 25°C$	$T_C = 125°C$	
UES2601 UES2602 UES2603	50V 100V 150V	.930V @ 15A $t_p = 300\mu S$	.825V @ 15A $t_p = 300\mu S$	$20\mu A$	4mA	35nS

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

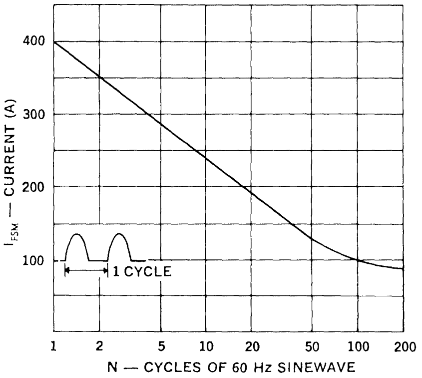
Typical Reverse Current vs. Reverse Voltage



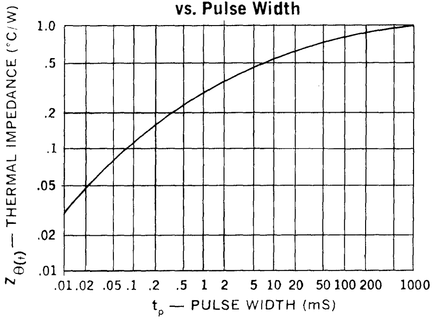
Forward Current vs. Forward Voltage



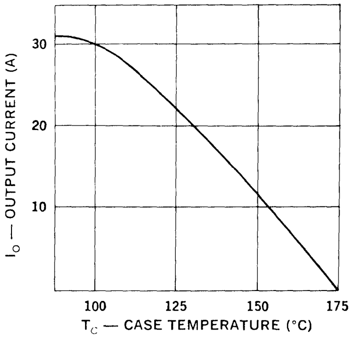
Maximum Forward Surge vs. Number of Cycles



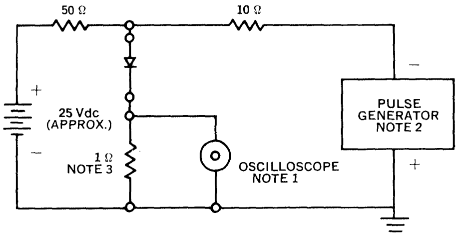
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 30A Center-Tap

UES2604–UES2606

FEATURES
- Very Low Forward Voltage (1.15V)
- Very Fast Recovery Times (50nSec)
- Low Profile Package
- High Surge Capability
- Low Thermal Resistance
- Mechanically Rugged
- Both Polarities Available

DESCRIPTION
The UES2604 series is specifically designed for operation in power switching circuits operating at frequencies of at least 20 KHz.

This series combines two high efficiency devices into one package, simplifying installation, reducing heat sink requirements and the need to purchase matched components.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES2604	200V
Peak Inverse Voltage, UES2605	300V
Peak Inverse Voltage, UES2606	400V
Maximum Average D.C. Output Current @ $T_C = 100°C$	30A
Surge Current, 8.3mSec	300A
Thermal Resistance, Junction to Case	1°C/W
Operating and Storage Temperature Range	−55°C to +150°C

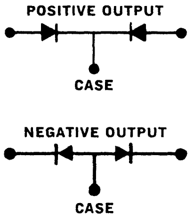
POWER CYCLING
These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

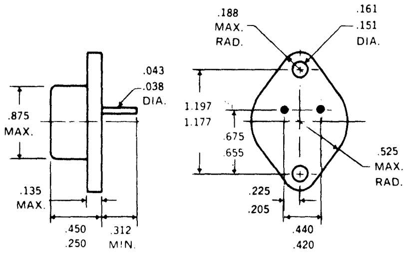
In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

SWITCHING CHARACTERISTICS
The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

MECHANICAL SPECIFICATIONS

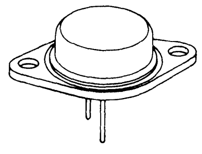
UES2604-UES2606





Dimensions in inches.

TO-3



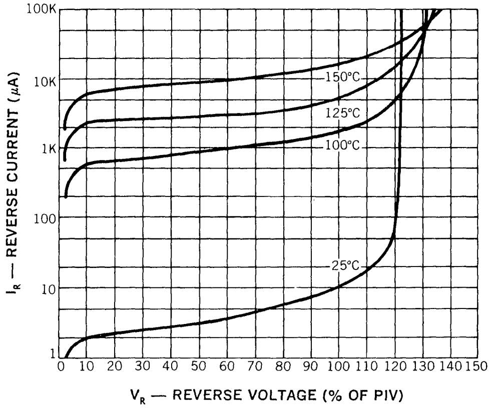
Note:
Standard polarity is positive output.
For reverse polarity (negative output) add suffix "R", ie. UES2604R.

ELECTRICAL SPECIFICATIONS, PER LEG

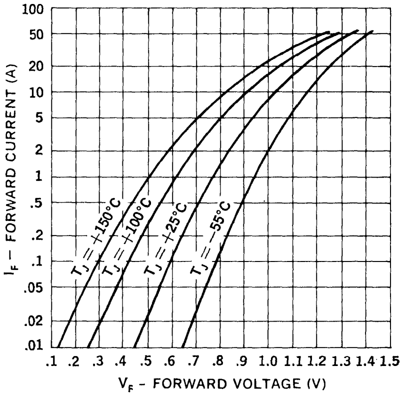
Type	PIV	Maximum Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	$T_C = 25°C$	$T_C = 125°C$	
UES2604 UES2605 UES2606	200V 300V 400V	1.25V @ 15A $t_p = 300\mu S$	1.15V @ 15A $t_p = 300\mu S$	50μA	10mA	50nS

*Measured in circuit I_F = .5A, I_R =1A, I_{REC} = .25A

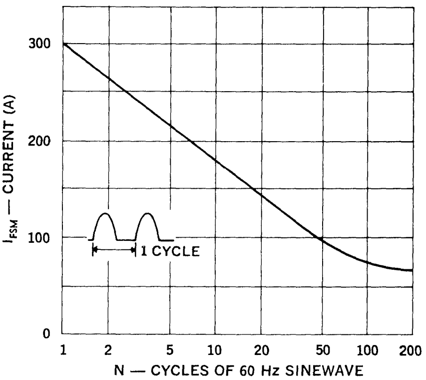
Typical Reverse Current vs. Reverse Voltage



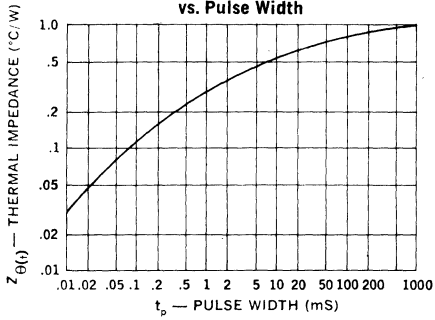
Forward Current vs. Forward Voltage



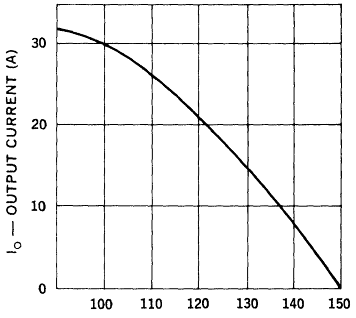
Maximum Forward Surge vs. Number of Cycles



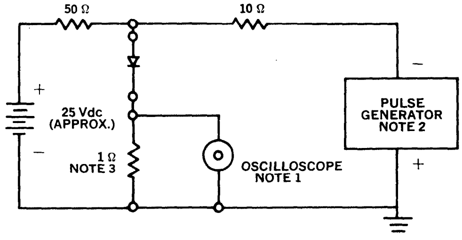
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
Radiation Tolerant, 1 Amp-2 Amp

UR105-UR125
UR205-UR225

FEATURES
- Radiation Tolerant: to 10^{16} NVT
- Continuous Rating: to 2A
- Controlled Avalanche
- Surge Rating: to 25A
- Miniature Package

DESCRIPTION
These devices are particularly suited to applications where radiation is present. These units have unique ability to withstand high levels of neutron, gamma and electron radiation.

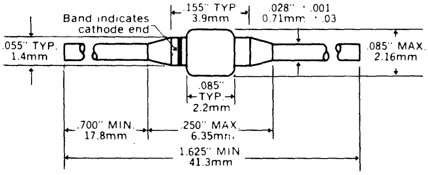
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	1 Amp Series	2 Amp Series
50V	UR105	UR205
100V	UR110	UR210
150V	UR115	UR215
200V	UR120	UR220
250V	UR125	UR225

	1 AMP SERIES	2 AMP SERIES
Maximum Average D.C. Output Current		
@ $T_A = 25°C$	1A	2A
@ $T_A = 100°C$	0.5A	1A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	20A	25A
Operating Temperature Range	−195°C to +175°C	
Storage Temperature Range	−195°C to +200°C	
Thermal Resistance	See Lead Temperature Derating Curve	

MECHANICAL SPECIFICATIONS

UR105-UR125 UR205-UR225



Part Identification: White band indicates "UR." Part number printed on body.

Polarity: Denoted by white band.

Weight: 0.26 grams, typical.

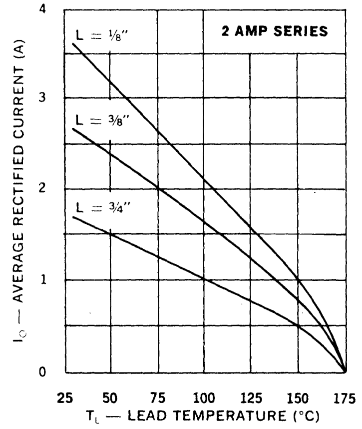
BODY A

UNITRODE

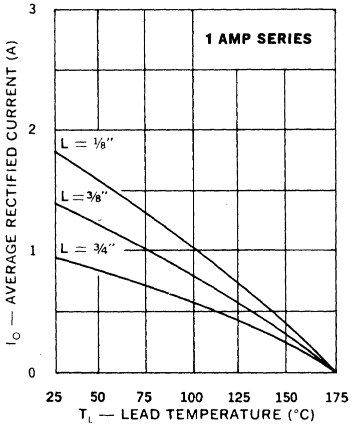
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	PIV	Maximum Forward Voltage Drop	Maximum Leakage Current @ PIV		Maximum Radiation Tolerance
			25°C	100°C	
UR205	50V	1.0V @ 1A	3μA	50μA	10^{16} NVT
UR210	100V				10^{16}
UR215	150V				10^{15}
UR220	200V				10^{14}
UR225	250V				10^{14}
UR105	50V	1.0V @ 0.5A	3μA	50μA	10^{16}
UR110	100V				10^{16}
UR115	150V				10^{15}
UR120	200V				10^{14}
UR125	250V				10^{14}

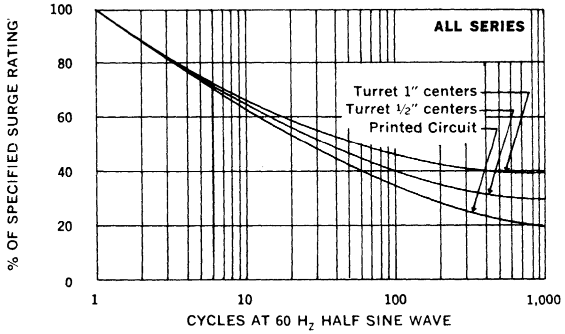
Maximum Current vs Lead Temperature



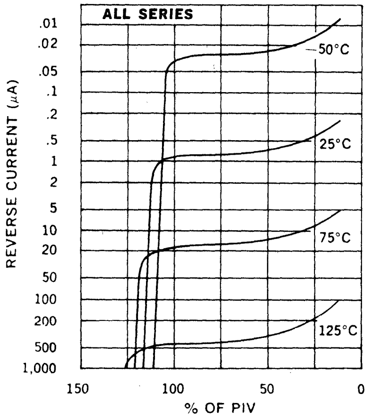
Maximum Current vs Lead Temperature



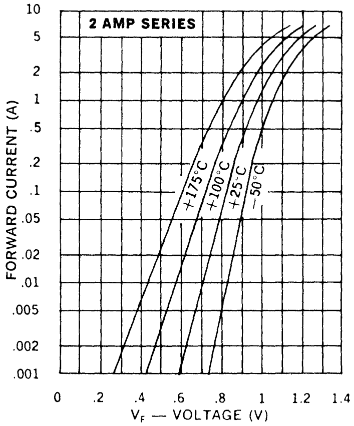
Allowable Forward Surge vs Number of Cycles



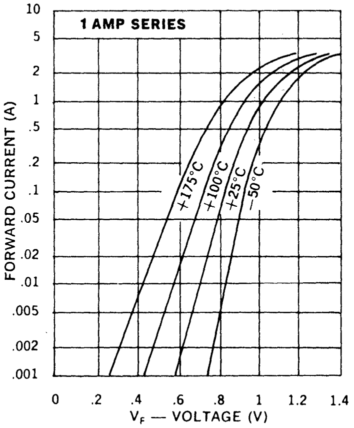
Typical Reverse Current vs PIV



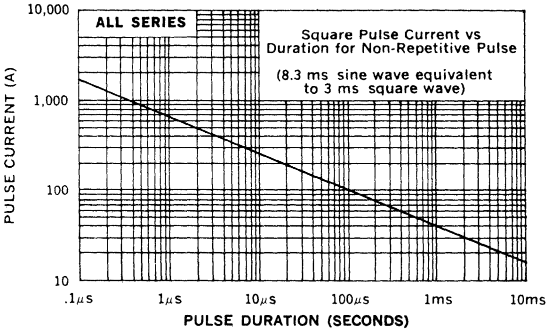
Typical Forward Current vs Forward Voltage



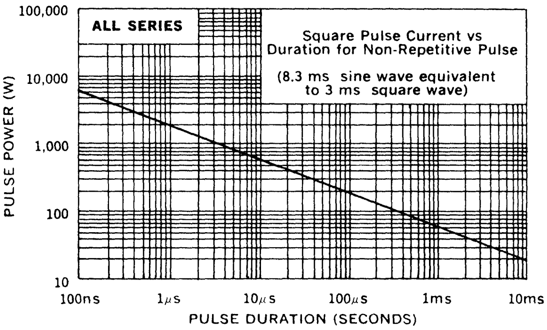
Typical Forward Current vs Forward Voltage



Forward Pulse Current vs Pulse Duration



Reverse Pulse Power vs Pulse Duration



POWER SCHOTTKY RECTIFIERS

150 Amp Pk, Up to 45V

USD520
USD535
USD545

FEATURES

- Very Low Forward Drop (0.6V at 60A, 125°C)
- Low Recovered Charge
- Rugged Package Design (DO-5)
- High Efficiency for Low Voltage Supplies
- Low Thermal Resistance (0.8° C/W)
- High Surge Current (1000A)
- Low Reverse Current (<50 mA at rated V_R at 125°C)
- Available with Flexible Top Lead

DESCRIPTION

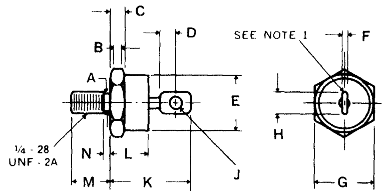
This series of Schottky barrier power rectifiers is ideally suited for output rectifiers and catch diodes in low voltage power supplies. The Unitrode high conductivity design, using a heavy copper top post and 4 point crimp, ensures cool thermal operation and low dynamic impedance. Rugged design absorbs stress that can damage glass-to-metal seal during installation and use.

ABSOLUTE MAXIMUM RATINGS

	USD520	USD535	USD545
Working Peak Reverse Voltage, V_{RWM}	20V	35V	45V
DC Blocking Voltage, V_R	20V	35V	45V
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 KHz, 50 percent Duty Cycle), I_{FRM}	150A (at $T_C = 115°C$)		
Average Rectified Forward Current, $I_{F(AV)}$	75A (at $T_C = 115°C$)		
Non-repetitive Peak Surge Current (8.3 mS), I_{FSM}	1000A		
Operating and Storage Temperature Range, T_j, T_{Stg}	−55°C to +165°C		
Peak Operating Junction Temperature, $T_{j(pk)}$	+175°C		
Thermal Resistance Junction-to-Case, $R_{\Theta JC}$	0.8°C/W		

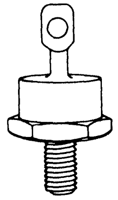
MECHANICAL SPECIFICATIONS

USD520
USD535
USD545



	ins.	mm
A	.225 ± .005	5.72 ± 0.13
B	.060 MIN.	1.52 MIN.
C	.156 ± .020	3.96 ± 0.51
D	.156 MIN. FLAT	3.96 MIN. FLAT
E	.667 DIA. MAX.	16.94 DIA. MAX.
F	.090 MAX.	2.29 MAX.
G	.677 ± .010	17.20 ± 0.25
H	.375 MAX.	9.53 MAX.
J	.140 MIN. DIA.	3.56 MIN. DIA.
K	1.000 MAX.	25.40 MAX.
L	.450 MAX.	11.43 MAX.
M	.438 ± .015	11.13 ± 0.38
N	.078 MAX.	1.98 MAX.

DO-5



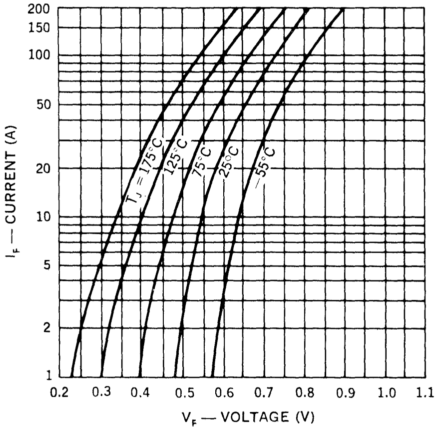
Notes:

1. Cathode is stud.
2. All metal surfaces tin plated.
3. Maximum unlubricated stud torque: 30 inch pounds (35 kg. cm).
4. Angular orientation of terminal is undefined.

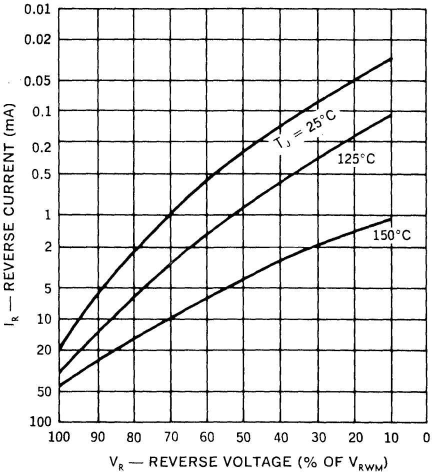
ELECTRICAL CHARACTERISTICS (T_{CASE} = 25°C)

Characteristic	Symbol	All	Units	Conditions
Maximum Instantaneous Reverse Current	i_R	50	mA	v_R = rated, T_C = 125°C Pulse Width = 300μS Duty Cycle = 1 percent
Maximum Instantaneous Forward Voltage	v_F	0.60	V	i_F = 60A T_C = 125°C
Flexible Top Lead Option	v_F	0.63	V	
Maximum Capacitance	C_t	4000	pF	V_R = 5.0V
Maximum Voltage Rate of Change	dv/dt	700	V/μS	v_R = rated

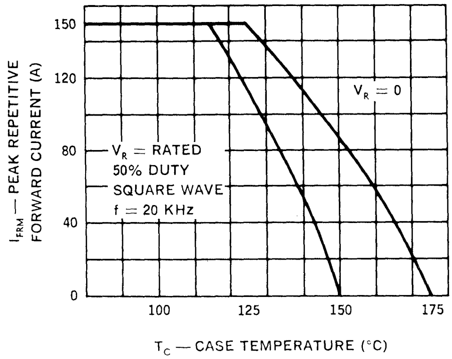
Typical Forward Current vs Forward Voltage



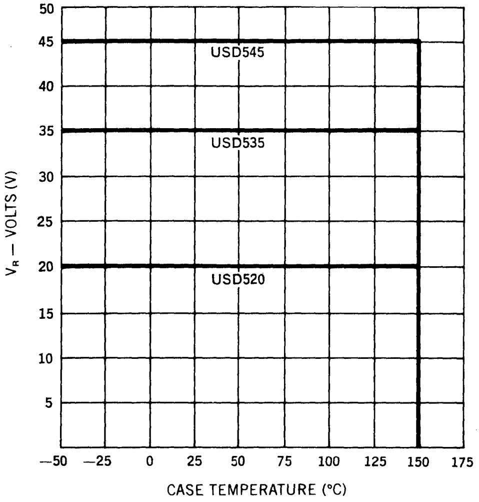
Typical Reverse Current vs Reverse Voltage



Maximum Current vs Case Temperature



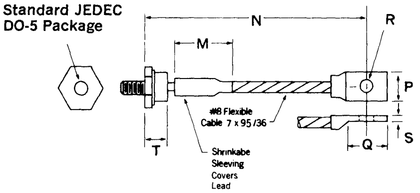
$V_{R(MAX)}$ Rating vs Case Temperature



MECHANICAL SPECIFICATIONS

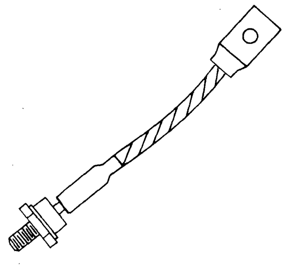
FLEXIBLE TOP LEAD (OPTIONAL)
Add an "F" Suffix to Part Number.

USD520F
USD535F
USD545F



	ins.	mm
M	1.500 ± .100	38.10 ± 2.54
N	.475 ± .250	12.07 ± 6.35
P	.425 ± .025	10.80 ± 0.64
Q	.678 ± .320	17.22 ± 8.13
R	.205 ± .005 DIA.	5.21 ± 0.13 DIA.
S	.075 ± .010	1.91 ± 0.25
T	.1 MIN.	2.54 MIN.

DO-5 with Flexible Lead



Note: Consult Factory for Non-standard Lead Lengths.

RECTIFIERS

Standard Recovery, 1 Amp to 2 Amp

UT236-UT347
UT249-UT363
UT251-UT364
UT261-UT268

FEATURES

- Continuous Rating: to 2A
- Controlled Avalanche
- Surge Rating: to 30A
- PIV: to 1000V
- Miniature Package

DESCRIPTION

These miniature power rectifiers offer the user extreme reliability for high-rel military supplies.

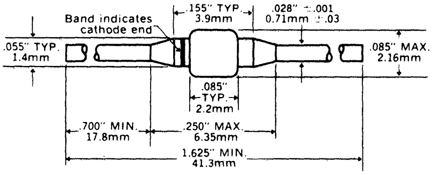
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	1 Amp Series	1.25 Amp Series	1.5 Amp Series	2 Amp Series
100V	UT236	UT249	UT251	UT261
200V	UT234	UT242	UT252	UT262
400V	UT235	UT244	UT254	UT264
500V	UT237	UT245	UT255	UT265
600V	UT238	UT247	UT257	UT267
800V	UT361	UT362	UT258	UT268
1000V	UT347	UT363	UT364	

	1 AMP SERIES	1.25 AMP SERIES	1.5 AMP SERIES	2 AMP SERIES
Maximum Average D.C. Output Current				
@ $T_A = 25°C$	1.0A	1.25A	1.5A	2.0A
@ $T_A = 100°C$	0.5A	0.65A	0.75A	1.0A
Non-Repetitive Sinuosoidal Surge (8.3ms)	20A	20A	25A	30A
Operating Temperature Range	—195°C to +175°C			
Storage Temperature Range	—195°C to +175°C			
Thermal Resistance	See lead temperature derating curve			

MECHANICAL SPECIFICATIONS

UT236-UT347 UT249-UT363 UT251-UT364 UT261-UT268



Part Identification: Orange band indicates "UT." Part number printed on body.

Polarity: Denoted by orange band.

Weight: 0.26 grams, typical.

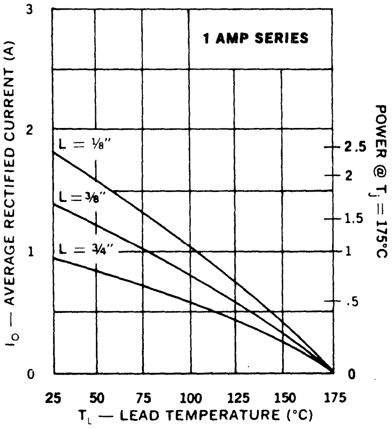
BODY A

UNITRODE

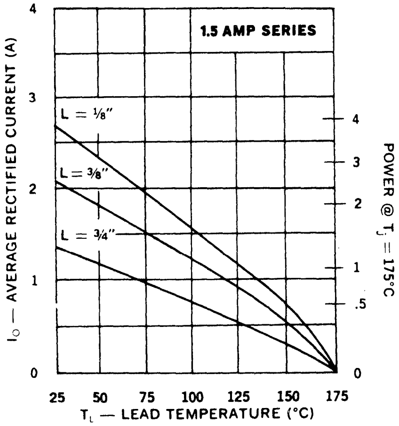
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	PIV	Maximum Forward Voltage Drop	Maximum Leakage Current @ PIV	
			25°C	100°C
UT261	100V	1V @ 900mA	2μA	75μA
UT262	200V			
UT264	400V			
UT265	500V			
UT267	600V			
UT268	800V			
UT251	100V	1V @ 750mA	2μA	75μA
UT252	200V			
UT254	400V			
UT255	500V			
UT257	600V			
UT258	800V			
UT364	1000V			
UT249	100V	1V @ 500mA	2μA	75μA
UT242	200V			
UT244	400V			
UT245	500V			
UT247	600V			
UT362	800V			
UT363	1000V			
UT236	100V	1V @ 400mA	2μA	75μA
UT234	200V			
UT235	400V			
UT237	500V			
UT238	600V			
UT361	800V			
UT347	1000V			

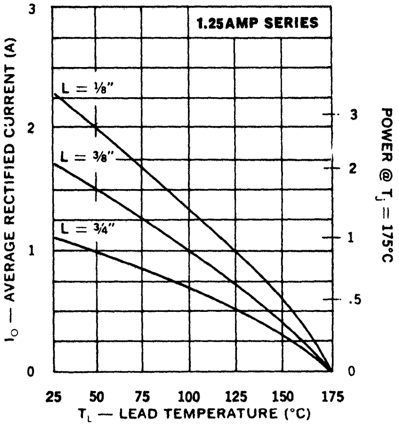
Maximum Current vs Lead Temperature



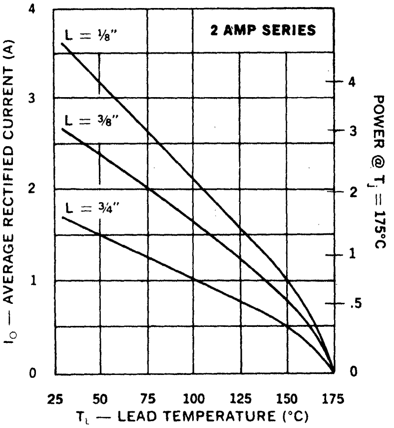
Maximum Current vs Lead Temperature



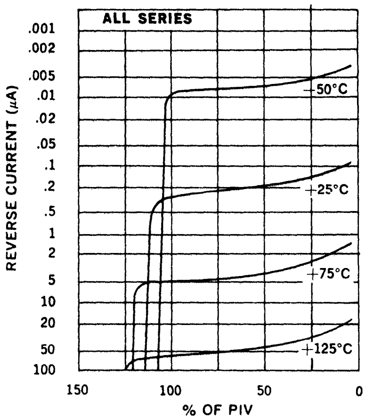
Maximum Current vs Lead Temperature



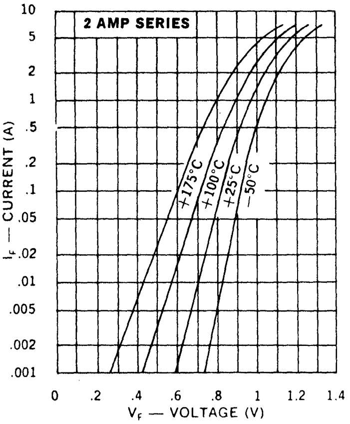
Maximum Current vs Lead Temperature



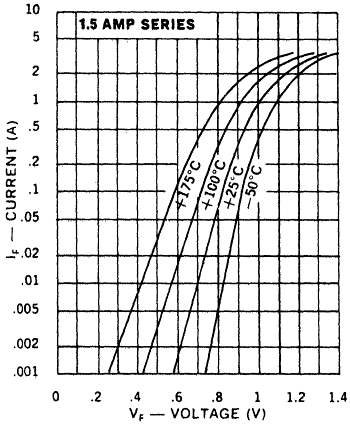
Typical Leakage Current vs. PIV



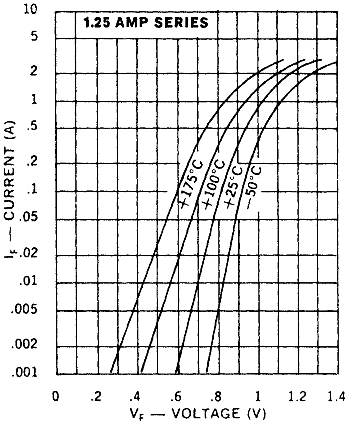
Typical Forward Current vs Forward Voltage



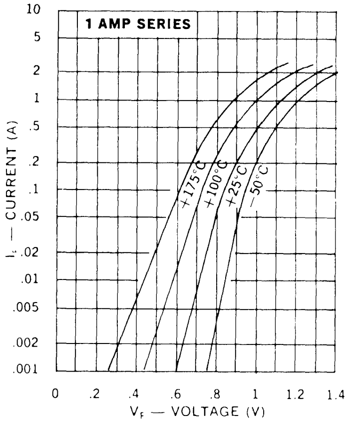
Typical Forward Current vs Forward Voltage



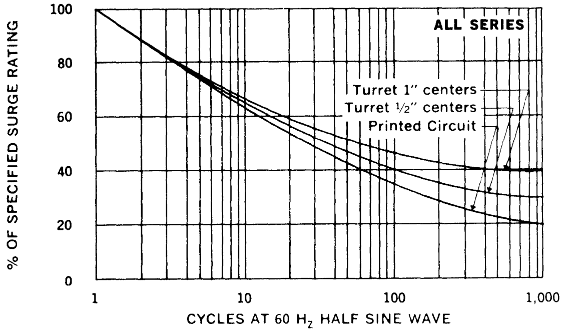
Typical Forward Current vs Forward Voltage



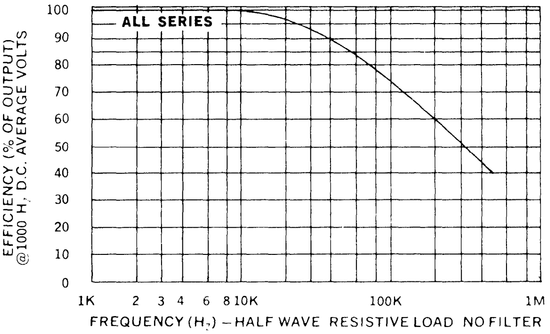
Typical Forward Current vs Forward Voltage



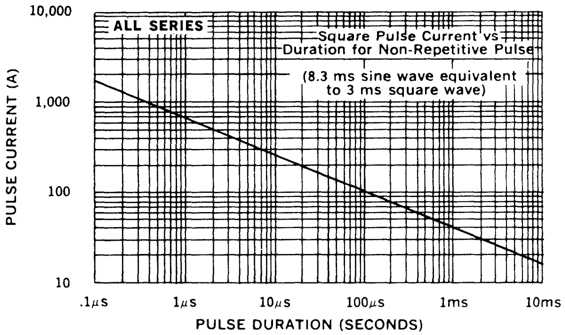
Allowable Forward Surge vs Number of Cycles



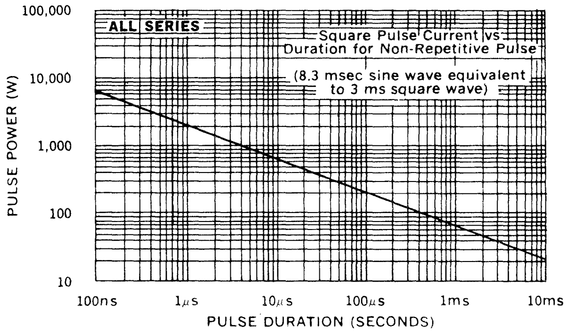
Efficiency vs Frequency at Rated Current (Sine Wave)



Forward Pulse Current vs Pulse Duration



Reverse Pulse Power vs Pulse Duration



RECTIFIERS

Standard Recovery, 2 Amp to 4 Amp

UT2005-UT2060
UT3005-UT3060
UT4005-UT4060

FEATURES

- Continuous Rating: to 4A
- Controlled Avalanche
- Surge Rating: to 100A
- PIV: to 600 V
- Miniature Package

DESCRIPTION

High average power and surge capability make these series of devices attractive in many high-rel applications.

All Unitrode rectifiers have a sleeve of pure hard glass fused to the silicon junction. Since the silicon sees only this glass, electrical characteristics are permanently stable. This voidless, monolithic package is totally unaffected by the most severe moisture or temperature testing.

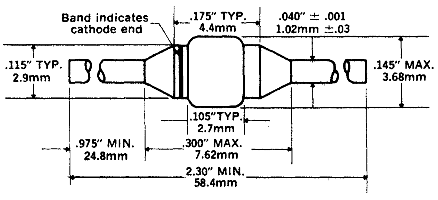
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2 Amp Series	3 Amp Series	4 Amp Series
50V	UT2005	UT3005	UT4005
100V	UT2010	UT3010	UT4010
200V	UT2020	UT3020	UT4020
400V	UT2040	UT3040	UT4040
600V	UT2060	UT3060	UT4060

	2 AMP SERIES	3 AMP SERIES	4 AMP SERIES
Maximum Average D.C. Output Current			
@ $T_A = 25°C$	2.0A	3.0A	4.0A
@ $T_A = 100°C$	1.0A	1.5A	2.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	60A	80A	100A
Operating Temperature Range		−195°C to +175°C	
Storage Temperature Range		−195°C to +200°C	
Thermal Resistance		See lead temperature derating curve	

MECHANICAL SPECIFICATIONS

UT2005-UT2060 UT3005-UT3060 UT4005-UT4060



Part Identification: Orange band indicates "UT." Part number printed on body.

Polarity: Denoted by orange band.

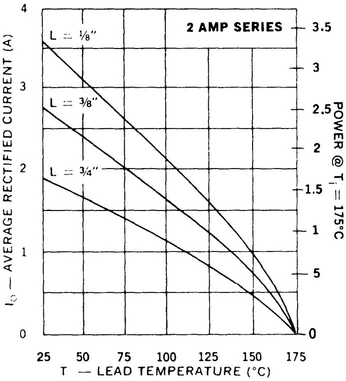
Weight: 0.75 grams, typical.

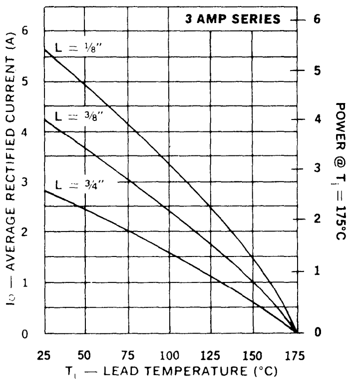
BODY B

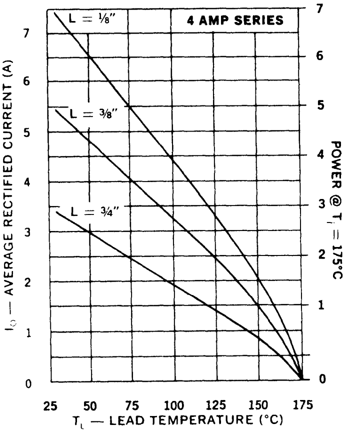
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

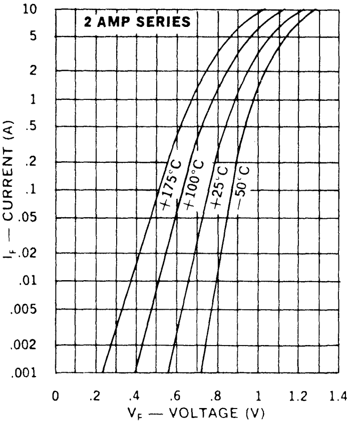
Type	PIV	Maximum Forward Voltage Drop	Maximum Leakage Current @ PIV	
			25°C	100°C
UT4005	50V	1V @ 3A	5μA	100μA
UT4010	100V			
UT4020	200V			
UT4040	400V			
UT4060	600V			
UT3005	50V	1V @ 2A	5μA	100μA
UT3010	100V			
UT3020	200V			
UT3040	400V			
UT3060	600V			
UT2005	50V	1V @ 1A	5μA	100μA
UT2010	100V			
UT2020	200V			
UT2040	400V			
UT2060	600V			


Maximum Current vs Lead Temperature

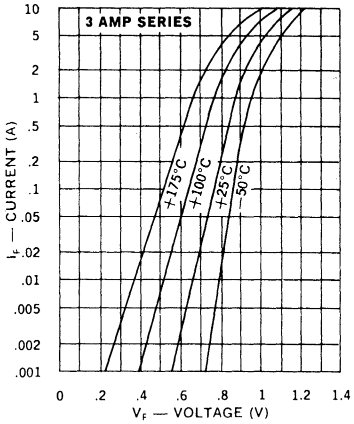

Maximum Current vs Lead Temperature


Maximum Current vs Lead Temperature

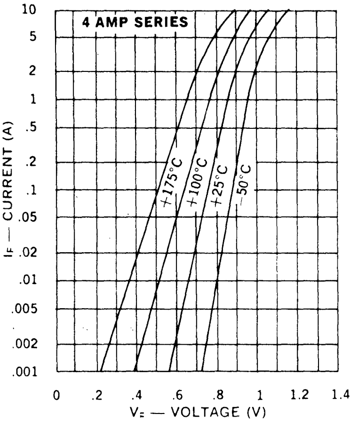
Typical Forward Current vs Forward Voltage



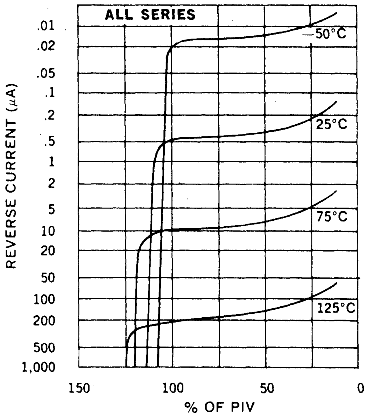
Typical Forward Current vs Forward Voltage



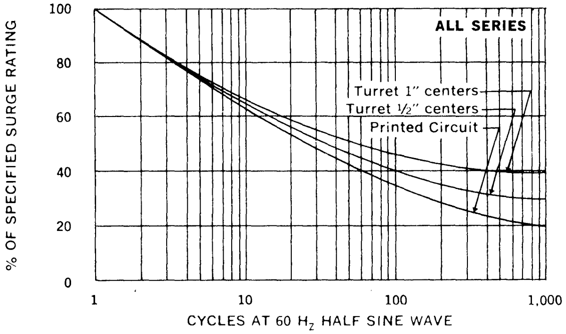
Typical Forward Current vs Forward Voltage



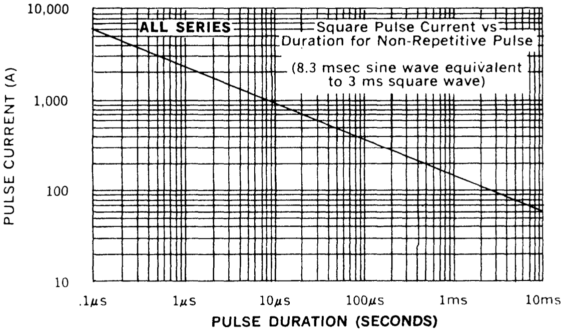
Typical Reverse Current vs PIV



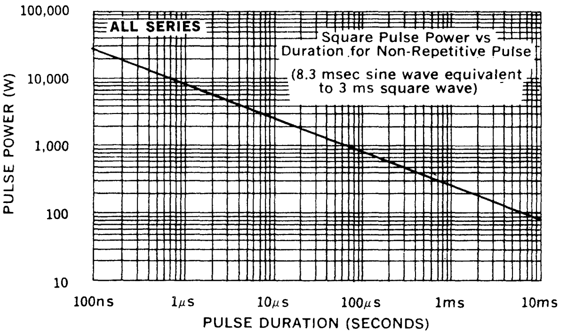
Allowable Forward Surge vs Number of Cycles



Forward Pulse Current vs Pulse Duration



Reverse Pulse Power vs Pulse Duration



RECTIFIERS
Standard Recovery, 7.5 Amp to 12 Amp

UT5105-UT5160
UT6105-UT6160
UT8105-UT8160

FEATURES
- Rating: 12A
- Controlled Avalanche
- Miniature Package
- Surge Rating: 200A

DESCRIPTION
These series of high current rectifiers offers opportunity for size and weight reduction in high power supplies.

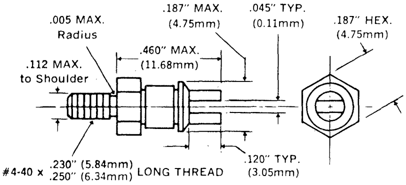
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	12 Amp Series	9 Amp Series	7.5 Amp Series
50V	UT8105	UT6105	UT5105
100V	UT8110	UT6110	UT5110
200V	UT8120	UT6120	UT5120
400V	UT8140	UT6140	UT5140
600V	UT8160	UT6160	UT5160

	12 AMP SERIES	9 AMP SERIES	7.5 AMP SERIES
Maximum Average D.C. Output Current @ $T_C = 100°C$	12.0A	9.0A	7.5A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	200A	175A	150A
Operating and Storage Temperature Range	—65°C to +175°C		
Thermal Resistance, Junction to Case	7.5°C/Watt		
Current Derating	See current vs. case temperature curve		

MECHANICAL SPECIFICATIONS

UT5105-UT5160 UT6105-UT6160 UT8105-UT8160



Part Identification: Numerals and polarity letter indicate "UT" type number; e.g., 8105R.

Polarity: Cathode to Stud is standard. Reverse polarity denoted by "R" Suffix.

Finish: Metal parts gold plated per MIL-G-45204, Type II.

Max. Weight: 1.5 grams.

Also available with insulated stud.

BODY C — Stud Mount

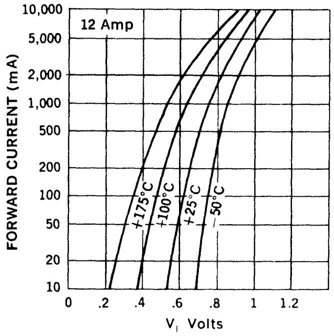
Installation
Maximum unlubricated stud torque: 28 inch-ounces.
Insulating hardware supplied.
Do not use a screwdriver in the turret slot for installation purposes, or damage may result.

UNITRODE

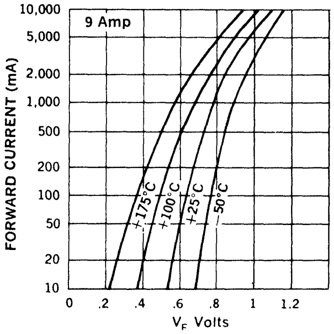
ELECTRICAL SPECIFICATIONS (at 25 C unless noted)

Type	Peak Inverse Voltage	Maximum Forward Voltage	Max. Reverse Current at PIV	
			25°C	100°C
UT8105 UT8110 UT8120 UT8140 UT8160	50V 100V 200V 400V 600V	1V @ 8A	10μA	300μA
UT6105 UT6110 UT6120 UT6140 UT6160	50V 100V 200V 400V 600V	1V @ 6A	10μA	300μA
UT5105 UT5110 UT5120 UT5140 UT5160	50V 100V 200V 400V 600V	1V @ 5A	10μA	300μA

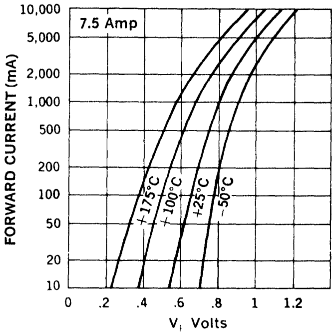
Typical Forward Voltage vs Forward Current



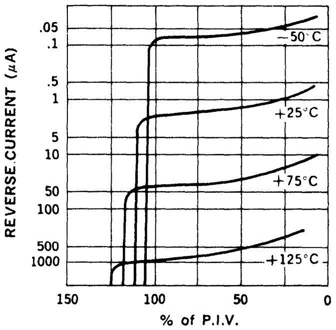
Typical Forward Voltage vs Forward Current



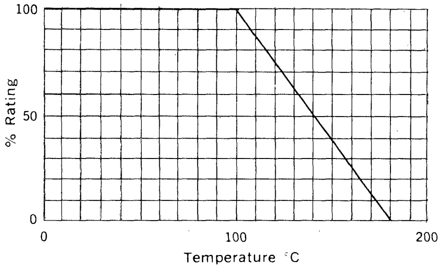
Typical Forward Voltage vs Forward Current



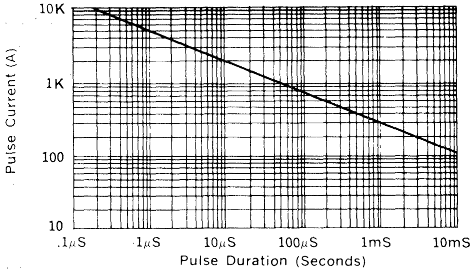
Typical P.I.V. vs Reverse Current



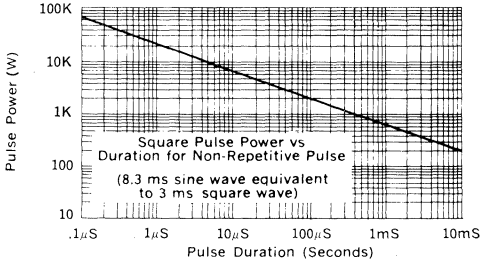
Current Rating vs Case Temperature



Forward Pulse Current vs. Pulse Duration



Reverse Pulse Power vs. Pulse Duration



RECTIFIERS

Fast Recovery, 0.5 Amp to 2 Amp

UTR10-UTR60
UTR01-UTR61
UTR02-UTR62

FEATURES

- Continuous Rating: to 2A
- Controlled Avalanche
- Surge Rating: to 25A
- Fast Recovery 40kHz Operation
- PIV: to 600V
- Miniature Package

DESCRIPTION

These miniature fast recovery rectifiers permit operation at full frequencies as high as 40kHz square wave. They have the unique Unitrode Fused in Glass construction.

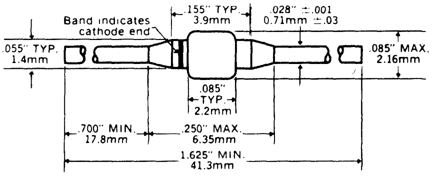
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	½ Amp Series	1 Amp Series	2 Amp Series
50V		UTR01	UTR02
100V	UTR10	UTR11	UTR12
200V	UTR20	UTR21	UTR22
300V	UTR30	UTR31	UTR32
400V	UTR40	UTR41	UTR42
500V	UTR50	UTR51	UTR52
600V	UTR60	UTR61	UTR62

	½ AMP SERIES	1 AMP SERIES	2 AMP SERIES
Maximum Average D.C. Output Current			
@ $T_A = 25°C$	0.5A	1.0A	2.0A
@ $T_A = 100°C$	0.25A	0.5A	1.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	15A	20A	25A
Operating Temperature Range		−195°C to +175°C	
Storage Temperature Range		−195°C to +200°C	
Thermal Resistance		See lead temperature derating curves	

MECHANICAL SPECIFICATIONS

UTR10-UTR60 UTR01-UTR61 UTR02-UTR62



Part Identification: Green band indicates "UTR." Part number printed on body.

Polarity: Denoted by Green band.

Weight: 0.26 grams, typical.

BODY A

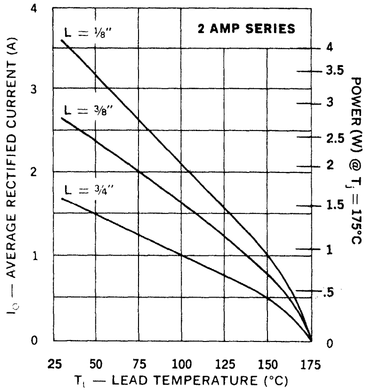
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

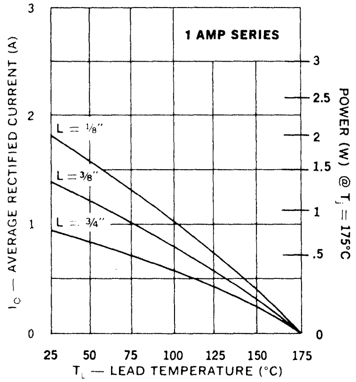
Type	PIV	Maximum Forward Voltage Drop	Maximum Leakage Current @ PIV		Maximum Reverse Recovery Time*	Maximum Junction Capacitance @ 25°C	
			25°C	100°C		0V	—10V
UTR02	50V	1.1V @ 1000mA	3μA	100μA	250ns	150pf	60pf
UTR12	100V				250ns	100pf	40pf
UTR22	200V				250ns	80pf	32pf
UTR32	300V				300ns	70pf	28pf
UTR42	400V				350ns	60pf	24pf
UTR52	500V				400ns	50pf	20pf
UTR62	600V				400ns	40pf	16pf
UTR01	50V	1.1V @ 500mA	3μA	100μA	250ns	150pf	60pf
UTR11	100V				250ns	100pf	40pf
UTR21	200V				250ns	80pf	32pf
UTR31	300V				300ns	70pf	28pf
UTR41	400V				350ns	60pf	24pf
UTR51	500V				400ns	50pf	20pf
UTR61	600V				400ns	40pf	16pf
UTR10	100V	1.1V @ 200mA	3μA	100μA	250ns	100pf	40pf
UTR20	200V				250ns	80pf	32pf
UTR30	300V				300ns	70pf	28pf
UTR40	400V				350ns	60pf	24pf
UTR50	500V				400ns	50pf	20pf
UTR60	600V				400ns	40pf	16pf

*Recovery time is measured from 10.0mA to 10.0mA recovery to 5.0mA

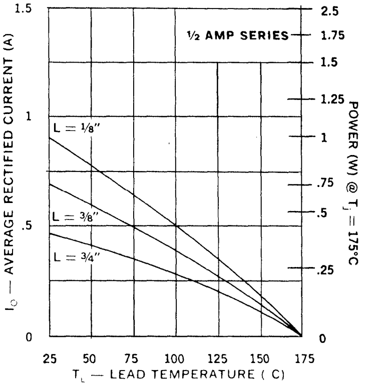
Maximum Current vs Lead Temperature



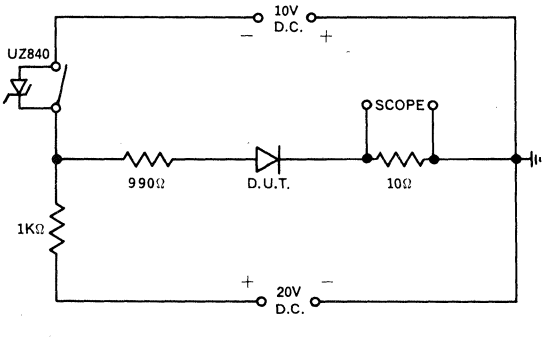
Maximum Current vs Lead Temperature



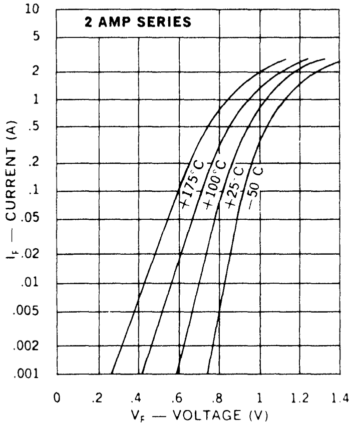
Maximum Current vs Lead Temperature



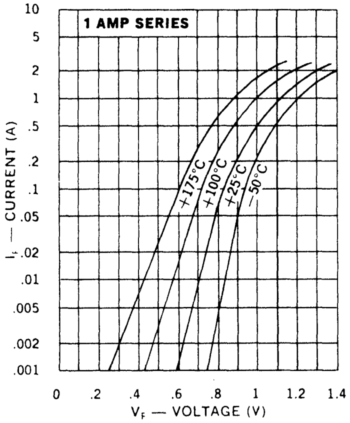
Reverse-Recovery Circuit



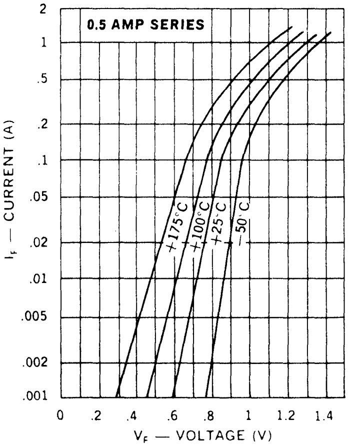
Typical Forward Current vs Forward Voltage



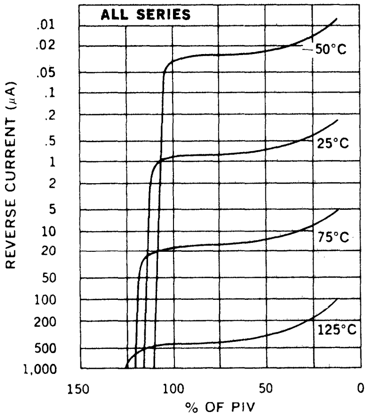
Typical Forward Current vs Forward Voltage



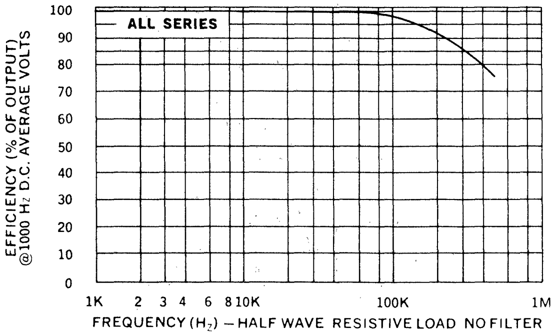
Typical Forward Current vs Forward Voltage



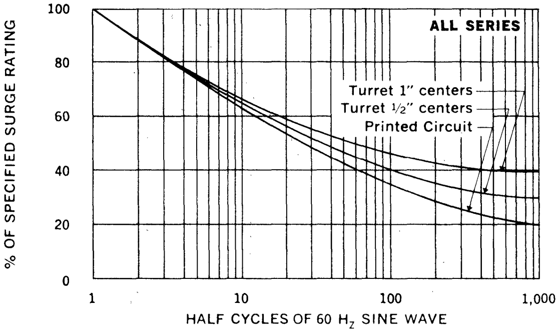
Typical Reverse Current vs PIV



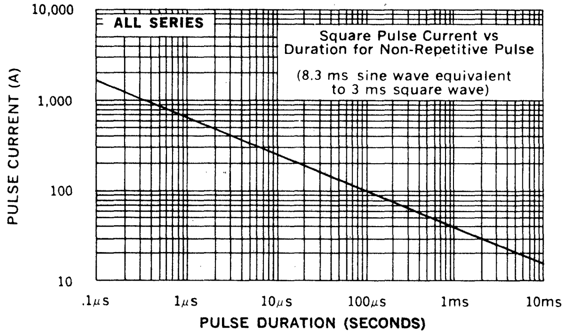
Efficiency vs Frequency at Rated Current (Sine Wave)



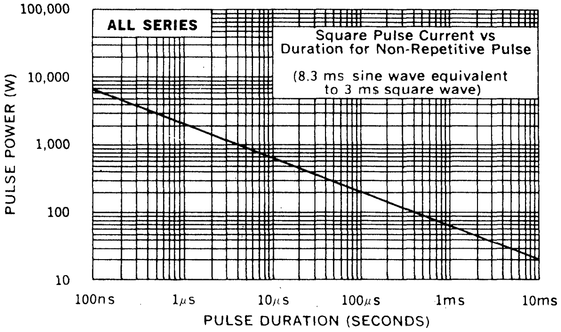
Allowable Forward Surge vs Number of Cycles



Forward Pulse Current vs Pulse Duration



Reverse Pulse Power vs Pulse Duration



RECTIFIERS

Fast Recovery, 2 Amp to 4 Amp

UTR2305-UTR2360
UTR3305-UTR3360
UTR4305-UTR4360

FEATURES

- Continuous Rating: to 4A
- Controlled Avalanche
- Surge Rating: to 100A
- PIV: to 600V
- Miniature Package

DESCRIPTION

Small size and high surge capability make this series of power switching rectifiers desirable for power supplies where size, weight and reliability are important.

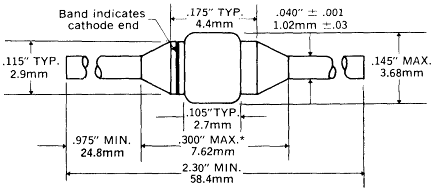
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2 Amp Series	3 Amp Series	4 Amp Series
50V	UTR2305	UTR3305	UTR4305
100V	UTR2310	UTR3310	UTR4310
200V	UTR2320	UTR3320	UTR4320
400V	UTR2340	UTR3340	UTR4340
500V	UTR2350	UTR3350	UTR4350
600V	UTR2360	UTR3360	UTR4360

	2 AMP SERIES	3 AMP SERIES	4 AMP SERIES
Maximum Average D.C. Output Current			
@ $T_A = 25°C$	2.0A	3.0A	4.0A
@ $T_A = 100°C$	1.0A	1.5A	2.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	60A	80A	100A
Operating Temperature Range		—195°C to +175°C	
Storage Temperature Range		—195°C to +200°C	
Thermal Resistance		See lead temperature derating curve	

MECHANICAL SPECIFICATIONS

UTR4305-UTR4360 UTR3305-UTR3360 UTR2305-UTR2360



Part Identification: Green band indicates "UTR." Part number printed on body.

Polarity: Denoted by Green band.

Weight: 0.75 grams, typical.

BODY B

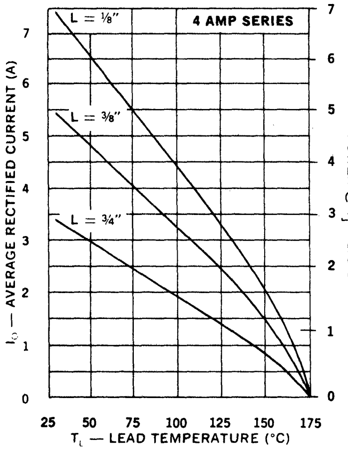
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

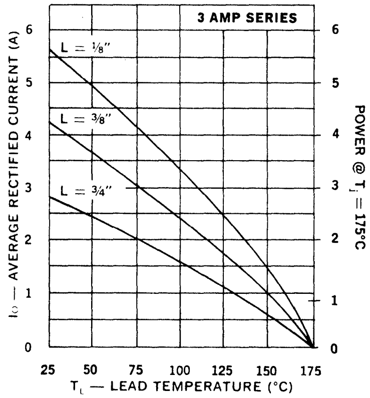
Type	PIV	Maximum Forward Voltage Drop	Maximum Leakage Current @ PIV		Maximum Reverse Recovery Time*	Maximum Junction Capacitance @ 25°C	
			25°C	100°C		0V	—10V
UTR4305	50V	1.1V @ 4A	5μA	100μA	250ns	600pf	240pf
UTR4310	100V				250ns	400pf	160pf
UTR4320	200V				250ns	320pf	128pf
UTR4340	400V				400ns	240pf	96pf
UTR4350	500V				400ns	200pf	80pf
UTR4360	600V				400ns	160pf	64pf
UTR3305	50V	1.1V @ 3A	5μA	100μA	250ns	600pf	240pf
UTR3310	100V				250ns	400pf	160pf
UTR3320	200V				250ns	320pf	128pf
UTR3340	400V				300ns	240pf	96pf
UTR3350	500V				350ns	200pf	80pf
UTR3360	600V				400ns	160pf	64pf
UTR2305	50V	1.1V @ 2A	5μA	100μA	250ns	600pf	240pf
UTR2310	100V				250ns	400pf	160pf
UTR2320	200V				250ns	320pf	128pf
UTR2340	400V				300ns	240pf	96pf
UTR2350	500V				350ns	200pf	80pf
UTR2360	600V				400ns	160pf	64pf

*Recovery time is measured from 1A to 1A recovering to 0.5A.

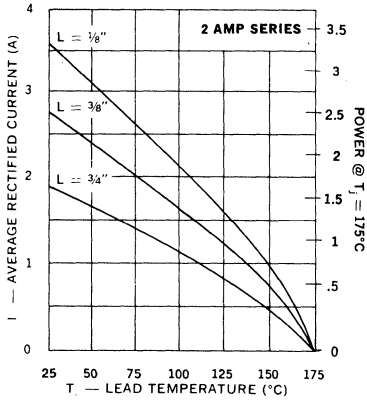
Maximum Current vs Lead Temperature



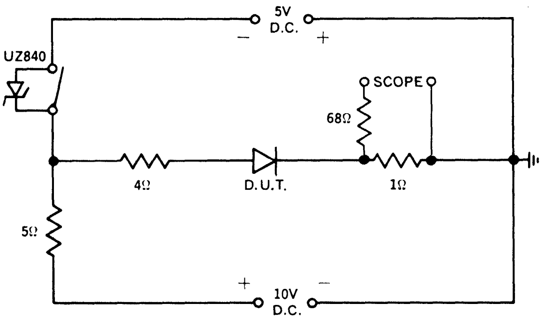
Maximum Current vs Lead Temperature



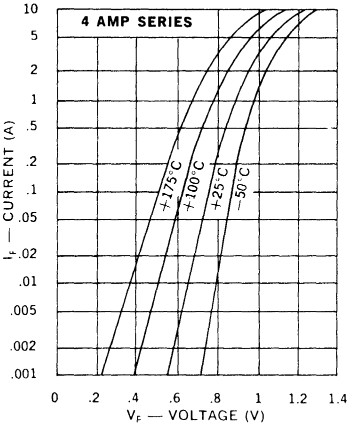
Maximum Current vs Lead Temperature



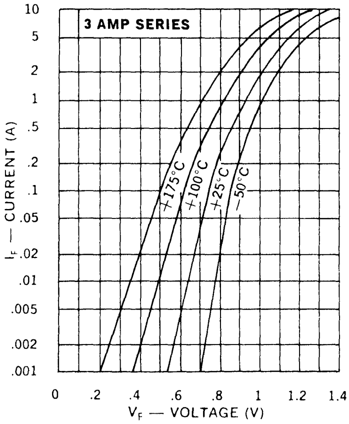
Reverse Recovery Circuit



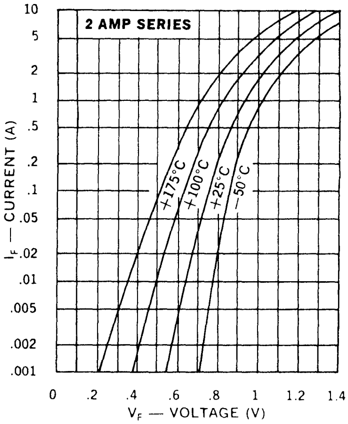
Typical Forward Current vs Forward Voltage



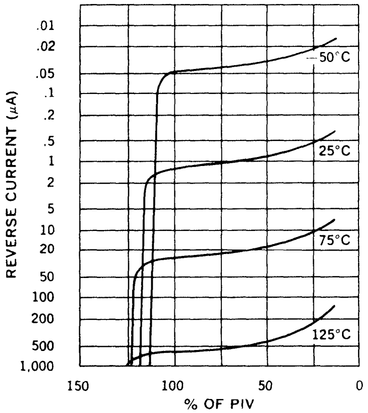
Typical Forward Current vs Forward Voltage



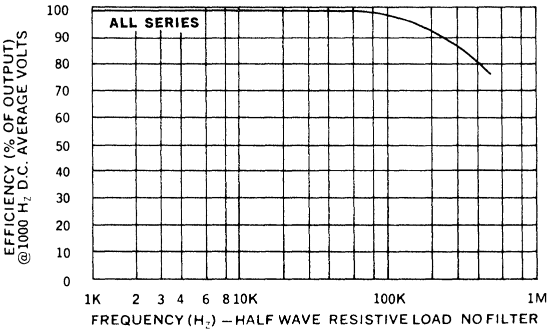
Typical Forward Current vs Forward Voltage



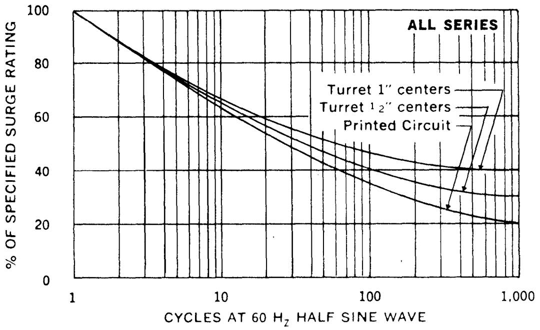
Typical Reverse Current vs PIV



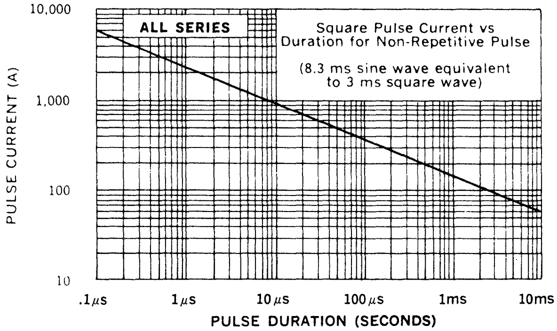
Efficiency vs Frequency at Rated Current (Sine Wave)



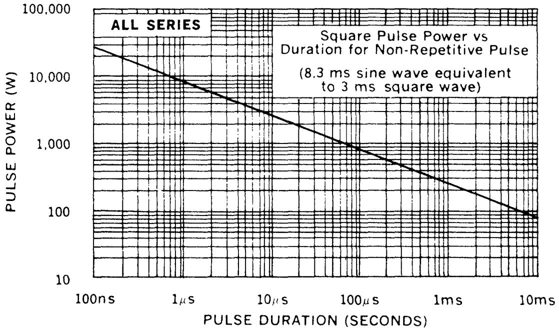
Allowable Forward Surge vs Number of Cycles



Forward Pulse Current vs Pulse Duration



Reverse Pulse Power vs Pulse Duration



RECTIFIERS

Fast Recovery, 6 Amp to 9 Amp

UTR4405-UTR4440
UTR5405-UTR5440
UTR6405-UTR6440

FEATURES

- Continuous Rating: to 9A
- Controlled Avalanche
- Surge Rating: to 150A
- Fast Recovery, 40kHz Operation
- PIV: to 400V
- Miniature Package

DESCRIPTION

The same basic construction as all Unitrode diodes, but using a miniature stud mounting and larger junction area, provides a 9 Amp continuous and 150 Amp surge rating in a package only one fifth the weight and one quarter the volume of conventional types.

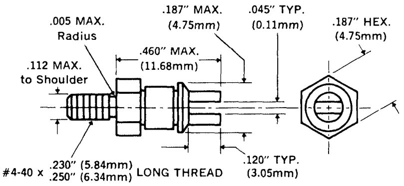
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	6 Amp Series	7.5 Amp Series	9 Amp Series
50V	UTR4405	UTR5405	UTR6405
100V	UTR4410	UTR5410	UTR6410
200V	UTR4420	UTR5420	UTR6420
400V	UTR4440	UTR5440	UTR6440

	6 AMP SERIES	7.5 AMP SERIES	9.0 AMP SERIES
Maximum Average D.C. Output Current @ $T_C = 100°C$	6.0A	7.5A	9.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	120A	135A	150A
Operating Temperature Range	−195°C to +175°C		
Storage Temperature Range	−195°C to +200°C		
Thermal Resistance	7.5°C/W		

MECHANICAL SPECIFICATIONS

UTR6405-UTR6440 UTR5405-UTR5440 UTR4405-UTR4440



Part Identification: Numerals and polarity letter indicate UTR type number, e.g., UTR 4405.

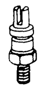
Polarity: Cathode to Stud is standard. Reverse polarity denoted by "R" suffix.

Finish: Metal parts gold plated per MIL-G-45204, Type II.

Weight: 1.5 grams, typical.

Also available with insulated stud.

BODY C — Stud Mount



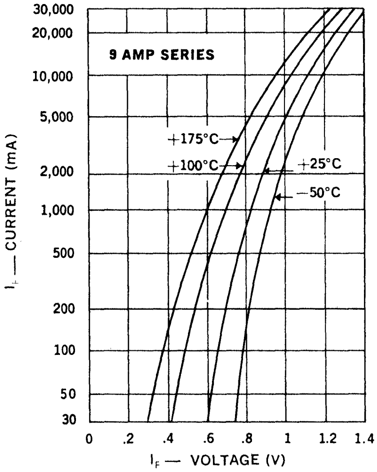
Installation
Maximum unlubricated stud torque: 28 inch-ounces.
Insulating hardware supplied.
Do not use a screwdriver in the turret slot for installation purposes, or damage may result.

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

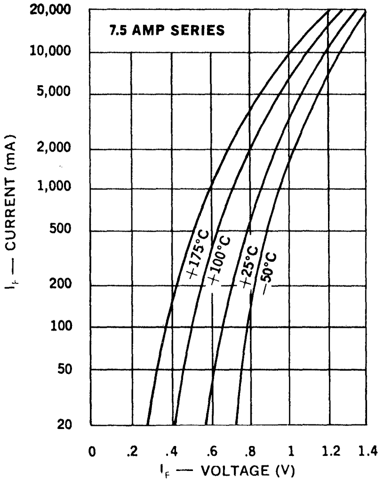
Type	PIV	Maximum Forward Voltage Drop	Maximum Reverse Current @ PIV		Maximum Reverse Recovery Time*
			25°C	100°C	
UTR6405	50V	1.1V @ 6.0A	10μA	300μA	300ns
UTR6410	100V				300ns
UTR6420	200V				400ns
UTR6440	400V				500ns
UTR5405	50V	1.1V @ 5.0A	10μA	300μA	300ns
UTR5410	100V				300ns
UTR5420	200V				400ns
UTR5440	400V				500ns
UTR4405	50V	1.1V @ 4.0A	10μA	300μA	300ns
UTR4410	100V				300ns
UTR4420	200V				400ns
UTR4440	400V				500ns

*Recovery time is measured from 1A to 1A, recovering to 0.5A.

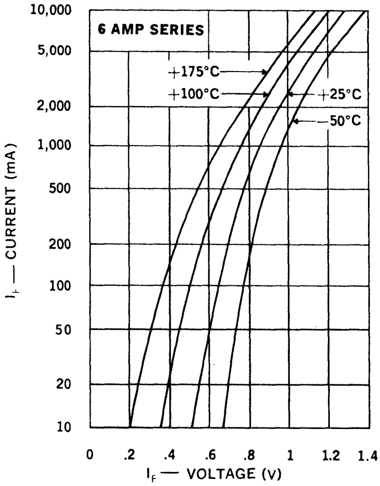
Typical Forward Voltage vs Forward Current



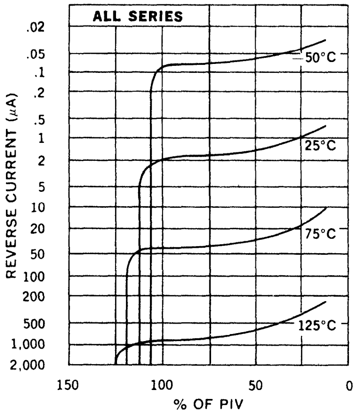
Typical Forward Voltage vs Forward Current



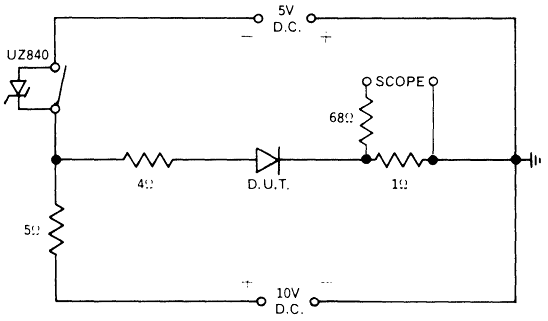
Typical Forward Voltage vs Forward Current



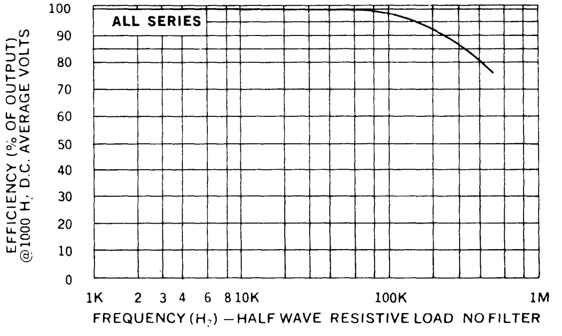
Typical Reverse Current vs PIV



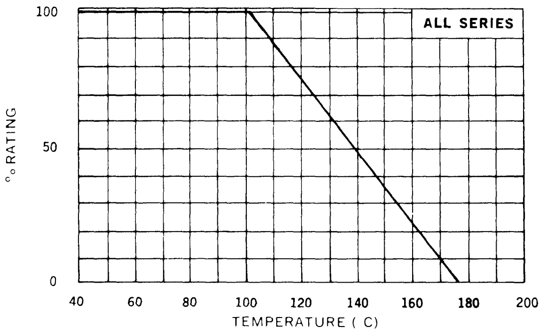
Reverse Recovery Circuit



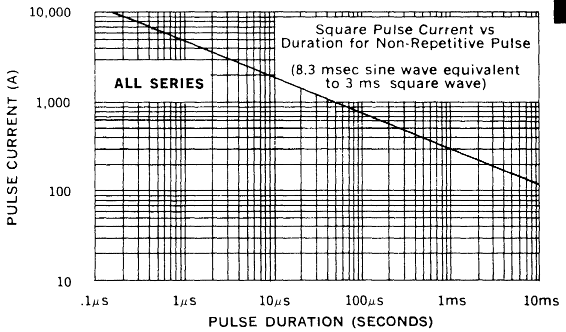
Efficiency vs Frequency at Rated Current (Sine Wave)



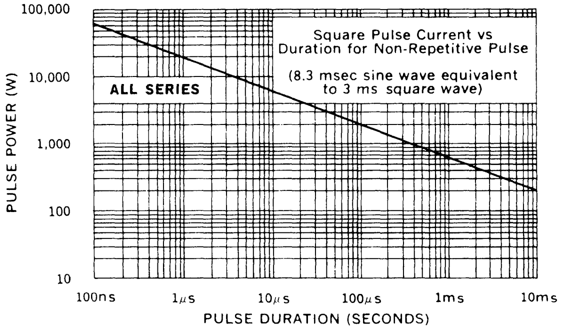
Current Rating vs Case Temperature



Forward Pulse Current vs Pulse Duration



Reverse Pulse Power vs Pulse Duration



RECTIFIERS

Ultra-Fast Recovery, 1 Amp and 2 Amp

UTX105-UTX125
UTX205-UTX225

FEATURES

- Continuous Rating: to 2A
- Controlled Avalanche
- Surge: to 25A
- Recovery Time less than 75ns
- Miniature Package

DESCRIPTION

These miniature ultra-fast recovery rectifiers permit operation at full power at frequencies as high as 100kHz square wave. They may be used as half wave rectifiers or as legs of a bridge.

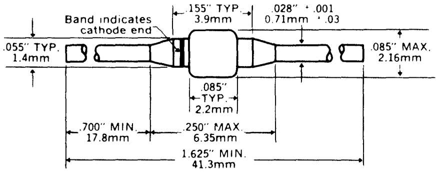
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	1 Amp Series	2 Amp Series
50V	UTX105	UTX205
100V	UTX110	UTX210
150V	UTX115	UTX215
200V	UTX120	UTX220
250V	UTX125	UTX225

	1 AMP SERIES	2 AMP SERIES
Maximum Average D.C. Output Current		
@ $T_A = 25°C$	1.0A	2.0A
@ $T_A = 100°C$	0.5A	1.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	20A	25A
Operating Temperature Range	—195°C to +175°C	
Storage Temperature Range	—195°C to +200°C	
Thermal Resistance	See Lead Temperature Derating Curve	

MECHANICAL SPECIFICATIONS

UTX105-UTX125 UTX205-UTX225



Part Identification: Green band indicates "UTX." Part number printed on body.

Polarity: Denoted by green band.

Weight: 0.26 grams, typical.

BODY A

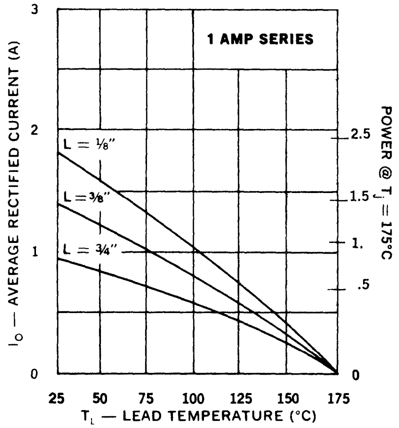
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

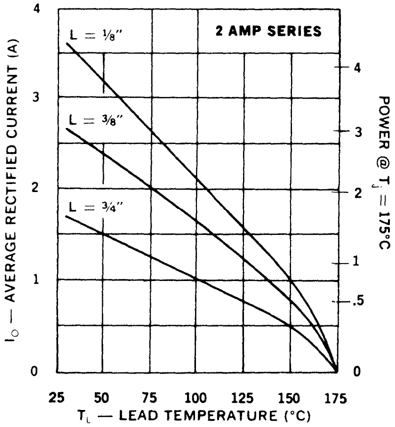
Type	PIV	Maximum Voltage Forward Drop	Leakage Current @ PIV		Max. Reverse Recovery Time*
			25°C	100°C	
UTX 205	50V	1.0V @ 1 Adc	3μA	50μA	75ns
UTX 210	100V				
UTX 215	150V				
UTX 220	200V				
UTX 225	250V				
UTX 105	50V	1.0V @ 0.5 Adc	3μA	50μA	75ns
UTX 110	100V				
UTX 115	150V				
UTX 120	200V				
UTX 125	250V				

*Recovery time is measured from 10.0mA to 10.0mA recovery to 5.0mA.

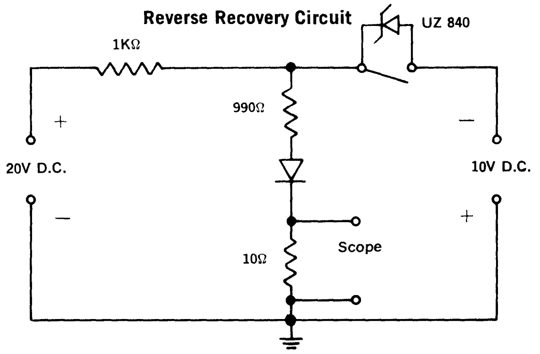
Maximum Current vs Lead Temperature



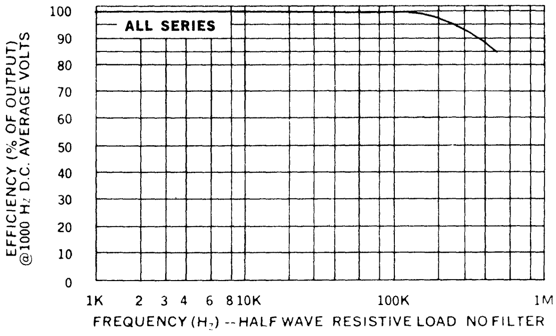
Maximum Current vs Lead Temperature



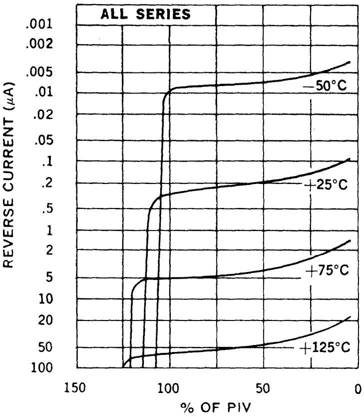
Reverse Recovery Circuit



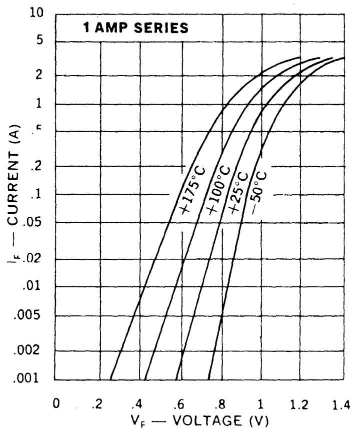
Efficiency vs Frequency at Rated Current (Sine Wave)



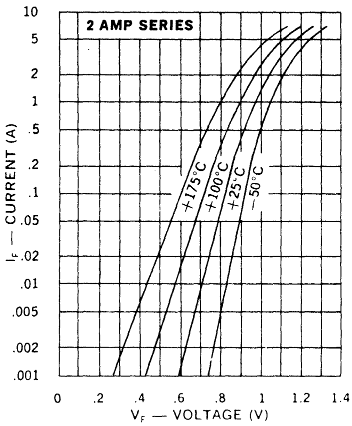
Typical Leakage Current vs. PIV



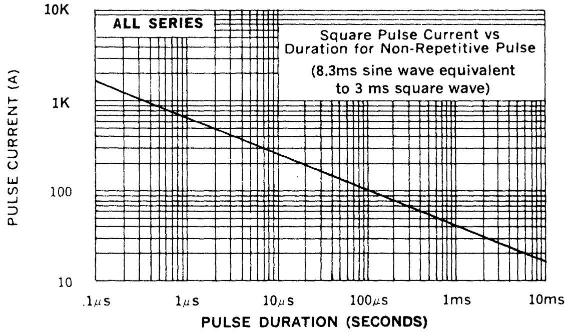
Typical Forward Current vs Forward Voltage



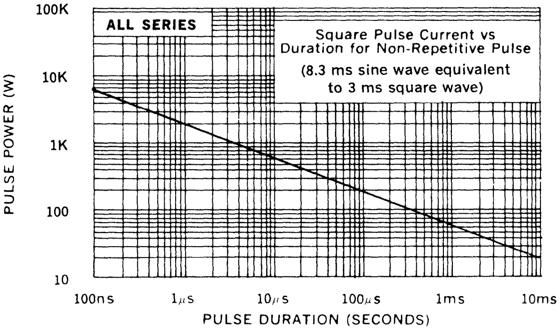
Typical Forward Current vs Forward Voltage



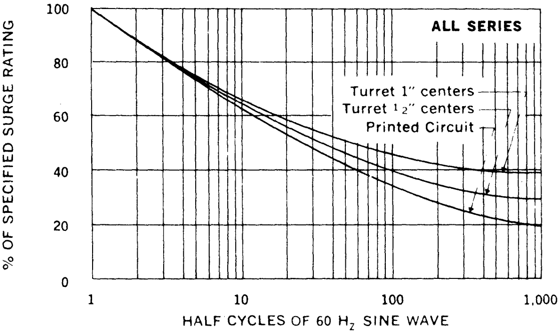
Forward Pulse Current vs Pulse Duration



Reverse Pulse Power vs Pulse Duration



Allowable Forward Surge vs Number of Cycles



RECTIFIERS
Ultra-Fast Recovery, 3 Amp and 4 Amp

UTX 3105-UTX 3120
UTX 4105-UTX 4120

FEATURES
- Continuous Rating: to 4A
- Controlled Avalanche
- Surge: to 80A
- Recovery Time less than 100ns
- Miniature Package

DESCRIPTION
These miniature ultra-fast recovery rectifiers permit operation at full power at frequencies as high as 100kHz square wave. They have the same unique Unitrode construction as the familiar 2 amp UTX series, but are scaled up in size to provide higher continuous and surge current capability.

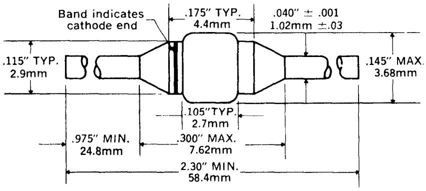
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	3 Amp Series	4 Amp Series
50V	UTX 3105	UTX 4105
100V	UTX 3110	UTX 4110
150V	UTX 3115	UTX 4115
200V	UTX 3120	UTX 4120

	3 AMP SERIES	4 AMP SERIES
Maximum Average D.C. Output Current		
@ $T_A = 25°C$	3.0A	4.0A
@ $T_A = 100°C$	1.5A	2.0A
Non-Repetitive Sinusoidal Surge Current (8.3ms)	60A	80A
Operating Temperature Range	—195°C to +175°C	
Storage Temperature Range	—195°C to +200°C	
Thermal Resistance	See Lead Temperature Derating Curve	

MECHANICAL SPECIFICATIONS

UTX 3105-UTX 3120 UTX 4105-UTX 4120



UTX Prefix is identified by a Green Cathode Band

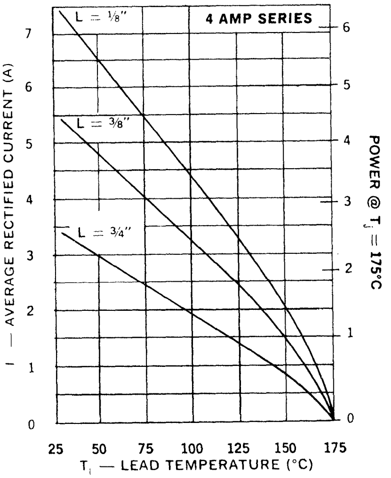
BODY B

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

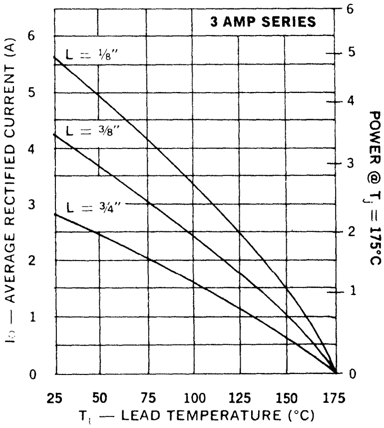
Type	PIV	Maximum Forward Voltage Drop*	Maximum Leakage Current @ PIV		Maximum Reverse Recovery Time**
			25°C	100°C	
UTX 4105	50V	1V @ 3 Adc	5μA	75μA	100ns
UTX 4110	100V				
UTX 4115	150V				
UTX 4120	200V				
UTX 3105	50V	1V @ 2 Adc	5μA	75μA	100ns
UTX 3110	100V				
UTX 3115	150V				
UTX 3120	200V				

*Forward voltage is measured at least 1 second after application of current.
**Recovery time is measured from 1A to 1A recovering to 0.5A.

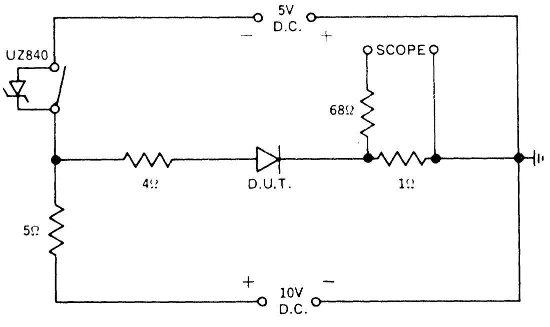
Maximum Current vs Lead Temperature



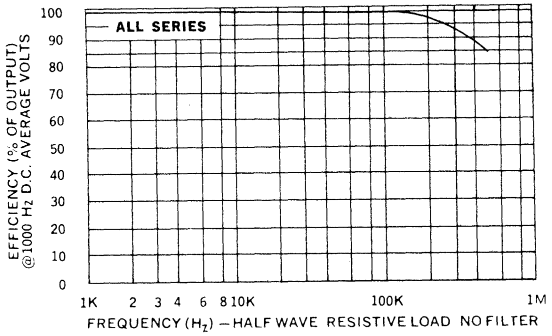
Maximum Current vs Lead Temperature

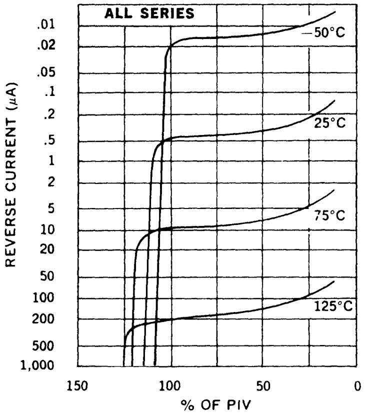


Reverse Recovery Circuit

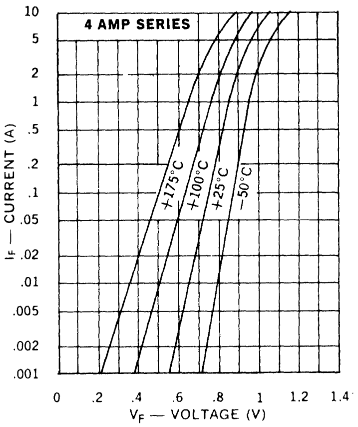


Efficiency vs Frequency at Rated Current (Sine Wave)

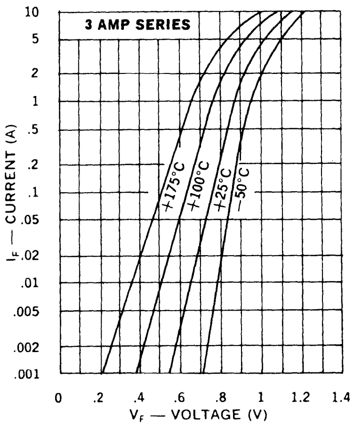




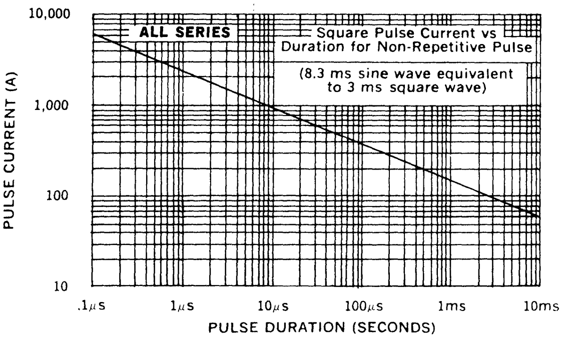
Typical Leakage Current vs PIV



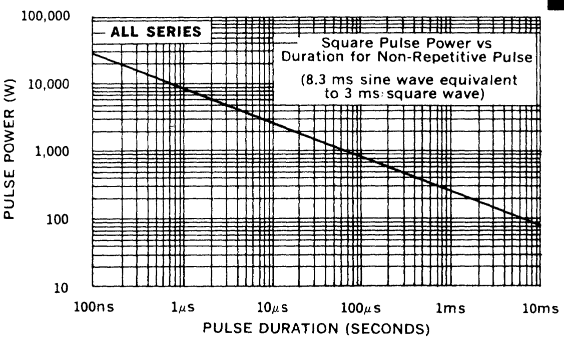
Typical Forward Current vs Forward Voltage



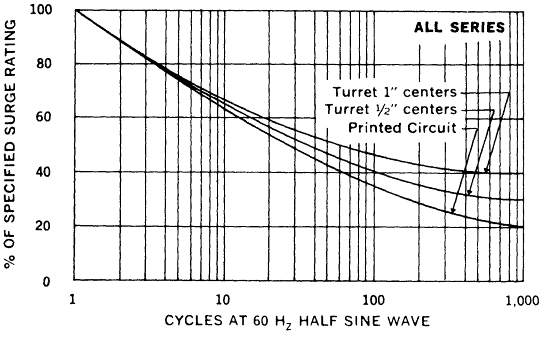
Typical Forward Current vs Forward Voltage



Forward Pulse Current vs Pulse Duration



Reverse Pulse Power vs Pulse Duration



Allowable Forward Surge vs Number of Cycles

RECTIFIERS

PART NUMBER INDEX

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER
229	1N3611, J, JTX	1.0A; 200V
229	1N3612, J, JTX	1.0A; 400V
229	1N3613, J, JTX	1.0A; 600V
229	1N3614, J, JTX	1.0A; 800V
*	1N3656	0.75A; 200V
*	1N3657	0.75A; 400V
*	1N3658	0.75A; 600V
231	1N3909, J, JTX	30A; 50V; DO-5
231	1N3910, J, JTX	30A; 100V; DO-5
231	1N3911, J, JTX	30A; 200V; DO-5
231	1N3912, J, JTX	30A; 300V; DO-5
231	1N3913, J, JTX	30A; 400V; DO-5
*	1N3957	1.0A; 1000V
*	1N3981	2.0A; 200V
*	1N3982	2.0A; 400V
*	1N3983	2.0A; 600V
233	1N4245, J, JTX, JTXV	1.0A; 200V
233	1N4246, J, JTX, JTXV	1.0A; 400V
233	1N4247, J, JTX, JTXV	1.0A; 600V
233	1N4248, J, JTX, JTXV	1.0A; 800V
233	1N4249, J, JTX, JTXV	1.0A; 1000V
235	1N4942, J, JTX, JTXV	1.0A; 200V
235	1N4944, J, JTX, JTXV	1.0A; 400V
235	1N4946, J, JTX, JTXV	1.0A; 600V
*	1N5180	4.0A; 100V
*	1N5185	3.0A; 60V
237	1N5186, J, JTX	3.0A; 100V
237	1N5187, J, JTX	3.0A; 200V
237	1N5188, J, JTX	3.0A; 400V
237	1N5190, J, JTX	3.0A; 600V
*	1N5207	4.0A; 400V
*	1N5320	1.0A; 120V
*	1N5330	0.5A; 1500V
239	1N5415, J, JTX, JTXV	3A; 50V
239	1N5416, J, JTX, JTXV	3A; 100V
239	1N5417, J, JTX, JTXV	3A; 200V
239	1N5418, J, JTX, JTXV	3A; 400V
239	1N5419, J, JTX, JTXV	3A; 500V
239	1N5420, J, JTX, JTXV	3A; 600V
*	1N5433	2.0A; 700V
*	1N5434	2.0A; 700V
*	1N5435	12.0A; 700V
241	1N5550, J, JTX, JTXV	5.0A; 200V
241	1N5551, J, JTX, JTXV	5.0A; 400V
241	1N5552, J, JTX, JTXV	5.0A; 600V
241	1N5553, J, JTX, JTXV	5.0A; 800V
243	1N5614, J, JTX, JTXV	1.0A; 200V
245	1N5615, J, JTX, JTXV	1.0A; 200V
243	1N5616, J, JTX, JTXV	1.0A; 400V
245	1N5617, J, JTX, JTXV	1.0A; 400V
243	1N5618, J, JTX, JTXV	1.0A; 600V
245	1N5619, J, JTX, JTXV	1.0A; 600V
243	1N5620, J, JTX, JTXV	1.0A; 800V
247	1N5802	2.5A; 50V
251	1N5802, J, JTX, JTXV	2.5A; 50V
247	1N5803	2.5A; 75V
247	1N5804	2.5A; 100V
251	1N5804, J, JTX, JTXV	2.5A; 100V
247	1N5805	2.5A; 125V
247	1N5806	2.5A; 150V
251	1N5806, J, JTX, JTXV	2.5A; 150V
247	1N5807	6.0A; 50V
251	1N5807, J, JTX, JTXV	6.0A; 50V
247	1N5808	6.0A; 75V
247	1N5809	6.0A; 100V
251	1N5809, J, JTX, JTXV	6.0A; 100V
		RECTIFIER
247	1N5810	6.0A; 125V
247	1N5811	6.0A; 150V
251	1N5811, J, JTX, JTXV	6.0A; 150V
247	1N5812	20.0A; 50V
254	1N5812, J, JTX, JTXV	20.0A; 50V; DO-4
247	1N5813	20.0A; 75V
247	1N5814	20.0A; 100V
254	1N5814, J, JTX, JTXV	20.0A; 100V; DO-4
247	1N5815	20.0A; 125V
247	1N5816	20.0A; 150V
254	1N5816, J, JTX, JTXV	20.0A; 150V; DO-4
		SCHOTTKY RECTIFIER
256	1N6095	25A; 30V; DO-4
256	1N6096	25A; 40V; DO-4
258	1N6097	50A; 30V; DO-5
258	1N6098	50A; 40V; DO-5
260	SD41	30A; 45V; DO-5
262	SD51	60A; 45V; DO-5
264	SD241	60A; 45V; TO-3
		RECTIFIER
266	SES5001	2.0A; 50V
266	SES5002	2.0A; 100V
266	SES5003	2.0A; 150V
268	SES5301	5.0A; 50V
268	SES5302	5.0A; 100V
268	SES5303	5.0A; 150V
270	SES5401	8.0A; 50V; sim to TO-220
270	SES5402	8.0A; 100V; sim to TO-220
270	SES5403	8.0A; 150V; sim to TO-220
		RECTIFIER, CENTER-TAP
272	SES5401C	16A; 50V; TO-220
272	SES5402C	16A; 100V; TO-220
272	SES5403C	16A; 150V; TO-220
274	SES5601C	25A; 50V; TO-3
274	SES5602C	25A; 100V; TO-3
274	SES5603C	25A; 150V; TO-3
		RECTIFIER
276	SES5701	20A; 50V; DO-4
276	SES5702	20A; 100V; DO-4
276	SES5703	20A; 150V; DO-4
278	SES5801	60A; 50V; DO-5
278	SES5802	60A; 100V; DO-5
278	SES5803	60A; 150V; DO-5
247	UES101 (1N5802)	2.5A; 50V
247	UES102 (1N5803)	2.5A; 75V
247	UES103 (1N5804)	2.5A; 100V
247	UES104 (1N5805)	2.5A; 125V
247	UES201 (1N5807)	6.0A; 50V
247	UES202 (1N5808)	6.0A; 75V
247	UES203 (1N5809)	6.0A; 100V
247	UES204 (1N5810)	6.0A; 125V
*	UES301	20.0A; 50V
*	UES302	20.0A; 75V
*	UES303	20.0A; 100V
*	UES304	20.0A; 125V
280	UES501	50.0A; 50V; DO-5
280	UES502	50.0A; 75V; DO-5
280	UES503	50.0A; 100V; DO-5
280	UES504	50.0A; 125V; DO-5
280	UES505	50.0A; 150V; DO-5
283	UES601	30A; 50V; TO-3
283	UES602	30A; 100V; TO-3
283	UES603	30A; 150V; TO-3
285	UES701	25A; 50V; DO-4

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER
285	UES702	25A; 100V; DO-4
285	UES703	25A; 150V; DO-4
287	UES704	20A; 200V; DO-4
287	UES705	20A; 300V; DO-4
287	UES706	20A; 400V; DO-4
289	UES801	70A; 50V; DO-5
289	UES802	70A; 100V; DO-5
289	UES803	70A; 150V; DO-5
292	UES804	50A; 200V; DO-5
292	UES805	50A; 300V; DO-5
292	UES806	50A; 400V; DO-5
294	UES1001	1A; 50V
294	UES1002	1A; 100V
294	UES1003	1A; 150V
296	UES1101	2.5A; 50V
296	UES1102	2.5A; 100V
296	UES1103	2.5A; 150V
298	UES1104	2.0A; 200V
298	UES1105	2.0A; 300V
298	UES1106	2.0A; 400V
300	UES1301	6A; 50V
300	UES1302	6A; 100V
300	UES1303	6A; 150V
302	UES1304	5.0A; 200V
302	UES1305	5.0A; 300V
302	UES1306	5.0A; 400V
304	UES1401	8.0A; 50V; TO-220
304	UES1402	8.0A; 100V; TO-220
304	UES1403	8.0A; 150V; TO-220
		RECTIFIER, CENTER-TAP
306	UES2401	16A; 50V; sim to TO-220
306	UES2402	16A; 100V; sim to TO-220
306	UES2403	16A; 150V; sim to TO-220
308	UES2601	30A; 50V; TO-3
308	UES2602	30A; 100V; TO-3
308	UES2603	30A; 150V; TO-3
310	UES2604	30A; 200V; TO-3
310	UES2605	30A; 300V; TO-3
310	UES2606	30A; 400V; TO-3
		RECTIFIER
312	UR105	2.0A; 50V
312	UR110	1.0A; 100V
312	UR115	1.0A; 150V
312	UR120	1.0A; 200V
312	UR125	1.0A; 250V
312	UR205	2.0A; 50V
312	UR210	2.0A; 100V
312	UR215	2.0A; 150V
312	UR220	2.0A; 200V
312	UR225	2.0A; 250V
*	UR710	1.0A; 100V
*	UR720	1.0A; 200V
		SCHOTTKY RECTIFIER
315	USD520	75A; 20V; DO-5
315	USD535	75A; 35V; DO-5
315	USD545	75A; 45V; DO-5
		RECTIFIER
*	UT111(1N536)	0.75A; 50V
*	UT112(1N537)	0.75A; 100V
*	UT113(1N3656)	0.75A; 200V
*	UT114(1N539)	0.75A; 300V
*	UT115(1N3657)	0.75A; 400V
*	UT117(1N547)	0.75A; 500V
*	UT118(1N3658)	0.75A; 600V
		RECTIFIER
*	UT119	0.75A; 800V
*	UT120	0.75A; 1000V
*	UT211(1N645)	0.75A; 225V
*	UT212(1N646)	0.75A; 300V
*	UT213(1N647)	0.75A; 400V
*	UT214(1N648)	0.75A; 500V
*	UT215(1N649)	0.75A; 600V
*	UT221(1N676)	0.5A; 100V
*	UT222(1N677)	0.75A; 100V
*	UT223(1N678)	0.5A; 200V
*	UT224(1N679)	0.75A; 200V
*	UT225(1N681)	0.5A; 300V
*	UT226(1N682)	0.75A; 300V
*	UT227(1N683)	0.5A; 400V
*	UT228(1N684)	0.75A; 400V
*	UT229(1N685)	0.5A; 500V
*	UT231(1N686)	0.75A; 500V
*	UT232(1N687)	0.5A; 600V
*	UT233(1N689)	0.75A; 600V
318	UT234	1.0A; 200V
318	UT235	1.0A; 400V
318	UT236	1.0A; 100V
318	UT237	1.0A; 500V
318	UT238	1.0A; 600V
318	UT242	1.25A; 200V
318	UT244	1.25A; 400V
318	UT245	1.25A; 500V
318	UT247	1.25A; 600V
318	UT249	1.25A; 100V
318	UT251	1.5A; 100V
318	UT252	1.5A; 200V
318	UT254	1.5A; 400V
318	UT255	1.5A; 500V
318	UT257	1.5A; 600V
318	UT258	1.5A; 800V
318	UT261	2.0A; 100V
318	UT262(1N3981)	2.0A; 200V
318	UT264(1N3982)	2.0A; 400V
318	UT265	2.0A; 500V
318	UT267(1N3983)	2.0A; 600V
318	UT268	2.0A; 800V
318	UT347	1.0A; 1000V
318	UT361	1.0A; 800V
318	UT362	1.2A; 800V
318	UT363	1.2A; 1000V
318	UT364	1.5A; 1000V
322	UT2005	2.0A; 50V
322	UT2010	2.0A; 100V
322	UT2020	2.0A; 200V
322	UT2040	2.0A; 400V
322	UT2060	2.0A; 600V
*	UT2080	2.0A; 800V
322	UT3005	3.0A; 50V
322	UT3010	3.0A; 100V
322	UT3020	3.0A; 200V
322	UT3040	3.0A; 400V
322	UT3060	3.0A; 600V
*	UT3080	3.0A; 800V
322	UT4005	4.0A; 50V
322	UT4010(1N5180)	4.0A; 100V
322	UT4020	4.0A; 200V
322	UT4040(1N5207)	4.0A; 400V
322	UT4060	4.0A; 600V
*	UT4080	4.0A; 800V
*	UT4100	4.0A; 1000V
326	UT5105	7.5A; 50V

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Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER
326	UT5110	7.5A; 100V
326	UT5120	7.5A; 200V
*	UT5130	7.5A; 300V
326	UT5140	7.5A; 400V
*	UT5150	7.5A; 500V
326	UT5160	7.5A; 600V
326	UT6105	9.0A; 50V
326	UT6110	9.0A; 100V
326	UT6120	9.0A; 200V
*	UT6130	9.0A; 300V
326	UT6140	9.0A; 400V
326	UT6160	9.0A; 600V
326	UT8105	12.0A; 50V
326	UT8110	12.0A; 100V
326	UT8120	12.0A; 200V
*	UT8130	12.0A; 300V
326	UT8140	12.0A; 400V
326	UT8160	12.0A; 600V
329	UTR01	1.0A; 50V
329	UTR02	2.0A; 50V
329	UTR10	0.5A; 100V
329	UTR11	1.0A; 100V
329	UTR12	2.0A; 100V
329	UTR20	0.5A; 200V
329	UTR21	1.0A; 200V
329	UTR22	2.0A; 200V
329	UTR30	0.5A; 300V
329	UTR31	1.0A; 300V
329	UTR32	2.0A; 300V
329	UTR40	0.5A; 400V
329	UTR41	1.0A; 400V
329	UTR42(1N5206)	2.0A; 400V
329	UTR50	0.5A; 500V
329	UTR51	1.0A; 500V
329	UTR52	2.0A; 500V
329	UTR60	0.5A; 600V
329	UTR61	1.0A; 600V
329	UTR62	2.0A; 600V
*	UTR70	0.5A; 700V
*	UTR71	1.0A; 700V
333	UTR2305	2.0A; 50V
333	UTR2310	2.0A; 100V
333	UTR2320	2.0A; 200V
333	UTR2340	2.0A; 400V
333	UTR2350	2.0A; 500V
333	UTR2360	2.0A; 600V
333	UTR3305	3.0A; 50V
333	UTR3310	3.0A; 100V
333	UTR3320	3.0A; 200V
333	UTR3340	3.0A; 400V
333	UTR3350	3.0A; 500V
333	UTR3360	3.0A; 600V
333	UTR4305	4.0A; 50V
333	UTR4310	4.0A; 100V
333	UTR4320	4.0A; 200V
333	UTR4340	4.0A; 400V
333	UTR4350	4.0A; 500V
333	UTR4360	4.0A; 600V
337	UTR4405	6.0A; 50V
337	UTR4410	6.0A; 100V
337	UTR4420	6.0A; 200V
*	UTR4430	6.0A; 300V
337	UTR4440	6.0A; 400V
337	UTR5405	7.5A; 50V
337	UTR5410	7.5A; 100V
337	UTR5420	7.5A; 200V

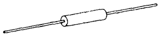
PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER
*	UTR5430	7.5A; 300V
337	UTR5440	7.5A; 400V
337	UTR6405	9.0A; 50V
337	UTR6410	9.0A; 100V
337	UTR6420	9.0A; 200V
*	UTR6430	9.0A; 300V
337	UTR6440	9.0A; 400V
340	UTX105	1.0A; 50V
340	UTX110	1.0A; 100V
340	UTX115	1.0A; 150V
340	UTX120	1.0A; 200V
340	UTX125	1.0A; 250V
340	UTX205	2.0A; 50V
340	UTX210	2.0A; 100V
340	UTX215	2.0A; 150V
340	UTX220	2.0A; 200V
340	UTX225	2.0A; 250V
343	UTX3105	3.0A; 50V
343	UTX3110	3.0A; 100V
343	UTX3115	3.0A; 150V
343	UTX3120	3.0A; 200V
*	UTX3125	3.0A; 250V
343	UTX4105	4.0A; 50V
343	UTX4110	4.0A; 100V
343	UTX4115	4.0A; 150V
343	UTX4120	4.0A; 200V
*	UTX4125	4.0A; 250V

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

HIGH VOLTAGE RECTIFIERS & RECTIFIER MODULES

PRODUCT SELECTION GUIDE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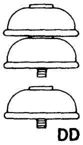
PC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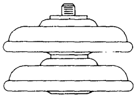
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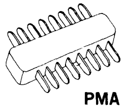
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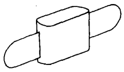
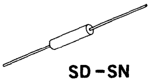

PME

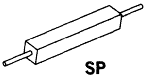
STANDARD RECOVERY

Peak Inverse Voltage	AVERAGE D.C. OUTPUT CURRENT											
	.025-.050A	.050-.100A	.100-.250A	.250-.50A	.50-.75A	.75-1A	1-1.5A	1.5-2A	2-2.5A	2.5-5A	5-6A	6-7A
1.0kV			HVE10 **SJ** HS10 **SK** 1N3643 **SJ**			SXS10 **SL**						
1.2kV							(US12) **SA**					
1.5kV		LS15 **SH** LMS15 **SG** MS15 **SH** MXS15 **SG**	HS15 **SK** HVE15 **SJ** 1N3644 **SJ**			SXS15 **SL** (US15) **SA**				KXS15 **SM**		
1.8kV					(US18) **SA**							
2.0kV		LS20 **SH** LMS20 **SG** MS20 **SH** MXS20 **SG**	HS20 **SK** HVE20 **SJ** 1N3645 **SJ**		(US20) **SA**	SXS20 **SL**				KXS20 **SM**		
2.5kV		LS25 **SH** LMS25 **SG** MS25 **SH** MXS25 **SG**	HS25 **SK** HVE25 **SJ** 1N3646 **SJ**		(US25) **SB**	SXS25 **SL** PME101 **PME**	(USB2.5) **DH**	PMA201 **PMA**	HVHS 2500 **PC**	KXS25 **SM** (UDB2.5) **DD**	(UDE2.5) **DD**	(UGE2.5) **DG**
3.0kV	LS30 **SH** LMS30 **SG** MS30 **SH** MXS30 **SG**		HS30 **SK** HVE30 **SJ** 1N3647 **SJ**		SXS30 **SL** (US30) **SB**				KXS30 **SM**			
3.5kV				(US35) **SC**								
4.0kV	LS40 **SH** LMS40 **SG** MS40 **SH** MXS40 **SG**	HS40 **SK** HVE40 **SJ** 1N5181 **SJ**		(US40) **SC**	SXS40 **SL** PME102 **PME**				KXS40 **SM**			
4.5kV				(US45A) **SD**								

Parentheses ( ) designates product using fused-in-glass single chip rectifiers; all others use stacked chips.

HIGH VOLTAGE RECTIFIERS & RECTIFIER MODULES





STANDARD RECOVERY

Peak Inverse Voltage	AVERAGE D.C. OUTPUT CURRENT													
	≤.025A	.025-.050A	.050-.100A	.100-.250A	.250-.50A	.50-.75A	.75-1A	1-1.5A	1.5-2A	2-2.5A	2.5-3A	3-4A	4-5A	5-6A
5.0kV		LS50 **SH** LMS50 **SG** MS50 **SH** MXS50 **SG**	HS50 **SK** HVE50 **SJ** 1N5182 **SJ**		HVH 5000 **PB** HVHF 5000 **PB** (US50A) **SD**	SXS50 **SL** (USB5) **DH** (USS5) **DH**	PMA101 **PMA**		(UDA5) **DD** (UDB5) **DD** (1N5600)* **DE** PMA202 **PMA**	KXS50 **SM** HVHS 5000 **PC**			(UDE5) **DG** (UGB5) **DD**	(UGE5) **DG** (1N5603)* **DF**
6.0kV	LS60 **SH** LMS60 **SG** MS60 **SH** MXS60 **SG**				SXS60 **SL** (US60A) **SD**			KXS60 **SM**						
7.0kV					(US70A) **SD**									
7.5kV			HS75 **SK** HVF75 **SJ** 1N5183 **SJ**		HVH 7500 **PB** HVHF 7500 **PB** (USS7.5) **DH**	(USB7.5) **DH**	PMA102 **PMA**	(UDA7.5) **DD** (UDB7.5) **DD**	PMA203 **PMA**	HVHS 7500 **PC**	(UGB7.5) **DG**	(UGE7.5) **DG**		
8.0kV	LS80 **SH** LMS80 **SG** MS80 **SH** MXS80 **SG**			(US80A) **SE**	SXS80 **SL** PME103 **PME**			KXS80 **SM**						
10kV	LS100 **SH** LMS100 **SG** MS100 **SH** MXS100 **SG**		HS100 **SK** HVE100 **SJ** 1N5184 **SJ**	(US100A) **SE**	HVH 10000 **PB** HVHF 10000 **PB** SXS100 **SL** (USB10) **DH** (USS10) **DH**	(688-10) **BE**	(UDA10) **DD** (1N5597)* **DE** PMA103 **PMA**	KXS100 **SM**	PMA204 **PMA**	HVHS 10000 **PC** (UGB10) **DG**				
12kV	LS120 **SH** LMS120 **SG** MS120 **SH** MXS120 **SG**			(US120A) **SE**	(688-12) **BE**									
12.5kV					HVH 12500 **PB** HVHF 12500 **PB**					HVHS 12500 **PC**				

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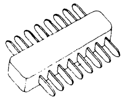
*Available as JAN

PRODUCT SELECTION GUIDE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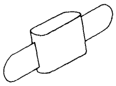
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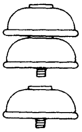
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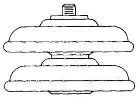
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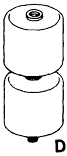
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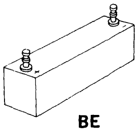
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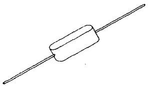
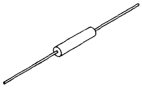

PA PC

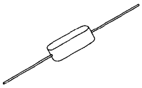
STANDARD RECOVERY

Peak Inverse Voltage	AVERAGE D.C. OUTPUT CURRENT														
	≤.025A	.025-.050A	.050-.100A	.100-.250A	.250-.50A	.50-.75A	.75-1A	1-1.5A	1.5-2A	2-2.5A	2.5-3A	3-4A	4-5A	5-6A	6-7A
15kV	LCS15 **SN** LMS150 **SG** MXS150 **SG** VXS15 **SP**	HVHJ 15K **PA**		(US150A) **SF** (USS15) **DH**	HVH 15000 **PB** HVHF 15000 **PB** (688-15) **BE**	(UDA15) **DD**	PMA104 **PMA**		PMA205 **PMA**	HVHS 15000 **PC**					
17.5kV										HVHS 17500 **PC**					
18kV	LMS180 **SG**			(US180A) **SF**	(688-18) **BE**										
20kV	LCS20 **SN** MXS200 **SG** VXS20 **SP**	HVHJ 20K **PA**		(US200A) **SF**	HVH 20000 **PB** HVHF 20000 **PB** (688-20) **BE**		PMA105 **PMA**		PMA206 **PMA**	HVHS 20000 **PC**					
22.5kV		HVHJ 22.5K **PA**													
25kV	LCS25 **SN** VXS25 **SP**	HVHJ 25K **PA**		(688-25) **BE**	HVH 25000 **PB** HVHF 25000 **PB**		PMA106 **PMA**		PMA207 **PMA**						
30kV	LCS30 **SN** VXS30 **SP**	HVHJ 30K **PA**					PMA107 **PMA**		PMA208 **PMA**						
35kV		HVHJ 35K **PA**					PMA108 **PMA**								
37.5kV		HVHJ 37.5K **PA**													
40kV	VXS40 **SP**	HVHJ 40K **PA**					PMA109 **PMA**								
45kV		HVHJ 45K **PA**													
50kV	VXS50 **SP**						PMA110 **PMA**								
60kV							PMA111 **PMA**								

Parentheses ( ) designates product using fused-in-glass single chip rectifiers; all others use stacked chips.

HIGH VOLTAGE RECTIFIERS & RECTIFIER MODULES


SA- SN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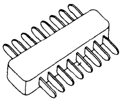
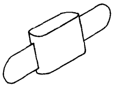
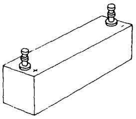

PMA


PME

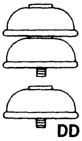
FAST RECOVERY

Peak Inverse Voltage	AVERAGE D.C. OUTPUT CURRENT									
	.025-.050A	.050-.100A	.100-.250A	.250-.50A	.50-.75A	.75-1.5A	1.5-2A	2-2.5A	2.5-4A	4-6A
1.0kV			HA10* **SK** HVX10* **SJ**			SX10* **SL**				
1.2kV						(USR12) **SA**				
1.5kV		LA15 **SH** LM15* **SG** MA15* **SH** MX15 **SG**	HA15* **SK** HVX15 **SJ**		(USR15) **SA**	SX15* **SL**			KX15* **SM**	
1.8kV					(USR18) **SA**					
2.0kV		LA20 **SH** LM20 **SG** MA20* **SH** MX20* **SG**	HA20* **SK** HVX20* **SJ**		(USR20) **SB**	SX20* **SL**			KX20* **SM**	
2.5kV		LA25 **SH** LM25 **SG** MA25* **SH** MX25* **SG**	HA25* **SK** HVX25* **SJ**	HVF 2500† **PB** (USR25) **SB**		SX25* **SL** (UFB2.5) **DH** PME101X* **PME**	PMA201X **PMA**	HVFS 2500† **PC** (UDD2.5) **DD**	KX25* **SM**	(UDF2.5) **DD** (UGF2.5) **DG**
3.0kV	LA30 **SH** LM30 **SG** MA30* **SH** MX30* **SG**		HA30* **SK** HVX30* **SJ**	(USR30) **SC**	SX30* **SL**			KX30* **SM**		
3.5kV				(USR35) **SC**						
4.0kV	LA40 **SH** LM40 **SG** MA40* **SH** MX40* **SG**	HA40* **SK** HVX40* **SJ**		(USR40A) **SD**	SX40* **SL** PME102X* **PME**			KX40* **SM**		
4.5kV			(USR45A) **SD**							
Reverse Recovery Time (Max.)	300nS 250nS*	300nS 250nS*	500nS 250nS*	500nS 250nS†	500nS 250nS*	500nS 250nS*	500nS 250nS	500nS 250nS* 150nS†	250nS*	500nS

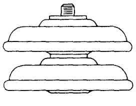
Parentheses ( ) designates product using fused-in-glass single chip rectifiers; all others use stacked chips.



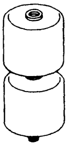
BE



DD



DG



DH

PRODUCT SELECTION GUIDE

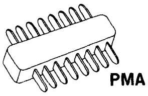
FAST RECOVERY

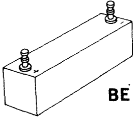
Peak Inverse Voltage	AVERAGE D.C. OUTPUT CURRENT										
	≤.025A	.025-.050A	.050-.100A	.100-.250A	.250-.50A	.50-.75A	.75-1A	1-1.5A	1.5-2A	2-2.5A	2.5-4A
5.0kV		LA50 **SH** LM50 **SG** MA50* **SH** MX50* **SG**	HA50 **SK** MVX50 **SJ**	(USR50A) **SD**	HVF 5000† **PB** (UFS5) **DH**	SX50* **SL** (UFB5) **DH**	PMA101X* **PMA**	(UDC5) **DD** (UDD5) **DD**	PMA202X* **PMA**	HVFS 5000† **PC** KX50* **SM**	(UDF5) **DD** (UGD5) **DG** (UGF5) **DG**
6.0kV	LA60 **SN** LM60 **SG** MA60* **SH** MX60* **SG**			(USR60A) **SD**	SX60* **SL**			KX60* **SM**			
7.0kV				(USR70A) **SE**							
7.5kV			HA75 **SK** HVX75 **SJ**		HVF 7500† **PB** (UFB7.5) **DH** (UFS7.5) **DH**		(UDC7.5) **DD** (UDD7.5) **DD** PMA102X* **PMA**		PMA203X* **PMA**	HVFS 7500† **PC** (UGD7.5) **DG** (UGF7.5) **DG**	
8.0kV	LA80 **SH** LM80 **SG** MA80* **SH** MX80* **SG**			(USR80A) **SE**	SX80* **SL** PME103X* **PME**			KX80* **SM**			
10kV	LA100 **SH** LM100 **SG** MA100* **SH** MX100* **SG**		HA100 **SK** HVX100 **SJ**	(USR100A) **SE**	HVF 10000† **PB** SX100* **SL** (UFS10) **DH**	(UDC10) **DD** (688-10R) **BE**	PMA103X* **PMA**	KX100* **SM**	(UGD10) **DG** PMA204X* **PMA**	HVFS 10000† **PC**	
12kV	LA120 **SH** LM120 **SG** MA120* **SH** MX120* **SG**			(USR120A) **SF**	(688-12R) **BE**						
12.5kV					HVF 12500† **PB**						HVFS 12500† **PC**
Reverse Recovery Time (Max.)	300nS 250nS*	300nS 250nS*	250nS	500nS	500nS 250nS* 150nS†	500nS 250nS*	500nS 250nS*	500nS 250nS*	500nS 250nS*	500nS 250nS* 150nS†	500nS

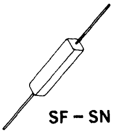
Parentheses ( ) designates product using fused-in-glass single chip rectifiers; all others use stacked chips.

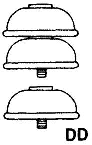
HIGH VOLTAGE RECTIFIERS & RECTIFIER MODULES

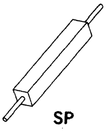
PRODUCT SELECTION GUIDE

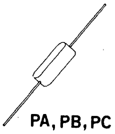












FAST RECOVERY

Peak Inverse Voltage	AVERAGE D.C. OUTPUT CURRENT						
	≤.025A	.025-.100A	.100-.250A	.250-.75A	.75-1.5A	1.5-2A	2-2.5A
15kV	LM150 **SG** MX150* **SG** VX15* **SP** LC15 **SN** CAX15 **CAX**	HVJX 15K **PA**	(USR150A) **SF**	HVF 15000† **PB** (UDC15) **DD** (688-15R) **BE**	PMA104X **PMA**	PMA205X **PMA**	HVFS 15000 **PC**
17.5kV							HVFS 17500 **PC**
18kV	LM180 **SG**		(USR180A) **SF**	(688-18R) **BE**			
20kV	MX200 **SG** VX20* **SP** LC20 **SN** CAX20 **CAX**	HVJX 20K **PA**	(688-20R) **BE**	HVF 20000† **PB**	PMA105X **PMA**	PMA206X **PMA**	HVFS 20000 **PC**
22.5kV		HVJX 22.5K **PA**					
25kV	VX25* **SP** LC25 **SN** CAX25 **CAX**	HVJX 25K **PA**	(688-25R) **BE**	HVF 25000† **PB**	PMA106X **PMA**	PMA207X **PMA**	
30kV	VX30* **SP** LC30 **SN** CAX30 **CAX**	HVJX 30K **PA**			PMA107X **PMA**	PMA208X **PMA**	
35kV		HVJX 35K **PA**			PMA108X **PMA**		
37.5kV		HVJX 37.5K **PA**					
40kV	VX40* **SP**	HVJX 40K **PA**			PMA109X **PMA**		
45kV		HVJX 45K **PA**					
50kV	VX50* **SP**				PMA110X **PMA**		
60kV					PMA111X **PMA**		
Reverse Recovery Time (Max.)	300nS 250nS*	250nS	500nS	500nS 150nS†	250nS	250nS	150nS

Parentheses ( ) designates product using fused-in-glass single chip rectifiers; all others use stacked chips.

RECTIFIER ASSEMBLIES
High Voltage Stacks, 1 Amp to 5 Amp, Military Approved

JAN 1N5597
JAN 1N5600
JAN 1N5603

FEATURES
- Qualified to MIL-S-19500/404A
- PIV: to 10kV
- Surge Ratings: to 200A
- Current Ratings: to 5A
- Only Fused-in-Glass Diodes Used
- Controlled Avalanche Characteristics
- Modular Package For Easy Stacking

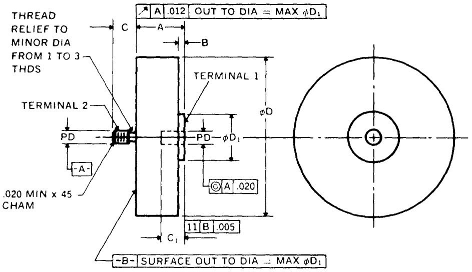
DESCRIPTION
This series of military high-voltage high-current stacks offers the utmost in reliability as required in military system designs. The rectifiers are assembled with diodes which have been subjected to TX type screening tests.

ABSOLUTE MAXIMUM RATINGS

	JAN 1N5597	JAN 1N5600	JAN 1N5603
Peak Inverse Voltage	10kV	5kV	5kV
Maximum Average D.C. Output Current @ $T_C = 75°C$	1A	2A	5A
Non-Repetitive Sinusoidal Surge (8.3ms) @ $T_C = 75°C$	30A	80A	200A
Operating and Storage Temperature Range		−65°C to +150°C	

VII

MECHANICAL SPECIFICATIONS



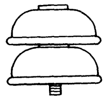
JAN 1N5597 JAN 1N5600

Ltr	Dimensions in inches with metric equivalents (mm) in parentheses		NOTES
	Minimum	Maximum	
A	.73 (18.54)	.83 (21.08)	8
B		.080 (2.03)	
C	.240 (6.10)	.264 (6.71)	2,6
C_1	.265 (6.73)	.400 (10.16)	4
ϕD	1.85 (46.99)	1.95 (49.53)	
$ϕD_1$	.57 (14.48)	.67 (17.02)	

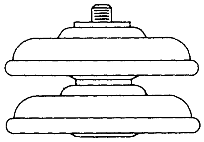
JAN 1N5603

Ltr	Dimensions in inches with metric equivalents (mm) in parentheses		NOTES
	Minimum	Maximum	
A	.970 (24.64)	1.020 (25.91)	8
B	.050 (1.27)	.080 (2.03)	
C	.307 (7.80)	.317 (8.05)	3
C_1	.318 (8.08)	.400 (10.16)	5,7
ϕD	3.450 (87.63)	3.650 (92.71)	
$ϕD_1$	.95 (24.13)	1.250 (31.75)	

JAN 1N5597, JAN 1N5600



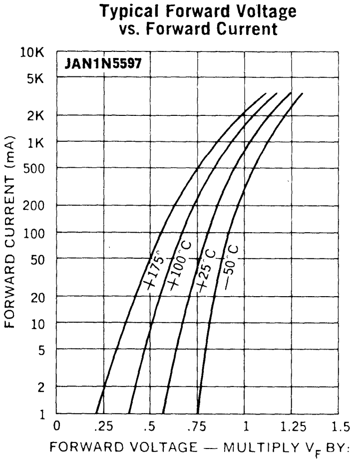
JAN 1N5603

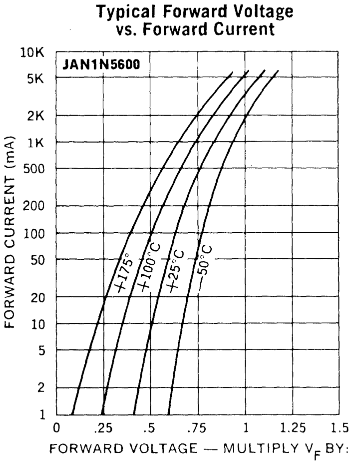


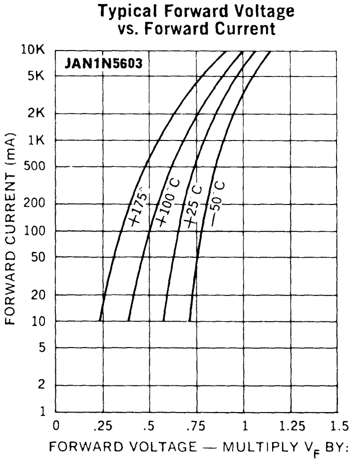
1. All marking shall be on cathode side of module.
2. Threaded stud ¼-28UNF-2A.
3. Threaded stud ⅜-24UNF-2A.
4. Threaded insert ¼-28UNF-2B.
5. Threaded insert ⅜-24UNF-2B.
6. Cathode connected to terminal 2.
7. Cathode connected to terminal 1.
8. Module contour within dimension A is not specified.

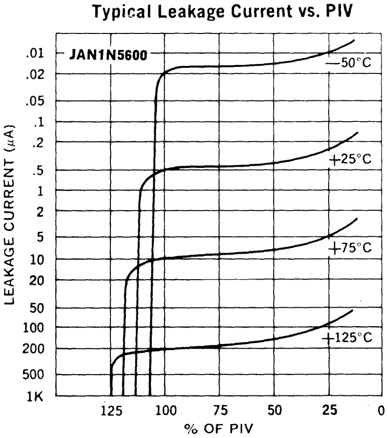
Electrical Specifications (at 25°C unless noted)

Type	PIV	Forward Voltage Drop		Maximum Leakage Current @ PIV		Capacitance @ V_R = 100V		Maximum Reverse Transient Energy Absorption
		Min.	Max.	T_A = 25°C	T_A = 100°C	Min.	Max.	
	kV			µA	µA	pf	pf	joules
JAN 1N5597	10	13V @ 1A	19V @ 1A	1	75	5	30	2
JAN 1N5600	5	6V @ 2A	10V @ 2A	5	100	7	30	6
JAN 1N5603	5	6V @ 5A	10V @ 5A	5	100	15	40	12

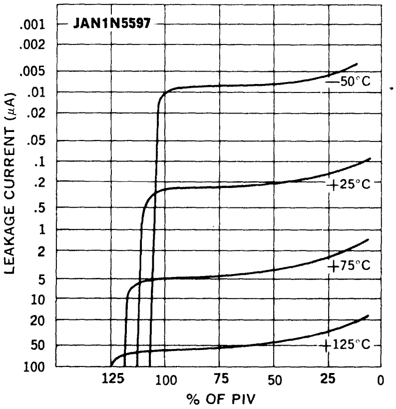




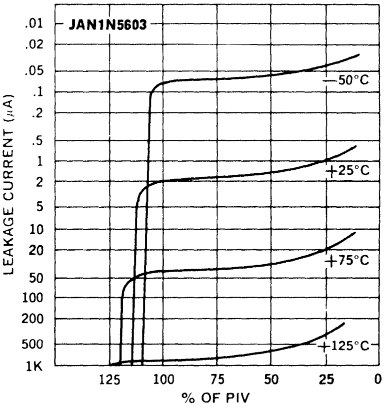




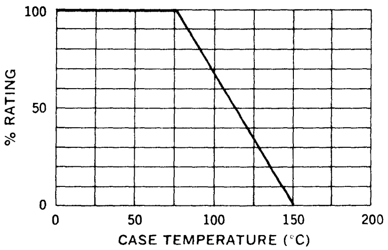
Typical Leakage Current vs. PIV

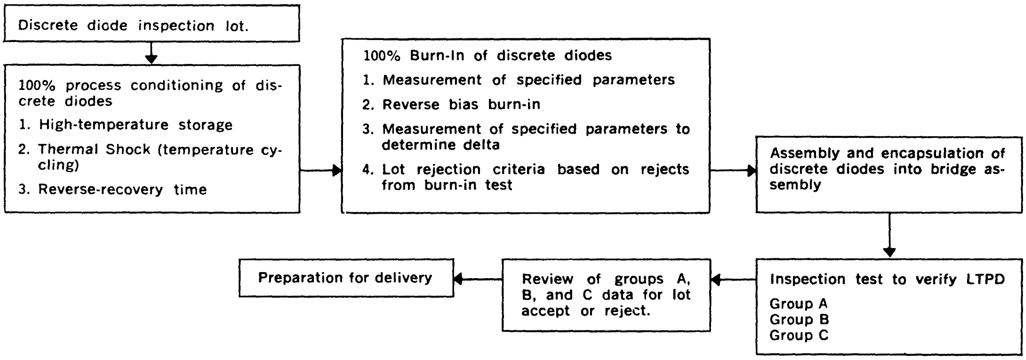


Typical Leakage Current vs. PIV



Current Derating Curve





Discrete diode inspection lot.

100% process conditioning of discrete diodes

1. High-temperature storage
2. Thermal Shock (temperature cycling)
3. Reverse-recovery time

100% Burn-In of discrete diodes

1. Measurement of specified parameters
2. Reverse bias burn-in
3. Measurement of specified parameters to determine delta
4. Lot rejection criteria based on rejects from burn-in test

Assembly and encapsulation of discrete diodes into bridge assembly

Inspection test to verify LTPD

Group A
Group B
Group C

Review of groups A, B, and C data for lot accept or reject.

Preparation for delivery

RECTIFIER ASSEMBLIES

High Voltage Stacks,
Standard and Fast Recovery

FEATURES

- PIV: from 10kV to 25kV
- Surge Rating: to 20A
- Recovery Time Available: to 500ns
- Current Ratings: to 0.6A
- Bonded Plate for Maximum Heat Transfer
- Controlled Avalanche Characteristics
- Only Fused-in-Glass Diodes Used

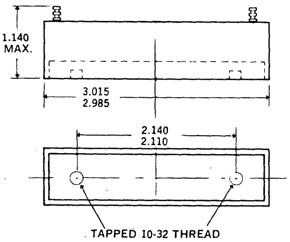
DESCRIPTION

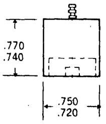
This series of high power stacks has a unique packaging design that provides characteristics not obtainable in conventional molded epoxy packages. This series, therefore, is ideally suited for high-voltage, high-power applications.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	10kV to 25kV
Maximum Average D.C. Output Current	See Electrical Specifications
Non-repetitive Sinusoidal Surge (8.3ms)	20A
Operating and Storage Temperature Range	−65°C to +150°C
Thermal Resistance Junction to Ambient	25°C/W
Junction to Case	10°C/W

688 SERIES

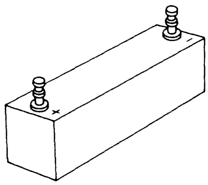




Add suffix R to denote Fast Recovery version. For example, for recovery time, $t_{rr} = 500$ns; order 688-10R.

Typical Weight — 2.5 ounces
70 grams

Dimensions in inches.



MARKING

Cathode — Positive Output	+
Anode — Negative	−

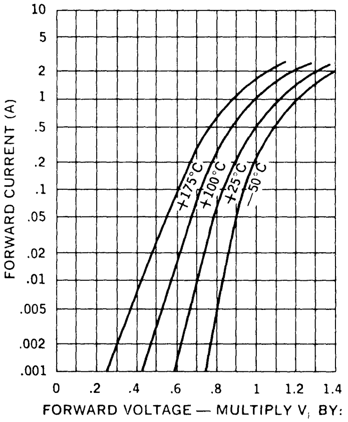
Part number is printed on the body.

UNITRODE

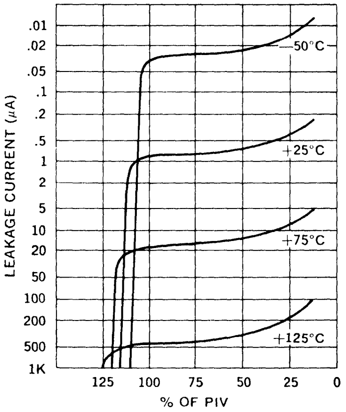
Electrical Specifications (at 25°C unless noted)						Maximum Ratings
Type		PIV	Maximum Forward Voltage Drop	Maximum Leakage Current @ PIV		Maximum Average D.C. Output Current
				$T_A = 25°C$	$T_A = 100°C$	$T_C = 100°C$
		kV		μA	μA	Amps
Standard	688-10	10	17V @ 0.4A			0.60
And Fast	688-12	12	20V @ 0.4A			0.50
Recovery*	688-15	15	25V @ 0.4A	2	100	0.40
	688-18	18	30V @ 0.4A			0.35
	688-20	20	34V @ 0.4A			0.30
	688-25	25	42V @ 0.4A			0.20

*Add suffix R to denote Fast Recovery version.

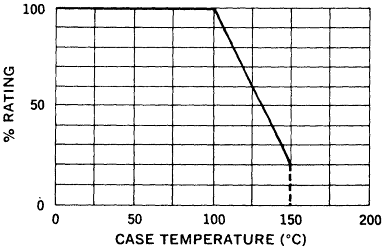
Typical Forward Voltage Per Leg vs. Forward Current



Typical Leakage Current vs. PIV



Current Derating Curve



HIGH VOLTAGE RECTIFIER ASSEMBLY

CAX15-30

10mA

WITN J1-21 Anode Cap

FEATURES

- PIV: From 15kV to 30kV
- 300nS Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- UL Rated Materials
- Corona Free
- Low Cost

DESCRIPTION

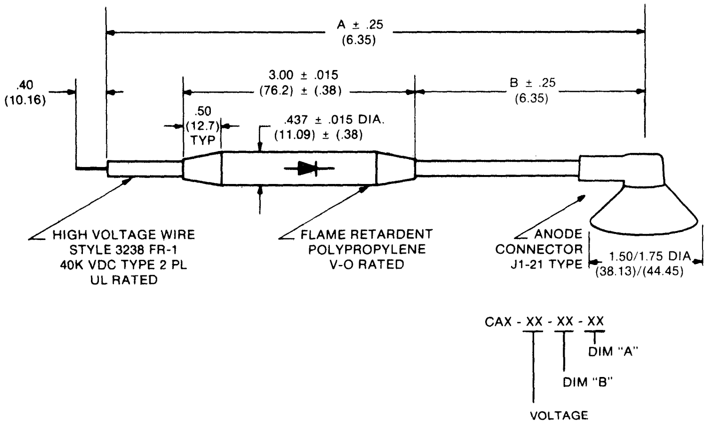
The CAX anode assembly combines a fast recovery high voltage silicon rectifier molded void free into a UL approved wire and terminated with a J1-21 anode cap. The high reliability & economy designed into the assembly makes it ideally suited for both commercial and industrial video monitors.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	15kV to 30kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-55° C to +90° C

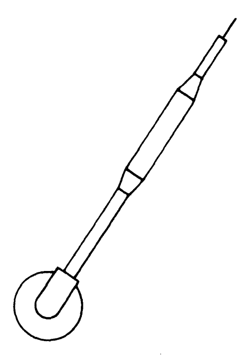
MECHANICAL SPECIFICATIONS

CAX15-30



Dimensions in inches and (millimeters)

CAX



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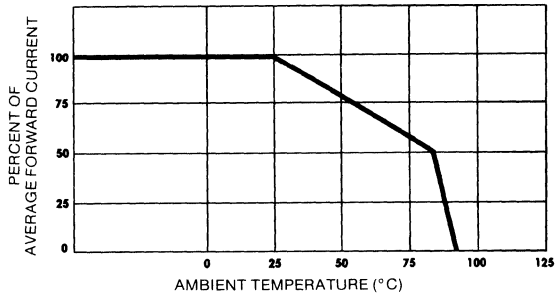
HIGH VOLTAGE DEVICES

Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS	
	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time	Maximum Junction Capacitance @ 100V	Maximum Average Rectified Current†	Maximum One Cycle Surge 8.3mS
	PIV	I_R		V_F	T_{RR}	C_J	I_O	I_F(surge)
	V	25°C	85°C	V	nS	pF	mA	A
		μA	μA					
CAX15	15000	.25	10	40	300	1.0	10	2
CAX20	20000	.25	10	40	300	1.0	10	2
CAX25	25000	.25	10	40	300	1.0	10	2
CAX30	30000	.25	10	40	300	1.0	10	2

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

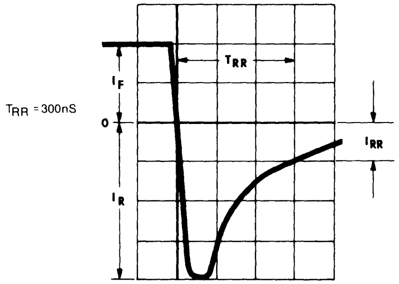
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE

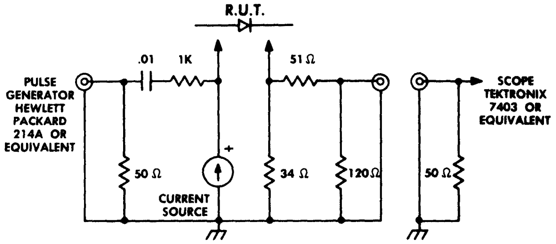


REVERSE RECOVERY TEST CONDITIONS: I_F = 5 mA, I_R = 10 mA, I_{RR} = 2.5 mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

100-250mA
Fast Recovery, Miniature

HA10-100
HVX10-100

FEATURES
- PIV: From 1.0kV to 10kV
- 250nS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

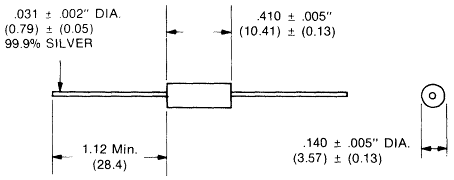
DESCRIPTION
The HVX/HA silicon rectifier series combine a medium rectified current capability and high reliability in a miniature package for commercial, industrial and military applications. The use of cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life. The fast reverse recovery characteristics enhance applications in high frequency power conversion and control circuits.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	1.0kV to 10kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Maximum Recurrent Peak Current Surge	See Electrical Specifications
Operating and Storage Temperature Ranges	-65° C to +150° C

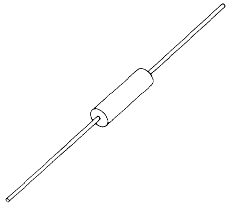
MECHANICAL SPECIFICATIONS

HVX10-100

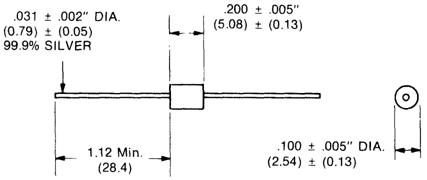


Dimensions in inches and (millimeters)

SJ

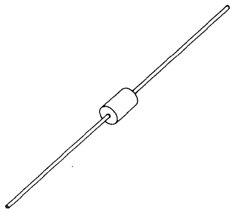


HA10-100



Dimensions in inches and (millimeters)

SK



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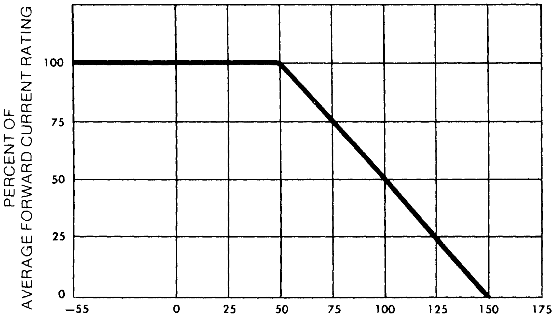
Type	Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)					MAXIMUM RATINGS				
		Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ 100mA	Maximum Reverse Recovery Time	Maximum Average Rectified Current†			Maximum Recurrent Peak Current	Maximum One Cycle Surge 8.3mS Surge
		PIV	I_R		V_F	T_{RR}	I_O			I_F	I_F(surge)
			25°C	100°C			50°C	100°C	125°C		
		V	μA	μA	V	nS	mA	mA	mA	A	A
HVX10	HA10	1000	1	20	5	250	250	125	62.5	14	2.5
HVX15	HA15	1500	1	20	5	250	250	125	62.5	14	2.5
HVX20	HA20	2000	1	20	5	250	250	125	62.5	14	2.5
HVX25	HA25	2500	1	20	5	250	250	125	62.5	14	2.5
HVX30	HA30	3000	1	20	5	250	250	125	62.5	14	2.5
HVX40	HA40	4000	1	20	12	250	100	50	25	4	1.0
HVX50	HA50	5000	1	20	12	250	100	50	25	4	1.0
HVX75	HA75	7500	1	20	12	250	100	50	25	4	1.0
HVX100	HA100	10000	1	20	12	250	100	50	25	4	1.0

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

NOTE: Maximum lead temperature for soldering is 250°C, 3/8" (9.5mm) from case for 5 seconds maximum.

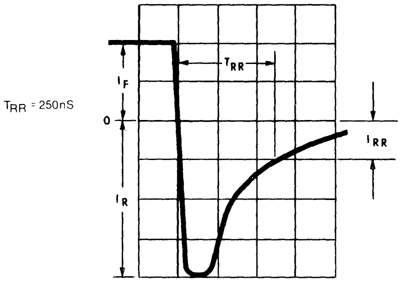
MAXIMUM FORWARD CURRENT VS. AMBIENT TEMPERATURE



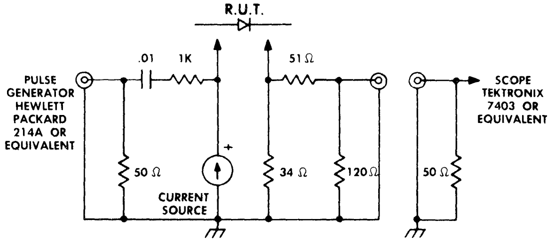
AMBIENT TEMPERATURE (°C)

REVERSE RECOVERY TEST CONDITIONS: $I_F = 50$ mA, $I_R = 100$ mA, $I_{RR} = 25$ mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

100-250mA
Standard Recovery, Minature

HS10-100
HVE10-30 (1N3643-47)
HVE40-100 (1N5181-84)

FEATURES

- PIV: From 1.0kV to 10kV
- JEDEC Types
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

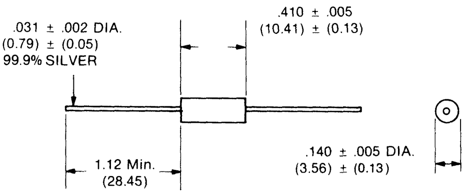
The HVE/HS silicon rectifier series combine a medium average rectified current capability and high reliability in a miniature package for commercial, industrial and military applications. The use of cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life. A 2 microsecond reverse recovery characteristic improves the circuit efficiency of power conversion and control systems.

ABSOLUTE MAXIMUM RATINGS

	HS	HVE
Peak Inverse Voltage	1.0kV	10kV
Maximum Average Rectified Current	See Electrical Specifications	
Maximum One Cycle Surge 8.3mS	See Electrical Specifications	
Maximum Recurrent Peak Current Surge	See Electrical Specifications	
Operating and Storage Temperature Ranges:	-65° C to +175° C	

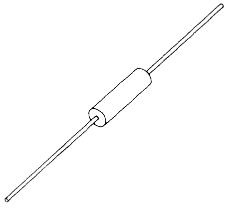
MECHANICAL SPECIFICATIONS

HVE10-30 (1N3643-47)
HVE40-100 (1N5181-84)

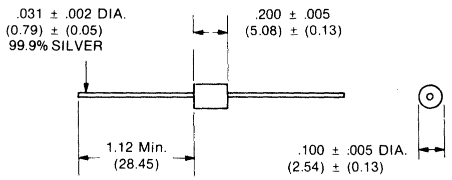


Dimensions in inches and (millimeters)

SJ

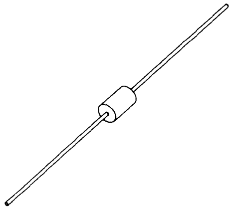


HS10-100



Dimensions in inches and (millimeters)

SK



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ELECTRICAL SPECIFICATIONS (at 25° C unless noted)						MAXIMUM RATINGS				
Maximum Reverse Recovery Time		Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ 100mA Max.	Maximum Average Rectified Current†			Maximum Recurrent Peak Current Surge	Maximum One Cycle Surge 8.3mS
		PIV	I_R		V_F	I_O			I_F	I_F(surge)
2µS	2µS		25° C	100° C	25° C	50° C	100° C	150° C		
Type	Type	V	µA	µA	V	mA	mA	mA	A	A
HS10	HVE10 (1N3643)	1000	1	20	3.5	250	150	50	2.5	14
HS15	HVE15 (1N3644)	1500	1	20	3.5	250	150	50	2.5	14
HS20	HVE20 (1N3645)	2000	1	20	3.5	250	150	50	2.5	14
HS25	HVE25 (1N3646)	2500	1	20	3.5	250	150	50	2.5	14
HS30	HVE30 (1N3647)	3000	1	20	3.5	250	150	50	2.5	14
HS40	HVE40 (1N5181)	4000	1	20	10.0	100	60	20	1.0	4
HS50	HVE50 (1N5182)	5000	1	20	10.0	100	60	20	1.0	4
HS75	HVE75 (1N5183)	7500	1	20	10.0	100	60	20	1.0	4
HS100	HVE100 (1N5184)	10000	1	20	10.0	100	60	20	1.0	4

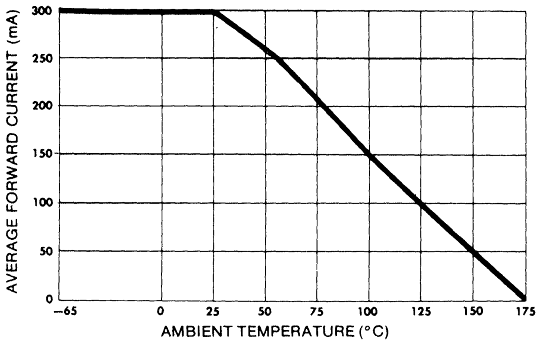
*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

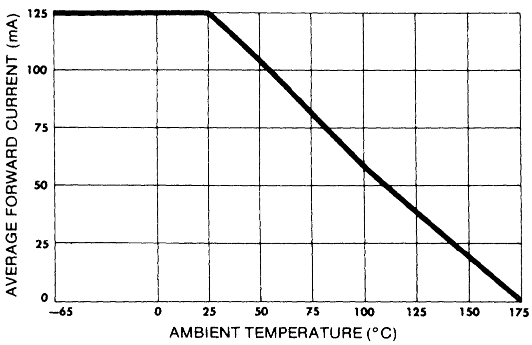
NOTE: Maximum lead temperature for soldering is 250° C 3/8" (9.5mm) from case for 5 seconds maximum.

VII

HVE/HVE10-30/1N3643-47

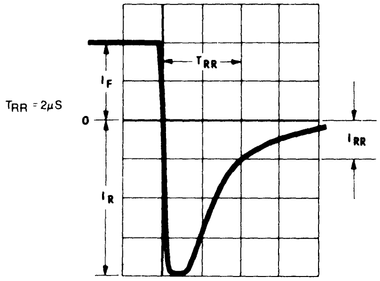


HVE/HVE40-100 /1N5181-84)

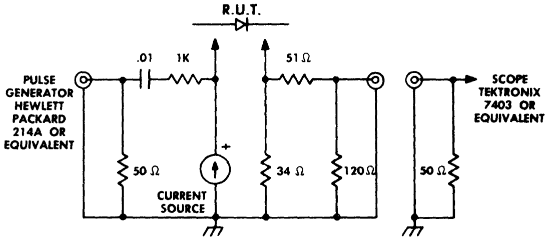


REVERSE RECOVERY TEST CONDITIONS: I_F = 50 mA, I_R = 100 mA, I_{RR} = 25 mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

HVF2500-25000

MULTISTAC
Fast Recovery, High Current

FEATURES

- PIV: From 2.5kV to 25kV
- 150nS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

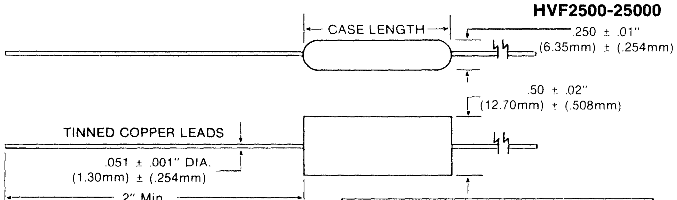
The HVF MULTISTAC high current, high voltage silicon rectifier's convenient size and high power capability meets the reliability requirements of commercial, industrial and military applications. Reliability with economy are obtained through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5kV to 25kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-55° C to +150° C

MECHANICAL SPECIFICATIONS

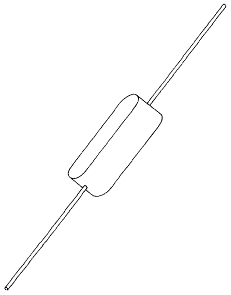
HVF2500-25000



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
HVF2500	1.125 ± .02	28.58 ± .508
HVF5000	2.000 ± .02	50.80 ± .508
HVF7500	2.750 ± .02	69.85 ± .508
HVF10000	3.500 ± .02	88.90 ± .508
HVF12500	4.250 ± .02	107.95 ± .508
HVF15000	4.250 ± .02	107.95 ± .508
HVF20000	4.250 ± .02	107.95 ± .508
HVF25000	4.250 ± .02	107.95 ± .508

Dimensions in inches and (millimeters)

PB



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HIGH VOLTAGE DEVICES

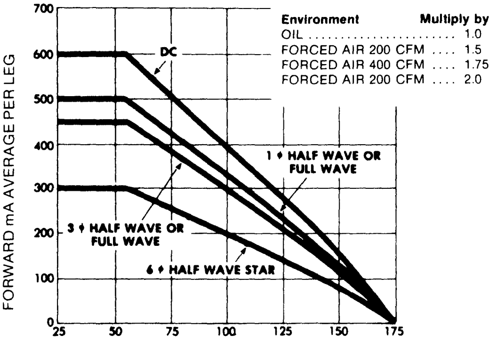
Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)					MAXIMUM RATINGS				Case Length	
	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O Max.	Maximum Reverse Recovery Time	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS			
	PIV	I_R		V_F	T_{RR}	I_O		I_F(surge)			
	V	25°C	100°C	V	nS	55°C	100°C	25°C	100°C		
		μA	μA			A	A	A	A	Ins.	MM
HVF 2500	2500	0.1	15	5.5	150	.5	.33	40	20	1.125	28.58
HVF 5000	5000	0.1	15	11.0	150	.5	.33	40	20	2.000	50.80
HVF 7500	7500	0.1	15	16.5	150	.5	.33	40	20	2.750	69.85
HVF 10000	10000	0.1	15	22.0	150	.5	.33	40	20	3.500	88.90
HVF 12500	12500	0.1	15	27.5	150	.5	.33	40	20	4.250	107.95
HVF 15000	15000	0.1	15	33.0	150	.5	.33	40	20	4.250	107.95
HVF 20000	20000	0.1	15	38.5	150	.5	.33	40	20	4.250	107.95
HVF 25000	25000	0.1	15	44.0	150	.5	.33	40	20	4.250	107.95

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

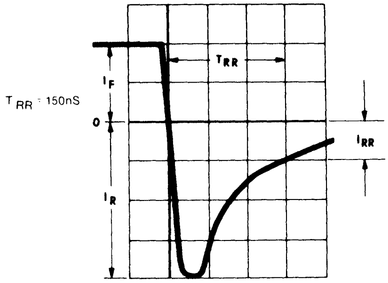
MAXIMUM FORWARD CURRENT VS. AMBIENT TEMPERATURE



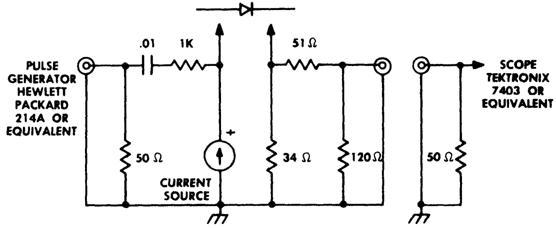
FORWARD CURRENT PER LEG VS. AMBIENT TEMPERATURE (°C)

REVERSE RECOVERY TEST CONDITIONS: $I_F = 0.1A$, $I_R = 0.2A$, $I_{RR} = 0.05A$

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



Reverse recovery is measured on each rectifier stack prior to manufacture of the assembly.

HIGH VOLTAGE SILICON RECTIFIERS

HVFS2500-20000

MULTISTAC
Fast Recovery, High Current

FEATURES

- PIV: From 2.5 kV to 20 kV
- 150 nS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

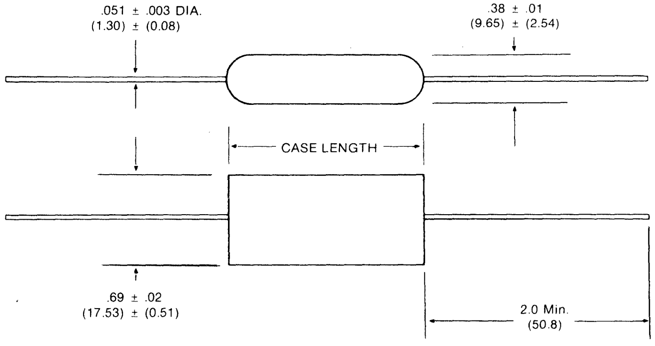
The HVFS MULTISTAC high current, high voltage silicon rectifier's convenient size and high power capability meets the reliability requirements of commercial, industrial and military applications. Reliability with economy are obtained through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5kV to 20kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3 mS	See Electrical Specifications
Operating and Storage Temperature Ranges	-55° C to 150° C

MECHANICAL SPECIFICATIONS

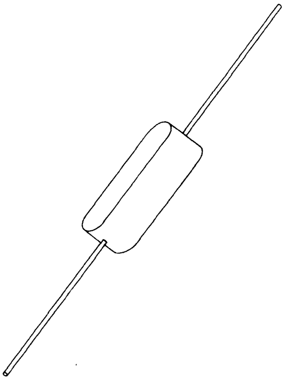
HVFS2500-20000



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
HVFS2500	1.5 ± .03	38.1 ± 0.76
HVFS5000	2.5 ± .03	63.5 ± 0.76
HVFS7500	3.5 ± .03	88.9 ± 0.76
HVFS10000	4.5 ± .03	114.3 ± 0.76
HVFS12500	5.5 ± .03	139.7 ± 0.76
HVFS15000	6.5 ± .03	165.1 ± 0.76
HVFS17500	6.5 ± .03	165.1 ± 0.76
HVFS20000	6.5 ± .03	165.1 ± 0.76

Dimensions in inches and (millimeters)

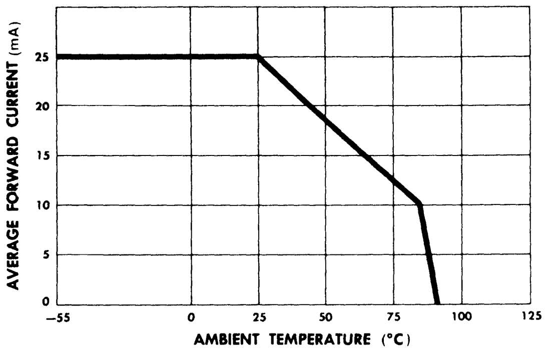
PC



	ELECTRICAL SPECIFICATIONS (at 25° C unless noted)					MAXIMUM RATINGS					
Type	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS		Case Length	
	PIV	I_R		V_F	T_{RR}	I_O		I_F(surge)			
	V	25° C	100° C	V	nS	55° C	100° C	25° C	100° C		
		μA	μA			A	A	A	A	Ins.	MM
HVFS2500	2500	10	120	8	150	2.2	1.3	200	100	1.5	38.1
HVFS5000	5000	10	120	16	150	2.2	1.3	200	100	2.5	63.5
HVFS7500	7500	10	120	21	150	2.2	1.3	200	100	3.5	88.9
HVFS10000	10000	10	120	29	150	2.2	1.3	200	100	4.5	114.9
HVFS12500	12500	10	120	36	150	2.2	1.3	200	100	5.5	139.7
HVFS15000	15000	10	120	44	150	2.2	1.3	200	100	6.5	165.1
HVFS17500	17500	10	120	51	150	2.2	1.3	200	100	6.5	165.1
HVFS20000	20000	10	120	58	150	2.2	1.3	200	100	6.5	165.1

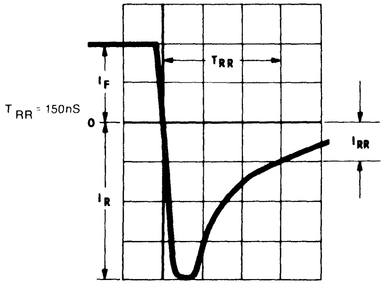
*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.
NOTE: Maximum lead temperature for soldering is 250° C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE

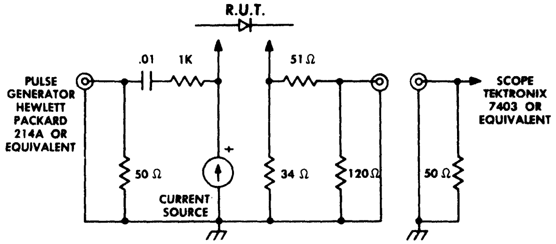


REVERSE RECOVERY TEST CONDITIONS: $I_F = 12.5A$, $I_R = 25A$, $I_{RR} = 6.25A$

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

MULTISTAC
Standard Recovery

HVH5000-25000

FEATURES

- PIV: From 5kV to 25kV
- 2μS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

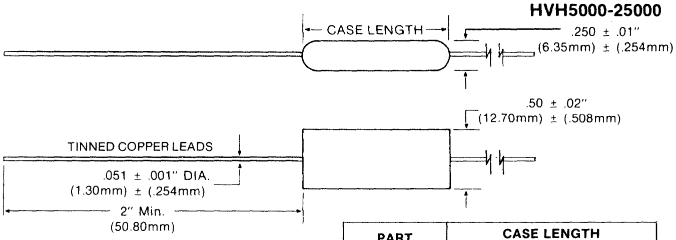
The HVH MULTISTAC silicon rectifier assemblies meet the stringent reliability requirements of commercial, industrial and military users through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life. The 2 microsecond reverse recovery time improves the circuit efficiency of power conversion and control systems.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	5kV to 25kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-55° C to +150° C

MECHANICAL SPECIFICATIONS

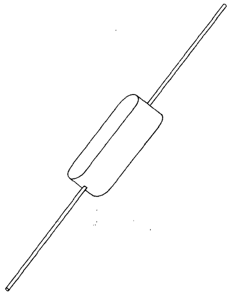
HVH5000-25000



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
HVH5000	1.125 ± .02	28.58 ± .508
HVH7500	1.625 ± .02	41.28 ± .508
HVH10000	2.000 ± .02	50.80 ± .508
HVH12500	2.375 ± .02	60.33 ± .508
HVH15000	2.750 ± .02	69.85 ± .508
HVH20000	3.500 ± .02	88.90 ± .508
HVH25000	4.250 ± .02	107.95 ± .508

Dimensions in inches and (millimeters)

PB

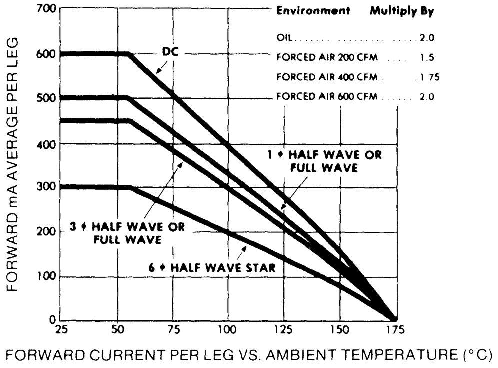


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)					MAXIMUM RATINGS					
Maximum Reverse Recovery Time	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Average Rectified Current†		Maximum One Cycle Surge		Case Length	
2µS	PIV	I_R		V_F	I_O		I_F(surge)			
Type	V	25°C	100°C	25°C	55°C	100°C	25°C	100°C		
		µA	µA	V	A	A	A	A	Ins.	MM
HVH 5000	5000	0.1	15	7	.5	.33	60	30	1.125	28.58
HVH 7500	7500	0.1	15	10	.5	.33	60	30	1.625	41.28
HVH10000	10000	0.1	15	14	.5	.33	60	30	2.000	50.80
HVH12500	12500	0.1	15	17	.5	.33	60	30	2.375	60.33
HVH15000	15000	0.1	15	20	.5	.33	60	30	2.750	69.85
HVH20000	20000	0.1	15	27	.5	.33	60	30	3.500	88.90
HVH25000	25000	0.1	15	33	.5	.33	60	30	4.250	107.95

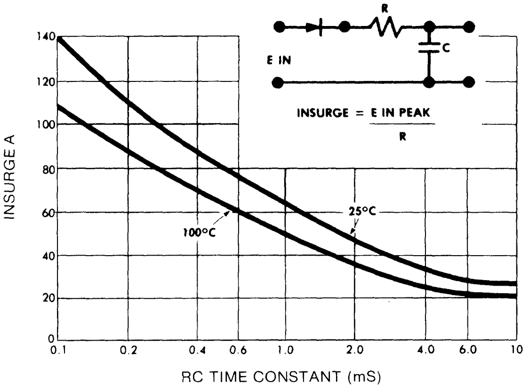
*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

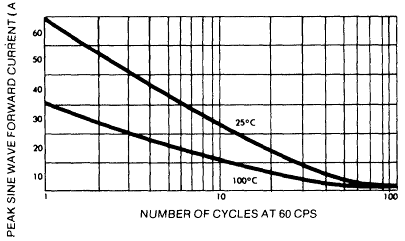
MAXIMUM FORWARD CURRENT VS. AMBIENT TEMPERATURE



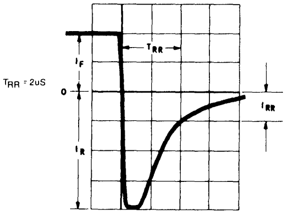
MAXIMUM RATINGS FOR CAPACITY LOADS



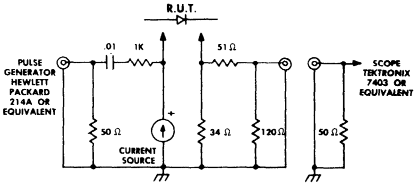
NON-RECURRENT FORWARD CURRENT SURGE CURVE



REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



Reverse recovery is measured on each rectifier stack prior to manufacture of the assembly.

HIGH VOLTAGE SILICON RECTIFIERS

HVHF5000-25000

MULTISTAC
Standard Recovery, High Current

FEATURES
- PIV: From 5kV to 25kV
- 1μS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

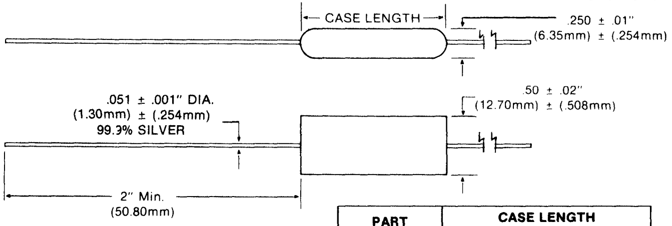
DESCRIPTION
The HVHF MULTISTAC high current, high voltage silicon rectifer's convenient size and high power capability meets the reliability requirements of commercial, industrial and military applications. Reliability with economy are obtained through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage .... 5kV to 25kV
Maximum Average Rectified Current .... See Electrical Specifications
Maximum One Cycle Surge 8.3mS .... See Electrical Specifications
Operating and Storage Temperature Range ....-55° C to +150° C

MECHANICAL SPECIFICATIONS

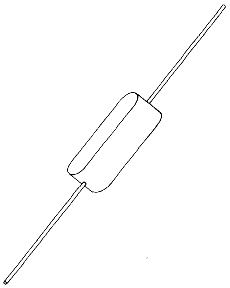
HVHF5000-25000



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
HVHF5000	1.125 ± .02	28.58 ± .508
HVHF7500	1.625 ± .02	41.28 ± .508
HVHF10000	2.000 ± .02	50.80 ± .508
HVHF12500	2.375 ± .02	60.33 ± .508
HVHF15000	2.750 ± .02	69.85 ± .508
HVHF20000	3.500 ± .02	88.90 ± .508
HVHF25000	4.250 ± .02	107.95 ± .508

Dimensions in inches and (millimeters)

PB

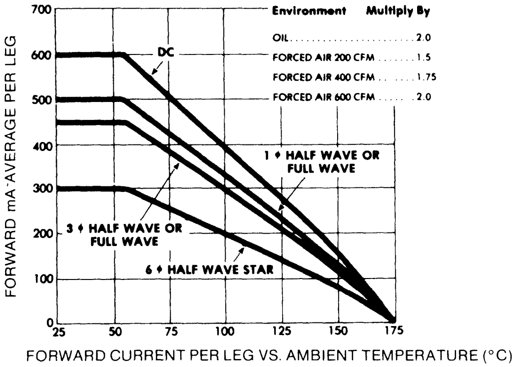


Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)					MAXIMUM RATINGS				Case Length	
	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS			
	PIV	I_R		V_F	T_{RR}	I_O		I_F(surge)			
	V	25°C	100°C	V	μS	55°C	100°C	25°C	100°C		
		μA	μA			A	A	A	A	Ins.	MM
HVHF5000	5000	0.1	15	7	1	.5	.33	60	30	1.125	28.58
HVHF7500	7500	0.1	15	10	1	.5	.33	60	30	1.625	41.28
HVHF10000	10000	0.1	15	14	1	.5	.33	60	40	2.000	50.80
HVHF12500	12500	0.1	15	17	1	.5	.33	60	40	2.375	60.33
HVHF15000	15000	0.1	15	20	1	.5	.33	60	40	2.750	69.85
HVHF20000	20000	0.1	15	27	1	.5	.33	60	40	3.500	88.90
HVHF25000	25000	0.1	15	33	1	.5	.33	60	40	4.250	107.95

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

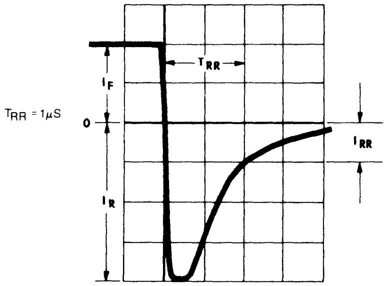
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS. AMBIENT TEMPERATURE

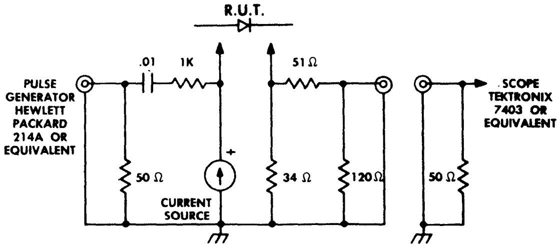


REVERSE RECOVERY TEST CONDITIONS: I_F=100mA, I_R=200mA, I_{RR}=50mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



Reverse recovery is measured on each rectifier stack prior to manufacture of the assembly.

HIGH VOLTAGE SILICON RECTIFIERS

HVHJ15K-45K

MULTISTAC

Medium Recovery, Medium Current

FEATURES

- PIV: From 15kV to 45kV
- 2μS Reverse Recovery
- High Surge
- Low Reverse Leakage
- Corona Free

DESCRIPTION

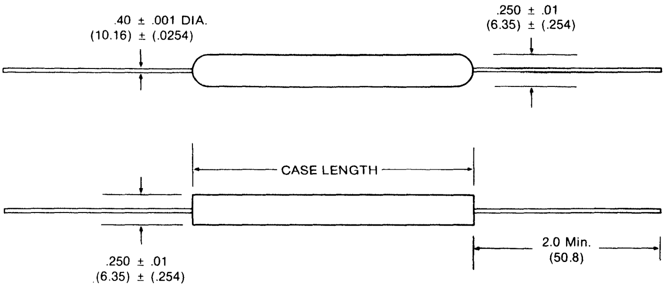
The HVHJ MULTISTAC medium current, high voltage silicon rectifer assembly's small size and high power capability meets the stringent reliability requirements of commercial, industrial and military applications. Reliability with economy are obtained through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	15kV to 45kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-55°C to +150°C

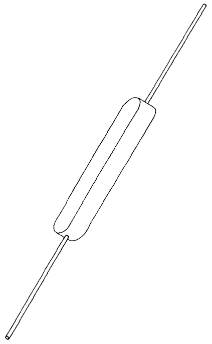
MECHANICAL SPECIFICATIONS

HVHJ15K-45K



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
HVHJ15K	1.5 ± .02	38.1 ± .508
HVHJ20K	2.0 ± .02	50.8 ± .508
HVHJ22.5K	2.0 ± .02	50.8 ± .508
HVHJ25K	2.5 ± .02	63.5 ± .508
HVHJ30K	2.5 ± .02	63.5 ± .508
HVHJ35K	3.0 ± .02	76.2 ± .508
HVHJ37.5K	3.0 ± .02	76.2 ± .508
HVHJ40K	3.5 ± .02	88.9 ± .508
HVHJ45K	3.5 ± .02	88.9 ± .508

PA



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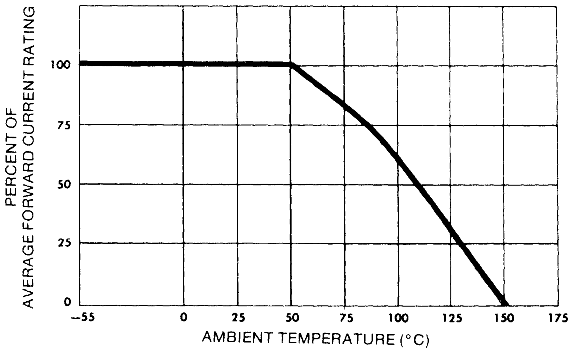
HIGH VOLTAGE DEVICES

Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)					MAXIMUM RATINGS				Case Length	
	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS			
	PIV	I_R		V_F	T_{RR}	I_O		I_F(surge)			
		25°C	100°C			55°C	100°C	25°C	100°C		
	V	μA	μA	V	μS	mA	mA	A	A	Ins.	MM
HVHJ15K	15000	0.1	25	20	2	50	30	5	2.5	1.5	38.1
HVJK20K	20000	0.1	25	30	2	50	30	5	2.5	2.0	50.8
HVHJ22.5K	22500	0.1	25	30	2	50	30	5	2.5	2.0	50.8
HVHJ25K	25000	0.1	25	40	2	50	30	5	2.5	2.5	63.5
HVHJ30K	30000	0.1	25	40	2	50	30	5	2.5	2.5	63.5
HVHJ35K	35000	0.1	25	50	2	50	30	5	2.5	3.0	76.2
HVHJ37.5K	37500	0.1	25	50	2	50	30	5	2.5	3.0	76.2
HVHJ40K	40000	0.1	25	60	2	50	30	5	2.5	3.5	88.9
HVHJ45K	45000	0.1	25	60	2	50	30	5	2.5	3.5	88.9

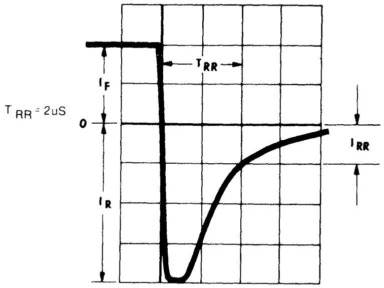
*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS. AMBIENT TEMPERATURE

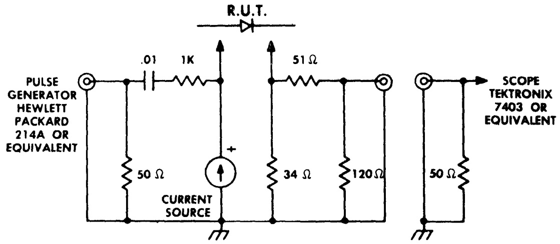


REVERSE RECOVERY TEST CONDITIONS: I_F = 50mA, I_R = 100mA, I_{RR} = 25mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

MULTISTAC

Medium Recovery, High Current

HVHS2500-20000

FEATURES

- PIV: From 2.5kV to 20kV
- 2uS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

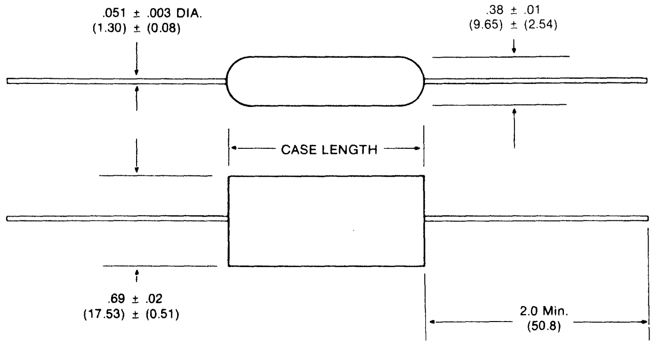
The HVHS MULTISTAC high current, high voltage silicon rectifier's convenient size and high power capability meets the reliability requirements of commercial, industrial and military applications. Reliability with economy are obtained through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5kV to 20kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-55° C to +150° C

MECHANICAL SPECIFICATIONS

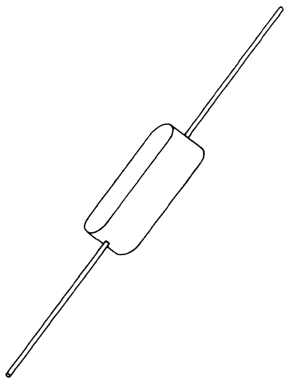
HVHS2500-20000



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
HVHS2500	1.5 ± .03	38.1 ± 0.76
HVHS5000	2.5 ± .03	63.5 ± 0.76
HVHS7500	3.5 ± .03	88.9 ± 0.76
HVHS10000	4.5 ± .03	114.3 ± 0.76
HVHS12500	5.5 ± .03	139.7 ± 0.76
HVHS15000	6.5 ± .03	165.1 ± 0.76
HVHS17500	6.5 ± .03	165.1 ± 0.76
HVHS20000	6.5 ± .03	165.1 ± 0.76

Dimensions in inches and (millimeters)

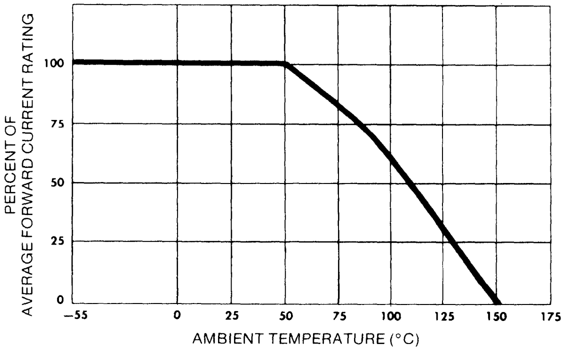
PC



	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)					MAXIMUM RATINGS					
Type	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS		Case Length	
	PIV	I_R		V_F	T_{RR}	I_O		$I_{F(surge)}$			
	V	25°C	100°C	V	µS	55°C	100°C	25°C	100°C		
		µA	µA			A	A	A	A	Ins.	MM
HVHS2500	2500	10	120	5	2	2.2	1.3	200	100	1.5	38.1
HVHS5000	5000	10	120	10	2	2.2	1.3	200	100	2.5	63.5
HVHS7500	7500	10	120	15	2	2.2	1.3	200	100	3.5	88.9
HVHS10000	10000	10	120	20	2	2.2	1.3	200	100	4.5	114.9
HVHS12500	12500	10	120	25	2	2.2	1.3	200	100	5.5	139.7
HVHS15000	15000	10	120	30	2	2.2	1.3	200	100	6.5	165.1
HVHS17500	17500	10	120	35	2	2.2	1.3	200	100	6.5	165.1
HVHS20000	20000	10	120	40	2	2.2	1.3	200	100	6.5	165.1

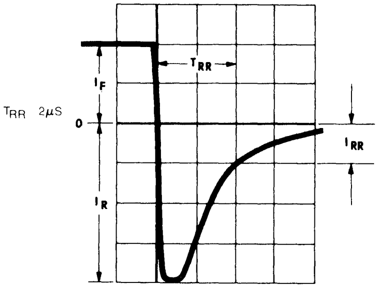
*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE

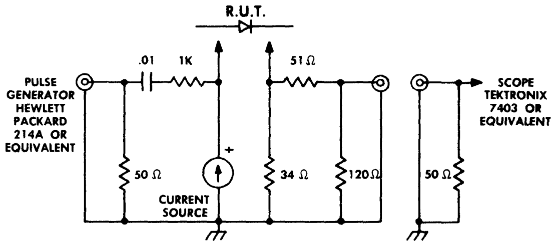


REVERSE RECOVERY TEST CONDITIONS: I_F =0.4mA, I_R =0.8mA, I_{RR} =0.2mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



Reverse recovery is measured on each rectifier stack prior to manufacture of the assembly.

HIGH VOLTAGE SILICON RECTIFIERS

MULTISTAC

Fast Recovery, Medium Current

HVJX15K-45K

FEATURES

- PIV: From 15kV to 45kV
- 200nS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

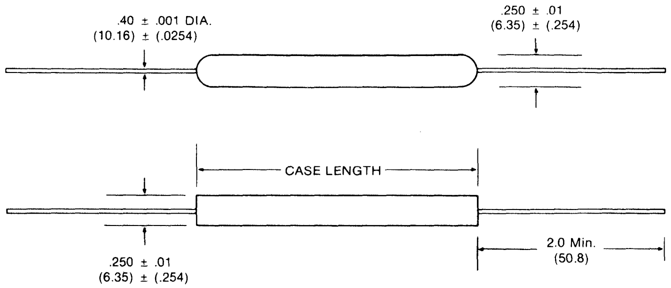
The HVJX MULTISTAC medium current high voltage silicon rectifier assembly's small size and high power capability meets the stringent reliability requirements of commercial, industrial and military applications. Reliability with economy are obtained through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	15kV to 45kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-55° C to +150° C

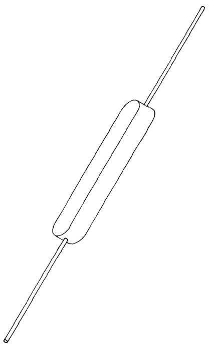
MECHANICAL SPECIFICATIONS

HVJX15K-45K



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
HVJX15K	1.5 ± .02	38.1 ± .508
HVJX20K	2.0 ± .02	50.8 ± .508
HVJX22.5K	2.0 ± .02	50.8 ± .508
HVJX25K	2.5 ± .02	63.5 ± .508
HVJX30K	2.5 ± .02	63.5 ± .508
HVJX35K	3.0 ± .02	76.2 ± .508
HVJX37.5K	3.0 ± .02	76.2 ± .508
HVJX40K	3.5 ± .02	88.9 ± .508
HVJX45K	3.5 ± .02	88.9 ± .508

PA



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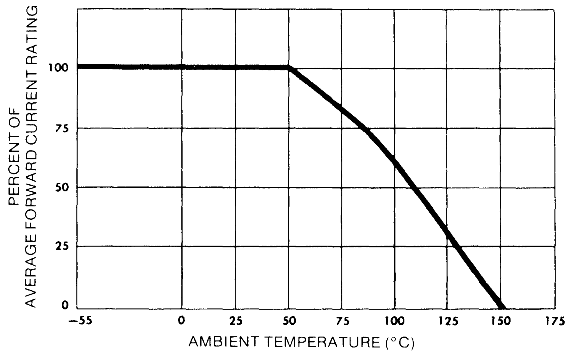
HIGH VOLTAGE DEVICES

Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)					MAXIMUM RATINGS				Case Length	
	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS			
	PIV	I_R		V_F	T_{RR}	I_O		I_F(surge)			
	V	25°C	100°C	V	nS	55°C	100°C	25°C	100°C		
		µA	µA			mA	mA	A	A	Ins.	MM
HVJX 15K	15000	0.1	25	24	200	50	30	5	2.5	1.5	38.1
HVJK 20K	20000	0.1	25	36	200	50	30	5	2.5	2.0	50.8
HVJX 22.5K	22500	0.1	25	36	200	50	30	5	2.5	2.0	50.8
HVJX 25K	25000	0.1	25	48	200	50	30	5	2.5	2.5	63.5
HVJX 30K	30000	0.1	25	48	200	50	30	5	2.5	2.5	63.5
HVJX 35K	35000	0.1	25	60	200	50	30	5	2.5	3.0	76.2
HVJX 37.5K	37500	0.1	25	60	200	50	30	5	2.5	3.0	76.2
HVJX 40K	40000	0.1	25	72	200	50	30	5	2.5	3.5	88.9
HVJX 45K	45000	0.1	25	72	200	50	30	5	2.5	3.5	88.9

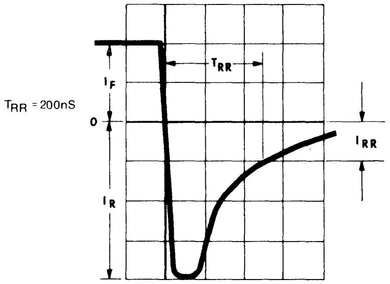
*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE

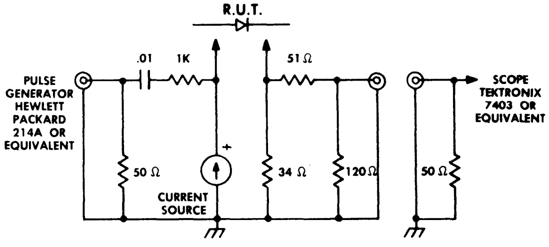


REVERSE RECOVERY TEST CONDITIONS: I_F = 50mA, I_R = 100mA, I_{RR} = 25mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

KX15-100
KXS15-100

POWERSTACK

1.5 to 3.0A

Very High Current, Miniature

FEATURES

- PIV: From 1.5kV to 10kV
- 1.5 to 3.0A
- 250nS Reverse Recovery
- High Surge Ratings
- Low Reverse Leakage
- Corona Free

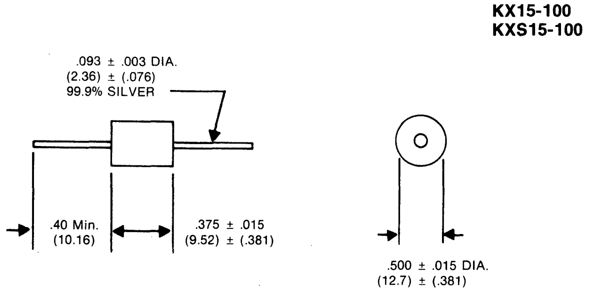
DESCRIPTION

The KX/KXS silicon rectifier series is a unique concept for high current high voltage applications. Matched junction characteristics and low stray capacitance due to metallurgically bonded junctions eliminates the need for external compensation networks. These rectifiers utilize HVD's cylindrical die construction, which minimizes electrical and mechanical stress, insuring long life for commercial, military and industrial applications.

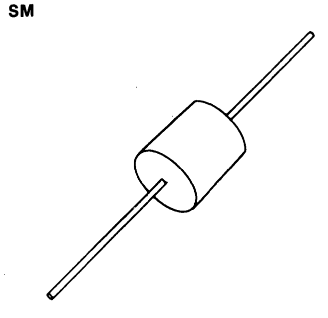
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	1.5kV to 10kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating Temperature Range	-55° C to +150° C
Storage Temperature Range	-55° C to +175° C

MECHANICAL SPECIFICATIONS



Dimensions in inches and (millimeters)



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS				
Maximum Reverse Recovery Time		Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Average Rectified Current†			Maximum One Cycle Surge 8.3mS	Typical Thermal Impedance††
250nS	2uS	PIV	I_R		V_F	I_O			I_F(surge)	θj-L
Type	Type	V	25°C	100°C	V	50°C	100°C	120°C		
			uA	uA		A	A	A	A	°C/Watt
KX15	KXS15	1500	2.0	100	5.0	3.00	1.50	.75	200	2.0
KX20	KXS20	2000	2.0	100	5.0	3.00	1.50	.75	200	2.0
KX25	KXS25	2500	2.0	100	5.0	3.00	1.50	.75	200	2.0
KX30	KXS30	3000	2.0	100	7.0	2.20	1.10	.55	150	2.5
KX40	KXS40	4000	2.0	100	7.0	2.20	1.10	.55	150	2.5
KX50	KXS50	5000	2.0	100	7.0	2.20	1.10	.55	150	2.5
KX60	KXS60	6000	2.0	100	11.0	1.50	.75	.37	100	3.0
KX80	KXS80	8000	2.0	100	11.0	1.50	.75	.37	100	3.0
KX100	KXS100	10000	2.0	100	11.0	1.50	.75	.37	100	3.0

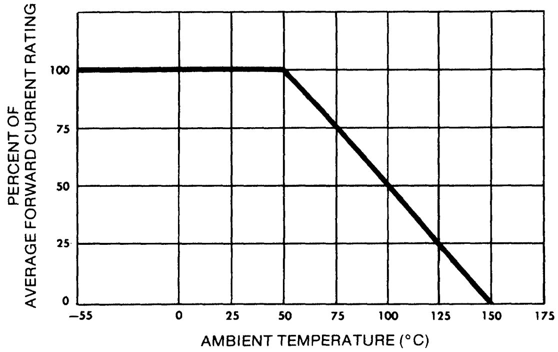
*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

††Typical thermal impedance determined with rectifier mounted on infinite heat sinks 0.10" from device body using temperature of center junction and lead temperature adjacent to body.

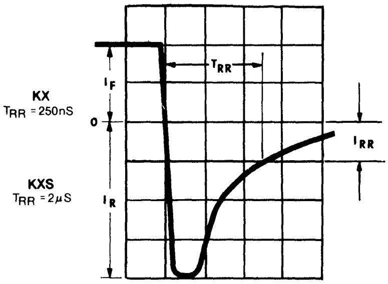
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS. AMBIENT TEMPERATURE



REVERSE RECOVERY TEST CONDITIONS: I_F =100mA, I_R =200mA, I_{RR} =50mA

REVERSE RECOVERY WAVE FORM



HIGH VOLTAGE SILICON RECTIFIERS

10-80mA
Fast Recovery, Miniature

LA15-120
LM15-180

FEATURES

- 1,500 to 18,000V
- 300nS reverse recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

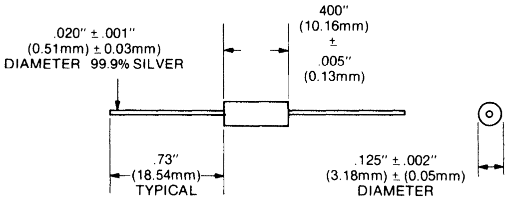
The LM/LA silicon rectifier series are designed to meet the economical needs of commercial and industrial requirements. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life. Fast reverse recovery characteristics improve circuit efficiency in high frequency power conversion and control applications.

ABSOLUTE MAXIMUM RATINGS

ABSOLUTE MAXIMUM RATINGS	LA	LM
Peak Inverse Voltage	1,500 to 12,000V	1,500 to 18,000V
Maximum Average Rectified Current	See Electrical Specifications	
Maximum One Cycle Surge 8.3mS	See Electrical Specifications	
Maximum Recurrent Peak Current Surge	See Electrical Specifications	
Operating Temperature Range	-55° C to +90° C	
Storage Temperature Range	-55° C to +175° C	

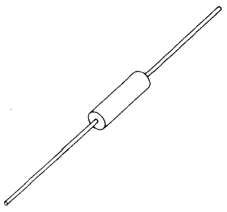
MECHANICAL SPECIFICATIONS

LM15-180

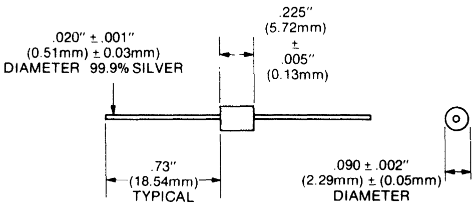


Dimensions in inches and (millimeters)

SG

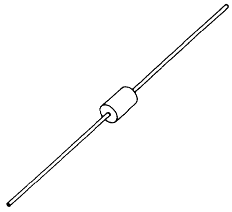


LA15-120



Dimensions in inches and (millimeters)

SH



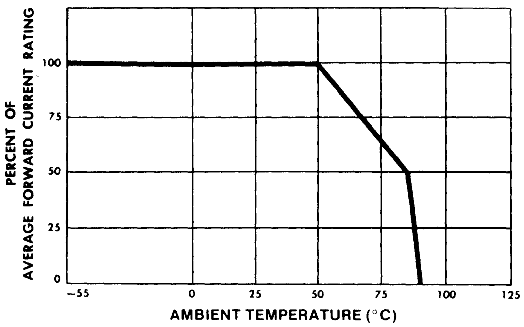
Type	Type	ELECTRICAL SPECIFICATIONS (at 25° C unless noted)						MAXIMUM RATINGS			
		Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time §	Maximum Junction Capacitance @ 100V	Maximum Average Rectified Current†		Maximum Recurrent Peak Current Surge	Maximum One Cycle Surge 8.3mS
		PIV	I_R		V_F	T_{RR}	C_J	I_O		I_F	I_F(surge)
		V	25° C	85° C	V	nS	pF	50° C	85° C	A	A
			uA	uA				mA	mA		
LM15	LA15	1500	.25	10	5	300(A)	2.0	80	40	0.8	8
LM20	LA20	2000	.25	10	5	300(A)	2.0	80	40	0.8	8
LM25	LA25	2500	.25	10	5	300(A)	2.0	80	40	0.8	8
LM30	LA30	3000	.25	10	8	300(B)	1.0	40	20	0.4	4
LM40	LA40	4000	.25	10	8	300(B)	1.0	40	20	0.4	4
LM50	LA50	5000	.25	10	8	300(B)	1.0	40	20	0.4	4
LM60	LA60	6000	.25	10	12	300(C)	1.0	25	12.5	0.2	2
LM80	LA80	8000	.25	10	12	300(C)	1.0	25	12.5	0.2	2
LM100	LA100	10000	.25	10	12	300(C)	1.0	25	12.5	0.2	2
LM120	LA120	12000	.25	10	24	300(D)	1.0	10	5	0.1	1
LM150		15000	.25	10	24	300(D)	1.0	10	5	0.1	1
LM180		18000	.25	10	24	300(D)	1.0	10	5	0.1	1

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

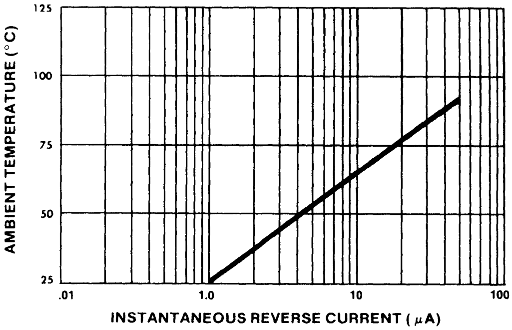
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

NOTE: Maximum lead temperature for soldering is 250° C, 3/8" (9.5mm) from case for 5 seconds.

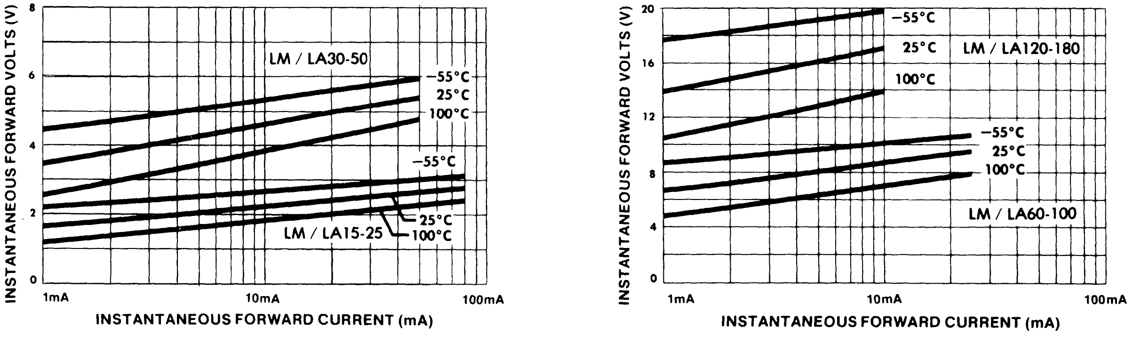
MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE



TYPICAL DYNAMIC REVERSE CHARACTERISTICS AT RATED PIV



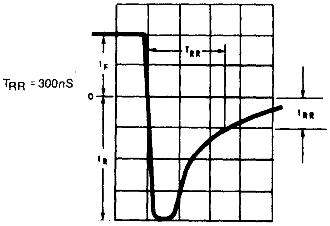
TYPICAL FORWARD CHARACTERISTICS AT VARIOUS JUNCTION TEMPERATURES



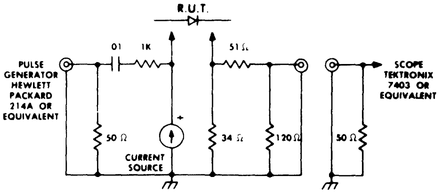
REVERSE RECOVERY TEST CONDITIONS §

TEST	I_F mA	I_R mA	I_{RR} mA
A	40	80	20
B	20	40	10
C	12.5	25	6.25
D	5	10	2.5

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



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HIGH VOLTAGE SILICON RECTIFIERS

LC15-30

MULTISTAC
Fast Recovery

FEATURES
- PIV: From 15kV to 30kV
- 300nS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

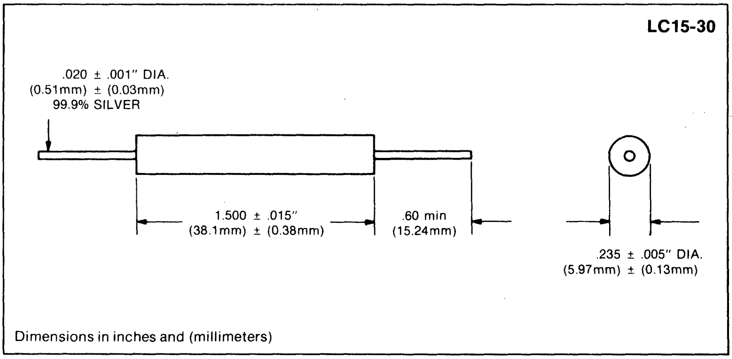
The LC MULTISTAC silicon rectifiers combine high reliability and economy to meet the requirements of commercial and industrial applications. Proprietary innovations in manufacturing technique, cylindrical die construction and metallurgical bonds are used to minimize electrical and mechanical stress, contributing to long life. The fast reverse recovery characteristics enhance their use in high frequency power conversion and control circuits.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	15kV to 30 kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating Temperature Range	-55° C to +90° C
Storage Temperature Range	-65° C to +150° C

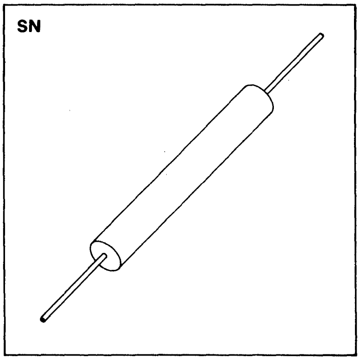
MECHANICAL SPECIFICATIONS

LC15-30



Dimensions in inches and (millimeters)

SN



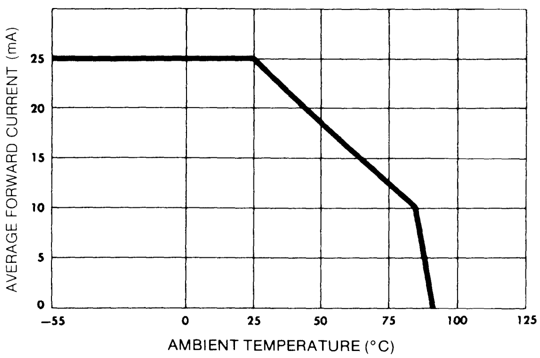
Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS		
	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Reverse Recovery Time	Maximum Junction Capacitance @ 100V	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS
	PIV	I_R		V_F	T_{RR}	C_J	I_O		I_F(surge)
	V	25°C	85°C	25°C	nS	pF	25°C	85°C	A
		µA	µA				mA	mA	
LC15	15000	.25	10	36	300	1	25	10	2
LC20	20000	.25	10	36	300	1	25	10	2
LC25	25000	.25	10	36	300	1	25	10	2
LC30	30000	.25	10	36	300	1	25	10	2

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

† The stated AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

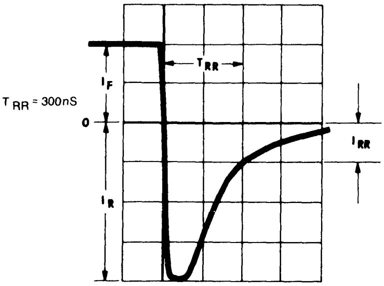
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5 mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE

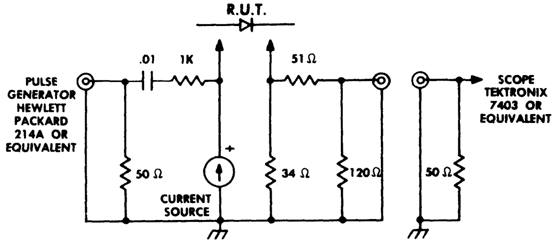


REVERSE RECOVERY TEST CONDITIONS: I_F = 12.5mA, I_R = 25mA, I_{RR} = 6.25mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

LCS15-30

MULTISTAC

Standard Recovery

FEATURES

- PIV: From 15kV to 30kV
- 2μS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

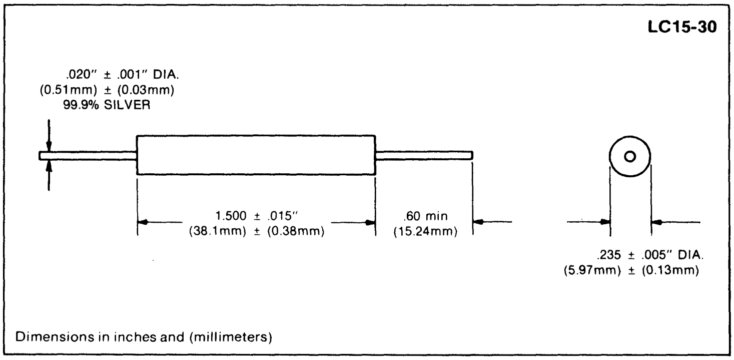
The LCS MULTISTAC silicon rectifiers combine high reliability and economy to meet the requirements of commercial and industrial applications. Proprietary innovations in manufacturing technique, cylindrical die construction and metallurgical bonds are used to minimize electrical and mechanical stress, contributing to long life. The 2 microsecond reverse recovery characteristics improve the circuit efficiency of power conversion and control systems.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	15kV to 30kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating Temperature Range	-55° C to +90° C
Storage Temperature Range	-65° C to +150° C

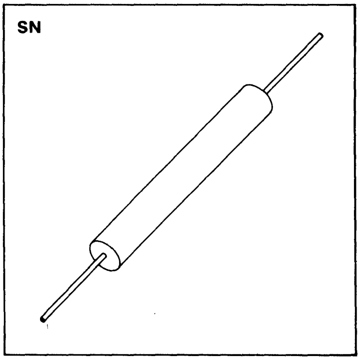
MECHANICAL SPECIFICATIONS

LC15-30



Dimensions in inches and (millimeters)

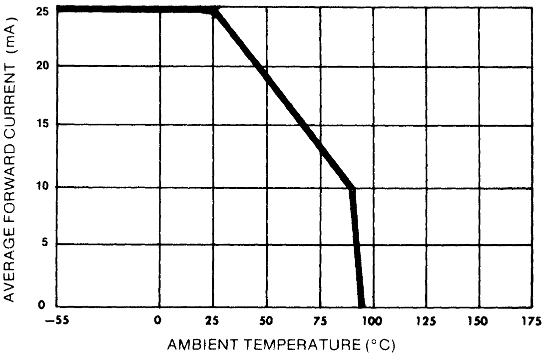
SN



Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS		
	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @I$_O$	Reverse Recovery Time	Maximum Junction Capacitance @ 100V	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS
	PIV	I$_R$		V$_F$	T$_{RR}$	C$_J$	I$_O$		I$_F$(surge)
		25°C	85°C	25°C			25°C	85°C	
	V	μA	μA	V	μS	pF	mA	mA	A
LCS15	15000	.25	10	36	2	1	25	10	2
LCS20	20000	.25	10	36	2	1	25	10	2
LCS25	25000	.25	10	36	2	1	25	10	2
LCS30	30000	.25	10	36	2	1	25	10	2

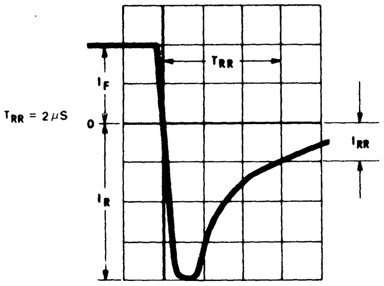
*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE

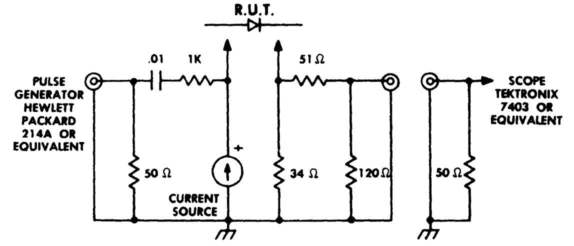


REVERSE RECOVERY TEST CONDITIONS: $I_F = 12.5mA$, $I_R = 25mA$, $I_{RR} = 6.25mA$

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



Reverse recovery is measured on each rectifier stack prior to manufacture of the assembly.

HIGH VOLTAGE SILICON RECTIFIERS

10-80mA
Standard Recovery, Miniature

LS15-120
LMS15-180

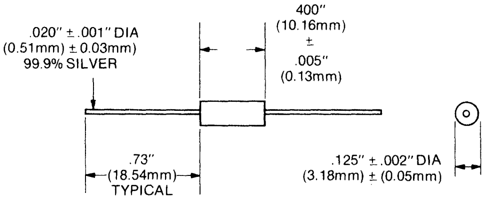
FEATURES
- PIV: From 1.5kV to 18kV
- 2μS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION
The LMS/LS silicon rectifier series are designed to meet the economical needs of commercial and industrial requirements. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life.

ABSOLUTE MAXIMUM RATINGS	LS	LMS
Peak Inverse Voltage	1.5kV to 12kV	1.5kV to 18kV
Maximum Average Rectified Current	See Electrical Specifications	
Maximum One Cycle Surge 8.3mS	See Electrical Specifications	
Maximum Recurrent Peak Current Surge	See Electrical Specifications	
Operating Temperature Range	-55° C to + 90° C	
Storage Temperature Range	-65° C to +175° C	

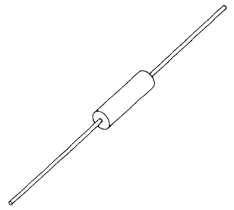
MECHANICAL SPECIFICATIONS

LMS15-180

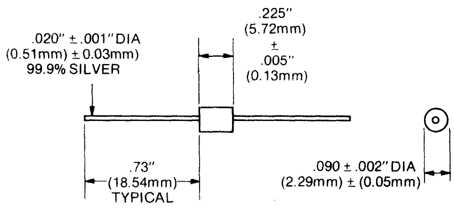


Dimensions in inches and (millimeters)

SG

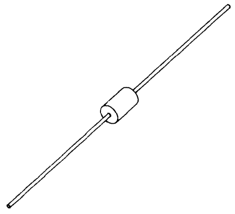


LS15-120



Dimensions in inches and (millimeters)

SH



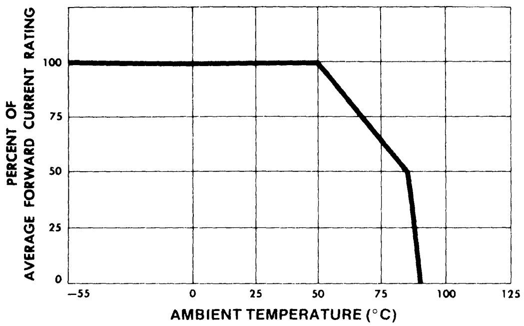
Type	Type	ELECTRICAL SPECIFICATIONS (@ 25° C unless noted)						MAXIMUM RATINGS			
		Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time §	Maximum Junction Capacitance @ 100 Volts	Maximum Average Rectified Current†		Max. Recurrent Peak Current Surge	Max. One Cycle Surge 8.3mS
Pkg. Style SG	Pkg. Style SH	PIV	I_R		V_F	T_{RR}	C_J	I_O		I_F	I_F (surge)
		V	25° C µA	85° C µA	25° C V	nS	pF	50° C mA	85° C mA	A	A
LMS 15	LS 15	1500	.25	10	5	2(A)	2.0	80	40	0.8	8
LMS 20	LS 20	2000	.25	10	5	2(A)	2.0	80	40	0.8	8
LMS 25	LS 25	2500	.25	10	5	2(A)	2.0	80	40	0.8	8
LMS 30	LS 30	3000	.25	10	8	2(B)	1.0	40	20	0.4	4
LMS 40	LS 40	4000	.25	10	8	2(B)	1.0	40	20	0.4	4
LMS 50	LS 50	5000	.25	10	8	2(B)	1.0	40	20	0.4	4
LMS 60	LS 60	6000	.25	10	12	2(C)	1.0	25	12.5	0.2	2
LMS 80	LS 80	8000	.25	10	12	2(C)	1.0	25	12.5	0.2	2
LMS 100	LS 100	10000	.25	10	12	2(C)	1.0	25	12.5	0.2	2
LMS 120	LS 120	12000	.25	10	24	2(D)	1.0	10	5	0.1	1
LMS 150		15000	.25	10	24	2(D)	1.0	10	5	0.1	1
LMS 180		18000	.25	10	24	2(D)	1.0	10	5	0.1	1

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

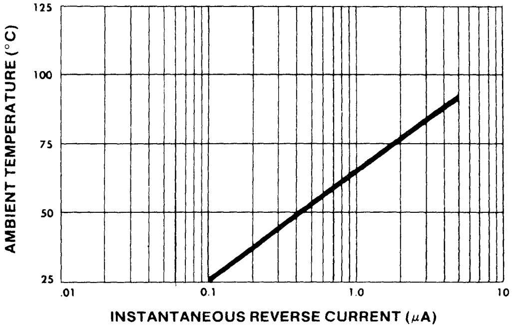
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

NOTE: Maximum lead temperature for soldering is 250° C, 3/8 inch (9.5 mm) from case for 5 seconds maximum.

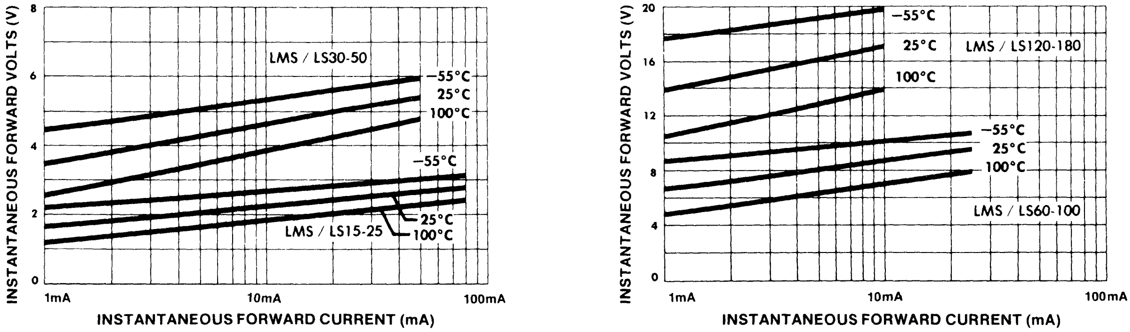
MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE



TYPICAL DYNAMIC REVERSE CHARACTERISTICS AT RATED PIV



TYPICAL FORWARD CHARACTERISTICS AT VARIOUS JUNCTION TEMPERATURES

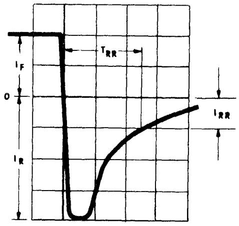


REVERSE RECOVERY TEST CONDITIONS §

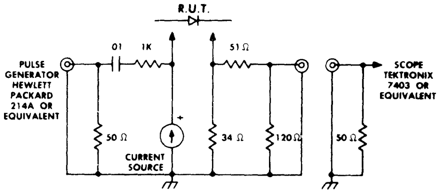
TEST	I_F mA	I_R mA	I_{RR} mA
A	40	80	20
B	20	40	10
C	12.5	25	6.25
D	5	10	2.5

T_{RR} = 2µS

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

15-200mA
Fast Recovery, Miniature

MA15-120
MX15-200

FEATURES

- PIV: From 1.5kV to 20kV
- 250nS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

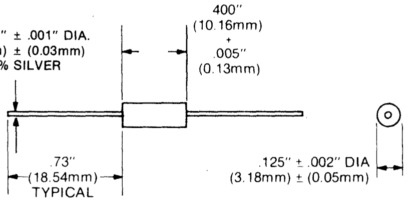
DESCRIPTION

The MX/MA silicon rectifier series utilizes manufacturing techniques that meet the reliability standards of commercial, industrial and military users. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life. The fast reverse recovery characteristics enhance applications in high frequency power supply circuits and voltage multipliers for television, CRT displays and instruments.

ABSOLUTE MAXIMUM RATINGS	MA	MX
Peak Inverse Voltage	1.5kV to 12kV	1.5kV to 20kV
Maximum Average Rectified Current	See Electrical Specifications	
Maximum One Cycle Surge 8.3mS	See Electrical Specifications	
Maximum Recurrent Peak Current Surge	See Electrical Specifications	
Operating Temperature Range	-55° C to +150° C	
Storage Temperature Range	-65° C to +175° C	

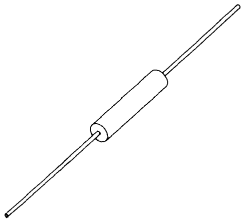
MECHANICAL SPECIFICATIONS

MX15-200

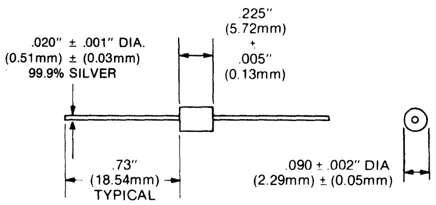


Dimensions in inches and (millimeters)

SG

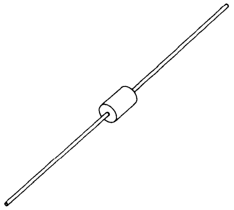


MA15-120



Dimensions in inches and (millimeters)

SH



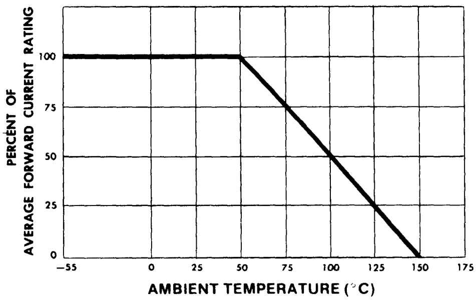
		ELECTRICAL SPECIFICATIONS (@ 25°C unless noted)						MAXIMUM RATINGS				
Type	Type	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time §	Maximum Junction Capacitance @ 100 Volts	Maximum Average Rectified Current †			Max. Recurrent Peak Current Surge	Max. One Cycle Surge 8.3mS
Pkg. Style SG	Pkg. Style SH	PIV	I_R		V_F	T_{RR}	C_J	I_O			I_F	I_F(surge)
			25°C	100°C	25°C			50°C	100°C	125°C		
		V	μA	μA	V	nS	pF	mA	mA	mA	A	A
MX15	MA15	1500	0.1	10	5	250(A)	2.0	80	40	20	0.8	8
MX20	MA20	2000	0.1	10	5	250(A)	2.0	80	40	20	0.8	8
MX25	MA25	2500	0.1	10	5	250(A)	2.0	80	80	20	0.8	8
MX30	MA30	3000	0.1	10	8	250(B)	1.0	40	20	10	0.4	4
MX40	MA40	4000	0.1	10	8	250(B)	1.0	40	20	10	0.4	4
MX50	MA50	5000	0.1	10	8	250(B)	1.0	40	20	10	0.4	4
MX60	MA60	6000	0.1	10	12	250(C)	1.0	25	12.5	6.25	0.2	2
MX80	MA80	8000	0.1	10	12	250(C)	1.0	25	12.5	6.25	0.2	2
MX100	MA100	10000	0.1	10	12	250(C)	1.0	25	12.5	6.25	0.2	2
MX120	MA120	12000	0.1	10	24	250(D)	1.0	10	5	2.5	0.1	1
MX150		15000	0.1	10	24	250(D)	1.0	10	5	2.5	0.1	1
MX200		20000	0.1	10	24	250(D)	1.0	10	5	2.5	0.1	1

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

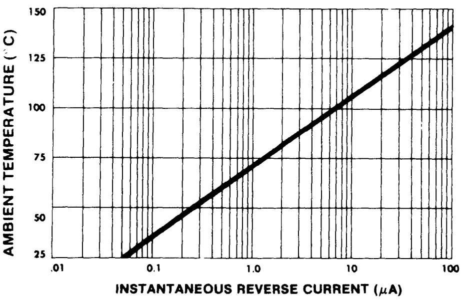
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

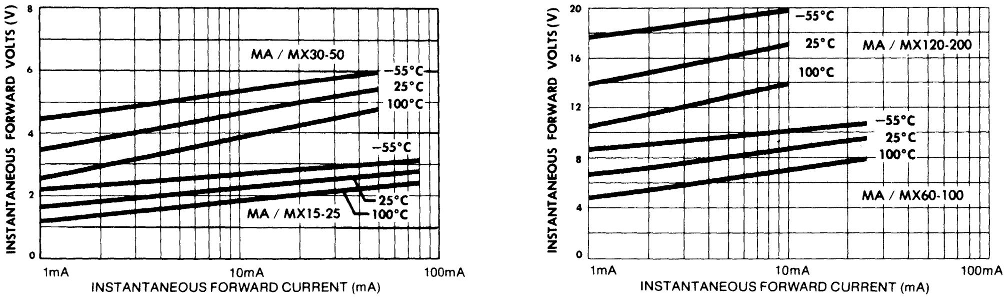
MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE



TYPICAL DYNAMIC REVERSE CHARACTERISTICS AT RATED PIV



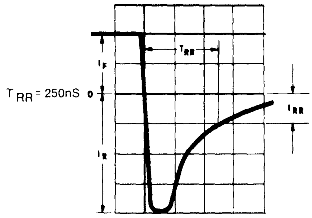
TYPICAL FORWARD CHARACTERISTICS AT VARIOUS JUNCTION TEMPERATURES



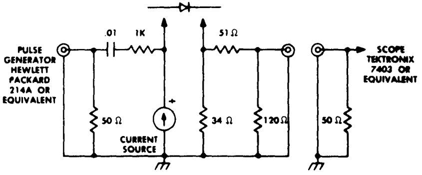
REVERSE RECOVERY TEST CONDITIONS §

TEST	I_F mA	I_R mA	I_{RR} mA
A	40	80	20
B	20	40	10
C	12.5	25	6.25
D	5	10	2.5

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



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HIGH VOLTAGE SILICON RECTIFIERS

10-80mA

Standard Recovery, Miniature

MS15-120
MXS15-200

FEATURES:

- PIV: From 1.5kV to 20kV
- 2μS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

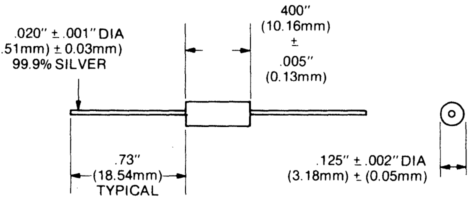
DESCRIPTION

The MXS/MS silicon rectifier series utilizes manufacturing techniques that meet the reliability standards of commercial, industrial and military users. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life. The medium reverse recovery characteristics improve the circuit efficiency of power conversion and control systems.

ABSOLUTE MAXIMUM RATINGS	MS	MXS
Peak Inverse Voltage	1.5kV to 12kV	1.5kV to 20kV
Maximum Average Rectified Current	See Electrical Specifications	
Maximum One Cycle Surge 8.3mS	See Electrical Specifications	
Maximum Recurrent Peak Current Surge	See Electrical Specifications	
Operating Temperature Range	-55° C to +150° C	
Storage Temperature Range	-65° C to +175° C	

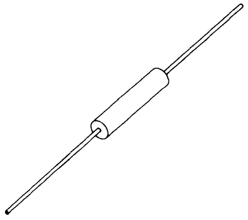
MECHANICAL SPECIFICATIONS

MXS15-200

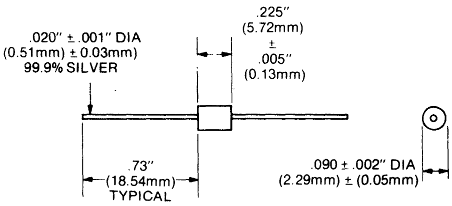


Dimensions in inches and (millimeters)

SG

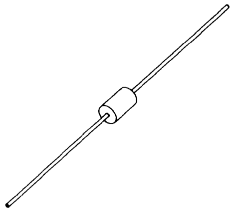


MS15-120



Dimensions in inches and (millimeters)

SH



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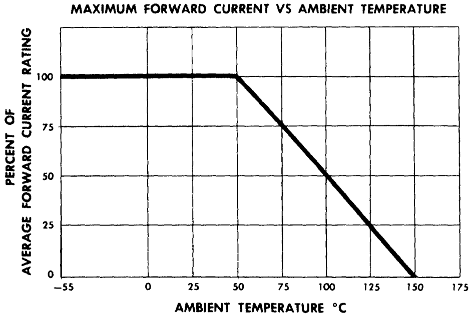
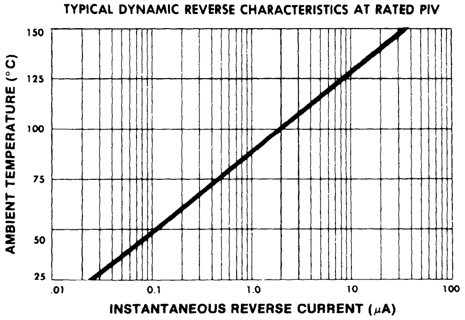
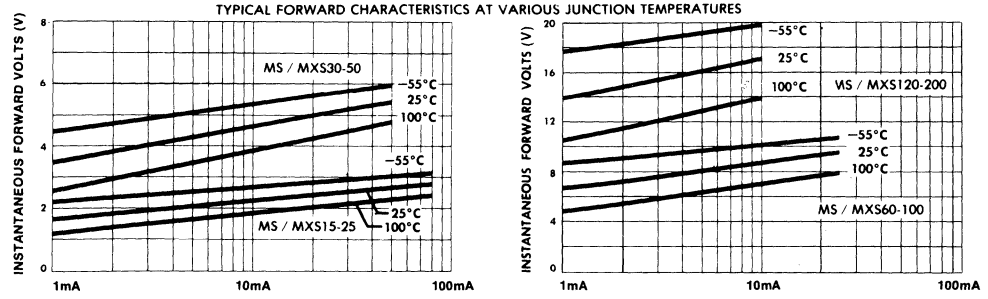
Type	Type	ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS				
		Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O Max.	Maximum Reverse Recovery Time §	Maximum Junction Capacitance @ 100V	Maximum Average Rectified Current†			Maximum Recurrent Peak Current Surge	Maximum One Cycle Surge 8.3mS
Pkg Style SG	Pkg Style SH	PIV	I_R		V_F	T_{RR}	C_J	I_O			I_F	I_F(surge)
			25°C	100°C	25°C			50°C	100°C	125°C		
		V	µA	µA	V	µS	pF	mA	mA	mA	A	A
MXS15	MS15	1500	0.1	10	5	2(A)	2.0	80	40	20	0.8	8
MXS20	MS20	2000	0.1	10	5	2(A)	2.0	80	40	20	0.8	8
MXS25	MS25	2500	0.1	10	5	2(A)	2.0	80	40	20	0.8	8
MXS30	MS30	3000	0.1	10	8	2(B)	1.0	40	20	10	0.4	4
MXS40	MS40	4000	0.1	10	8	2(B)	1.0	40	20	10	0.4	4
MXS50	MS50	5000	0.1	10	8	2(B)	1.0	40	20	10	0.4	4
MXS60	MS60	6000	0.1	10	12	2(C)	1.0	25	12.5	6.25	0.2	2
MXS80	MS80	8000	0.1	10	12	2(C)	1.0	25	12.5	6.25	0.2	2
MXS100	MS100	10000	0.1	10	12	2(C)	1.0	25	12.5	6.25	0.2	2
MXS120	MS120	12000	0.1	10	24	2(D)	1.0	10	5	2.5	0.1	1
MXS150		15000	0.1	10	24	2(D)	1.0	10	5	2.5	0.1	1
MXS200		20000	0.1	10	24	2(D)	1.0	10	5	2.5	0.1	1

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

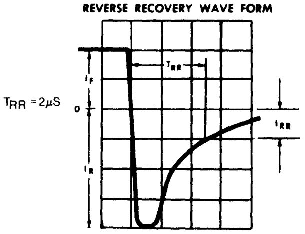

MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE

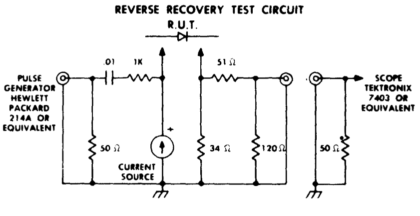

TYPICAL DYNAMIC REVERSE CHARACTERISTICS AT RATED PIV


TYPICAL FORWARD CHARACTERISTICS AT VARIOUS JUNCTION TEMPERATURES

REVERSE RECOVERY TEST CONDITIONS §

TEST	I_F mA	I_R mA	I_{RR} mA
A	40	80	20
B	20	40	10
C	12.5	25	6.25
D	5	10	2.5


REVERSE RECOVERY WAVE FORM


REVERSE RECOVERY TEST CIRCUIT

RECTIFIER ASSEMBLIES
PMA Power Modules
High Voltage, High Current

PMA101-PMA111
PMA101X-PMA111X
PMA201-PMA208
PMA201X-PMA208X

FEATURES

- PIV: From 2.5kV to 60kV
- 6A in Oil
- 300A Surge Current
- Dense Packaging
- Convenient Mounting

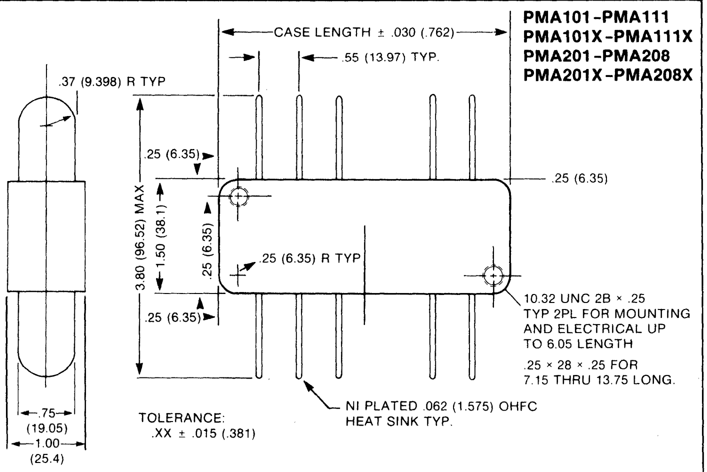
DESCRIPTION

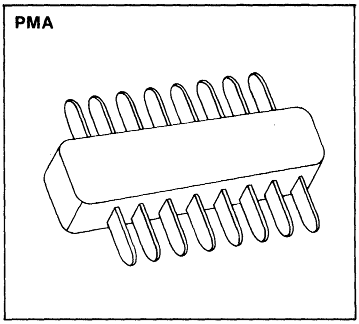
The PMA POWER MODULE is ideally suited for high current applications such as charging, hold off and clipper diodes in large ground based radar systems. This device can be operated in static air, forced air or oil for many different high power applications where size and reliability are important design parameters.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5kV to 60kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-65°C to +150°C

MECHANICAL SPECIFICATIONS





PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
PMA101, 101X	1.65	41.91
PMA102, 102X	2.20	55.88
PMA103, 103X	2.75	69.85
PMA104, 104X	3.85	97.79
PMA105, 105X	4.95	125.73
PMA106, 106X	6.05	153.67
PMA107, 107X	7.15	181.61
PMA108, 108X	8.25	209.55
PMA109, 109X	9.35	237.49
PMA110, 110X	11.55	293.37
PMA111, 111X	13.75	349.25

PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
PMA201, 201X	1.65	41.91
PMA202, 202X	2.75	69.85
PMA203, 203X	3.85	97.79
PMA204, 204X	4.95	125.73
PMA205, 205X	7.15	181.61
PMA206, 206X	9.35	237.49
PMA207, 207X	11.55	293.37
PMA208, 208X	13.75	349.25

Dimensions in inches and (millimeters)

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HIGH VOLTAGE DEVICES

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS				Case Length	
Maximum Reverse Recovery Time		Peak Inverse Voltage	Maximum Reverse Current @ PIV		Maximum Forward Voltage	Maximum Average Rectified Current†			Maximum One Cycle Surge 8.3mS		
T_{RR}*		PIV	I_R		V_F	I_O @ 50°C			I_F(surge)		
Type	Type	kV	25°C	100°C	@ 3.0A Peak	NC	FA	Oil			
2µS	250nS		µA	µA	V	A**	A***	A	A	Inches	MM
PMA101	PMA101X	5.0	2	100	10	1.0	2.4	3.0	150	1.65	41.91
PMA102	PMA102X	7.5	2	100	15	1.0	2.4	3.0	150	2.20	55.88
PMA103	PMA103X	10	2	100	20	1.0	2.4	3.0	150	2.75	69.85
PMA104	PMA104X	15	2	100	30	1.0	2.4	3.0	150	3.85	97.79
PMA105	PMA105X	20	2	100	40	1.0	2.4	3.0	150	4.95	125.73
PMA106	PMA106X	25	2	100	50	1.0	2.4	3.0	150	6.05	153.67
PMA107	PMA107X	30	2	100	60	1.0	2.4	3.0	150	7.15	181.61
PMA108	PMA108X	35	2	100	70	1.0	2.4	3.0	150	8.25	209.55
PMA109	PMA109X	40	2	100	80	1.0	2.4	3.0	150	9.35	237.49
PMA110	PMA110X	50	2	100	100	1.0	2.4	3.0	150	11.55	293.37
PMA111	PMA111X	60	2	100	120	1.0	2.4	3.0	150	13.75	349.25
					@ 6.0A Peak						
PMA201	PMA201X	2.5	2	100	5	2.0	4.8	6.0	300	1.65	41.91
PMA202	PMA202X	5	2	100	10	2.0	4.8	6.0	300	2.75	69.85
PMA203	PMA203X	7.5	2	100	15	2.0	4.8	6.0	300	3.85	97.79
PMA204	PMA204X	10	2	100	20	2.0	4.8	6.0	300	4.95	125.73
PMA205	PMA205X	15	2	100	30	2.0	4.8	6.0	300	7.15	181.61
PMA206	PMA206X	20	2	100	40	2.0	4.8	6.0	300	9.35	237.49
PMA207	PMA207X	25	2	100	50	2.0	4.8	6.0	300	11.55	293.37
PMA208	PMA208X	30	2	100	60	2.0	4.8	6.0	300	13.75	349.25

* Reverse recovery test conditions for each cell prior to assembly I_F=400mA, I_R=800mA, I_{RR}=200mA.
** For natural air convection operation unit must be mounted horizontally with no air restrictions.
*** Forced air ratings are with a minimum air flow of (TBD).

Notes:
1. For operation in air unit to be corona free to (TBD) test conditions (TBD).
2. Junction to heat sink thermal resistance (TBD).
3. Consult factory for series and/or parallel applications for special matching.
4. I_O ratings @ 50°C linearly derate to 0 @ 150°C.
5. Oil and air operation any position.

RECTIFIER ASSEMBLIES
PME Power Modules
High Voltage

PME101-PME103
PME101X-PME103X

FEATURES
- PIV: From 2.5kV to 8.0kV
- 3A Current
- Small Size
- Integral Heat Sinks
- 200A Surge Mounting
- Fast Recovery Time

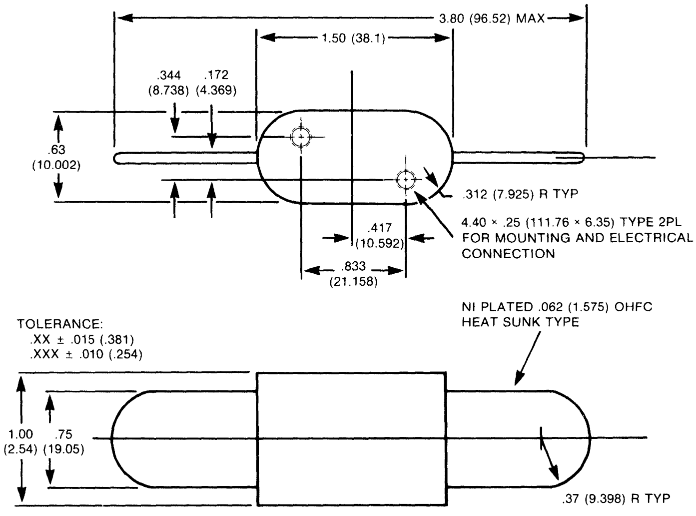
DESCRIPTION
The PME POWER MODULE is a high voltage high current single cell silicon rectifier assembly. This device is designed with common mounting and electrical inserts and integral heat sinks for oil operation. The PME unit is ideal for use in high current TWT power supply applications and high-power transmitters to name a few.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5kV to 8.0kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-65° C to +150° C

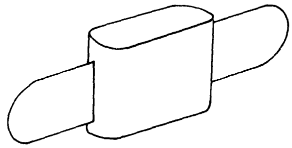
MECHANICAL SPECIFICATIONS

PME101 - PME103
PME101X - PME103X



Dimensions in inches and (millimeters)

PME



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS			
Maximum Reverse Recovery Time		Peak Inverse Voltage	Maximum Reverse Current @ PIV		Maximum Forward Voltage	Maximum Average Rectified Current†			Maximum One Cycle Surge 8.3mS
T_{RR}*		PIV	I_R		V_F	I_O @ 50°C			I_F(surge)
Type	Type	kV	25°C	100°C	V	NC	FA	Oil	A
2µS	250nS		µA	µA		A **	A***	A	
PME101	PME101X	2.5	2	100	5 @ 3.0A peak	1.0	2.4	3.0	200
PME102	PME102X	4	2	100	7 @ 2.2A peak	.75	1.75	2.2	150
PME103	PME103X	8	2	100	11 @ 1.5A peak	.50	1.2	1.5	100

* Reverse recovery test conditions for each cell prior to assembly I_F=400mA, I_R=800mA, I_{RR}=200mA.

** For natural air convection operation unit must be mounted horizontally with no air restrictions.

*** Forced air ratings are with a minimum air flow of (TBD).

Notes:
1. For operation in air unit to be corona free to (TBD) test conditions (TBD).
2. Junction to heat sink thermal resistance (TBD).
3. Consult factory for series and/or parallel applications for special matching.
4. I_O ratings @ 50°C linearly derate to 0 @ 150°C.
5. Oil and air operation any position.

HIGH VOLTAGE SILICON RECTIFIERS

SX10-100
SXS10-100

POWERSTACK
400mA - 1.0A
High Current, Miniature

FEATURES

- PIV: From 1kV to 10kV
- 400mA to 1.0A
- 250nS Reverse Recovery
- High Surge Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

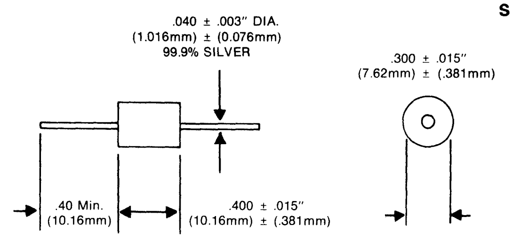
The SX/SXS silicon rectifier series is a unique concept for high current high voltage applications. Matched junction characteristics and low stray capacitance due to metallurgically bonded junctions eliminate the need for external compensation networks. These rectifiers utilize HVD's cylindrical die construction, which minimizes electrical and mechanical stress, insuring long life for commercial, military and industrial applications.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	1 kV to 10 kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3 mS	See Electrical Specifications
Operating Storage Temperature Range	-65° C to +150° C

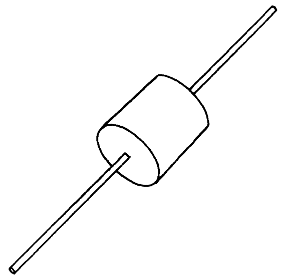
MECHANICAL SPECIFICATIONS

SX10-100
SXS10-100



Dimensions in inches and (millimeters)

SL

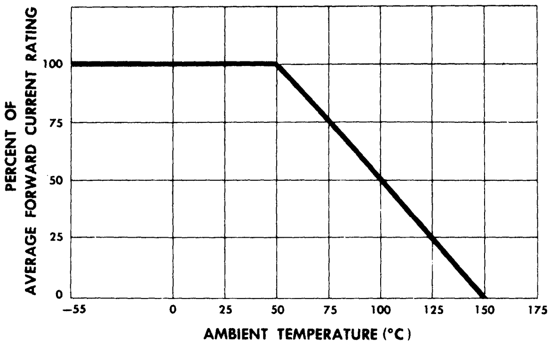


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS			
Maximum Reverse Recovery Time §		Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Average Rectified Current†			Maximum One Cycle Surge 8.3mS
250nS	2µS	PIV	I_R		V_F	I_O			I_F(surge)
Type	Type	V	25°C	100°C	25°C	50°C	100°C	125°C	A
			µA	µA	V	mA	mA	mA	
SX10	SXS10	1000	1.0	25	5.5	1000	500	250	60
SX15	SXS15	1500	1.0	25	5.5	1000	500	250	60
SX20	SXS20	2000	1.0	25	5.5	1000	500	250	60
SX25	SXS25	2500	1.0	25	5.5	1000	500	250	60
SX30	SXS30	3000	1.0	25	7.5	600	300	150	40
SX40	SXS40	4000	1.0	25	7.5	600	300	150	40
SX50	SXS50	5000	1.0	25	7.5	600	300	150	40
SX60	SXS60	6000	1.0	25	11.0	400	200	100	25
SX80	SXS80	8000	1.0	25	11.0	400	200	100	25
SX100	SXS100	10000	1.0	25	11.0	400	200	100	25

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.
† The stated, AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

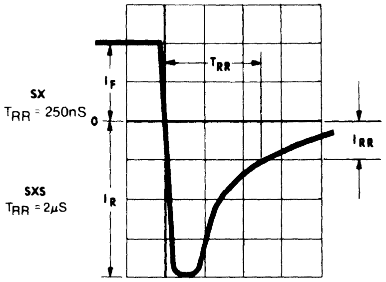
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS AMBIENT TEMPERATURE



Reverse recovery test conditions: I_F = 100mA, I_R = 200mA, I_{RR} = 50mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CONDITIONS §

TEST	I_F mA	I_R mA	I_{RR} mA
A	40	80	20
B	20	40	10
C	12.5	25	6.25
D	5	10	2.5

RECTIFIER ASSEMBLIES
High Voltage Doorbell® Modules, Standard and Fast Recovery

UDA, UDB, UDC, UDD , UDE, UDF SERIES

FEATURES
- PIV: from 2.5kV to 15kV
- Stackable to 600kV
- Current Ratings: to 7.7A
- Controlled Avalanche Characteristics
- Only Fused-in-Glass Diodes Used
- Recovery Time: to 500ns
- Modular Package For Easy Stacking

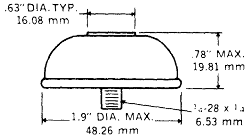
DESCRIPTION
This series of high-voltage, high-current stacks that incorporate a unique modular design makes it ideally suited for high power applications such as in radar systems as charger, hold-off and clipper diodes.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	
UDA, UDC Series	5kV to 15kV
UDB, UDD Series	2.5kV to 7.5kV
UDE, UDF Series	2.5kV to 5kV
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C

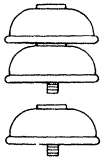
MECHANICAL SPECIFICATIONS

UDA, UDB, UDC, UDD, UDE, UDF SERIES

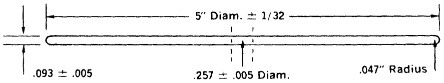


1. Polarity — Cathode connected to base.
2. Part Number — On base of unit.

Typical Weight — 2.1 ounces
60 grams



EXTENDER PLATE D



Typical Weight — 2.75 ounces
78 grams

Dimensions in inches.

Doorbell® is a registered trademark of Unitrode Corporation

UNITRODE

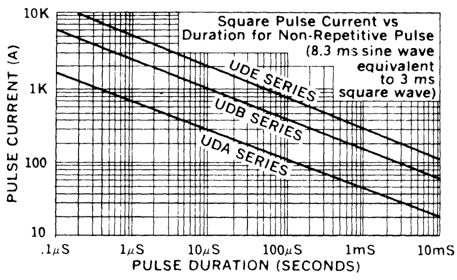
Electrical Specifications (at 25°C unless noted)						Maximum Ratings				
						Maximum Average D.C. Output Current				
Type		PIV	Maximum Forward Voltage Drop	Maximum Leakage Current @ PIV	Maximum Reverse Recovery Time	$T_C = 75°C$ Air	$T_C = 60°C$ Air with Extender Plate**	$T_C = 50°C$ Oil	Non-Repetitive Sinusoidal Surge (8.3ms) $T_C = 100°C$	Maximum Reverse Transient Energy Absorption
		kV		µA	ns	Amps	Amps	Amps	Amps	joules
Standard Recovery	UDE-2.5	2.5	5V @ 3.00A	10		‡ 6.00	7.00	7.70	200	8
	UDB-2.5	2.5	4V @ 1.50A	5		3.00	3.75	4.25	100	4
	UDE-5	5	10V @ 2.20A	10		‡ 4.50	5.00	5.50	200	14
	UDB-5	5	8V @ 1.00A	5		2.00	2.50	2.75	100	8
	UDA-5	5	8V @ 0.82A	2	—	1.65	2.00	2.20	30	1.5
	UDB-7.5	7.5	12V @ 0.70A	5		1.33	1.65	2.00	100	12
	UDA 7.5	7.5	12V @ 0.60A	2		1.25	1.55	1.75	30	2.5
	UDA-10	10	16V @ 0.50A	2		1.00	1.25	1.40	30	3
	UDA-15	15	25V @ 0.33A	2		0.67	0.80	0.90	30	5
Fast Recovery	UDF-2.5	2.5	6V @ 2.20A	10		4.50	5.00	5.30	150	8
	UDD-2.5	2.5	6V @ 1.20A	5		2.25	2.80	3.30	80	4
	UDF-5	5	11V @ 1.60A	10		3.30	4.00	4.40	150	14
	UDD-5	5	11V @ 0.75A	5		1.50	1.85	2.00	80	8
	UDC-5	5	10V @ 0.70A	2	500*	1.20	1.50	1.70	25	1.5
	UDD-7.5	7.5	17V @ 0.50A	5	350†	1.00	1.25	1.50	80	12
	UDC-7.5	7.5	15V @ 0.50A	2		0.90	1.10	1.25	25	2.5
	UDC-10	10	20V @ 0.37A	2		0.75	0.90	1.00	25	3
	UDC-15	15	30V @ 0.25A	2		0.50	0.60	0.70	25	5

*Measured in a reverse recovery circuit switching from 1.0A forward to 1.0A reverse current recovering to 0.5A.
†Measured in a reverse recovery circuit switching from 0.5A forward to 1.0A reverse current recovering to 0.25A.

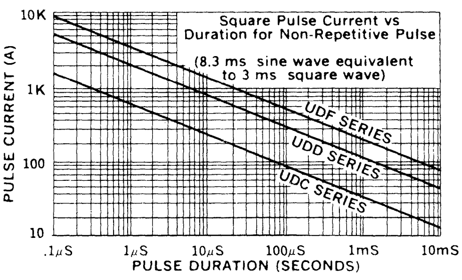
**These ratings are based on using "extender plates" that provide additional surface area to radiate heat. Because of possible corona effects caused by scratches on these plates, extreme care is necessary in their handling and they are not recommended where the working voltage exceeds 7.5KV/module. They should be carefully polished prior to installation.

‡These ratings are based on $T_C = 100°C$.

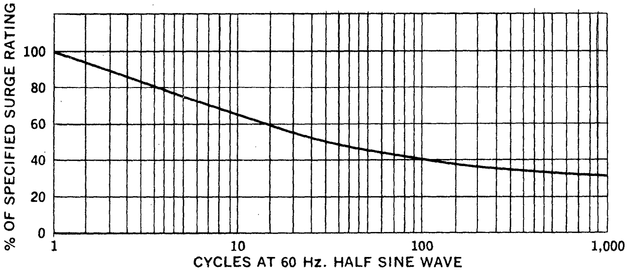
Forward Pulse Current vs. Pulse Duration



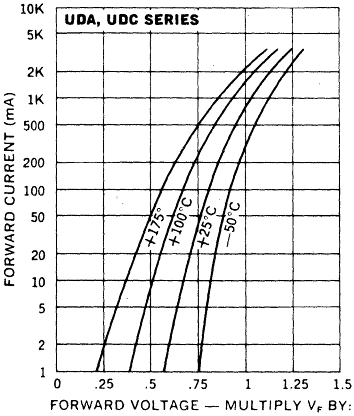
Forward Pulse Current vs. Pulse Duration



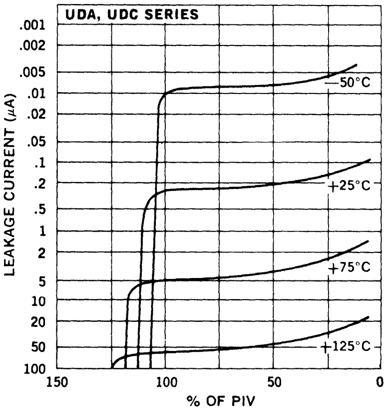
Multiple Surge Rating vs. Duration



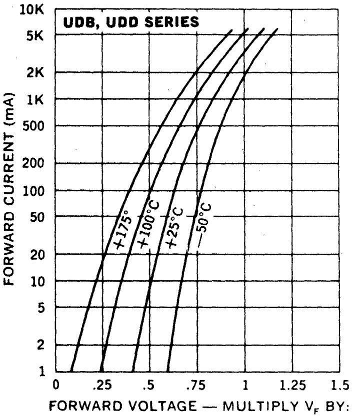
Typical Forward Voltage vs. Forward Current



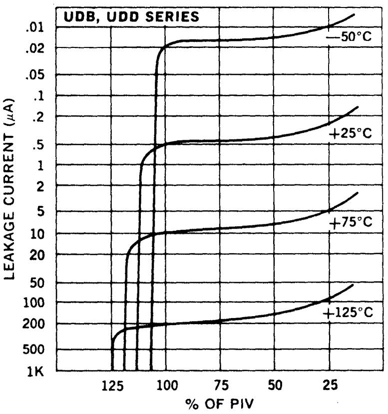
Typical Leakage Current vs. PIV



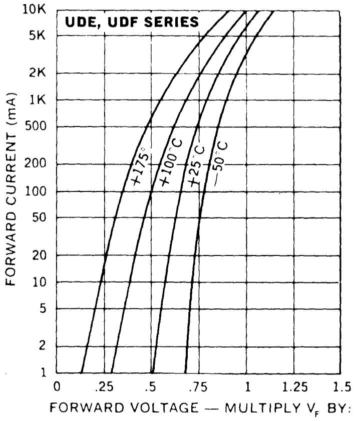
Typical Forward Voltage vs. Forward Current



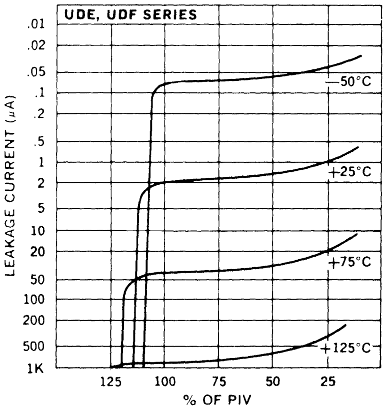
Typical Leakage Current vs. PIV



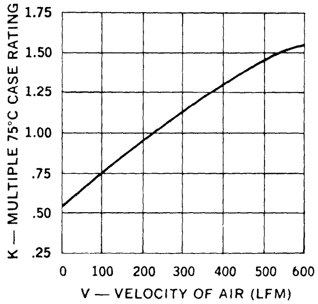
Typical Forward Voltage vs. Forward Current



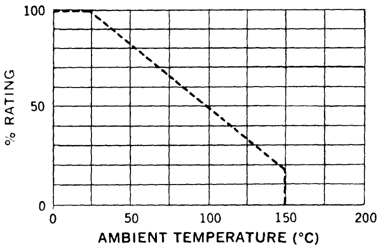
Typical Leakage Current vs. PIV



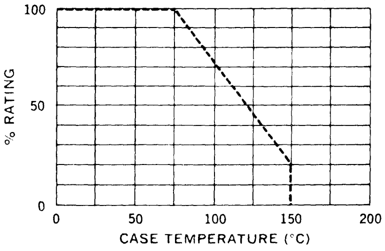
Output Current Ratio vs. Velocity of Air Flow



Current Derating Curve

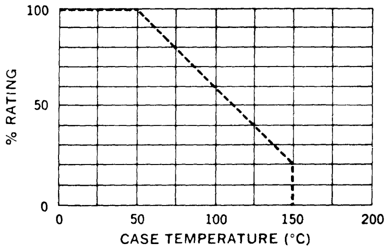


Current Derating Curve



Air Cooled

Current Derating Curve



Oil Immersed

RECTIFIER ASSEMBLIES

UFB, UFS, USB, USS SERIES

High Voltage Stacks, Standard and Fast Recovery

FEATURES

- Controlled Avalanche Characteristics
- Only Fused-in-Glass Diodes Used
- High Forward and Reverse Surge Capability
- Transfer Molded for Voidless Construction
- Modular for Easy Stacking
- PIV: from 2.5 kV to 15 kV
- Recovery Times: to 500ns
- Continuous Ratings: to 2.3A

DESCRIPTION

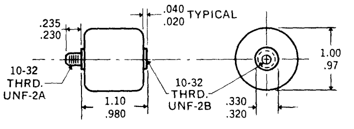
These assemblies uniquely combine a versatile stackable design with all the requirements for reliable high voltage operation. All modules are suitable for bridge or series operations.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, USS Series	5.0 kV to 15 kV
Peak Inverse Voltage, USB Series	2.5 kV to 10 kV
Peak Inverse Voltage, UFS Series	5.0 kV to 10 kV
Peak Inverse Voltage, UFB Series	2.5 kV to 7.5 kV
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C

MECHANICAL SPECIFICATIONS

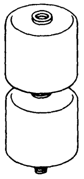
UFB, UFS, USB, USS SERIES



Typical Weight: USS & UFS Series — 1.0 ounce
28 grams

USB & UFB Series — 1.1 ounce
31 grams

Dimensions in inches.



MARKING

Type number marked on unit.

Polarity — Cathode connected to stud.

UNITRODE

Electrical Specifications (at 25°C unless noted)							Maximum Ratings		
Type		PIV	Maximum Forward Voltage Drop	Leakage Current @ PIV	Maximum Reverse Recovery Time	Maximum Reverse Transient Energy Absorption	Maximum Average D.C. Output Current T_A = 25°C AIR	Maximum Average D.C. Output Current T_A = 50°C OIL	Non-Repetitive Sinusoidal Surge (8.3ms)
		kV		µA	ns	joules	Amps	Amps	Amps
Standard Recovery	USS 5	5.0	9V @ 0.6A	5	—	1.5	0.60	1.1	25
	USS 7.5	7.5	13V @ 0.5A			2.5	0.45	0.91	
	USS 10	10	17V @ 0.3A			3.0	0.35	0.71	
	USS 15	15	25V @ 0.2A			5.0	0.25	0.51	
Standard Recovery	USB 2.5	2.5	5V @ 1.1A	10	—	3.0	1.1	2.3	80
	USB 5	5.0	9V @ 0.7A			6.0	0.68	1.5	
	USB 7.5	7.5	13V @ 0.5A			9.0	0.53	1.2	
	USB 10	10	17V @ 0.4A			12	0.43	1.0	
Fast Recovery	UFS 5	5.0	12V @ 0.5A	5	500* 350†	1.5	0.50	0.90	20
	UFS 7.5	7.5	18V @ 0.4A			2.5	0.38	0.75	
	UFS 10	10	23V @ 0.3A			3.0	0.30	0.58	
Fast Recovery	UFB 2.5	2.5	6V @ 0.9A	10	500* 350†	3.0	0.90	2.0	70
	UFB 5	5.0	12V @ 0.6A			6.0	0.58	1.3	
	UFB 7.5	7.5	18V @ 0.4A			9.0	0.45	1.0	

*Measured in a reverse recovery circuit switching from 1A forward to 1A reverse current recovering to 0.5A.
†Measured in a reverse recovery circuit switching from .5A foward current to 1A reverse current, recovery to .25A.

Output Current Ratio vs. Velocity of Air Flow

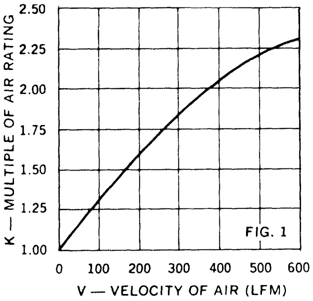


FIG. 1

Output Current vs. Ambient (Air) Temperature

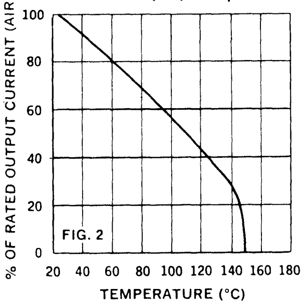


FIG. 2

Output Current vs. Ambient (Oil) Temperature

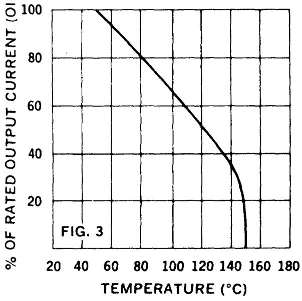
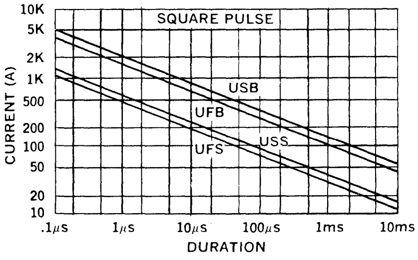


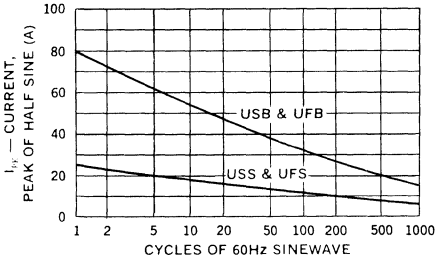
FIG. 3

Application example: The rectifier is to be used in a cabinet at 60°C with ambient air moving at 400 LFM. The rating is reduced (Fig. 2) by a factor of 0.81 due to the elevated temperature, but it is enhanced by 2 X (Fig. 1) due to the air flow. Hence the DC output current is 0.81 x 2, or 1.6 times the 25°C air rating.

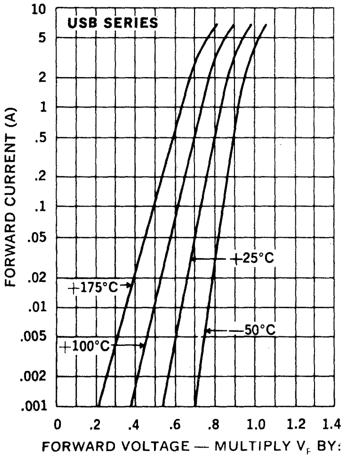
Forward Pulse Current vs. Duration



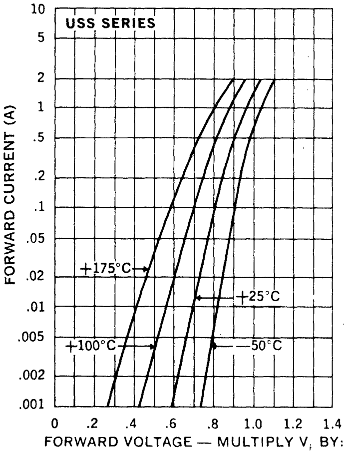
Multiple Surge Current vs. Duration



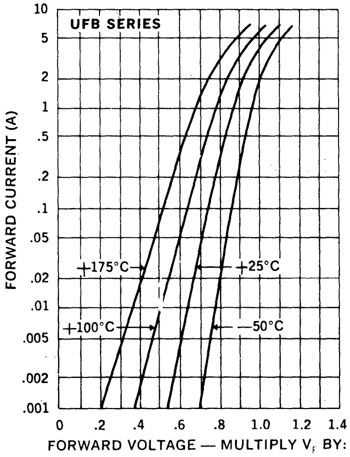
Typical Forward Voltage vs. Forward Current



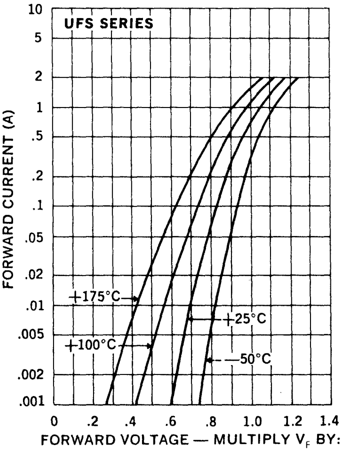
Typical Forward Voltage vs. Forward Current



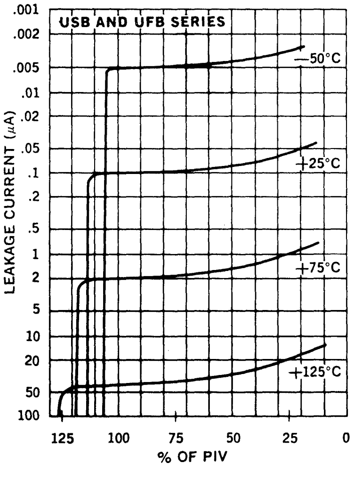
Typical Forward Voltage vs. Forward Current



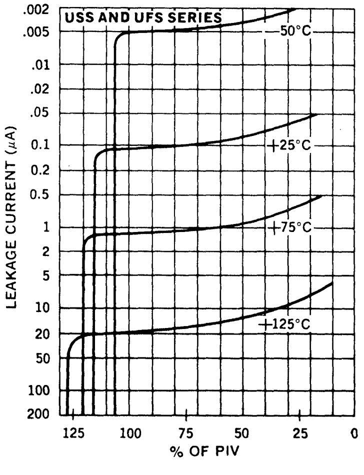
Typical Forward Voltage vs. Forward Current



Typical Leakage Current vs. PIV



Typical Leakage Current vs. PIV



RECTIFIER ASSEMBLIES

UGB, UGD, UGE, UGF SERIES

High Voltage Doorbell® Modules
Standard and Fast Recovery

FEATURES

- Current Ratings: to 10A
- PIV: 2.5 kV to 10kV
- Recovery Times: to 500ns
- Only Fused-in-Glass Diodes Used
- Controlled Avalanche Characteristics
- Stackable to 600KV
- Modular Package for Easy Stacking

DESCRIPTION

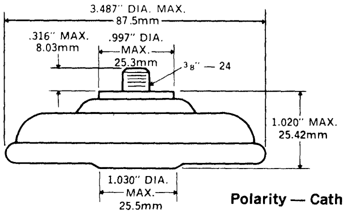
This series of high-voltage, high-current stacks that incorporate a unique modular design makes it particularly well-suited for high power applications such as in radar systems as charge, hold-off and clipper diodes.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	
UGB, UGD Series	5 kV to 10 kV
UGS, UGF Series	2.5 kV to 7.5 kV
Maximum Average D.C. Output Current	See Electrical Specifications
Non-repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	−65°C to +150°C

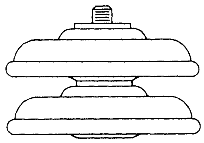
MECHANICAL SPECIFICATIONS

UGB, UGD, UGE, UGF SERIES

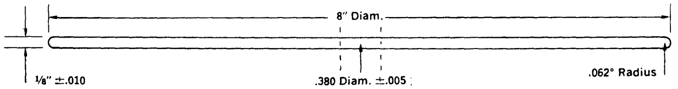


Polarity — Cathode connected to base.
Part Number — On base of unit.

Typical Weight — 7.0 ounces
200 grams



EXTENDER PLATE G



Typical Weight — 9.25 ounces
265 grams

Dimensions in inches.

UNITRODE

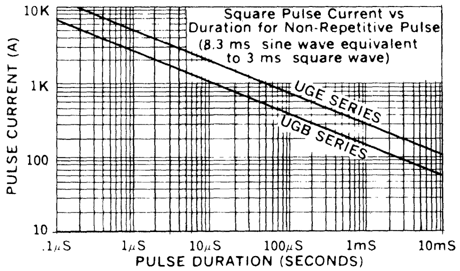
Doorbell® is a registered trademark of Unitrode Corporation

Electrical Specifications (at 25°C unless noted)						Maximum Ratings				
Type		PIV	Maximum Forward Voltage Drop	Maximum Leakage Current @ PIV	Maximum Reverse Recovery Time	Maximum Average D.C. Output Current			Non-repetitive Sinusoidal Surge (8.3ms)	Maximum Reverse Transient Energy Absorption
						$T_C = 75°C$ Air	$T_C = 60°C$ Air with Extender Plate**	$T_C = 50°C$ Oil	$T_C = 100°C$	
		kV		μA	ns	Amps	Amps	Amps	Amps	joules
Standard Recovery	UGE-2.5	2.5	5V @ 3.30A	10	—	6.60	8.25	10.00	200	8
	UGE-5	5	10V @ 2.50A	15		5.00	6.25	7.50	200	14
	UGB-5	5	9V @ 2.20A	5		4.40	5.50	6.60	100	7
	UGE-7.5	7.5	13V @ 1.60A	10		3.30	4.10	5.00	200	20
	UGB-7.5	7.5	13V @ 1.50A	5		3.00	3.75	5.00	100	10
	UGB-10	10	17V @ 1.10A	5		2.30	2.85	3.50	100	14
Fast Recovery	UGF-2.5	2.5	6V @ 2.50A	10	500* 350†	5.00	6.25	8.00	150	8
	UGF-5	5	11V @ 1.80A	10		3.75	4.70	6.00	150	14
	UGD-5	5	11V @ 1.60A	5		3.30	4.10	4.80	80	7
	UGF-7.5	7.5	17V @ 1.20A	10		2.50	3.10	4.00	150	20
	UGD-7.5	7.5	17V @ 1.10A	5		2.25	2.80	3.50	80	10
	UGD-10	10	22V @ 0.85A	5		1.75	2.20	2.50	80	14

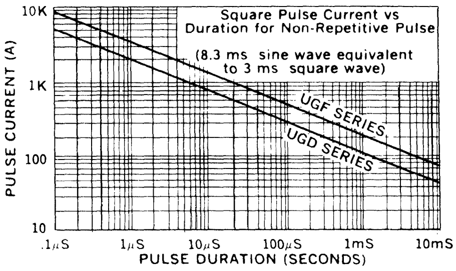
***Measured in a reverse recovery circuit switching from 1.0A forward to 1.0A reverse current recovering to 0.5A.**
†Measured in a reverse recovery circuit switching from 0.5A forward to 1.0A reverse current recovering to 0.25A.

**These ratings are based on using "extender plates" that provide additional surface area to radiate heat. Because of possible corona effects caused by scratches on these plates, extreme care is necessary in their handling and they are not recommended where the working voltage exceeds 7.5KV/module. They should be carefully polished prior to installation.

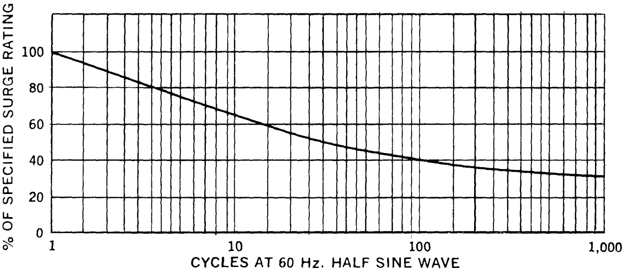
Forward Pulse Current vs. Pulse Duration



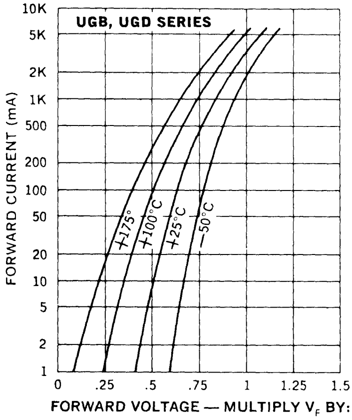
Forward Pulse Current vs. Pulse Duration



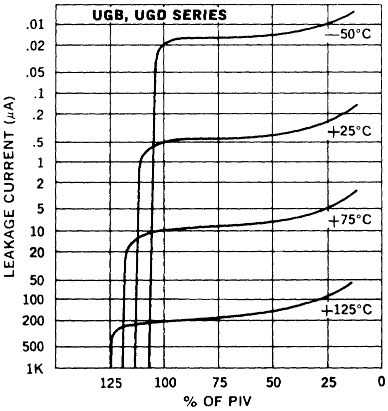
Multiple Surge Rating vs. Duration



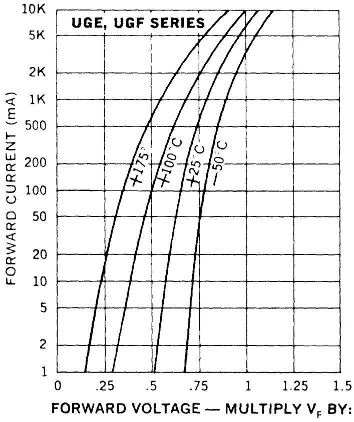
Typical Forward Voltage vs. Forward Current



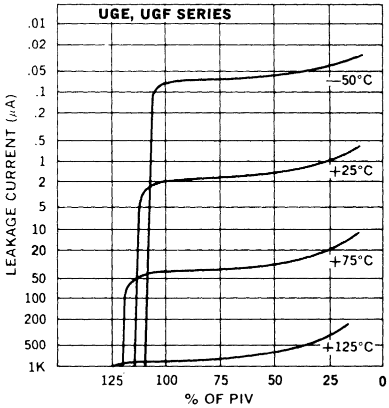
Typical Leakage Current vs. PIV



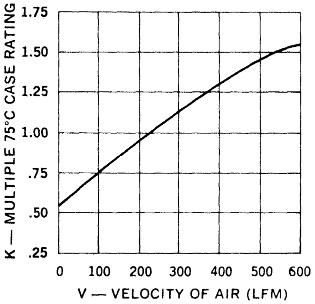
Typical Forward Voltage vs. Forward Current



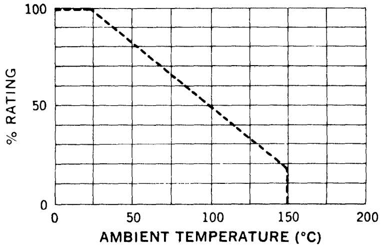
Typical Leakage Current vs. PIV



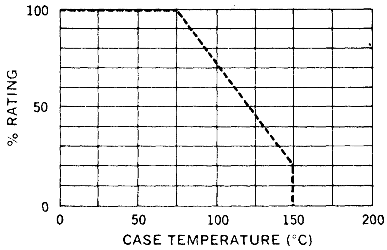
Output Current Ratio vs. Velocity of Air Flow



Current Derating Curve

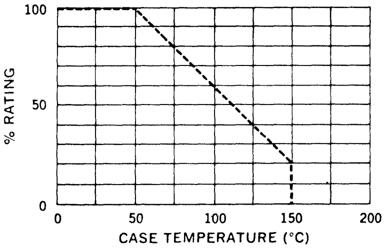


Current Derating Curve



Air Cooled

Current Derating Curve



Oil Immersed

RECTIFIER ASSEMBLIES

High Voltage Stacks, .125 Amp to 1 Amp, Standard and Fast Recovery

US12–US200A
USR12–USR180A

FEATURES

- Controlled Avalanche Characteristics
- Recovery Times: to 500ns
- Transfer Molded for Voidless Encapsulation
- High Forward and Reverse Surge Capability
- PIV: from 1200 to 20,000V
- Only Fused-in-Glass Diodes Used

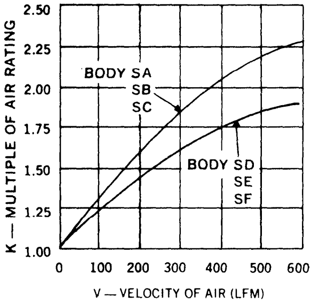
DESCRIPTION

This series of High Voltage, Medium Current Stacks are assembled from hermetically sealed, controlled avalanche individual diodes. Therefore, they offer the ultimate in reliability for such applications as clipper diodes, back swing diodes and hold-off diodes in pulse modulators.

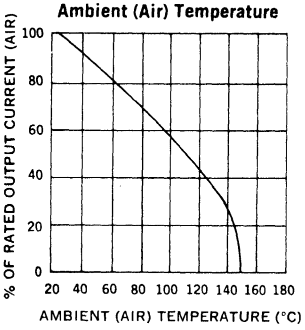
ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	1200 to 20,000V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	20A
Operating and Storage Temperature Range	−65°C to +150°C

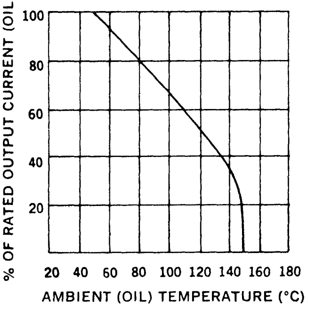
Output Current Ratio vs Velocity of Air Flow



Output Current vs Ambient (Air) Temperature



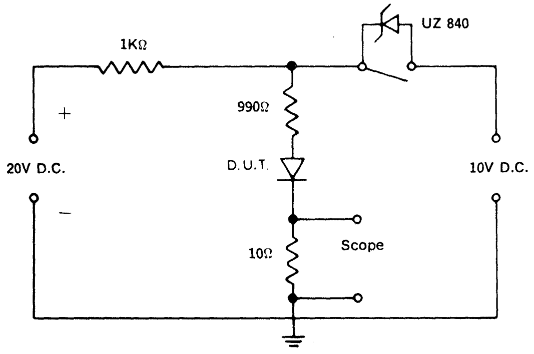
Output Current vs Ambient (Oil) Temperature



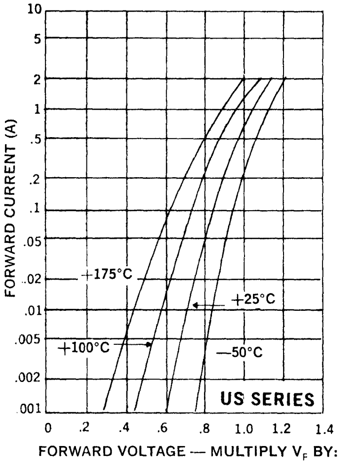
Electrical Specifications (at 25°C unless noted)							Maximum Ratings	
Type	PIV	Maximum Leakage Current at PIV		Maximum Forward Voltage Drop	Maximum Reverse Recovery Time†	Body Size	Max. Avg. D.C. Output Current	
		$T_A = 25°C$	$T_A = 100°C$				$T_A = 25°C$ (Air)	$T_A = 50°C$ (Oil)
	V	μA	μA		ns		mA	mA
Standard Recovery								
US 12	1200	2	100	2.0V @ 400mA	—	SA	1000	2500
US 15	1500	2	100	3.0V @ 400mA		SA	800	2000
US 18	1800	2	100	3.0V @ 400mA		SA	700	1750
US 20	2000	2	100	4.0V @ 400mA		SA	600	1500
US 25	2500	2	100	5.0V @ 400mA	—	SB	600	1500
US 30	3000	2	100	6.0V @ 400mA		SB	500	1250
US 35	3500	2	100	7.0V @ 200mA	—	SC	400	1000
US 40	4000	2	100	7.0V @ 200mA		SC	350	850
US 45A	4500	2	100	8.0V @ 200mA	—	SD	330	750
US 50A	5000	2	100	9.0V @ 200mA		SD	330	750
US 60A	6000	2	100	10.0V @ 200mA		SD	300	620
US 70A	7000	2	100	12.0V @ 200mA		SD	300	620
US 80A	8000	2	100	14.0V @ 100mA	—	SE	250	500
US 100A	10000	2	100	17.0V @ 100mA		SE	250	500
US 120A	12000	2	100	21.0V @ 100mA		SE	200	400
US 150A	15000	2	100	26.0V @ 100mA	—	SF	200	400
US 180A	18000	2	100	31.0V @ 100mA		SF	180	360
US 200A	20000	2	100	34.0V @ 100mA		SF	180	360
Fast Recovery								
USR 12	1200	5	150	3.3V @ 400mA	500	SA	750	1850
USR 15	1500	5	150	4.0V @ 400mA	500	SA	600	1500
USR 20	2000	5	150	5.5V @ 400mA	500	SB	500	1250
USR 25	2500	5	150	6.6V @ 400mA	500	SB	400	1000
USR 30	3000	5	150	7.7V @ 400mA	500	SC	400	1000
USR 35	3500	5	150	8.8V @ 200mA	500	SC	350	850
USR 40A	4000	5	150	9.9V @ 200mA	500	SD	300	750
USR 45A	4500	5	150	11.0V @ 100mA	500	SD	250	625
USR 50A	5000	5	150	13.0V @ 100mA	500	SD	250	625
USR 60A	6000	5	150	15.4V @ 100mA	500	SD	220	500
USR 70A	7000	5	150	17.6V @ 100mA	500	SE	220	500
USR 80A	8000	5	150	20.0V @ 100mA	500	SE	200	400
USR 100A	10000	5	150	24.0V @ 100mA	500	SE	200	400
USR 120A	12000	5	150	31.0V @ 100mA	500	SF	150	300
USR 150A	15000	5	150	33.0V @ 100mA	500	SF	150	300
USR 180A	18000	5	150	35.0V @ 100mA	500	SF	125	250

†Measured in a reverse recovery circuit switching from 10mA forward to 10mA reverse current recovering to 5mA.

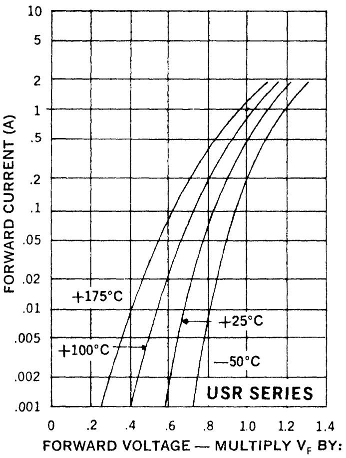
Reverse Recovery Circuit



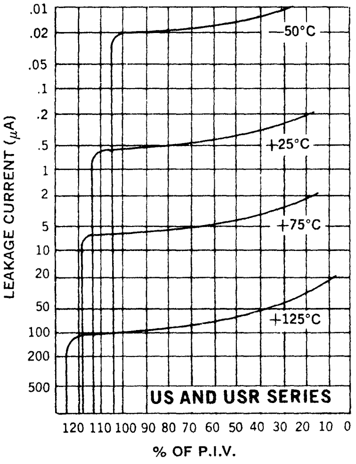
Typical Forward Current vs. Forward Voltage



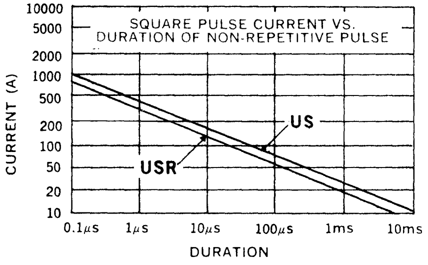
Typical Forward Current vs. Forward Voltage



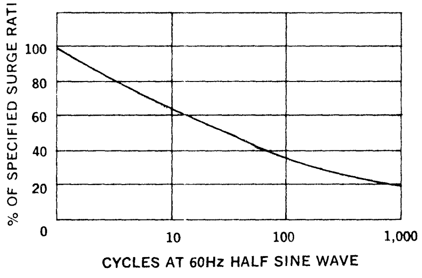
Typical Leakage Current vs. Voltage



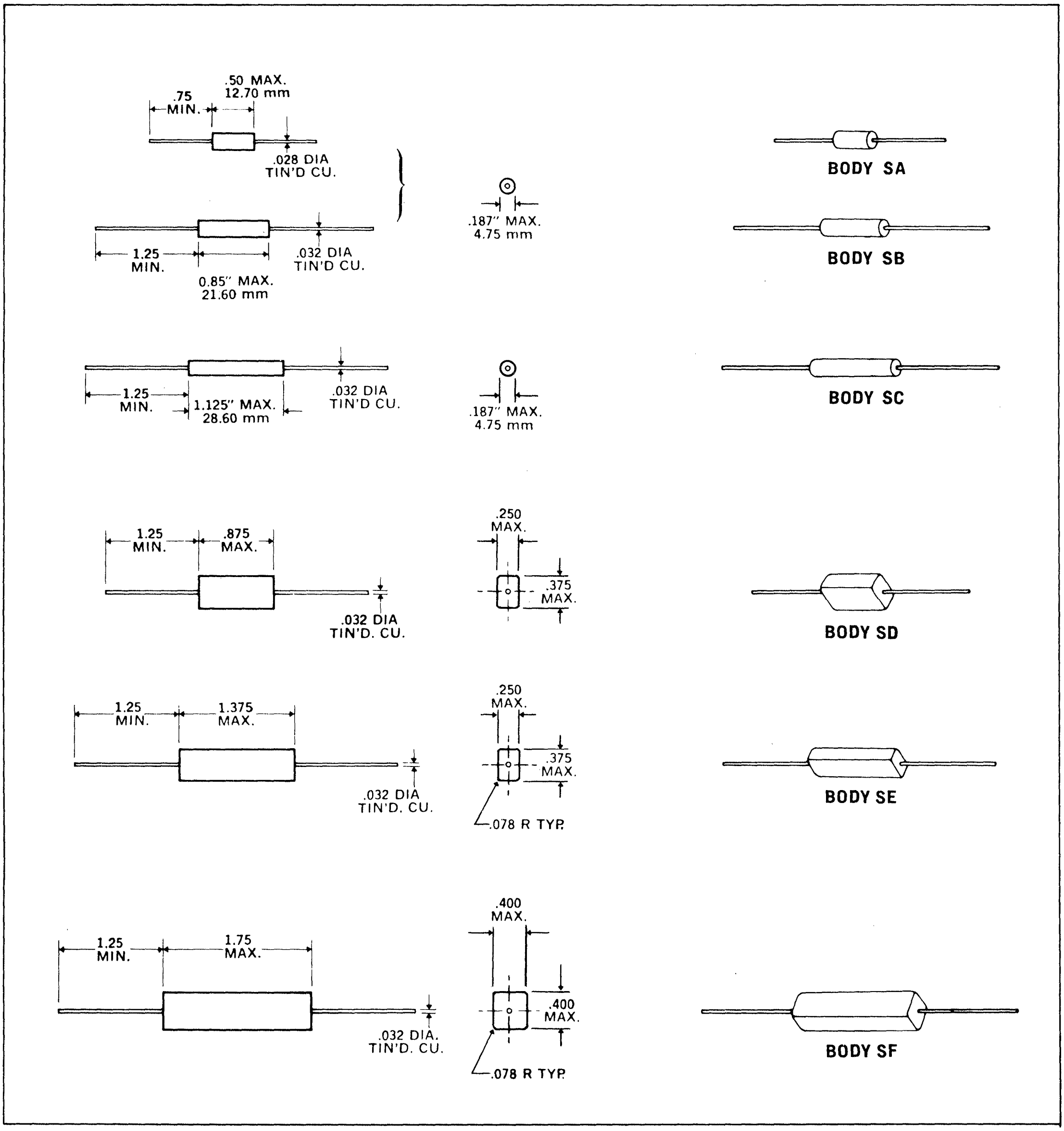
Forward Pulse Current vs Duration



Multiple Forward Surge Rating



MECHANICAL SPECIFICATIONS



HIGH VOLTAGE SILICON RECTIFIERS

MULTISTAC
Fast Recovery

VX15-50

FEATURES

- PIV: From 15kV to 50kV
- 250nS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

DESCRIPTION

The VX MULTISTAC silicon rectifier assemblies meet the stringent reliability requirements of commercial, industrial and military users through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life. The fast reverse recovery characteristics enhance applications in high frequency power conversion and control circuits.

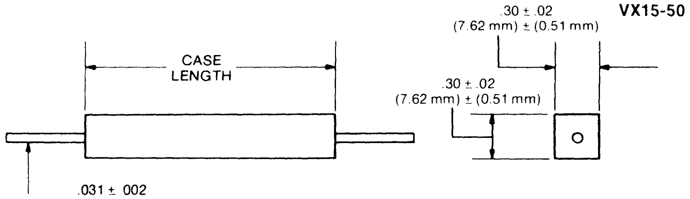
VII

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	15kV to 50kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3 mS	See Electrical Specifications
Operating Temperature Range	-55° C to +150° C
Storage Temperature Range	-65° C to +150° C

MECHANICAL SPECIFICATIONS

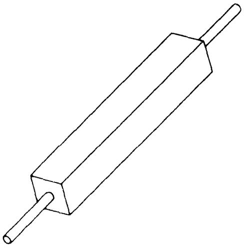
VX15-50



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
VX15	1.50 ± .03	38.10 ± 0.76
VX20, 25	2.00 ± .03	50.80 ± 0.76
VX30, 40, 50	2.50 ± .03	63.50 ± 0.76

Dimensions in inches and (millimeters)

SP

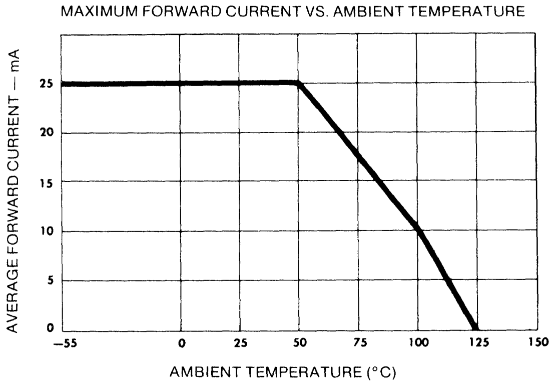


ELECTRICAL SPECIFICATIONS (@ 25°C unless noted)						MAXIMUM RATINGS			Case Length	
Maximum Reverse Recovery Time	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Junction Capacitance @ 100V	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS		
250nS	PIV	I_R		V_F	C_J	I_O		I_F (surge)		
Type	V	25°C	100°C	V	pF	50°C	100°C	A		
		µA	µA			mA	mA		Ins	MM
VX15	15000	0.1	10	24	1.0	25	10	2	1.50	38.10
VX20	20000	0.1	10	36	1.0	25	10	2	2.00	50.80
VX25	25000	0.1	10	36	1.0	25	10	2	2.00	50.80
VX30	30000	0.1	10	48	1.0	25	10	2	2.50	63.50
VX40	40000	0.1	10	48	1.0	25	10	2	2.50	63.50
VX50	50000	0.1	10	60	1.0	25	10	2	2.50	63.50

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

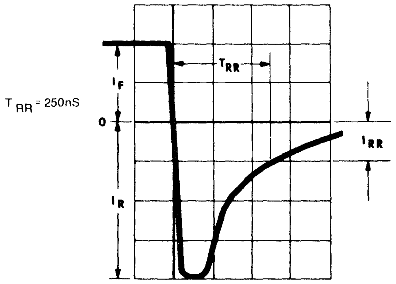
† The stated AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5 mm) from case for 5 seconds.

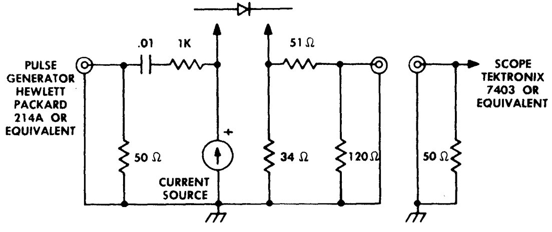


REVERSE RECOVERY TEST CONDITIONS: I_F = 12.5mA, I_R = 25mA, I_{RR} = 6.25mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE SILICON RECTIFIERS

MULTISTAC
Standard Recovery

FEATURES

- PIV: From 15kV-50kV
- 2μS Reverse Recovery
- High Surge Current Ratings
- Low Reverse Leakage
- Corona Free

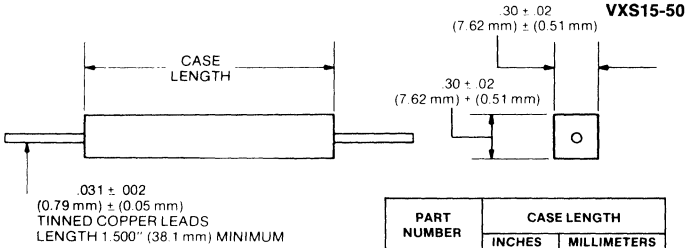
DESCRIPTION

The VXS MULTISTAC silicon rectifier assemblies meet the stringent reliability requirements of commercial, industrial and military users through the use of proprietary innovations in manufacturing technique. Cylindrical die construction and metallurgical bonds minimize electrical and mechanical stress, contributing to long life. The 2 microsecond reverse recovery time improves the circuit efficiency of power conversion and control systems.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	15 kV to 50 kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3 mS	See Electrical Specifications
Operating Temperature Range	-55° C to +150° C
Storage Temperature Range	-65° C to +150° C

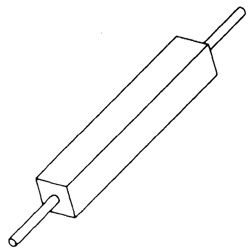
MECHANICAL SPECIFICATIONS



PART NUMBER	CASE LENGTH	
	INCHES	MILLIMETERS
VXS15	1.50 ± .03	38.10 ± 0.76
VXS20, 25	2.00 ± .03	50.80 ± 0.76
VXS30, 40, 50	2.50 ± .03	63.50 ± 0.76

Dimensions in inches and (millimeters)

SP



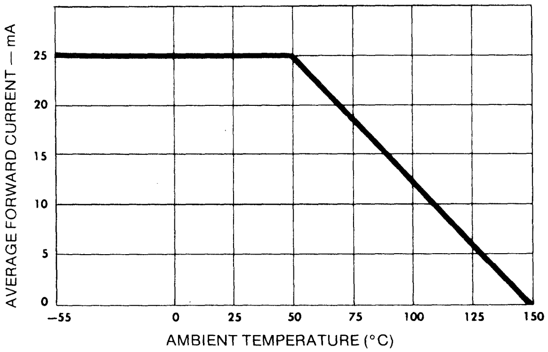
Type	ELECTRICAL SPECIFICATIONS (@ 25°C unless noted)						MAXIMUM RATINGS			Case Length	
	Peak Inverse Voltage*	Maximum Reverse Current @ PIV		Maximum Forward Voltage @ I_O	Maximum Reverse Recovery Time	Maximum Junction Capacitance @ 100 V	Maximum Average Rectified Current†		Maximum One Cycle Surge 8.3mS		
	PIV	I_R		V_F	T_{RR}	C_J	I_O		I_{F} (surge)		
		25°C	100°C				50°C	100°C			
	V	μA	μA	V	μS	pF	mA	mA	A	Ins	MM
VXS15	15000	0.1	10	24	2	1	25	12.5	2	1.50	38.10
VXS20	20000	0.1	10	36	2	1	25	12.5	2	2.00	50.80
VXS25	25000	0.1	10	36	2	1	25	12.5	2	2.00	50.80
VXS30	30000	0.1	10	48	2	1	25	12.5	2	2.50	63.50
VXS40	40000	0.1	10	48	2	1	25	12.5	2	2.50	63.50
VXS50	50000	0.1	10	60	2	1	25	12.5	2	2.50	63.50

*Operation and testing of devices over 10,000 V/inch may require re-encapsulation or immersion in a suitable dielectric material.

† The stated AVERAGE RECTIFIED CURRENT ratings require no heat sinking, special mounting or forced air across the body of the device.

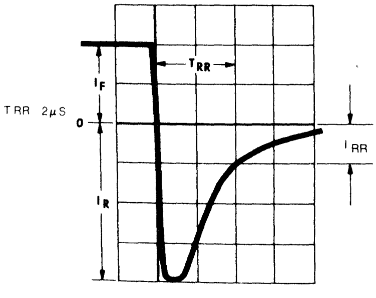
NOTE: Maximum lead temperature for soldering is 250°C 3/8" (9.5 mm) from case for 5 seconds.

MAXIMUM FORWARD CURRENT VS. AMBIENT TEMPERATURE

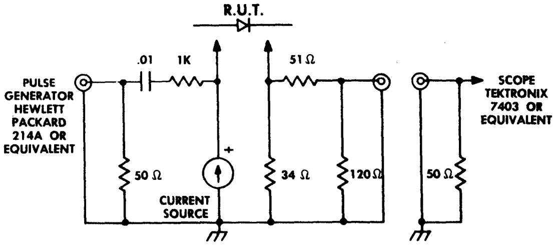


REVERSE RECOVERY TEST CONDITIONS: I_F = 12.5mA, I_R= 25mA, I_{RR}= 6.25mA

REVERSE RECOVERY WAVE FORM



REVERSE RECOVERY TEST CIRCUIT



HIGH VOLTAGE RECTIFIERS, RECTIFIER MODULES & MULTIPLIERS

PAGE	PART NUMBER	DESCRIPTION
		HIGH VOLTAGE RECTIFIER
366	1N3643 (HVE10)	1.0kV
366	1N3644 (HVE15)	1.5kV
366	1N3645 (HVE20)	2.0kV
366	1N3646 (HVE25)	2.5kV
366	1N3647 (HVE30)	3.0kV
*	1N3764	3.0kV
366	1N5181 (HVE40)	4.0kV
366	1N5182 (HVE50)	5.0kV
366	1N5183 (HVE75)	7.5kV
366	1N5184 (HVE100)	10kV
		RECTIFIER MODULE
357	1N5597, J	10kV
357	1N5600, J	5.0kV
357	1N5603, J	5.0kV
360	688-10	10kV
360	688-12	12kV
360	688-15	15kV
360	688-18	18kV
360	688-20	20kV
360	688-25	25kV
362	CAX15	15kV
362	CAX20	2.0kV
362	CAX25	25kV
362	CAX30	30kV
		HIGH VOLTAGE RECTIFIER
364	HA10	1.0kV
364	HA15	1.5kV
364	HA20	2.0kV
364	HA25	2.5kV
364	HA30	3.0kV
364	HA40	4.0kV
364	HA50	5.0kV
364	HA75	7.5kV
364	HA100	10kV
366	HS10	1.0kV
366	HS15	1.5kV
366	HS20	2.0kV
366	HS25	2.5kV
366	HS30	3.0kV
366	HS40	4.0kV
366	HS50	5.0kV
366	HS75	7.5kV
366	HS100	10kV
366	HVE10(1N3643)	1.0kV
366	HVE15(1N3644)	1.5kV
366	HVE20(1N3645)	2.0kV
366	HVE25(1N3646)	2.5kV
366	HVE30(1N3647)	3.0kV
366	HVE40(1N5181)	4.0kV
366	HVE50(1N5182)	5.0kV
366	HVE75(1N5183)	7.5kV
366	HVE100(1N5184)	10kV
368	HVF2500	2.5kV
368	HVF5000	5.0kV
368	HVF7500	7.5kV
368	HVF10000	10kV
368	HVF12500	12.5kV
368	HVF15000	15kV
368	HVF20000	20kV
368	HVF25000	25kV
370	HVFS2500	2.5kV
370	HVFS5000	5.0kV
		HIGH VOLTAGE RECTIFIER
370	HVFS7500	7.5kV
370	HVFS10000	10kV
370	HVFS12500	12.5kV
370	HVFS15000	15kV
370	HVFS17500	17.5kV
370	HVFS20000	20kV
372	HVH5000	5.0kV
372	HVH7500	7.5kV
372	HVH10000	10kV
372	HVH12500	12.5kV
372	HVH15000	15kV
372	HVH20000	20kV
372	HVH25000	25kV
374	HVHF5000	5.0kV
374	HVHF7500	7.5kV
374	HVHF10000	10kV
374	HVHF12500	12.5kV
374	HVHF15000	15kV
374	HVHF20000	20kV
374	HVHF25000	25kV
376	HVHJ15K	15kV
376	HVHJ20K	20kV
376	HVHJ22.5K	22.5kV
376	HVHJ25K	25kV
376	HVHJ30K	30kV
376	HVHJ35K	35kV
376	HVHJ37.5K	37.5kV
376	HVHJ40K	40kV
376	HVHJ45K	45kV
378	HVHS2500	2.5kV
378	HVHS5000	5.0kV
378	HVHS7500	7.5kV
378	HVHS10000	10kV
378	HVHS12500	12.5kV
378	HVHS15000	15kV
378	HVHS17500	17.5kV
378	HVHS20000	20kV
380	HVJX15K	15kV
380	HVJX20K	20kV
380	HVJX22.5K	22.5kV
380	HVJX25K	25kV
380	HVJX30K	30kV
380	HVJX35K	35kV
380	HVJX37.5	37.5kV
380	HVJX40K	40kV
380	HVJX45K	45kV
364	HVX10	1.0kV
364	HVX15	1.5kV
364	HVX20	2.0kV
364	HVX25	2.5kV
364	HVX30	3.0kV
364	HVX40	4.0kV
364	HVX50	5.0kV
364	HVX75	7.5kV
364	HVX100	10kV
382	KX15	1.5kV
382	KX20	2.0kV
382	KX25	2.5kV
382	KX30	3.0kV
382	KX40	4.0kV
382	KX50	5.0kV
382	KX60	6.0kV
382	KX80	8.0kV
382	KX100	10kV

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER MODULE
396	PMA203	7.5kV
396	PMA204	10kV
396	PMA205	15kV
396	PMA206	20kV
396	PMA207	25kV
396	PMA208	30kV
396	PMA201X	2.5kV
396	PMA202X	5.0kV
396	PMA203X	7.5kV
396	PMA204X	10kV
396	PMA205X	15kV
396	PMA206X	20kV
396	PMA207X	25kV
396	PMA208X	30kV
398	PME101	2.5kV
398	PME102	4.0kV
398	PME103	8.0kV
398	PME101X	2.5kV
398	PME102X	4.0kV
398	PME103X	8.0kV
		HIGH VOLTAGE RECTIFIER
400	SX10	1.0kV
400	SX15	1.5kV
400	SX20	2.0kV
400	SX25	2.5kV
400	SX30	3.0kV
400	SX40	4.0kV
400	SX50	5.0kV
400	SX60	6.0kV
400	SX80	8.0kV
400	SX100	10kV
400	SXS10	1.0kV
400	SXS15	1.5kV
400	SXS20	2.0kV
400	SXS25	2.5kV
400	SXS30	3.0kV
400	SXS40	4.0kV
400	SXS50	5.0kV
400	SXS60	6.0kV
400	SXS80	8.0kV
400	SXS100	10kV
		RECTIFIER MODULE
402	UDA5	5.0kV
402	UDA7.5	7.5kV
402	UDA10	10kV
402	UDA15	15.0kV
402	UDB2.5	2.5kV
402	UDB5	5.0kV
402	UDB7.5	7.5kV
402	UDC5	5.0kV
402	UDC7.5	7.5kV
402	UDC10	10kV
402	UDC15	15kV
402	UDD2.5	2.5kV
402	UDD5	5.0kV
402	UDD7.5	7.5kV
402	UDE2.5	2.5kV
402	UDE5	5.0kV
402	UDF2.5	2.5kV
402	UDF5	5.0kV
406	UFB2.5	2.5kV
406	UFB5	5.0kV
406	UFB7.5	7.5kV
406	UFS5	5.0kV

PAGE	PART NUMBER	DESCRIPTION
		RECTIFIER MODULE
406	UFS7.5	7.5kV
406	UFS10	10kV
409	UGB5	5.0kV
409	UGB7.5	7.5kV
409	UGB10	10kV
409	UGD5	5.0kV
409	UGD7.5	7.5kV
409	UGD10	10kV
409	UGE2.5	2.5kV
409	UGE5	5.0kV
409	UGE7.5	7.5kV
409	UGF2.5	2.5kV
409	UGF5	5.0kV
409	UGF7.5	7.5kV
413	US12	1.2kV
413	US15	1.5kV
413	US18	1.8kV
413	US20	2.0kV
413	US25	2.5kV
413	US30	3.0kV
413	US35	3.5kV
413	US40	4.0kV
413	US45A	4.5kV
413	US50A	5.0kV
413	US60A	6.0kV
413	US70A	7.0kV
413	US80A	8.0kV
413	US100A	10kV
413	US120A	12kV
413	US150A	15kV
413	US180A	18kV
413	US200A	20kV
406	USB2.5	2.5kV
406	USB5	5.0kV
406	USB7.5	7.5kV
406	USB10	10kV
413	USR12	1.2kV
413	USR15	1.5kV
413	USR18	1.8kV
413	USR20	2.0kV
413	USR25	2.5kV
413	USR30	3.0kV
413	USR35	3.5kV
413	USR40A	4.0kV
413	USR45A	4.5kV
413	USR50A	5.0kV
413	USR60A	6.0kV
413	USR70A	7.0kV
413	USR80A	8.0kV
413	USR100A	10kV
413	USR120A	12kV
413	USR150A	15kV
413	USR180A	18kV
406	USS5	5.0kV
406	USS7.5	7.5kV
406	USS10	10kV
406	USS15	15kV

*Contact Unitrode for specifications and ratings.

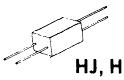
Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		HIGH VOLTAGE RECTIFIER
417	VX15	15kV
417	VX20	20kV
417	VX25	25kV
417	VX30	30kV
417	VX40	40kV
417	VX50	50kV
419	VXS15	15kV
419	VXS20	20kV
419	VXS25	25kV
419	VXS30	30kV
419	VXS40	40kV
419	VXS50	50kV

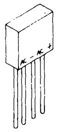
*Contact Unitrode for specifications and ratings.
Legend: J — JAN JTX — JANTX JTXV — JANTXV

RECTIFIER BRIDGES

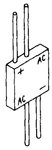
Single Phase Full-Wave Bridges



HJ, HK, HL, HM, HN, HO, HP



S



G, GA, GH

STANDARD RECOVERY

Peak Inverse Voltage Per Leg	AVERAGE D.C. OUTPUT CURRENT					
	≤.25A	.25—.75A	.75—1.5A	1.5—2.5A	4—10A	10—25A
100V			673-1 **G or S**	697-1 **GA**	680-1 **NA**	679-1 **NB** SPA-25* **MC**
200V			673-2 **G or S**	697-2 **GA**	680-2 **NA** 469-1** **MD**	679-2 **NB** SPB-25* **MC**
300V			673-3 **G or S**	697-3 **GA**	680-3 **NA**	679-3 **NB**
400V			673-4 **G or S**	697-4 **GA**	680-4 **NA** 469-2** **MD**	679-4 **NB** SPC-25* **MC**
500V			673-5 **G or S**	697-5 **GA**	680-5 **NA**	679-5 **NB**
600V			673-6 **G or S**	697-6 **GA**	680-6 **NA** 469-3** **MD**	679-6 **NB** SPD-25* **MC**
1.2kV		673-7 **GH**				
1.8kV		673-75 **HJ**				
2.4kV		673-8 **HK**				
2.5kV				(PMC101) **PMA**	(PMC201) **PMA**	
3.0kV		673-85 **HL**				
3.6kV	673-9 **HM**					
4.0kV						
4.2kV	673-10 **HN**					
4.8kV	673-11 **HO**					
5.0kV	673-12 **HO**			(PMC102) **PMA**	(PMC202) **PMA**	
7.5kV				(PMC103) **PMA**	(PMC203) **PMA**	
10kV				(PMC104) **PMA**		
15kV				(PMC105) **PMA**		

*Available as JAN

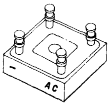
**Available as JAN, JANTX

Parentheses ( ) designates product using stacked chips

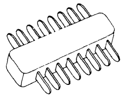
RECTIFIER BRIDGES

Single Phase Full-Wave Bridges

NA, NB



MA, MB, MC, MD



PMA

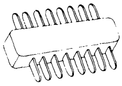
FAST RECOVERY

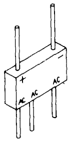
Peak Inverse Voltage Per Leg	AVERAGE D.C. OUTPUT CURRENT							
	≤.25A	.25–.75A	.75–1.5A	1.5–2.5A	4–10A	10–25A		25–35A
50V							803-1 **MB**	802-1 **MA**
100V			676-1 **G or S**	698-1 **GA**	684-1 **NA**	683-1 **NB**	803-2 **MB**	802-2 **MA**
125V							803-3 **MB**	802-3 **MA**
150V							803-4 **MB**	802-4 **MA**
200V			676-2 **G or S**	698-2 **GA**	684-2 **NA**	683-2 **NB**		
300V			676-3 **G or S**	698-3 **GA**	684-3 **NA**	683-3 **NB**		
400V			676-4 **G or S**	698-4 **GA**	684-4 **NA**	683-4 **NB**		
500V			676-5 **G or S**	698-5 **GA**	684-5 **NA**	683-5 **NB**		
600V			676-6 **G or S**	698-6 **GA**	684-6 **NA**	683-6 **NB**		
1.2kV		676-12 **HJ**						
1.8kV		676-18 **HK**						
2.4kV		676-24 **HL**						
2.5kV				(PMC101X) **PMA**	(PMC201X) **PMA**			
3.0kV		676-30 **HM**						
3.6kV	676-36 **HN**							
4.0kV								
4.2kV	676-42 **HO**							
4.8kV	676-48 **HP**							
5.0kV	676-50 **HP**			(PMC102X) **PMA**	(PMC202X) **PMA**			
7.5kV				(PMC103X) **PMA**	(PMC203X) **PMA**			
10kV				(PMC104X) **PMA**				
15kV				(PMC105X) **PMA**				
Reverse Recovery Time (max.)	500nS	500nS	500nS	500nS (X)250nS	500nS (X)250nS	500nS	50nS	50nS

Parentheses ( ) designates product using stacked chips

RECTIFIER BRIDGES

Three Phase Full-Wave Bridge


PMA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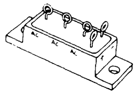
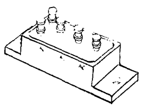

NC


ME

NDARD RECOVERY

eak verse ltage r Leg	AVERAGE D.C. OUTPUT CURRENT			
	1—3A	4.5—15A	15—25A	
50V				
00V	700-1 **F**	695-1 **NC**	678-1 **NC**	
25V				
50V				
00V	700-2 **F**	695-2 **NC**	678-2 **NC**	483-1* **ME**
00V	700-3 **F**	695-3 **NC**	678-3 **NC**	
00V	700-4 **F**	695-4 **NC**	678-4 **NC**	483-2* **ME**
00V	700-5 **F**	695-5 **NC**	678-5 **NC**	
00V	700-6 **F**	695-6 **NC**	678-6 **NC**	483-3* **ME**
5kV	(PMD101) **PMA**	(PMD201) **PMA**		
0kV	(PMD102) **PMA**	(PMD202) **PMA**		
5kV	(PMD103) **PMA**			
0kV	(PMD104) **PMA**			

able as JANTX

heses (   ) designates product using stacked chips

FAST RECOVERY

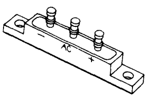
Peak Inverse Voltage Per Leg	AVERAGE D.C. OUTPUT CURRENT				
	1—3A	4.5—15A	15—25A		25—40A
50V				801-1 **ME**	800-1 **ME**
100V	701-1 **F**	696-1 **NC**	682-1 **NC**	801-2 **ME**	800-2 **ME**
125V				801-3 **ME**	800-3 **ME**
150V				801-4 **ME**	800-4 **ME**
200V	701-2 **F**	696-2 **NC**	682-2 **NC**		
300V	701-3 **F**	696-3 **NC**	682-3 **NC**		
400V	701-4 **F**	696-4 **NC**	682-4 **NC**		
500V	701-5 **F**	696-5 **NC**	682-5 **NC**		
600V	701-6 **F**	696-6 **NC**	682-6 **NC**		
2.5kV	(PMD101X) **PMA**	(PMD201X) **PMA**			
3.0kV	(PMD102X) **PMA**	(PMD202X) **PMA**			
4.0kV	(PMD103X) **PMA**				
5.0kV	(PMD104X) **PMA**				
Reverse Recovery Time (max.)	500nS (X)250nS	500nS (X)250nS	500nS	50nS	50nS

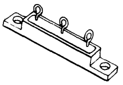
Parentheses (   ) designates product using stacked chips

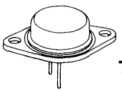
RECTIFIER BRIDGES

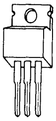
Doublers and Center-Tap Rectifiers

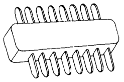
PRODUCT SELECTION GUIDE


MF


ND


TO-3


TO-220


PMA

Peak Inverse Voltage Per Leg	**SCHOTTKY**	**STANDARD RECOVERY**		**FAST RECOVERY**		**SUPER FAST RECOVERY**		**ULTRA-FAST RECOVERY**		
	AVERAGE D.C. OUTPUT CURRENT									
	30A	0—2A	2—15A	1—2A	2—15A	1—16A	25A	1—16A	20A	30A
20V	USD320C* **TO-3**									
35V	USD335C* **TO-3**									
45V	USD345C* SD241* **TO-3**									
50V						SES5401C* **TO-220**	SES5601C* **TO-3**	UES2401C* **TO-220**	804-1 **MF**	UES2601 **TO-3**
100V			681-1 **ND**		689-1 **ND**	SES5402C* **TO-220**	SES5602C* **TO-3**	UES2402* **TO-220**	804-2 **MF**	UES2602 **TO-3**
125V									804-3 **MF**	
150V						SES5403C* **TO-220**	SES5603C* **TO-3**	UES2403* **TO-220**	804-4 **MF**	UES2603 **TO-3**
200V			681-2 **ND**		689-2 **ND**					UES2604 **TO-3**
300V			681-3 **ND**		689-3 **ND**					UES2605 **TO-3**
400V			681-4 **ND**		689-4 **ND**					UES2606 **TO-3**
500V			681-5 **ND**		689-5 **ND**					
600V			681-6 **ND**		689-6 **ND**					
2.5kV		(PMB101) (PMB201) **PMA**		(PMB101X) (PMB201X) **PMA**						
5kV		(PMB102) (PMB202) **PMA**		(PMB102X) (PMB202X) **PMA**						
7.5kV		(PMB103) (PMB203) **PMA**		(PMB103X) (PMB203X) **PMA**						
10kV		(PMB104) (PMB204) **PMA**		(PMB104X) (PMB204X) **PMA**						
15kV		(PMB105) (PMB205) **PMA**		(PMB105X) (PMB205X) **PMA**						
20kV		(PMB106) **PMA**		(PMB106X) **PMA**						
30kV		(PMB107) **PMA**		(PMB107X) **PMA**						
Reverse Recovery Time (max.)				250nS	500nS	100nS	100nS	35nS	50nS	35-50nS

*Center-tap only

Parentheses ( ) designates product using stacked chips

RECTIFIER ASSEMBLIES
Single Phase Bridges, 10 Amp, Military Approved

JAN & JANTX 469-1
JAN & JANTX 469-2
JAN & JANTX 469-3

FEATURES
- Qualified to MIL-S-19500/469
- Current Rating: to 10A
- PIV: from 200 to 600V
- Surge Ratings: to 100A
- Only Fused-in-Glass Diodes Used
- Controlled Avalanche Characteristics
- Aluminum Heat Sink Case, Electrically Insulated

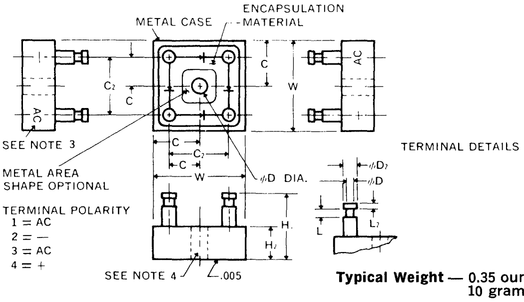
DESCRIPTION
This series of military high-current single-phase bridge offer the utmost in reliability as required in military system designs. The TX series is assembled with diodes which have been subjected to 100% screening tests.

ABSOLUTE MAXIMUM RATINGS
Peak Inverse Voltage	200 to 600V
Maximum Average D.C. Output Current	
@ $T_C = +55°C$	10A
@ $T_C = +100°C$	6A
Non-Repetitive Sinusoidal Surge (8.3ms)	
@ $T_C = +55°C$	100A
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient	25°C/W
Junction to Case	5°C/W

Ltr	Dimensions			
	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
C_1	.367	.375	9.32	9.53
C_2	.350	.450	8.89	11.43
C_3	.175	.225	4.45	5.72
ϕD_1	.139	.149	3.53	3.78
ϕD_2	.091	.101	2.31	2.57
ϕD_3	.066	.076	1.68	1.93
H_1		.570		14.48
H_2		.370		9.40
L_1	.088	.098	2.24	2.49
L_2	.020	.030	.51	.76
W	.735	.750	18.67	19.05

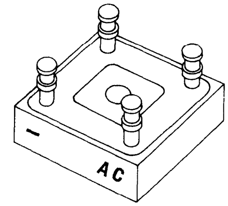
MECHANICAL SPECIFICATIONS

JAN & JANTX 469-1, JAN & JANTX 469-2, JAN & JANTX 469-3



See table above

Typical Weight — 0.35 ounces
10 grams



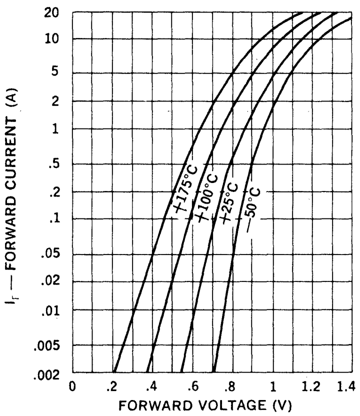
NOTES:
1. Metric equivalents (to the nearest .01 mm) are given for general information only and are based upon 1 inch = 25.4 mm.
2. Terminals shall be tinned.
3. Polarity shall be marked on the bridge body adjacent to terminals. Terminal numbers are for reference and do not have to be marked on the bridge; however, terminal (1) shall be indicated by a mechanical index such as a line, flattened corner, etc., visible from the top (terminal surface) of the device.
4. Point at which T_C is read shall be in metal part of a case as shown on drawing.

Electrical Specification (at 25°C unless noted)

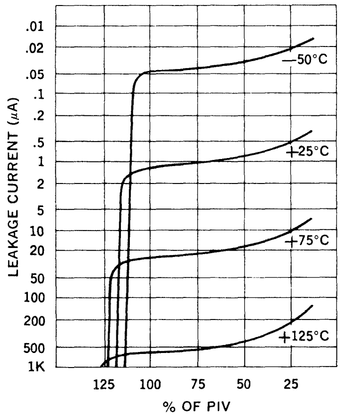
Type	PIV Per Leg	Minimum Reverse Breakdown Voltage Per Leg @ 50μA	Maximum Forward Voltage Drop Per Leg*	Maximum Reverse Recovery Time†	Maximum Leakage Current Per Leg @ PIV	
					$T_C = 25°C$	$T_C = 100°C$
	Volts	Volts		μS	μA	μA
JAN & JANTX 469-1 JAN & JANTX 469-2 JAN & JANTX 469-3	200 400 600	240 460 660	1.35V @ 15.7A(pk)	2	2	125

*Maximum forward voltage drop is measured at a pulse width of 8.3ms.
†Measured in a reverse-recovery circuit switching from 0.5A forward to 1.0A reverse current recovering to 0.25A.

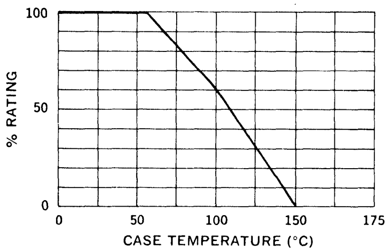
Typical Forward Voltage Per Leg vs. Forward Current

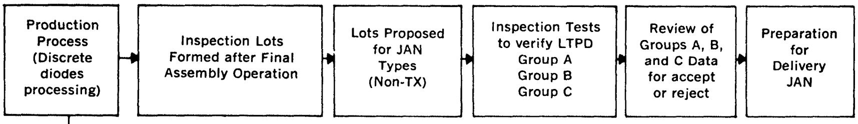


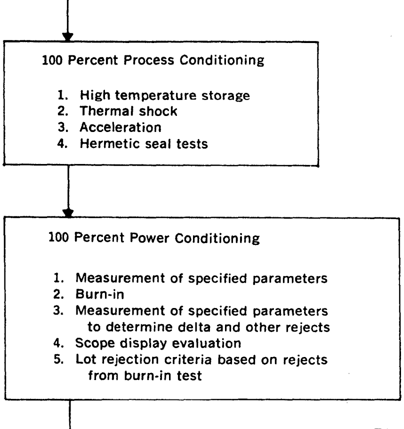
Typical Leakage Current vs. PIV

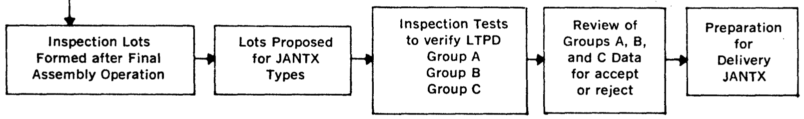


Current Derating Curve

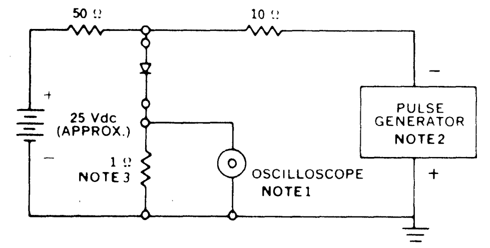








Reverse-Recovery Circuit



NOTES:
1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIER ASSEMBLIES
Three Phase Bridges, 25 Amp, Military Approved

JANTX 483-1
JANTX 483-2
JANTX 483-3

FEATURES
- Qualified to MIL-S-19500/483
- Current Rating: 25A
- PIV: from 200 to 600V
- Surge Ratings: 150A
- Only Fused-in-Glass Diodes Used
- Controlled Avalanche Characteristics
- Aluminum Heat Sink Case, Electrically Insulated

DESCRIPTION
This military high-current three phase bridge series is assembled with diodes which have been subjected to TX type screening tests. This series of bridges offers the utmost in high reliability as normally required in military system design.

ABSOLUTE MAXIMUM RATINGS

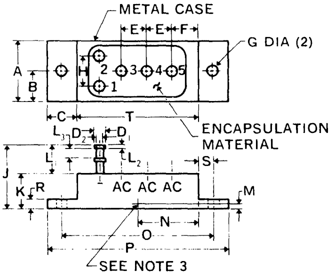
Peak Inverse Voltage	200 to 600V
Maximum Average D.C. Output Current	
@ $T_C = 55°C$	25A
@ $T_C = 100°C$	18.5A
Non-Repetitive Sinusoidal Surge (8.3ms)	
@ $T_C = 55°C$	150A
Operating and Storage Temperature Range	−65°C to +150°C
Thermal Resistance Junction to Ambient	20°C/W
Junction to Case	2.5°C/W

DIMENSIONS				
LTR	INCH		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.730	.770	18.54	19.56
B	.355	.395	9.02	10.03
C	.355	.395	9.02	10.03
D_1	.141	.151	3.58	3.84
D_2	.108	.118	2.74	3.00
E	.355	.395	9.02	10.03
F	.230	.270	5.84	6.86
G	.149	.189	3.78	4.80
H	.355	.395	9.02	10.03
J		.82		20.83
K	.39	.51	9.91	12.95
L_1	.240	.320	6.10	8.13
L_2	.015	.030	.38	.76
L_3	.100	.125	2.54	3.18
M	.040	.060	1.02	1.52
N	.72	.78	18.29	19.81
O	1.84	1.90	46.74	48.26
P	2.22	2.28	56.39	57.91
R	.09	.15	2.29	3.81
S	.168	.208	4.27	5.28
T	1.47	1.53	37.34	38.86

VIII

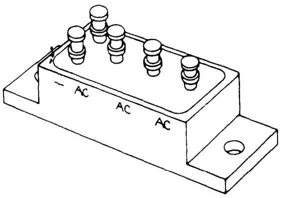
MECHANICAL SPECIFICATIONS

JANTX 483-1 JANTX 483-2 JANTX 483-3



See Table Above

Typical Weight — 1.0 ounces
30 grams



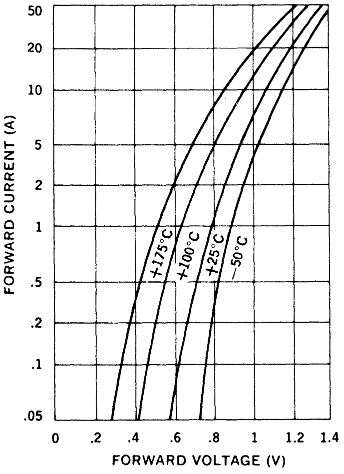
NOTES:
1. Terminals shall be tinned.
2. Polarity shall be marked as shown on drawing.
3. Point at which T_C is read (shall be in metal part of case).

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

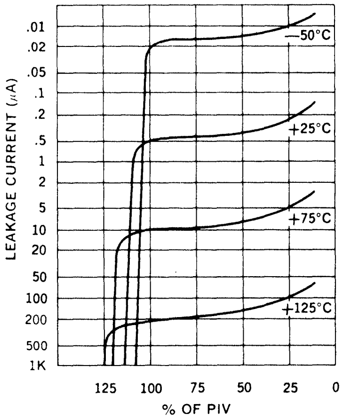
Type	PIV Per Leg	Breakdown Voltage Per Leg @ 50μA	Maximum Forward Voltage Drop Per Leg*	Maximum Leakage Current Per Leg @ PIV	
				$T_C = 25°C$	$T_C = 100°C$
	Volts	Volts		μA	μA
JAN 483-1	200	240	1.3V @ 39A (pk)	2	200
JAN 483-2	400	480			
JAN 483-3	600	660			

* Maximum forward voltage drop is measured at a pulse width of 8.3ms, duty cycle ⩽2%.

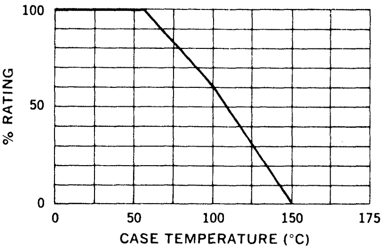
Typical Forward Voltage Per Leg vs. Forward Current

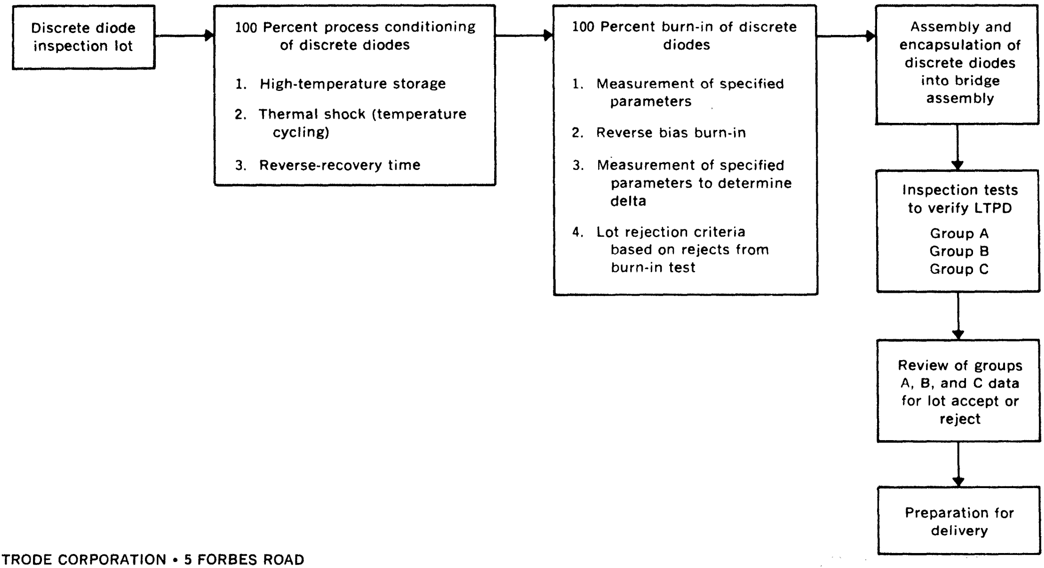


Typical Leakage Current vs. PIV



Current Derating Curve





RECTIFIER ASSEMBLIES

Single Phase Bridges, 1.5Amp, Standard and Fast Recovery

673, 676 SERIES

FEATURES

- Miniature Package
- Surge Ratings: to 25A
- PIV's: from 100 to 600V
- Recovery Times: to 500ns
- Controlled Avalanche Characteristics
- Only Fused-in-Glass Diodes Used

DESCRIPTION

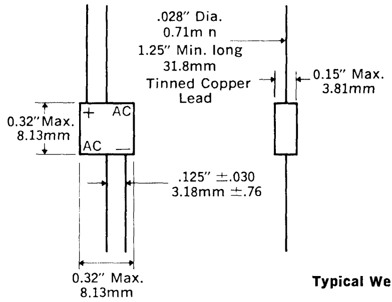
These miniature transfer-molded single-phase power bridges are designed for universal application in power supplies. One basic bridge assembly comes in a choice of lead configurations for mounting in wired chassis or on printed boards.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	100 to 600V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3mS)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient	50°C/W

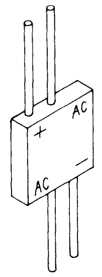
MECHANICAL SPECIFICATIONS

673, 676 SERIES

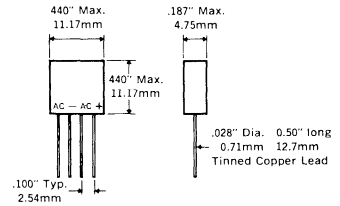


Typical Weight G: 0.05 ounces
1.4 grams

G BODY



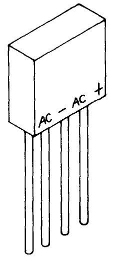
673, 676 SERIES



When specifying S body, add suffix S i.e., 673-1S

Typical Weight S: 0.11 ounces
3.1 grams

S BODY



MARKING

Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative	—

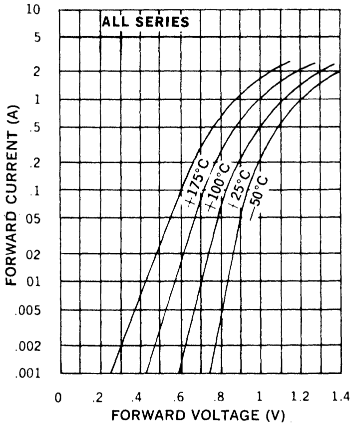
Part number is printed on the body.

UNITRODE

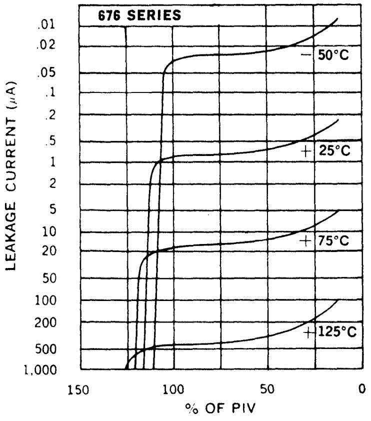
Electrical Specifications (at 25°C unless noted)							Maximum Ratings	
Type		PIV Per Leg	Maximum Forward Drop Per Leg	Leakage Current Per Leg		Maximum Reverse Recovery Time†	Maximum Average D.C. Output Current $T_A = 25°C$	Non-Repetitive Sinusoidal Surge (8.3mS)
				$T_A = 25°C$	$T_A = 100°C$			
		Volts		μA	μA	ns	Amps	Amps
Standard Recovery	673-1	100	1.1V @ 1.0A	2	100	—	1.5	25
	673-2	200						
	673-3	300						
	673-4	400						
	673-5	500						
	673-6	600						
Fast Recovery	676-1	100	1.1V @ 0.5A	3	150	500	1.0	20
	676-2	200						
	676-3	300						
	676-4	400						
	676-5	500						
	676-6	600						

†Measured in a reverse recovery circuit switching from 10mA forward to 10mA reverse current recovering to 5mA.

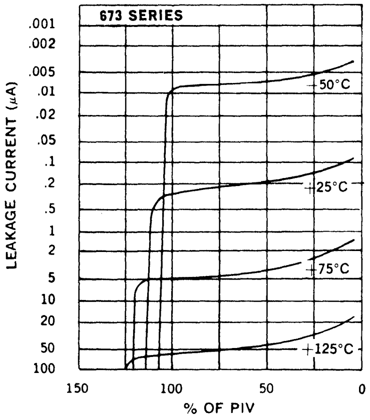
Typical Forward Voltage Per Leg vs. Forward Current



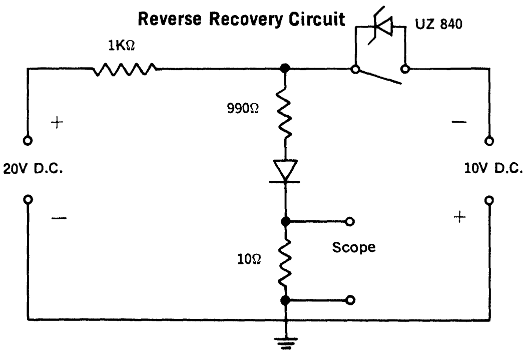
Typical Leakage Current vs. PIV



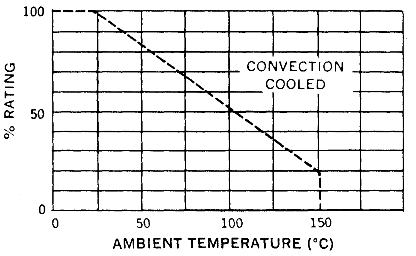
Typical Leakage Current vs. PIV



Reverse Recovery Circuit



Current Derating Curve



RECTIFIER ASSEMBLIES

Single Phase Bridges, High Voltage 0.125-0.6 Amp, Standard and Fast Recovery

673, 676 SERIES
(1200-5000V)

FEATURES

- Miniature High Voltage Bridges
- Continuous Ratings: to 0.6A
- Surge Ratings: to 15A
- PIV's: from 1200 to 5000V
- Recovery Times: to 500ns
- Controlled Avalanche Characteristics
- Only Fused in Glass Diodes Used

DESCRIPTION

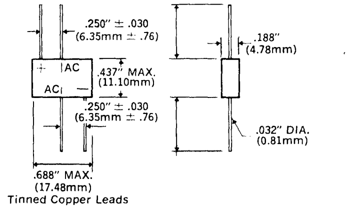
These miniature molded high-voltage single phase bridges are designed for universal application in power supplies. The miniature package is shatterproof and is capable of handling extremes in temperature, vibration and shock. These bridges, therefore are ideally suited for miniaturized, tightly packaged equipment operating in extreme environments.

ABSOLUTE MAXIMUM RATINGS

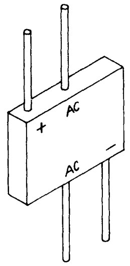
Peak Inverse Voltage	1200 to 5000V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	−65°C to +150°C
Thermal Resistance Junction-to-Ambient	50°C/W

MECHANICAL SPECIFICATIONS

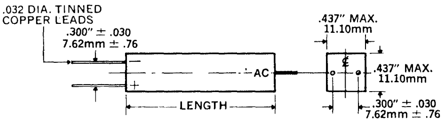
673-7



Body H



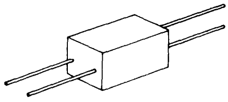
673, 676 SERIES



MAX. LENGTHS

J	K	L	M	N	O	P
.562" 14.27mm	.688" 17.48mm	.875" 22.23mm	1.125" 28.58mm	1.25" 31.75mm	1.375" 34.92mm	1.625" 41.28mm

BODY J through P



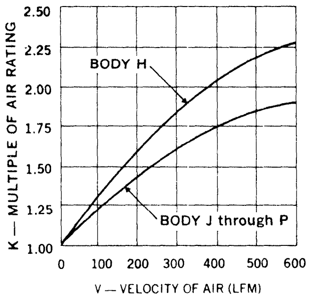
MARKING

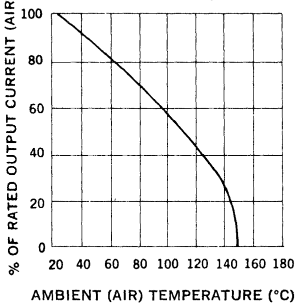
Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative Output	—

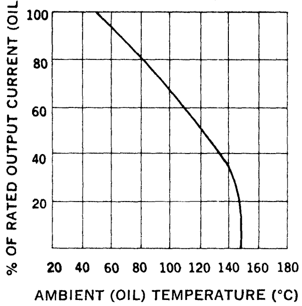
Part number is printed on the body.

Type		Electrical Specifications at 25°C						Maximum Ratings		
		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Leakage Current Per Leg @ PIV		Maximum Reverse Recovery Time*	Body Size	Maximum Average D.C. Output Current		Non-repetitive Sinusoidal Surge (8.3ms)
				$T_A = 25°C$	$T_A = 100°C$			$T_A = 25°C$ Air	$T_A = 50°C$ Oil	
		Volts		μA	μA	ns		Amps	Amps	Amps
Standard Recovery	673-7	1200	2.2V @ 0.4A	2	100		H	0.6	1.5	15
	673-75	1800	3.3V @ 0.4A				J	0.5	1.25	
	673-8	2400	4.4V @ 0.4A				K	0.4	1.0	
	673-85	3000	5.5V @ 0.3A				L	0.3	0.75	
	673-9	3600	6.6V @ 0.2A				M	0.2	0.5	
	673-10	4200	7.7V @ 0.2A				N	0.18	0.45	
	673-11	4800	8.8V @ 0.15A				O	0.16	0.4	
	673-12	5000	9.0V @ 0.15A				O	0.16	0.4	
Fast Recovery	676-12	1200	3.3V @ 0.3A	5	150	500	J	0.4	1.0	10
	676-18	1800	4.4V @ 0.2A				K	0.35	0.85	
	676-24	2400	5.5V @ 0.2A				L	0.325	0.8	
	676-30	3000	7.7V @ 0.2A				M	0.25	0.625	
	676-36	3600	8.8V @ 0.15A				N	0.175	0.425	
	676-42	4200	9.9V @ 0.15A				O	0.15	0.375	
	676-48	4800	11V @ 0.15A				P	0.135	0.325	
	676-50	5000	11V @ 0.15A				P	0.125	0.3	

†Measured in a reverse recovery circuit switching from 10mA forward to 10mA reverse current recovering to 5mA.

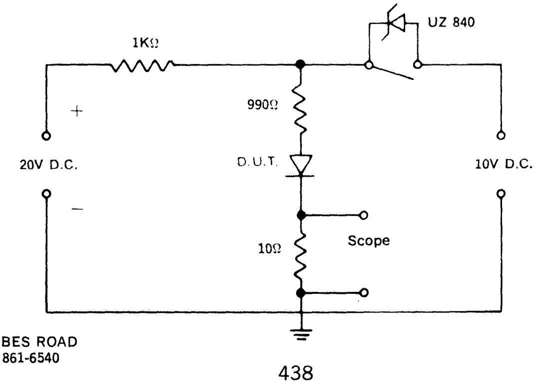

Output Current Ratio vs Velocity of Air Flow

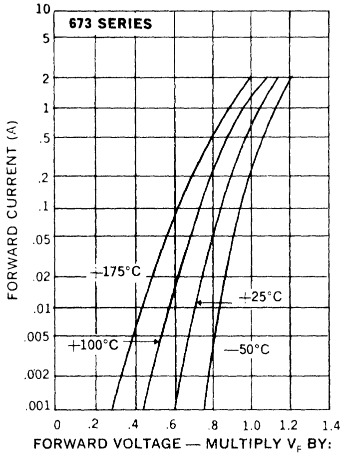

Output Current vs Ambient (Air) Temperature


Output Current vs Ambient (Oil) Temperature

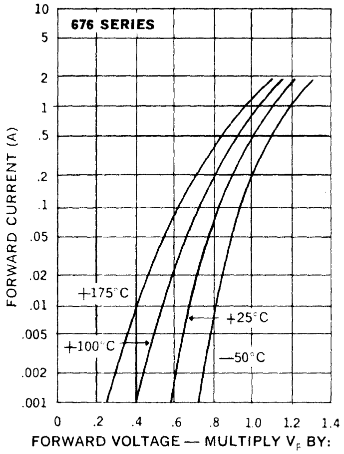
Application example: The rectifier is to be used in a cabinet at 60°C with ambient air moving at 400 LFM. The rating is reduced (Fig. 2) by a factor of 0.81 due to the elevated temperature, but is enhanced by 2.X (Fig. 1) due to the air flow. Hence the DC output current is 0.81 x 2, or 1.6 times the 25°C air rating.

Reverse-Recovery Circuit

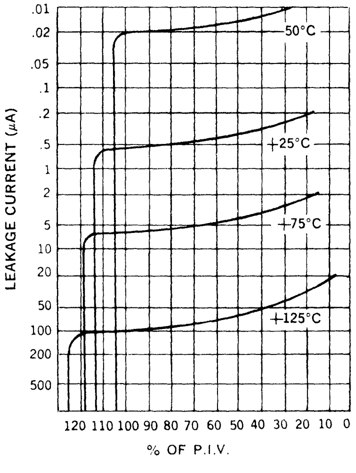




Typical Forward Voltage vs Forward Current



Typical Forward Voltage vs Forward Current



Typical Leakage Current vs. Voltage

RECTIFIER ASSEMBLIES

Three Phase Bridges, 15-25 Amp, Standard and Fast Recovery Magnum®

678, 682, 695 696 SERIES

FEATURES

- Current Rating: to 25A
- PIVs: from 100 to 600V
- Only Fused-in-Glass Diodes Used
- Recovery Times: to 500ns
- Controlled Avalanche Characteristics
- Surge Ratings: to 150A
- Aluminum Heat Sink Case, Electrically Insulated

DESCRIPTION

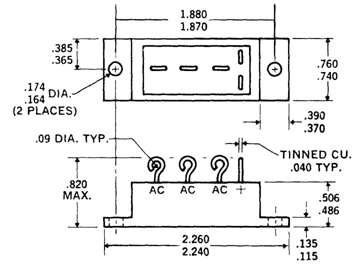
This series of three phase MAGNUM® bridges offer the ultimate in high current power supply applications. The fast recovery series allows operation at full power at high frequencies (up to 40KHz squarewave), often used in choppers, inverters and converters in aircraft, missiles, etc., equipment.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	100 to 600V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient, All Series	20°C/W
Junction to Case, 678, 682 Series	1.5°C/W
Junction to Case, 695, 696 Series	3.0°C/W

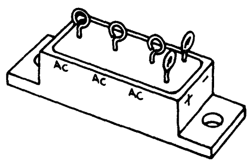
MECHANICAL SPECIFICATIONS

678, 682, 695, 696 SERIES



Dimensions in inches.

Typical Weight — 30 grams



MARKING

Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative	—

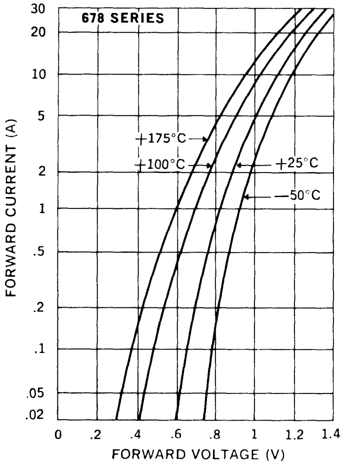
Part number is printed on the body.

Magnum® is a registered trademark of Unitrode Corporation

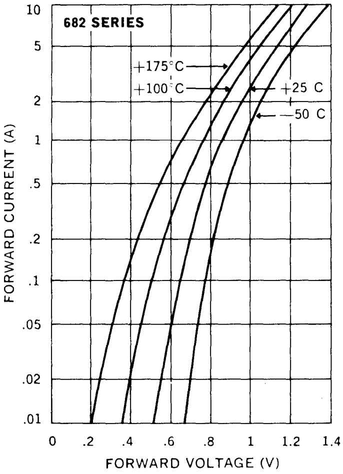
Electrical Specifications (at 25°C unless noted)							Maximum Ratings		
Type		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Maximum Leakage Current Per Leg @ PIV		Maximum Reverse Recovery Time*	Maximum Average D.C. Output Current		Non-Repetitive Sinusoidal Surge (8.3ms)
				$T_A = 25°C$	$T_A = 100°C$		$T_C = 55°C$	$T_C = 100°C$	$T_A = 100°C$
		Volts		µA	µA	ns	Amps	Amps	Amps
Standard Recovery	678-1	100	1.2V @ 10A	10	200	—	25	18.5	150
	678-2	200							
	678-3	300							
	678-4	400							
	678-5	500							
	678-6	600							
Standard Recovery	695-1	100	1.2V @ 2A	5	150	—	15	9	80
	695-2	200							
	695-3	300							
	695-4	400							
	695-5	500							
	695-6	600							
Fast Recovery	682-1	100	1.2V @ 6A	10	200	500	20	14	150
	682-2	200							
	682-3	300							
	682-4	400							
	682-5	500							
	682-6	600							
Fast Recovery	696-1	100	1.2V @ 2A	5	150	500	15	9	60
	696-2	200							
	696-3	300							
	696-4	400							
	696-5	500							
	696-6	600							

*Measured in a reverse recovery circuit switching from 1.0A forward to 1.0A reverse current recovering to 0.5A.

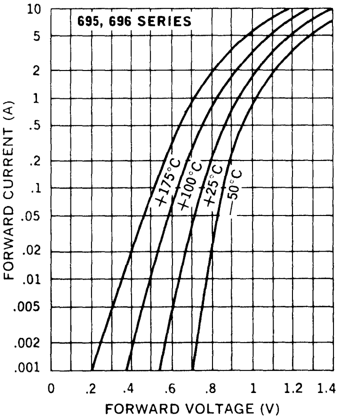
Typical Forward Voltage Per Leg vs. Forward Current



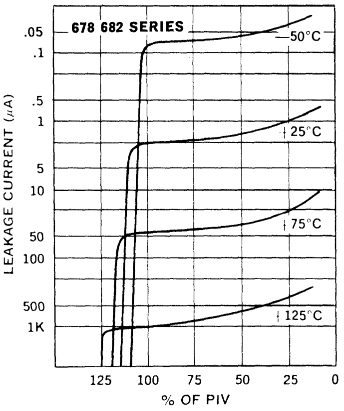
Typical Forward Voltage Per Leg vs. Forward Current



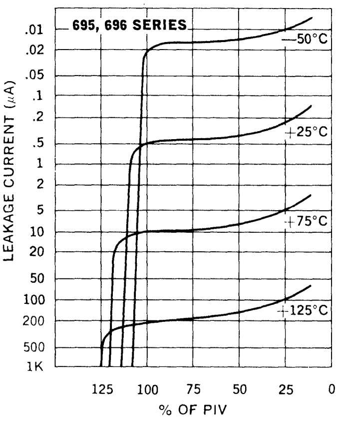
Typical Forward Voltage Per Leg vs. Forward Current



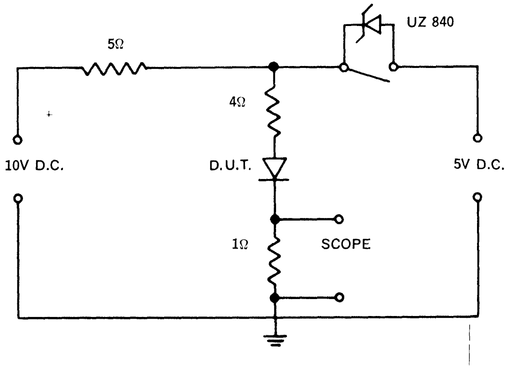
Typical Leakage Current vs. PIV



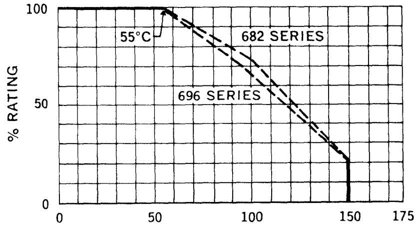
Typical Leakage Current vs. PIV



Reverse Recovery Circuit

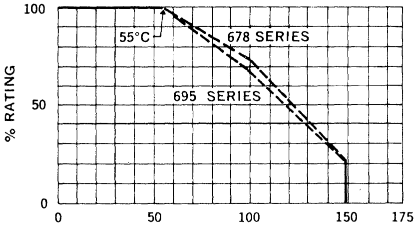


Current Derating Curve



Fast Recovery Series

Current Derating Curve



Standard Recovery Series

RECTIFIER ASSEMBLIES

679, 680, 683, 684 SERIES

Single Phase Bridges, 10-25 Amp, Standard and Fast Recovery Magnum™

FEATURES

- Current Ratings: to 25A
- Recovery Time: to 500ns
- PIVs: from 100 to 600V
- Surge Ratings: to 150A
- Only Fused-in-Glass Diodes Used
- Controlled Avalanche Characteristics
- Aluminum Heat Sink Case, Electrically Insulated

DESCRIPTION

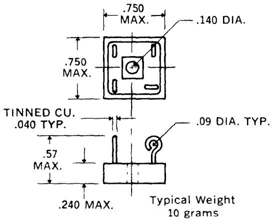
This series of single phase MAGNUM™ bridge offers the designer the ultimate in high current power supply applications. The fast recovery series allows operation at full power at high frequencies, up to 40kHz square wave, which is often used in chopper, inverters and converters in aircraft, missiles, etc., equipment.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	100 to 600V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient, 679, 683 Series	20°C/W
Junction to Ambient, 680, 684 Series	25°C/W
Junction to Case, 679, 683 Series	2.0°C/W
Junction to Case, 680, 684 Series	4.0°C/W

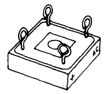
MECHANICAL SPECIFICATIONS

680, 684 SERIES

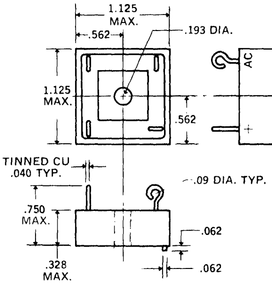


Dimensions in inches.

Typical Weight — 0.35 ounces
10 grams

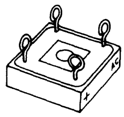


679, 683 SERIES



Dimensions in inches.

Typical Weight — 0.7 ounces
20 grams



MARKING

Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative	—

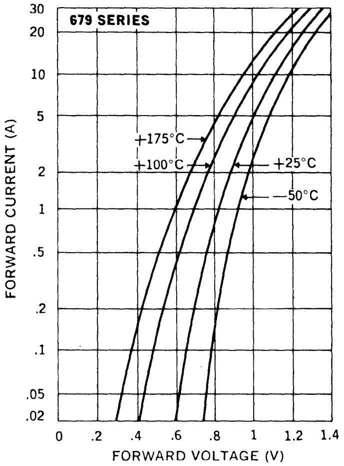
Part number is printed on the body.

UNITRODE

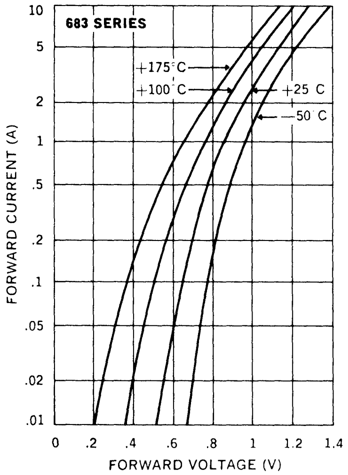
Electrical Specifications (at 25°C unless noted)							Maximum Ratings		
Type		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Maximum Leakage Current Per Leg @ PIV		Maximum Reverse Recovery Time*	Maximum Average D.C. Output Current		Non-Repetitive Sinusoidal Surge (8.3ms)
				T_A = 25°C	T_A = 100°C		T_C = 55°C	T_C = 100°C	T_A = 100°C
		Volts		µA	µA	ns	Amps	Amps	Amps
Standard Recovery	679-1	100	1.2V @ 10A	10	200	—	25	18.5	150
	679-2	200							
	679-3	300							
	679-4	400							
	679-5	500							
	679-6	600							
Standard Recovery	680-1	100	1.2V @ 2A	2	50	—	10	6	50
	680-2	200							
	680-3	300							
	680-4	400							
	680-5	500							
	680-6	600							
Fast Recovery	683-1	100	1.2V @ 6A	10	200	500	20	14	150
	683-2	200							
	683-3	300							
	683-4	400							
	683-5	500							
	683-6	600							
Fast Recovery	684-1	100	1.2V @ 2A	5	100	500	10	6	50
	684-2	200							
	684-3	300							
	684-4	400							
	684-5	500							
	684-6	600							

*Measured in a reverse recovery circuit switching from 1.0A forward to 1.0A reverse current recovering to 0.5A.

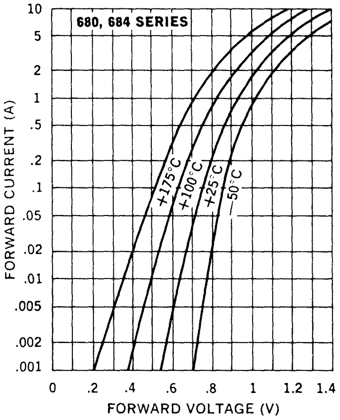
Typical Forward Voltage Per Leg vs. Forward Current



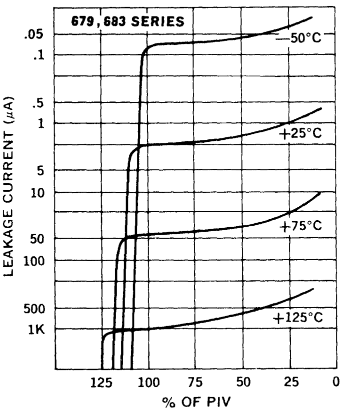
Typical Forward Voltage Per Leg vs. Forward Current



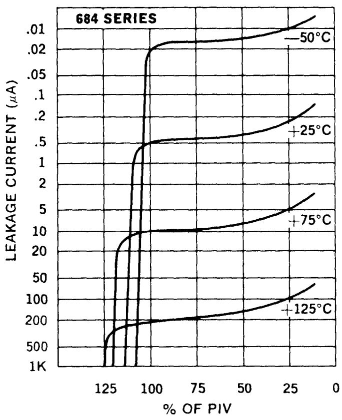
Typical Forward Voltage Per Leg vs. Forward Current



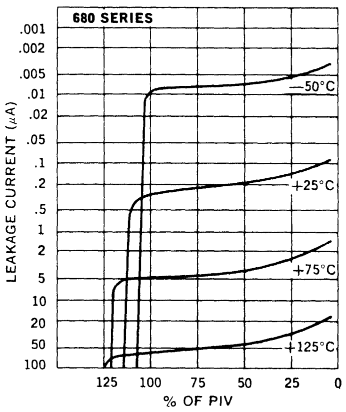
Typical Leakage Current vs. PIV



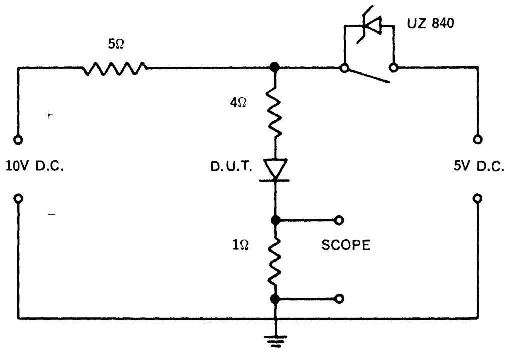
Typical Leakage Current vs. PIV



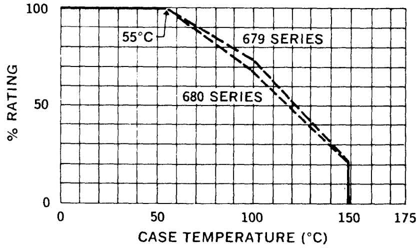
Typical Leakage Current vs. PIV



Reverse Recovery Circuit

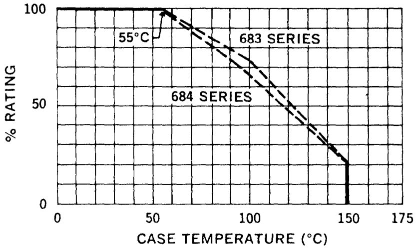


Current Derating Curve



Standard Recovery Series

Current Derating Curve



Fast Recovery Series

RECTIFIER ASSEMBLIES

681, 689 SERIES

Doubler and Center Tap, 15 Amp, Standard and Fast Recovery, Magnum®

FEATURES

- Current Ratings: to 15A
- Aluminum Heat Sink Case, Electrically Insulated
- Only Fused-in-Glass Diodes Used
- Controlled Avalanche Characteristics
- PIV: 100 to 600V
- Surge Ratings: to 150A

DESCRIPTION

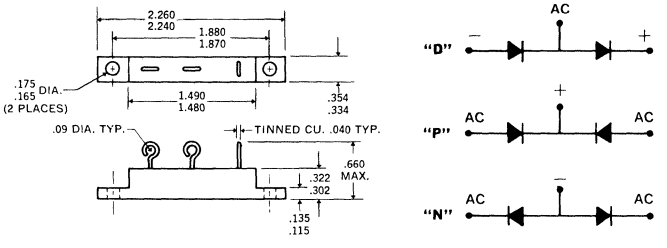
This series of MAGNUM® doublers and center tap rectifiers offers high current and high thermal conductivity needed in high current power supply applications. The MAGNUM® package is virtually indestructable and lends its use to high environmental stresses, as seen in aircraft, missile and satellite equipment.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltages	100 to 600V
Maximum Average D.C. Output Current	
@ $T_C = +55°C$	15A
@ $T_C = +100°C$	10A
Non-Repetitive Sinusoidal Surge (8.3ms)	
@ $T_A = +100°C$	150A
Operating and Storage Temperature Range	−65°C to +150°C
Thermal Resistance Junction to Ambient	20°C/W
Junction to Case	6.0°C/W

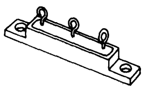
MECHANICAL SPECIFICATIONS

681, 689 SERIES



Typical Weight — 0.35 ounces
10 grams

Dimensions in inches.



MARKING

Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative	—

Part number is printed on the body.

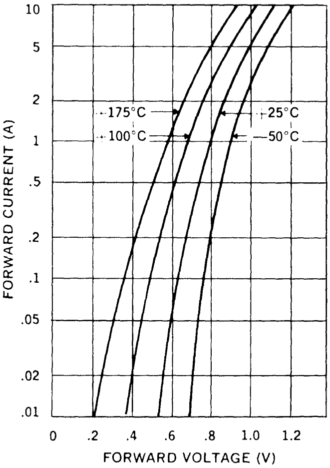
† Add suffix P, N, or D for terminal configuration P, N, or D. For example, for center tap configuration, P, order 681-IP.

Electrical Specifications (at 25°C unless noted)

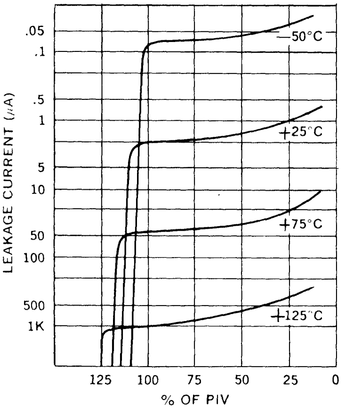
Type		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Maximum Reverse Recovery Time*	Maximum Leakage Current Per Leg @ PIV	
					$T_A = 25°C$	$T_A = 100°C$
		Volts		nS	μA	μA
Standard Recovery	681-1	100	1.2V @ 10A		10	200
	681-2	200				
	681-3	300				
	681-4	400				
	681-5	500				
	681-6	600				
Fast Recovery	689-1	100	1.2V @ 10A	500	10	200
	689-2	200				
	689-3	300				
	689-4	400				
	689-5	500				
	689-6	600				

*Measured in a reverse recovery circuit from 1A forward to 1A reverse current recovery to 0.5A.

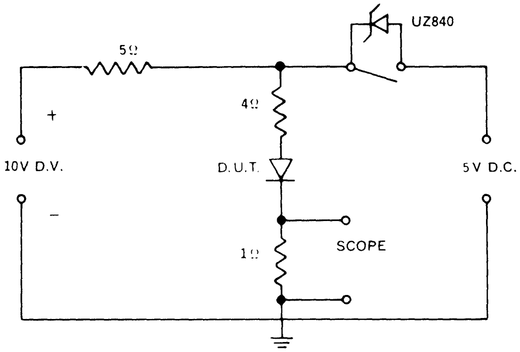
Typical Forward Voltage Per Leg vs. Forward Current



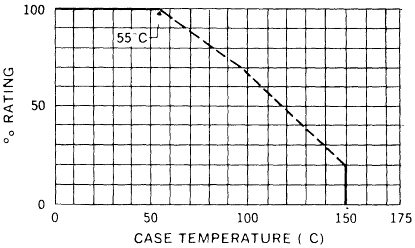
Typical Leakage Current vs. PIV



Reverse-Recovery Circuit



Current Derating Curve



RECTIFIER ASSEMBLIES

Single Phase Bridges, 7.5 Amp, Standard and Fast Recovery

697, 698 SERIES

FEATURES

- Miniature High Current Assemblies
- Continuous Ratings: to 7.5A
- Surge Ratings: to 80A
- PIV's: from 100V to 600V
- Recovery Times: to 500ns
- Only Fused-in-Glass Diodes Used
- Controlled Avalanche Characteristics

DESCRIPTION

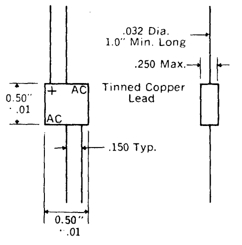
These miniature molded high-current single-phase bridges are designed for universal application in power supplies. One basic bridge fills current requirements up to 7.5A, with PIV's from 100 to 600 volts and recovery times of standard, and 500ns max.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	100 to 600V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient	32°C/W
Junction to Case	10°C/W

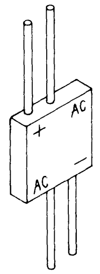
MECHANICAL SPECIFICATIONS

697, 698 SERIES



Dimensions in inches.

Typical Weight — 0.14 ounces
4.0 grams



MARKING

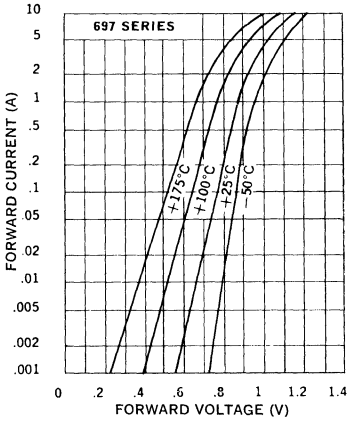
Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative	—

Part number is printed on the body.

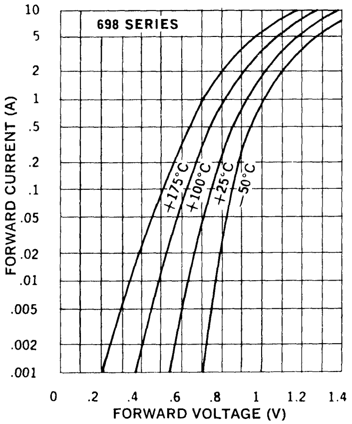
Electrical Specifications (at 25°C unless noted)							Maximum Ratings		
Type		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Leakage Current Per Leg @ PIV		Maximum Reverse Recovery Time†	Maximum Average D.C. Output Current		Non-Repetitive Sinusoidal Surge (8.3ms)
				T_A = 25°C	T_A = 100°C		T_A = 25°C	T_C = 55°C	
		Volts		μA	μA	ns	Amps	Amps	Amps
Standard Recovery	697-1	100	1.0V @ 2A	5	200		2.5	7.5	80
	697-2	200							
	697-3	300							
	697-4	400							
	697-5	500							
	697-6	600							
Fast Recovery	698-1	100	1.1V @ 2A	5	200	500	2.25	7.0	70
	698-2	200							
	698-3	300							
	698-4	400							
	698-5	500							
	698-6	600							

†Measured in a reverse recovery circuit switching from 1A forward to 1A reverse current recovering to .5A.

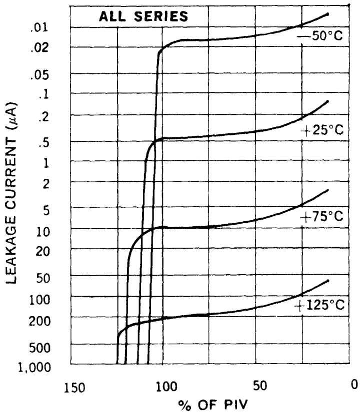
Typical Forward Voltage Per Leg vs. Forward Current



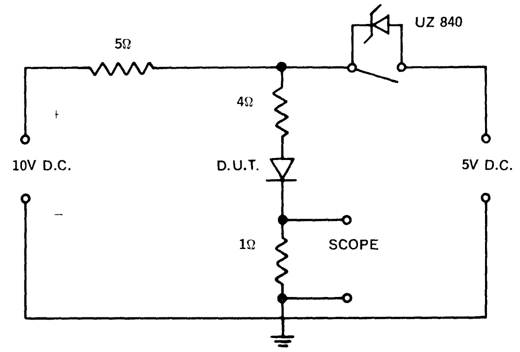
Typical Forward Voltage Per Leg vs. Forward Current



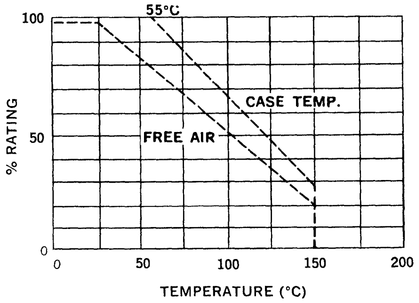
Typical Leakage Current vs. PIV



Reverse Recovery Circuit



Current Derating Curve



RECTIFIER ASSEMBLIES

700, 701 SERIES

Three Phase Bridges, 2.5 Amp, Standard and Fast Recovery

FEATURES

- Miniature Package
- Recovery Time: to 500ns
- Surge Ratings: to 25A
- PIV: from 100 to 600V
- Controlled Avalanche Characteristics
- Only Fused-in-Glass Diodes Used

DESCRIPTION

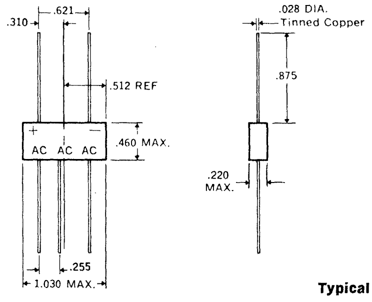
These miniature transfer-molded high-voltage three-phase power bridges are designed for universal application in power supplies. One basic bridge fills current requirements up to 2.5A, with PIV's from 100 to 600 volts and recovery times of standard and 500ns.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	100 to 600V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction-to-Ambient	25°C/W

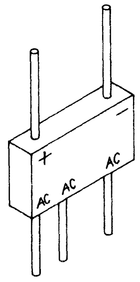
MECHANICAL SPECIFICATIONS

700, 701 SERIES



Dimensions in inches.

Typical Weight — 0.12 ounces
3.5 grams



MARKING

Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative	—

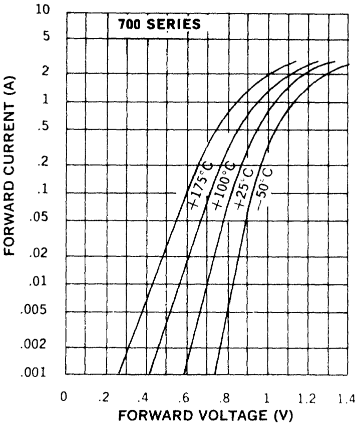
Part number is printed on the body.

UNITRODE

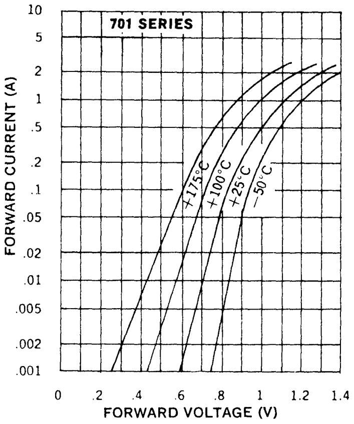
Electrical Specifications (at 25°C unless noted)							Maximum Ratings	
Type		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Leakage Current Per Leg @ PIV		Maximum Reverse Recovery Time†	Maximum Average D.C. Output Current	Non-Repetitive Sinusoidal Surge (8.3ms)
				T_A = 25°C	T_A = 100°C		T_A = 55°C	
		Volts		μA	μA	ns	Amps	Amps
Standard Recovery	700-1	100	1.0V @ 0.5A	2	100		2.5	25
	700-2	200						
	700-3	300						
	700-4	400						
	700-5	500						
	700-6	600						
Fast Recovery	701-1	100	1.1V @ 0.5A	2	100	500	2.25	20
	701-2	200						
	701-3	300						
	701-4	400						
	701-5	500						
	701-6	600						

†Measured in a reverse recovery circuit switching from 10mA forward to 10mA reverse current recovering to 5mA.

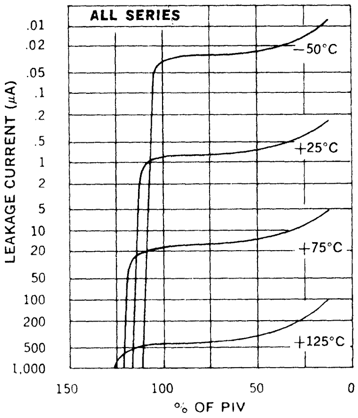
Typical Forward Voltage Per Leg vs. Forward Current



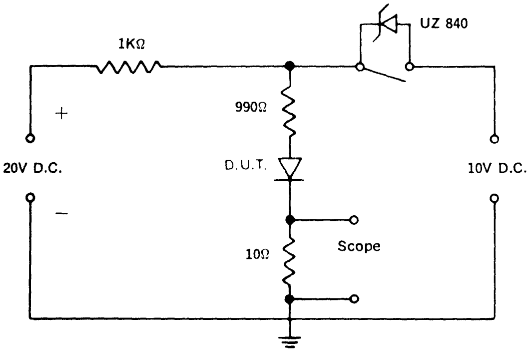
Typical Forward Voltage Per Leg vs. Forward Current



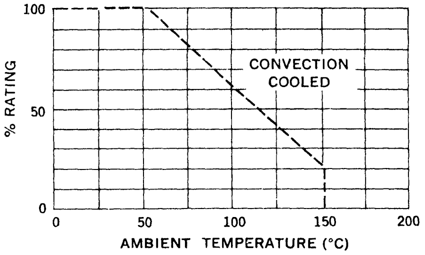
Typical Leakage Current vs. PIV



Reverse Recovery Circuit



Current Derating Curve



RECTIFIER ASSEMBLIES

Three Phase Bridges, 20-40 Amp, High Efficiency, ESP

800, 801 SERIES

FEATURES

- Current Ratings: to 40A
- Recovery Time: 50ns
- Surge Ratings: to 250A
- PIVs: from 50 to 150V
- Only Fused-in-Glass Diodes Used
- Exceptionally High Efficiency
- Aluminum Heat Sink Case, Electrically Insulated

DESCRIPTION

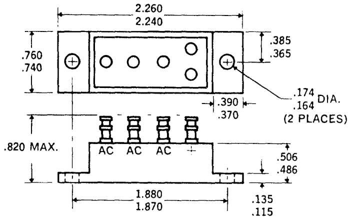
This series of three phase bridges offers the highest efficiency possible for applications where nothing else will do. The series allows operation at full power at high frequencies.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltages	50 to 150V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient, All Series	20°C/W
Junction to Case, 800 Series	2.5°C/W
Junction to Case, 801 Series	3.0°C/W

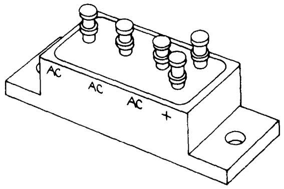
MECHANICAL SPECIFICATIONS

800, 801 SERIES



Dimensions in inches.

Typical Weight — 1.0 ounce
30 grams



MARKING

Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative	—

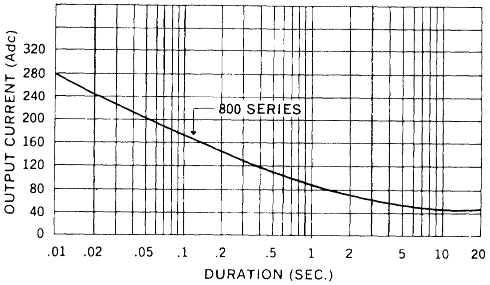
Part number is printed on the body.

UNITRODE

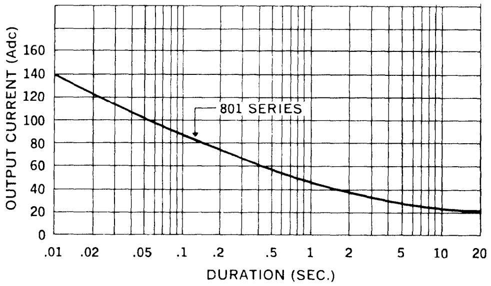
Electrical Specifications (at 25°C unless noted)							Maximum Ratings		
Type		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Maximum Reverse Leakage Current Per Leg @ PIV		Maximum Reverse Recovery Time*	Maximum Average D.C. Output Current		Non-Repetitive Sinusoidal Surge (8.3ms)
				$T_A = 25°C$	$T_A = 100°C$		$T_C = 55°C$	$T_C = 100°C$	$T_A = 100°C$
		Volts		µA	µA	ns	Amps	Amps	Amps
ESP Recovery	800-1	50	.95V @ 10A	20	1000	50	40	25	250
	800-2	100							
	800-3	125							
	800-4	150							
ESP Recovery	801-1	50	.95V @ 6A	10	300	50	20	16	125
	801-2	100							
	801-3	125							
	801-4	150							

*Measured in a reverse recovery circuit switching from 1A forward to 1A reverse current recovering to 0.5A.

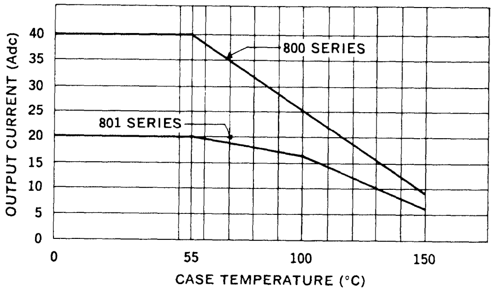
Forward Surge Current vs. Duration



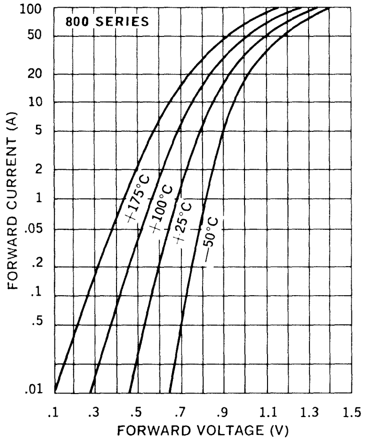
Forward Surge Current vs. Duration



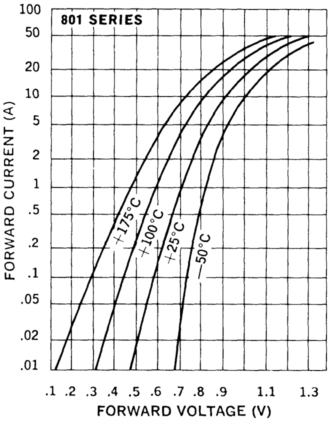
Current Derating Curve



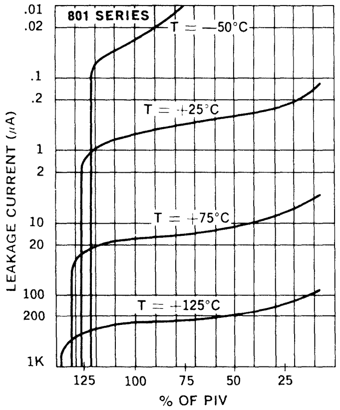
Typical Forward Voltage Per Leg vs. Forward Current



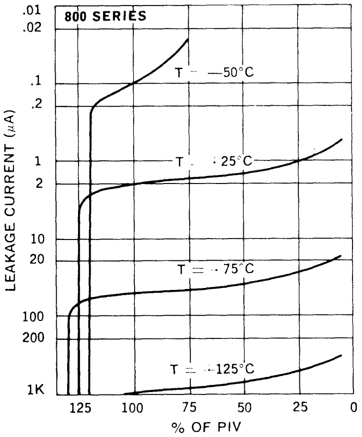
Typical Forward Voltage Per Leg vs. Forward Current



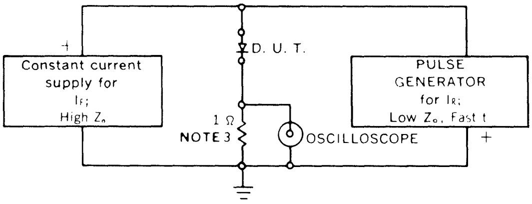
Typical Leakage Current vs. PIV



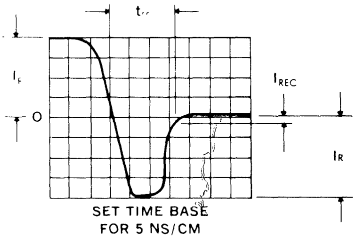
Typical Leakage Current vs. PIV



Reverse-Recovery Circuit



Characteristic Waveform



NOTES:

1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIER ASSEMBLIES

802, 803 SERIES

Single Phase Bridges, 20-35 Amp, High Efficiency ESP Series

FEATURES

- Current Ratings: to 35A
- Recovery Time: 50ns
- Surge Ratings: to 250A
- PIVs: from 50 to 150V
- Only Fused-in-Glass Diodes Used
- Exceptional High Efficiency
- Aluminum Heat Sink Case, Electrically Insulated

DESCRIPTION

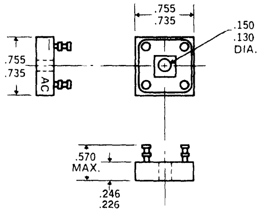
This series of single phase bridges offer the highest efficiency possible for applications where nothing else will do. The series allow operation at full power at very high frequency.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	50 to 150V
Maximum Average D.C. Output Current	See Electrical Specifications
Non-Repetitive Sinusoidal Surge (8.3ms)	See Electrical Specifications
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient, 802 Series	20°C/W
803 Series	25°C/W
Junction to Case, 802 Series	2.0°C/W
803 Series	4.0°C/W

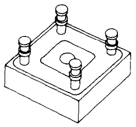
MECHANICAL SPECIFICATIONS

803 SERIES

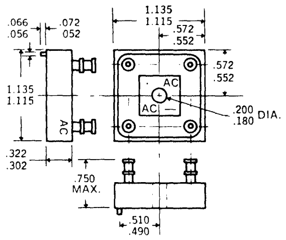


Dimensions in inches.

Typical Weight — 0.35 ounces
10 grams

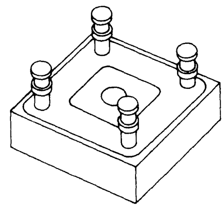


802 SERIES



Dimensions in inches.

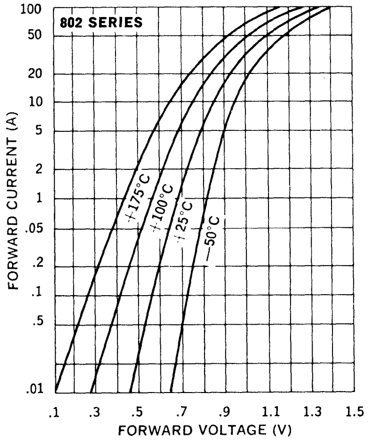
Typical Weight — 0.70 ounces
20 grams



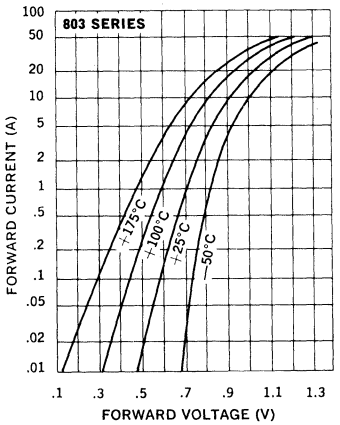
Electrical Specifications (at 25°C unless noted)							Maximum Ratings		
Type		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Maximum Reverse Leakage Current Per Leg @ PIV		Maximum Reverse Recovery Time*	Maximum Average D.C. Output Current		Non-Repetitive Sinusoidal Surge (8.3ms)
				$T_A = 25°C$	$T_A = 100°C$		$T_C = 55°C$	$T_C = 100°C$	$T_A = 100°C$
		Volts		µA	µA	ns	Amps	Amps	Amps
ESP Recovery	802-1	50	.95V @ 10A	20	1000	50	35	22.5	250
	802-2	100							
	802-3	125							
	802-4	150							
ESP Recovery	803-1	50	.95V @ 6A	10	300	50	20	16	125
	803-2	100							
	803-3	125							
	803-4	150							

*Measured in a reverse recovery circuit switching from 1A forward to 1A reverse current recovering to 0.5A.

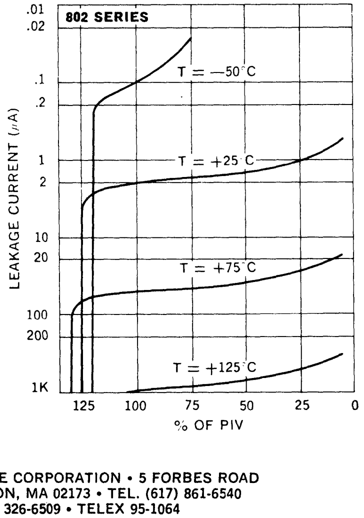
Typical Forward Voltage Per Leg vs. Forward Current



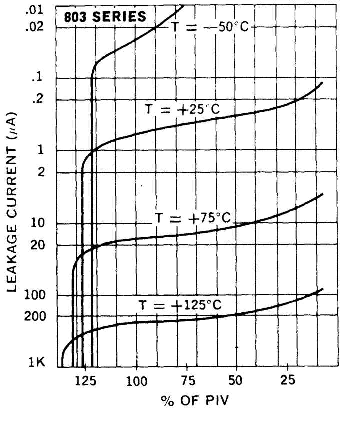
Typical Forward Voltage Per Leg vs. Forward Current



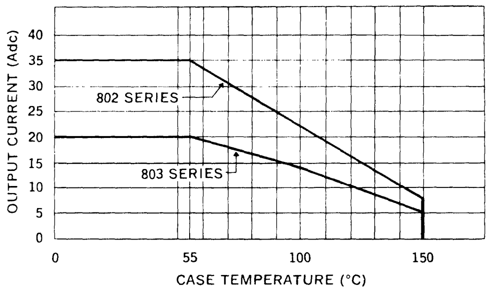
Typical Leakage Current vs. PIV



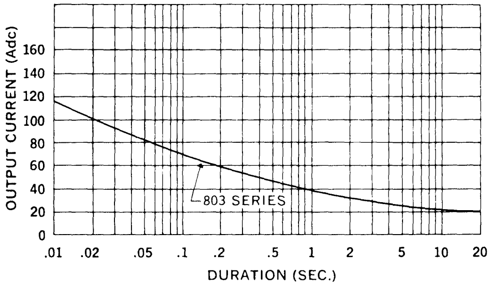
Typical Leakage Current vs. PIV



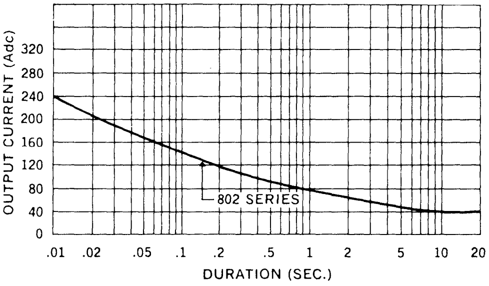
Current Derating Curve



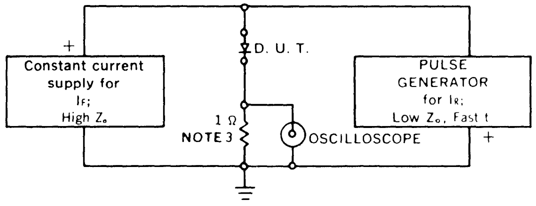
Forward Surge Current vs. Duration



Forward Surge Current vs. Duration



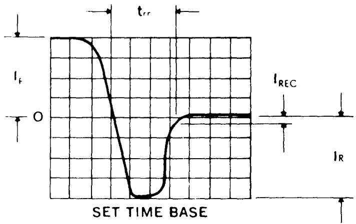
Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

Characteristic Waveform



SET TIME BASE FOR 5 NS/CM

RECTIFIER ASSEMBLIES

804 SERIES

Doublers and Center Tap, 20 Amp, High Efficiency, ESP

FEATURES

- Current Rating: to 20A
- Aluminum Heat Sink Case, Electrically Insulated
- Recovery Time: 50ns
- Surge Rating: to 250A
- PIVs: from 50 to 150V
- Only Fused-in-Glass Diodes Used
- Exceptional High Efficiency

DESCRIPTION

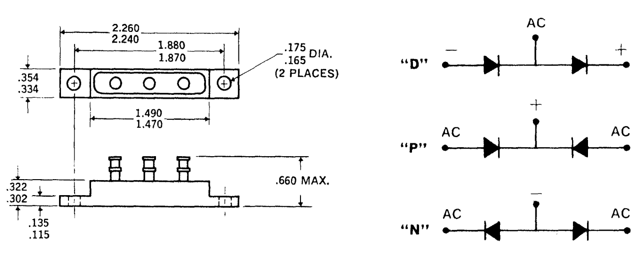
This series of doublers and center tap rectifiers offer the ultimate in high efficiency application. The rectifiers are particularly suited to switching regulator supplies where very fast recovery time and low forward drop are of prime importance.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	50 to 150V
Maximum Average D.C. Output Current	
@ $T_C = +55°C$	20A
@ $T_C = +100°C$	14A
Non-Repetitive Sinusoidal Surge (8.3ms)	
@ $T_A = +100°C$	250A
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient	20°C/W
Junction to Case	6.0°C/W

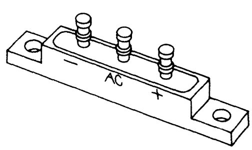
MECHANICAL SPECIFICATIONS

804 SERIES



Typical Weight — 0.35 ounces
10 grams

Dimensions in inches.



MARKING

Alternating Current Input	A.C.
Cathode — Positive Output	+
Anode — Negative	—

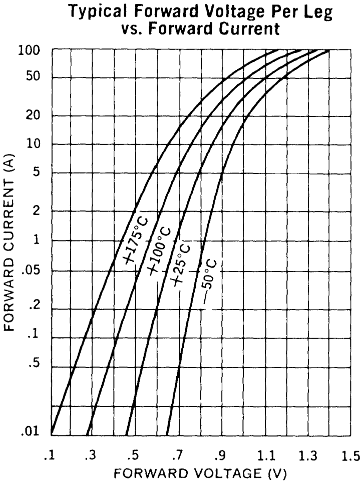
Part number is printed on the body.

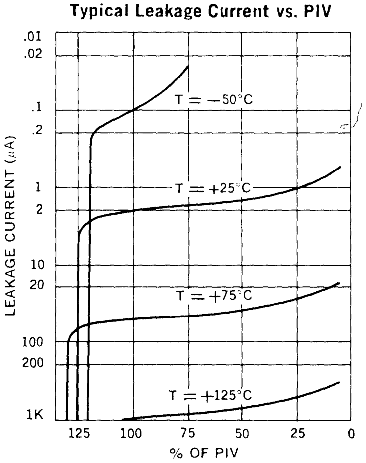
† Add suffix P, N, or D for terminal configuration P, N, or D. For example, for center tap configuration, P, order 804-1P

Electrical Specifications (at 25°C unless noted)

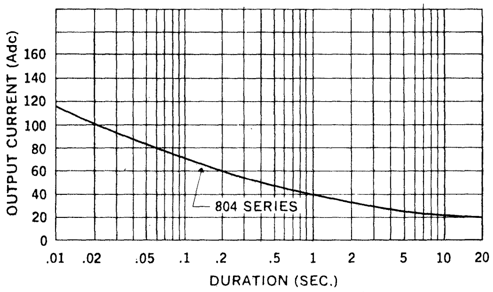
Type		PIV Per Leg	Maximum Forward Voltage Drop Per Leg	Maximum Leakage Current (μA) Per Leg @ PIV		Maximum Reverse Recovery Time*
				T_A = 25°C	T_A = 100°C	
		Volts		μA	μA	ns
ESP	804-1	50	.95V @ 10A	10	500	50
Recovery	804-2	100				
	804-3	125				
	804-4	150				

*Measured in a reverse recovery circuit switching from 1A forward to 1A reverse current recovering to 0.5A.

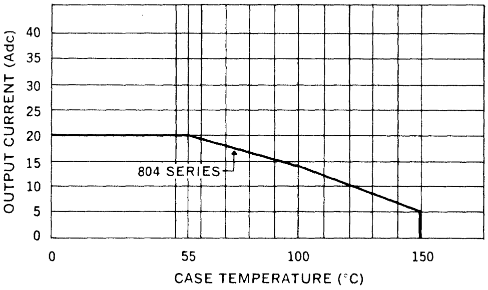




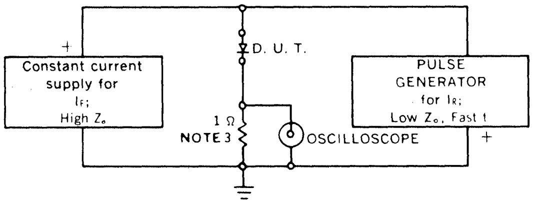
Forward Surge Current vs. Duration



Current Derating Curve



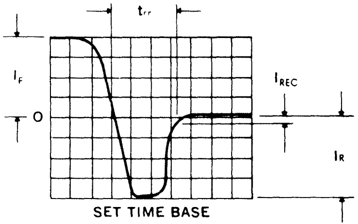
Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

Characteristic Waveform



SET TIME BASE
FOR 5 NS/CM

UNITRODE CORPORATION • 5 FORBES ROAD
LEXINGTON, MA 02173 • TEL. (617) 861-6540
TWX (710) 326-6509 • TELEX 95-1064

RECTIFIER ASSEMBLIES
Doubler and Center-Tap PMB Power Modules High Voltage, High Current

PMB101-PMB107
PMB101X-PMB107X
PMB201-PMB205
PMB201X-PMB205X

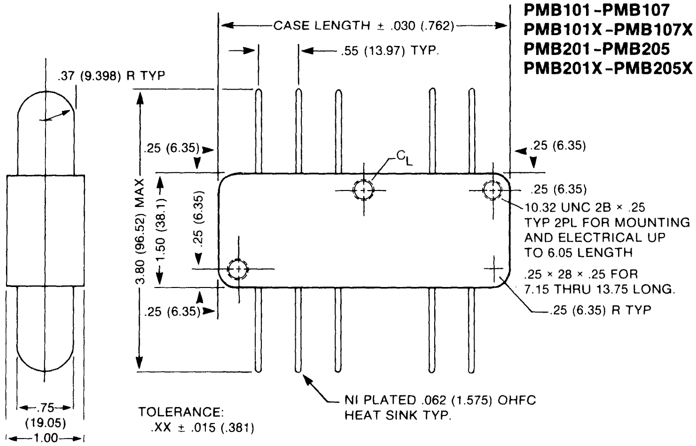
FEATURES
- PIV: From 2.5kV to 30kV
- 6A in Oil
- 300A Surge Current
- Dense Packaging
- Convenient Mounting

DESCRIPTION
The PMB POWER MODULE is available as a high voltage doubler or center tap with either a positive or negative tap. The high current capabilities suggest such applications as high power TWT amplifiers, power supplies and precipitators. The molded heat sunk configuration allows operation in oil and air.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5kV to 30kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-65°C to +150°C

MECHANICAL SPECIFICATIONS



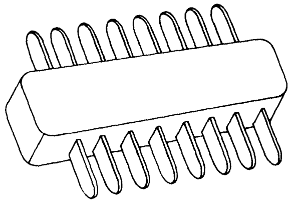
PART NUMBER	CASE LENGTH INCHES	CASE LENGTH MILLIMETERS
PMB101, 101X	1.65	41.91
PMB102, 102X	2.75	69.85
PMB103, 103X	3.85	97.79
PMB104, 104X	4.95	125.73
PMB105, 105X	7.15	181.61
PMB106, 106X	9.35	237.49
PMB107, 107X	13.75	349.25

PART NUMBER	CASE LENGTH INCHES	CASE LENGTH MILLIMETERS
PMB201, 201X	2.75	69.85
PMB202, 202X	4.95	125.73
PMB203, 203X	7.15	181.61
PMB204, 204X	9.35	237.49
PMB205, 205X	13.75	349.25

NOTE:
Add "P" to P/N for positive center-tap.
Add "N" to P/N for negative center-tap.
Add "D" to P/N for doubler configuration.

Dimensions in inches and (millimeters)

PMA



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						MAXIMUM RATINGS				Case Length	
Maximum Reverse Recovery Time		Peak Inverse Voltage	Maximum Reverse Current @ PIV		Maximum Forward Voltage	Maximum Average Rectified Current†			Maximum One Cycle Surge 8.3mS		
T_{RR}*		PIV	I_R		V_F	I_O @ 50°C			I_F(surge)		
Type	Type	kV	25°C	100°C	@ 3.0A Peak	NC	FA	Oil			
2µS	250nS		µA	µA	V	A**	A***	A	A	Inches	MM
PMB101	PMB101X	2.5	2	100	5	1.0	2.4	3.0	150	1.65	41.91
PMB102	PMB102X	5	2	100	10	1.0	2.4	3.0	150	2.75	69.85
PMB103	PMB103X	7.5	2	100	15	1.0	2.4	3.0	150	3.85	97.79
PMB104	PMB104X	10	2	100	20	1.0	2.4	3.0	150	4.95	125.73
PMB105	PMB105X	15	2	100	30	1.0	2.4	3.0	150	7.15	181.61
PMB106	PMB106X	20	2	100	40	1.0	2.4	3.0	150	9.35	237.49
PMB107	PMB107X	30	2	100	50	1.0	2.4	3.0	150	13.75	349.25
					@ 6.0A Peak						
PMB201	PMB201X	2.5	2	100	5	2.0	4.8	6.0	300	2.75	69.85
PMB202	PMB202X	5	2	100	10	2.0	4.8	6.0	300	4.95	125.73
PMB203	PMB203X	7.5	2	100	15	2.0	4.8	6.0	300	7.15	181.61
PMB204	PMB204X	10	2	100	20	2.0	4.8	6.0	300	9.35	237.49
PMB205	PMB205X	15	2	100	30	2.0	4.8	6.0	300	13.75	349.25

* Reverse recovery test conditions for each cell prior to assembly I_F =400mA, I_R =800mA, I_{RR} =200mA.

** For natural air convection operation unit must be mounted horizontally with no air restrictions.

*** Forced air ratings are with a minimum air flow of (TBD).

Notes:
1. For operation in air unit to be corona free to (TBD) test conditions (TBD).
2. Junction to heat sink thermal resistance (TBD).
3. Consult factory for series and/or parallel applications for special matching.
4. I_O ratings @ 50°C linearly derate to 0 @ 150°C.
5. Oil and air operation any position.

RECTIFIER ASSEMBLIES
Single Phase Full Wave Bridges
PMC Power Modules
High Voltage, High Current

PMC101-PMC105
PMC101X-PMC105X
PMC201-PMC203
PMC201X-PMC203X

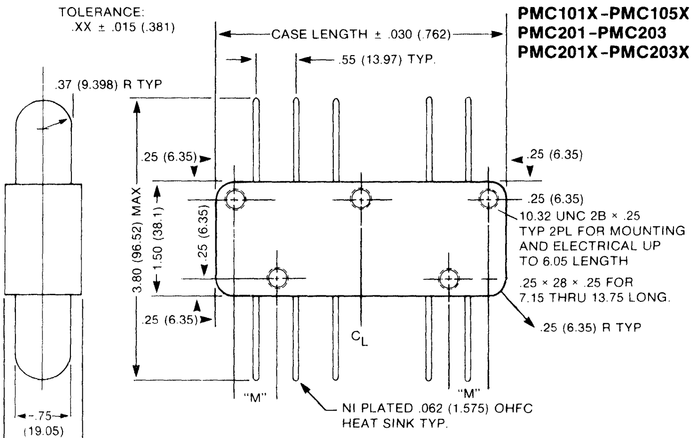
FEATURES
- PIV: From 2.5kV to 60kV
- 12A in Oil
- 300A Surge Current
- Fast Recovery
- Low Leakage

DESCRIPTION
The PMC POWER MODULE is a densely packaged single phase high voltage bridge rectifier assembly. Typical applications include high power transmitters, cable fault detectors, and shipboard radar systems, to name a few.

ABSOLUTE MAXIMUM RATINGS
Peak Inverse Voltage .... 2.5kV to 15kV
Maximum Average Rectified Current .... See Electrical Specifications
Maximum One Cycle Surge 8.3mS .... See Electrical Specifications
Operating and Storage Temperature Range .... -65°C to +150°C

MECHANICAL SPECIFICATIONS

PMC101-PMC105
PMC101X-PMC105X
PMC201-PMC203
PMC201X-PMC203X

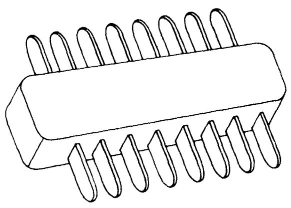


PART NUMBER	"M" MOUNTING & ELECTRICAL SPACING INCHES	MM	CASE LENGTH INCHES	MM
PMC101, 101X	.58	14.73	2.75	69.85
PMC102, 102X	1.13	28.70	4.95	125.73
PMC103, 103X	1.68	42.67	7.15	181.61
PMC104, 104X	2.23	56.64	9.35	237.49
PMC105, 105X	3.33	84.58	13.75	349.25
PMC201, 201X	1.13	28.70	4.95	125.73
PMC202, 202X	2.23	56.64	9.35	237.49
PMC203, 203X	3.33	84.58	13.75	349.25

NOTE: SINGLE PHASE FWB REQUIRES EXTERNAL CONNECTION. UNIT AVAILABLE WITH EITHER POSITIVE OR NEGATIVE OUTBOARD TERMINATION. ADD SUFFIX "P" OR "N".

Dimensions in inches and (millimeters)

PMA



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						**MAXIMUM RATINGS**							
Maximum Reverse Recovery Time		Peak Inverse Voltage	Maximum Reverse Current @ PIV		Maximum Forward Voltage	Maximum Average Rectified Current†			Maximum One Cycle Surge 8.3mS	"M" Mounting & Electrical Spacing		Case Length	
T_{RR}*		PIV	I_R		V_F	I_O @ 50°C			I_F(surge)				
Type	Type	kV	25°C	100°C	@ 3.0A Peak	NC	FA	Oil					
2µS	250nS		µA	µA	V	A**	A***	A	A	Inches	MM	Inches	MM
PMC101	PMC101X	2.5	2	100	5	2	4.8	6	150	.58	14.73	2.75	69.85
PMC102	PMC102X	5	2	100	10	2	4.8	6	150	1.13	28.70	4.95	125.73
PMC103	PMC103X	7.5	2	100	15	2	4.8	6	150	1.68	42.67	7.15	181.61
PMC104	PMC104X	10	2	100	20	2	4.8	6	150	2.23	56.64	9.35	237.49
PMC105	PMC105X	15	2	100	30	2	4.8	6	150	3.33	84.58	13.75	349.25
					@ 6.0A Peak								
PMC201	PMC201X	2.5	2	100	5	4	9.6	12	300	1.13	28.70	4.95	125.73
PMC202	PMC202X	5	2	100	10	4	9.6	12	300	2.23	56.64	9.35	237.49
PMC203	PMC203X	7.5	2	100	15	4	9.6	12	300	3.33	84.58	13.75	349.25

* Reverse recovery test conditions for each cell prior to assembly I_F =400mA, I_R=800mA, I_{RR}=200mA.

** For natural air convection operation unit must be mounted horizontally with no air restrictions.

*** Forced air ratings are with a minimum air flow of (TBD).

Notes:
1. For operation in air unit to be corona free to (TBD) test conditions (TBD).
2. Junction to heat sink thermal resistance (TBD).
3. Consult factory for series and/or parallel applications for special matching.
4. I_O ratings @ 50°C linearly derate to 0 @ 150°C.
5. Oil and air operation any position.

RECTIFIER ASSEMBLIES
Three Phase Full Wave Bridges
PMD Power Modules
High Voltage, High Current

PMD101 -PMD104
PMD101X -PMD104X
PMD201 -PMD202
PMD201X -PMD202X

FEATURES
- PIV: From 2.5kV to 10kV
- 18A in Oil
- 300A Surge Current
- High Density Packaging
- Low Leakage
- Fast Recovery

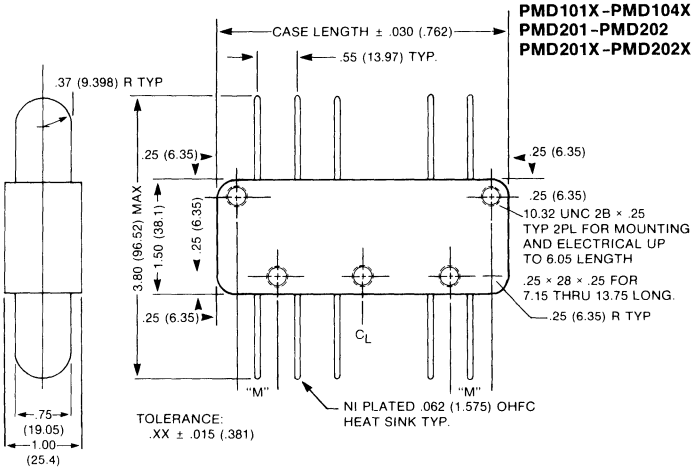
DESCRIPTION
The PMD POWER MODULE is a high density three phase high voltage bridge rectifier assembly. This package combines the low ripple and high efficiency characteristics with the high current capabilities to enhance the design of microwave systems, high current power supplies and transmitters of all types where high power is a key factor.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage	2.5kV to 10kV
Maximum Average Rectified Current	See Electrical Specifications
Maximum One Cycle Surge 8.3mS	See Electrical Specifications
Operating and Storage Temperature Range	-65°C to +150°C

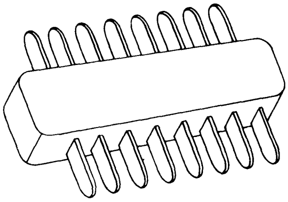
MECHANICAL SPECIFICATIONS

PMD101 -PMD104
PMD101X -PMD104X
PMD201 -PMD202
PMD201X -PMD202X



TOLERANCE:
.XX ± .015 (.381)

PMA



	"M" MOUNTING & ELECTRICAL SPACING		CASE LENGTH	
PART NUMBER	INCHES	MM	INCHES	MM
PMD101, 101X	.58	14.73	3.85	97.79
PMD102, 102X	1.13	28.70	7.15	181.61
PMD103, 103X	1.68	42.67	10.45	265.43
PMD104, 104X	2.23	56.64	13.75	349.25
PMD201, 201X	1.13	28.70	7.15	181.61
PMD202, 202X	2.23	56.64	13.75	349.25

Dimensions in inches and (millimeters)

A SUBSIDIARY OF UNITRODE CORPORATION
HIGH VOLTAGE DEVICES

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)						**MAXIMUM RATINGS**				"M" Mounting & Electrical Spacing		Case Length	
Maximum Reverse Recovery Time		Peak Inverse Voltage	Maximum Reverse Current @ PIV		Maximum Forward Voltage	Maximum Average Rectified Current†			Maximum One Cycle Surge 8.3mS				
T_{RR}*		PIV	I_R		V_F	I_O @ 50°C			I_F(surge)				
Type	Type	kV	25°C	100°C	@ 3.0A Peak	NC	FA	Oil					
2µS	250nS		µA	µA	V	A**	A***	A	A	Inches	MM	Inches	MM
PMD101	PMD101X	2.5	2	100	5	3	7.2	9	150	.58	14.73	3.85	97.79
PMD102	PMD102X	5	2	100	10	3	7.2	9	150	1.13	28.70	7.15	181.61
PMD103	PMD103X	7.5	2	100	15	3	7.2	9	150	1.68	42.67	10.45	265.43
PMD104	PMD104X	10	2	100	20	3	7.2	9	150	2.23	56.64	13.75	349.25
					@ 6.0A Peak								
PMD201	PMD201X	2.5	2	100	5	6	14.4	18	300	1.13	28.70	7.15	181.61
PMD202	PMD202X	5	2	100	10	6	14.4	18	300	2.23	56.64	13.75	349.25

* Reverse recovery test conditions for each cell prior to assembly I_F =400mA, I_R=800mA, I_{RR}=200mA.
** For natural air convection operation unit must be mounted horizontally with no air restrictions.
*** Forced air ratings are with a minimum air flow of (TBD).

Notes:
1. For operation in air unit to be corona free to (TBD) test conditions (TBD).
2. Junction to heat sink thermal resistance (TBD).
3. Consult factory for series and/or parallel applications for special matching.
4. I_O ratings @ 50°C linearly derate to 0 @ 150°C.
5. Oil and air operation any position.

RECTIFIERS

High Efficiency, 16A Center-Tap

SES5401C-SES5403C

FEATURES

- Low Forward Voltage
- Fast Recovery Times
- Economical, Convenient TO-220 Package
- Low Thermal Resistance
- Mechanically Rugged

DESCRIPTION

The SES5401C Series, in the economical, convenient TO-220 package, is specifically designed for operation in power switching circuits to frequencies in excess of 100KHz. The series combines two high efficiency devices into one package, simplifying installation, reducing heatsink requirements and the need to purchase matched components.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, SES5401C	50V
Peak Inverse Voltage, SES5402C	100V
Peak Inverse Voltage, SES5403C	150V
Maximum Average D.C. Output Current	
@ T_C = 125°C	16A
@ T_A = 25°C	3A
@ T_A = 25°C (Note 1)	10A
Non-Repetitive Sinusoidal Surge Current, 8.3mS	70A
Thermal Resistance, Junction to Case, $\Theta_{J\text{-}C}$	1.75 °C/W
Thermal Resistance, Junction to Ambient, $\Theta_{J\text{-}A}$	60 °C/W
Operating and Storage Temperature Range	−55 °C to +150 °C

NOTE 1. Using Wakefield Type 295 heatsink with convection cooling. For more definitive data refer to the Output Current vs. Temperature Curves on this datasheet.

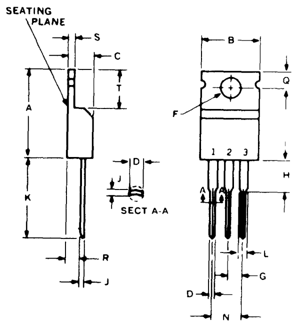
ELECTRICAL SPECIFICATIONS

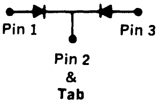
Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*	Typical Forward Recovery Voltage @1A t_r = 8nS
		T_J = 25°C	T_J = 100°C	@ T_J = 25°C	@ T_J = 100°C		
SES5401C SES5402C SES5403C	50V 100V 150V	1.025V @ 8A	0.945V @ 8A	5μA	150μA	100nS	1.4V

*Measured in circuit I_F = 0.5A, I_R = 1.0A, I_{REC} = 0.25A

MECHANICAL SPECIFICATIONS

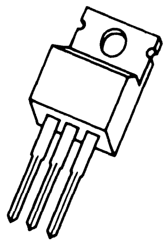
SES5401C-SES5403C



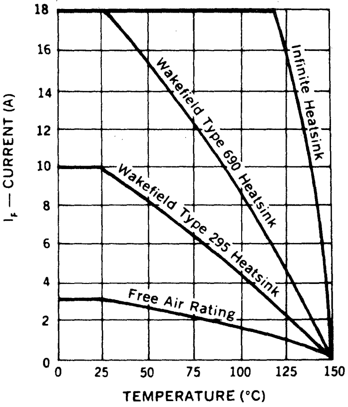


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H	—	6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

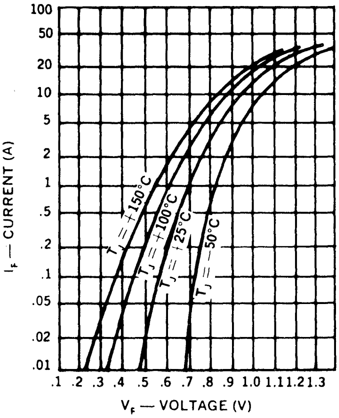
TO-220



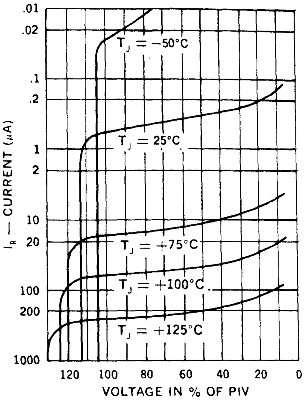
Output Current vs. Temperature



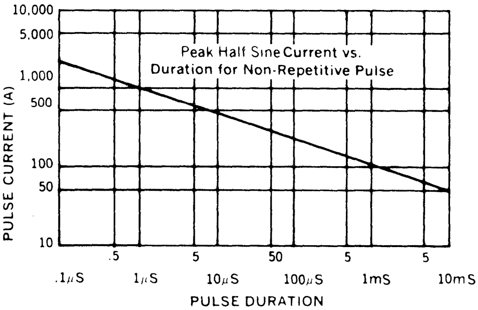
Typical Forward Current vs. Forward Voltage



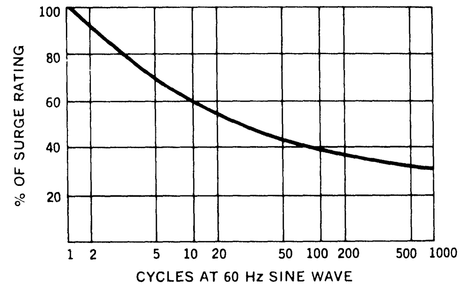
Typical Reverse Current vs. Voltage



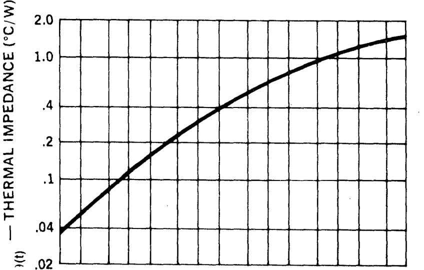
Forward Pulse Current vs. Duration



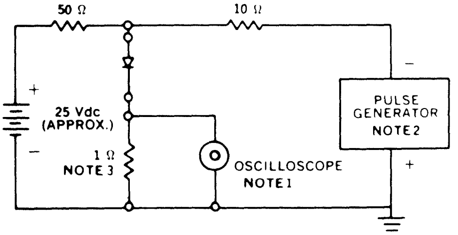
Multiple Surge Current vs. Duration



Thermal Impedance vs. Pulse Width



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 25A Center-Tap

SES5601C
SES5602C
SES5603C

FEATURES

- Low Forward Voltage Drop
- Fast Switching Speed
- Convenient Package
- High Surge Capability
- Low Thermal Resistance
- Mechanically Rugged TO-3 Package
- Available as Positive or Negative Center-Tap

DESCRIPTION

The SES, super-fast recovery, rectifiers are specifically designed for operation in power switching circuits. Their super-fast recovery time and very low forward voltage drop make them particularly efficient in most switching applications.

ABSOLUTE MAXIMUM RATINGS

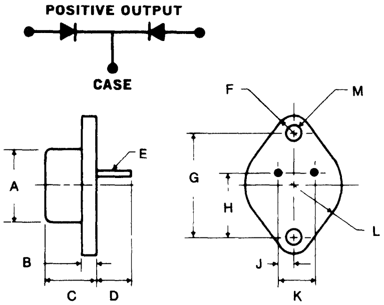
Peak Inverse Voltage, SES5601C	50V
Peak Inverse Voltage, SES5602C	100V
Peak Inverse Voltage, SES5603C	150V
Maximum Average D.C. Output Current at $T_C = 100°C$	25A
Non-Repetitive Sinusoidal Surge Current 8.3 mS	400A
Thermal Resistance, Junction to Case	1 °C/W
Operating and Storage Temperature Range	−55 °C to +175 °C

ELECTRICAL SPECIFICATIONS PER DIODE

Type	PIV	Maximum Forward Voltage (V_F) @		Maximum Reverse Current (I_R) @PIV		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	@$T_C = 25°C$	@$T_C = 125°C$	
SES5601C SES5602C SES5603C	50V 100V 150V	0.990V @ 12.5A $t_p = 300\mu S$	0.830V @ 12.5A $t_p = 300\mu S$	20µA	4mA	100nS

*Measured in circuit $I_F = 0.5A$, $I_R = 1.0A$, $I_{REC} = 0.25A$

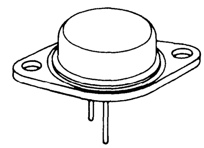
MECHANICAL SPECIFICATIONS



SES5601C-SES5603C

	ins.	mm
A	.875 MAX.	22.23 MAX.
B	.135 MAX.	3.43 MAX.
C	.250-.450	6.35-11.43
D	.312 MIN.	7.92 MIN.
E	.038-.043 DIA.	0.97-1.09 DIA.
F	.188 MAX. RAD.	4.78 MAX. RAD.
G	1.177-1.197	29.00-30.40
H	.655-.675	16.64-17.15
J	.205-.225	5.21-5.72
K	.420-.440	10.67-11.18
L	.525 MAX. RAD.	13.34 MAX. RAD.
M	.151-.161	3.84-4.09 DIA.

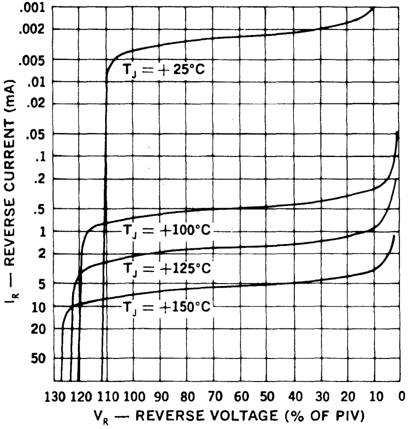
TO-3



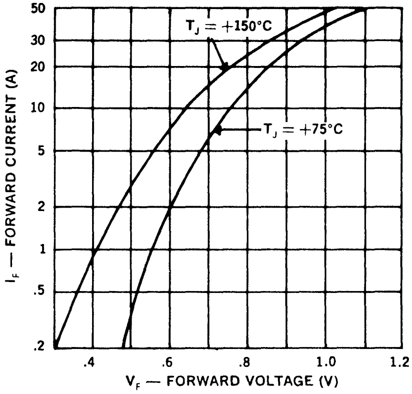
NOTES:

1. Standard polarity is positive output.
   For reverse polarity (negative output) add suffix "R", ie, SES5601CR.
2. All metal surfaces tin plated.

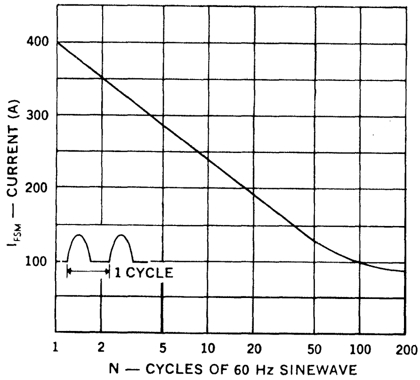
Typical Reverse Current vs. Reverse Voltage



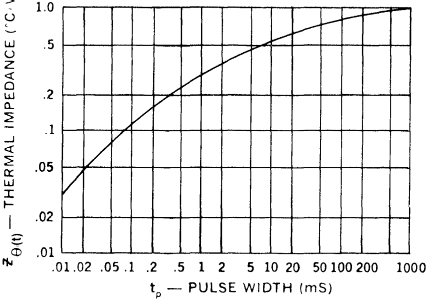
Typical Forward Current vs. Forward Voltage



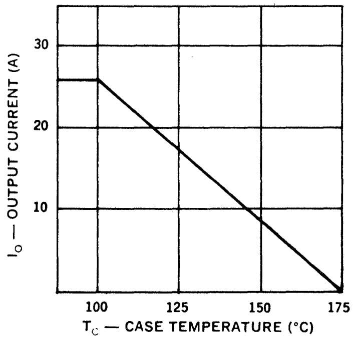
Maximum Forward Surge vs. Number of Cycles



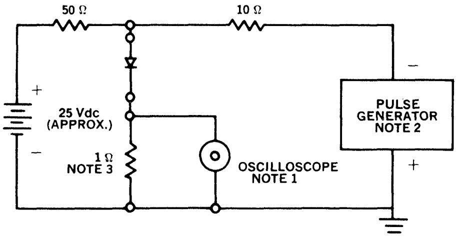
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIER ASSEMBLIES
Single Phase Bridges, 25 Amp, Military Approved

JAN SPA25
JAN SPB25
JAN SPC25
JAN SPD25

FEATURES
- Qualified to MIL-S-19500/446
- Current Rating: to 25A
- PIV: from 100 to 600V
- Surge Ratings: to 150A
- Only Fused-in-Glass Diodes Used
- Controlled Avalanche Characteristics
- Aluminum Heat Sink Case, Electrically Insulated

DESCRIPTION
This series of military high-current single-phase bridges offer the utmost in reliability as required in military system designs. This series is assembled with diodes which have been subjected to 100% screening tests.

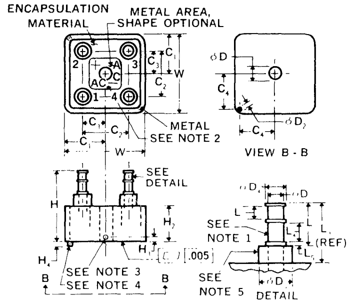
ABSOLUTE MAXIMUM RATINGS

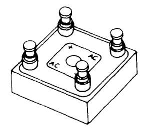
Peak Inverse Voltage	100 to 600V
Maximum Average D.C. Output Current	
@ $T_C = 55°C$	25A
@ $T_C = 100°C$	15A
Non-Repetitive Sinusoidal Surge (8.3ms)	
@ $T_C = 55°C$	150A
Operating and Storage Temperature Range	—65°C to +150°C
Thermal Resistance Junction to Ambient	20°C/W
Junction to Case	2.5°C/W

Ltr	Dimensions			
	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
C_1	.552	.572	14.02	14.53
C_2	.624	.760	15.85	19.30
C_3	.312	.380	7.92	9.65
C_4	.495	.512	12.57	13.00
ϕD_1	.189	.195	4.80	4.95
ϕD_2	.057	.067	1.45	1.70
ϕD_3	.108	.118	2.74	3.00
ϕD_4	.141	.151	3.58	3.84
ϕD_5	.225	.235	5.72	5.97
H_1	.669	1.060	17.53	26.92
H_2	.300	.500	7.62	12.70
H_3	.040	.060	1.02	1.52
H_4	.042	.062	1.07	1.57
L_1	.370	.560	9.40	14.22
L_2	.307	.365	7.80	9.27
L_3	.089	.099	2.26	2.49
L_4	.132	.142	3.35	3.61
L_5	.026	.036	.66	.91
W	1.104	1.144	28.04	29.06

MECHANICAL SPECIFICATIONS

SPA25 SPB25 SPC25 SPD25





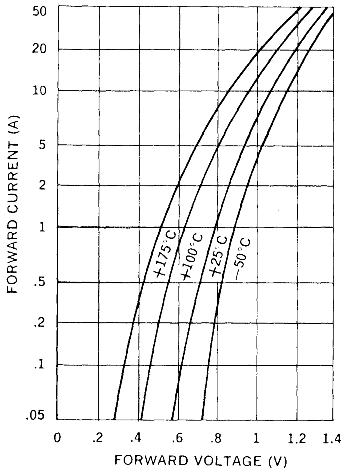
NOTES:
1. Terminals shall be hot tin dipped or silver plated.
2. Polarity shall be marked on terminal side of device.
3. Point at which Tc is read (must be in metal part of case).
4. Locating pin shall be adjacent to positive terminal.
5. Insulating sleeve shall be alumina (AL_2O_3) or equivalent.

Electrical Specifications (at 25°C unless noted)

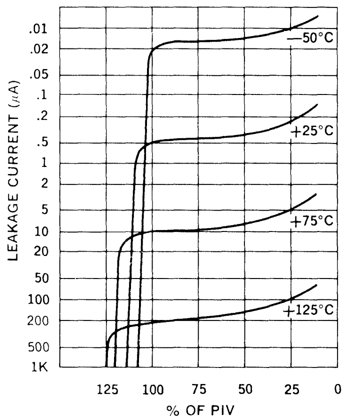
Type	PIV Per Leg	Peak Forward Voltage Drop*		Maximum Reverse Recovery Time†	Maximum Leakage Current Per Leg @ PIV $T_C = 25°C$	Maximum Leakage Current Per Leg @ PIV $T_C = 150°C$
	Volts	Minimum	Maximum	µS	µA	µA
JAN SPA25	100	0.9V	1.4V	2	2	250
JAN SPB25	200					
JAN SPC25	400	@ 39A(pk)				
JAN SPD25	600					

*Peak forward voltage drop is measured at a pulse width of 8.3ms.
†Measured in a reverse recovery circuit switching from 0.5A forward to 1.0A reverse current recovery to 0.5A.

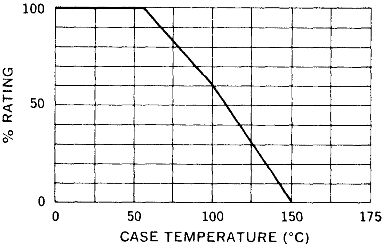
Typical Forward Voltage Per Leg vs. Forward Current



Typical Leakage Current vs. PIV



Current Derating Curve



Discrete diode inspection lot

100 Percent process conditioning of discrete diodes

1. High-temperature storage
2. Thermal shock (temperature cycling)
3. Reverse-recovery time

100 Percent burn-in of discrete diodes

1. Measurement of specified parameters
2. Reverse bias burn-in
3. Measurement of specified parameters to determine delta
4. Lot rejection criteria based on rejects from burn-in test

Assembly and encapsulation of discrete diodes into bridge assembly

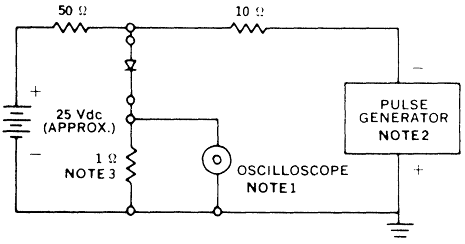
Inspection tests to verify LTPD

Group A
Group B
Group C

Review of groups A, B, and C data for lot accept or reject

Preparation for delivery

Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 16A Center-Tap

UES2401-UES2403

FEATURES

- Very Low Forward Voltage
- Very Fast Recovery Times
- Economical, Convenient TO-220 Package
- Low Thermal Resistance
- Mechanically Rugged

DESCRIPTION

The UES2401 Series in the economical, convenient TO-220 package, is specifically designed for operation in power switching circuits to frequencies in excess of 100KHz. The series combines two high efficiency devices into one package, simplifying installation, reducing heatsink requirements and the need to purchase matched components.

ABSOLUTE MAXIMUM RATINGS

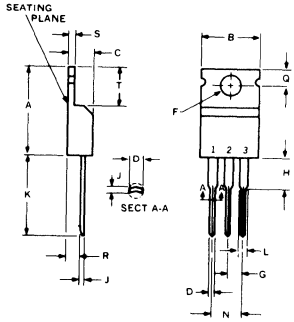
Peak Inverse Voltage, UES2401	50V
Peak Inverse Voltage, UES2402	100V
Peak Inverse Voltage, UES2403	150V
Maximum Average D.C. Output Current	
@ T_C =125°C (Note 1)	16A
@ T_A = 25°C	3A
@ T_A = 25°C (Note 2)	10A
Non-Repetitive Sinusoidal Surge Current, 8.3mS	80A
Thermal Resistance, Junction to Case, $\theta_{J\text{-}C}$	1.75°C/W
Thermal Resistance, Junction to Ambient, $\theta_{J\text{-}A}$	60°C/W
Operating and Storage Temperature Range	–55°C to +150°C

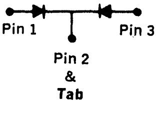
Note 1. Above 8A use the tab for electrical connection.

Note 2. Using Wakefield Type 295 heatsink with convection cooling. For more definitive data refer to the Output Current vs. Temperature Curves on this datasheet.

MECHANICAL SPECIFICATIONS

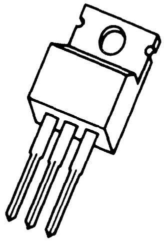
UES2401-2403





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H		6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

TO-220



6-79
(Revised)

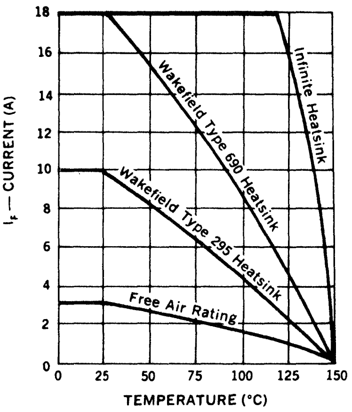
UNITRODE

ELECTRICAL SPECIFICATIONS

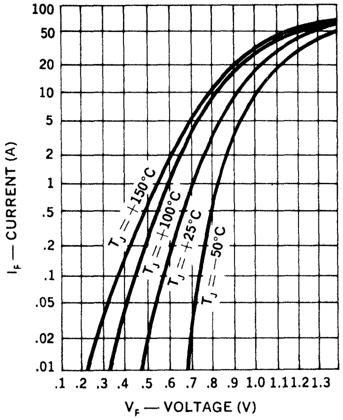
Type	PIV	Maximum Forward Voltage		Maximum Reverse Current @ PIV		Maximum Reverse Recovery Time*	Typical Forward Recovery Voltage @ 1A $t_r = 8nS$
		$T_J = 25°C$	$T_J = 100°C$	$T_J = 25°C$	$T_J = 100°C$		
UES2401 UES2402 UES2403	50V 100V 150V	0.9V @ 4A 0.975V @ 8A tp = 300μS	0.8V @ 4A 0.895V @ 8A	5μA	150μA	35nS	1.4V

*Measured in circuit $I_F = 0.5A$, $I_R = 1.0A$, $I_{REC} = 0.25A$

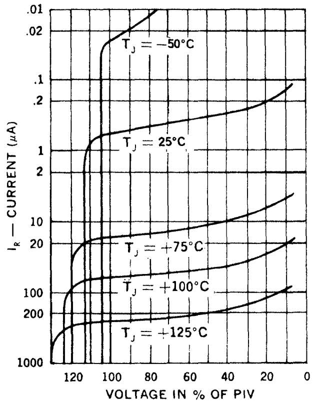
Output Current vs. Temperature



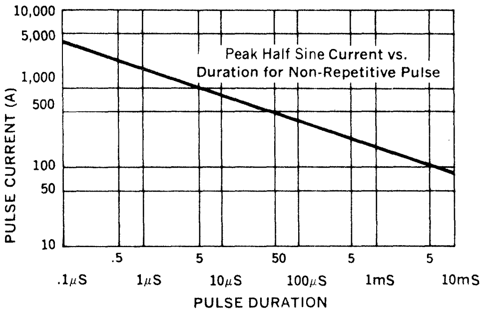
Typical Forward Current vs. Forward Voltage



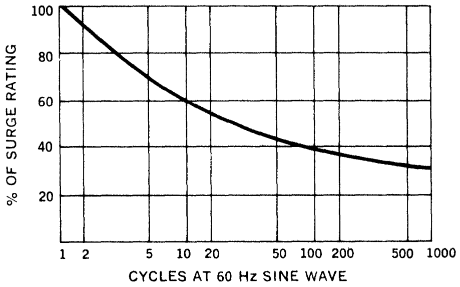
Typical Reverse Current vs. Voltage



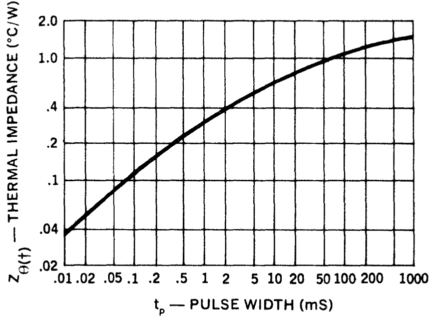
Forward Pulse Current vs. Duration



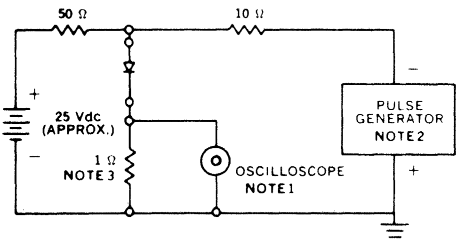
Multiple Surge Current vs. Duration



Thermal Impedance vs. Pulse Width



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ≤ 3nS; input impedance = 50Ω.
2. Pulse Generator: Rise time ≤ 8nS; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS

High Efficiency, 30A Center-Tap

UES-2601-UES2603

FEATURES

- Very Low Forward Voltage
- Very Fast Switching Speed
- Convenient Package
- High Surge
- Low Thermal Resistance
- Mechanically Rugged
- Both Polarities Available

DESCRIPTION

This series combines two high efficiency devices into one package, simplifying installation, reducing heat sink requirements and the need to purchase matched components.

ABSOLUTE MAXIMUM RATINGS

Peak Inverse Voltage, UES2601	50V
Peak Inverse Voltage, UES2602	100V
Peak Inverse Voltage, UES2603	150V
Maximum Average D.C. Output Current at $T_C = 100°C$	30A
Non-Repetitive Sinusoidal Surge Current 8.3 ms	400A
Thermal Resistance, Junction to Case	1°C/W
Operating and Storage Temperature Range	−55°C to +175°C

POWER CYCLING

These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

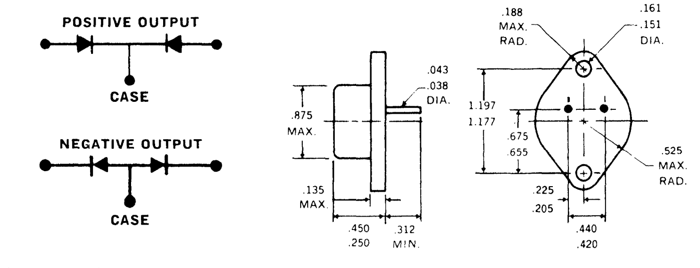
In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

SWITCHING CHARACTERISTICS

The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

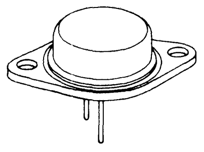
MECHANICAL SPECIFICATIONS

UES2601-UES2603



Dimensions in inches.

TO-3



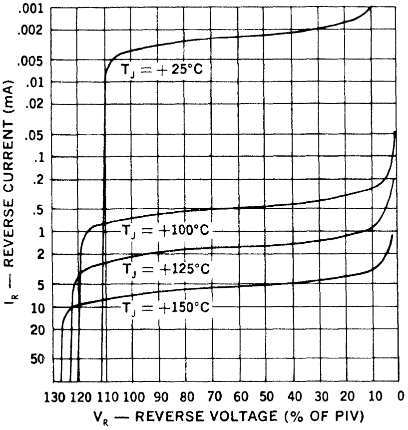
Note:
Standard polarity is positive output.
For reverse polarity (negative output) add suffix "R", ie. UES2601R.

ELECTRICAL SPECIFICATIONS

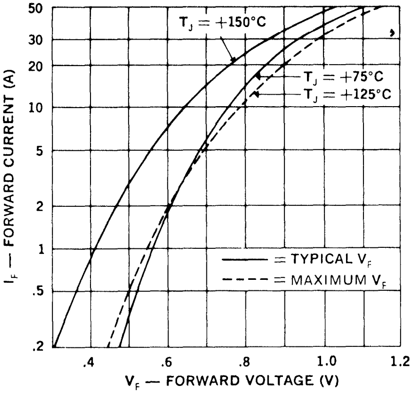
Type	PIV	Maximum Forward Voltage @		Maximum Reverse Current @		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	$T_C = 25°C$	$T_C = 125°C$	
UES2601 UES2602 UES2603	50V 100V 150V	.930V @ 15A $t_p = 300\mu S$	.825V @ 15A $t_p = 300\mu S$	20μA	4mA	35nS

* Measured in circuit $I_F = 0.5A$, $I_R = 1A$, $I_{REC} = 0.25A$

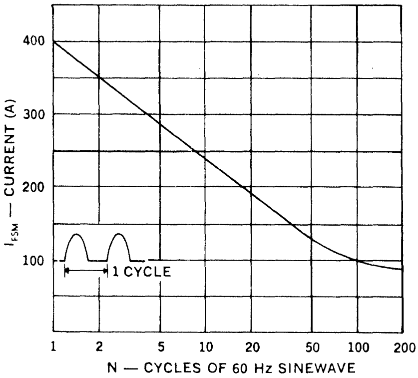
Typical Reverse Current vs. Reverse Voltage



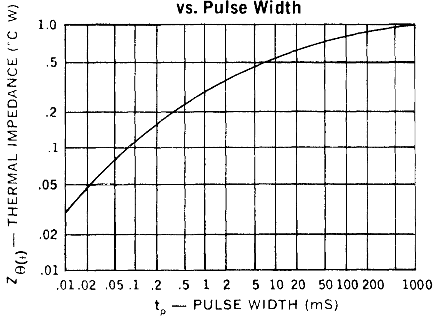
Forward Current vs. Forward Voltage



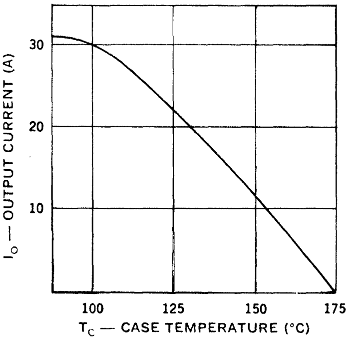
Maximum Forward Surge vs. Number of Cycles



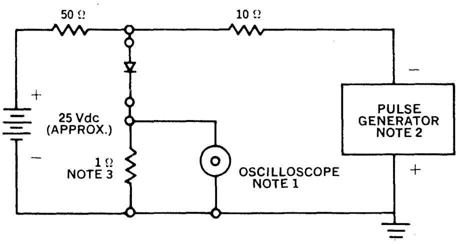
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:

1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIERS
High Efficiency, 30A Center-Tap

UES2604–UES2606

FEATURES
- Very Low Forward Voltage (1.15V)
- Very Fast Recovery Times (50nSec)
- Low Profile Package
- High Surge Capability
- Low Thermal Resistance
- Mechanically Rugged
- Both Polarities Available

DESCRIPTION
The UES2604 series is specifically designed for operation in power switching circuits operating at frequencies of at least 20 KHz.

This series combines two high efficiency devices into one package, simplifying installation, reducing heat sink requirements and the need to purchase matched components.

ABSOLUTE MAXIMUM RATINGS

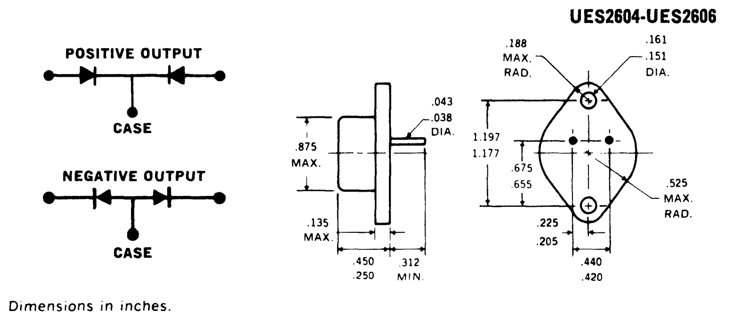
Peak Inverse Voltage, UES2604	200V
Peak Inverse Voltage, UES2605	300V
Peak Inverse Voltage, UES2606	400V
Maximum Average D.C. Output Current @ $T_C = 100°C$	30A
Surge Current, 8.3mSec	300A
Thermal Resistance, Junction to Case	1°C/W
Operating and Storage Temperature Range	−55°C to +150°C

POWER CYCLING
These devices possess the unique ability to pass many thousands of cycles of a stress test designed to evaluate the integrity of the bonding systems used in the construction of power rectifiers.

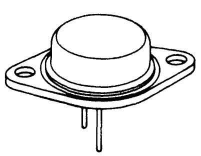
In this stress test, the case of the device is not heat sunk. Full rated forward current is supplied to force a case temperature increase at least 75°C, at which time, the current is removed and the case allowed to cool. The cycle is repeated a minimum of 5,000 times to simulate equipment being turned on and off. Extended power cycling tests demonstrate a product capability in excess of 25,000 cycles.

SWITCHING CHARACTERISTICS
The switching times of these ultra-fast rectifiers increase relatively little, with temperature or at different currents. Even in severe applications, such as catch diodes for switching regulators and output rectifiers for high frequency square wave inverters, these devices switch many times faster than the fastest associated transistors. Thus, the stresses on and powers dissipated in the switching transistors are substantially less than when using other rectifiers.

MECHANICAL SPECIFICATIONS



TO-3



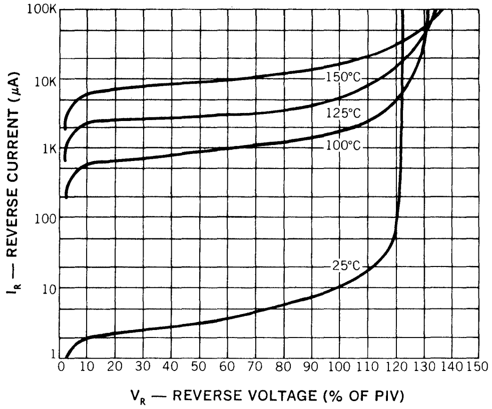
Note:
Standard polarity is positive output.
For reverse polarity (negative output) add suffix "R", ie. UES2604R.

ELECTRICAL SPECIFICATIONS, PER LEG

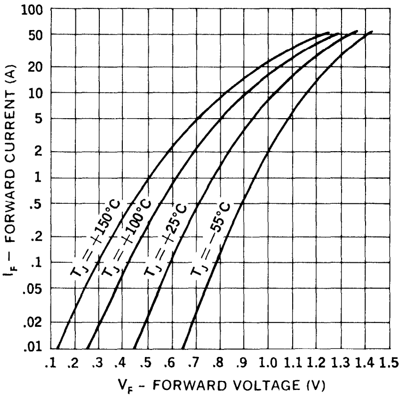
Type	PIV	Maximum Forward Voltage		Maximum Reverse Current		Maximum Reverse Recovery Time*
		$T_C = 25°C$	$T_C = 125°C$	$T_C = 25°C$	$T_C = 125°C$	
UES2604 UES2605 UES2606	200V 300V 400V	1.25V @ 15A $t_p = 300\mu S$	1.15V @ 15A $t_p = 300\mu S$	50μA	10mA	50nS

*Measured in circuit $I_F = .5A$, $I_R = 1A$, $I_{REC} = .25A$

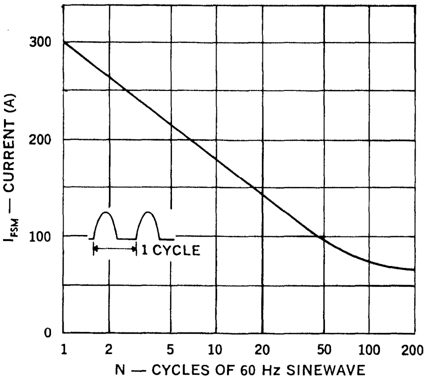
Typical Reverse Current vs. Reverse Voltage



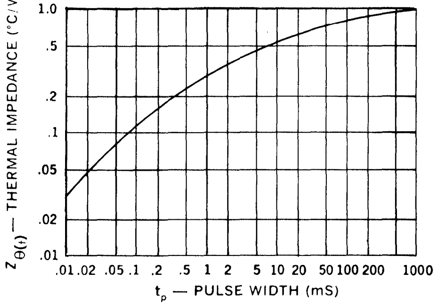
Forward Current vs. Forward Voltage



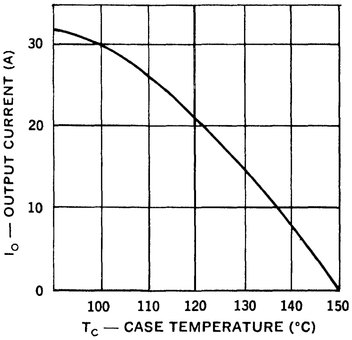
Maximum Forward Surge vs. Number of Cycles



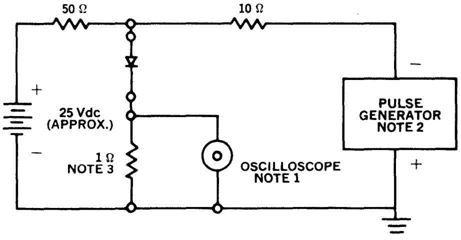
Thermal Impedance vs. Pulse Width



Output Current vs. Case Temperature



Reverse-Recovery Circuit



NOTES:
1. Oscilloscope: Rise time ⩽ 3ns; input impedance = 50Ω.
2. Pulse Generator: Rise time ⩽ 8ns; source impedance 10Ω.
3. Current viewing resistor, non-inductive, coaxial recommended.

RECTIFIER BRIDGE ASSEMBLIES

PART NUMBER INDEX

PAGE	PART NUMBER	DESCRIPTION
		FULL WAVE BRIDGE
431	469-1, J, JTX	1 ph; 10A; 200V
431	469-2, J, JTX	1 ph; 10A; 400V
431	469-3, J, JTX	1 ph; 10A; 600V
433	483-1JTX	3 ph; 25A; 200V
433	483-2JTX	3 ph; 25A; 400V
433	483-3JTX	3 ph; 25A; 600V
435	673-1	1 ph; 1.5A; 100V
435	673-2	1 ph; 1.5A; 200V
435	673-3	1 ph; 1.5A; 300V
435	673-4	1 ph; 1.5A; 400V
435	673-5	1 ph; 1.5A; 500V
435	673-6	1 ph; 1.5A; 600V
437	673-7	1 ph; H.V.; 1200V
437	673-7.5	1 ph; H.V.; 1800V
437	673-8	1 ph; H.V.; 2400V
437	673-8.5	1 ph; H.V.; 3000V
437	673-9	1 ph; H.V.; 3600V
437	673-10	1 ph; H.V.; 4200V
437	673-11	1 ph; H.V.; 4800V
437	673-12	1 ph; H.V.; 5000V
435	676-1	1 ph; 1.0A; 100V
435	676-2	1 ph; 1.0A; 200V
435	676-3	1 ph; 1.0A; 300V
435	676-4	1 ph; 1.0A; 400V
435	676-5	1 ph; 1.0A; 500V
435	676-6	1 ph; 1.0A; 600V
437	676-12	1 ph; H.V.; 1200V
437	676-18	1 ph; H.V.; 1800V
437	676-24	1 ph; H.V.; 2400V
437	676-30	1 ph; H.V.; 3000V
437	676-36	1 ph; H.V.; 3600V
437	676-42	1 ph; H.V.; 4200V
437	676-48	1 ph; H.V.; 4800V
437	676-50	1 ph; H.V.; 5000V
440	678-1	3 ph; 25A; 100V
440	678-2	3 ph; 25A; 200V
440	678-3	3 ph; 25A; 300V
440	678-4	3 ph; 25A; 400V
440	678-5	3 ph; 25A; 500V
440	678-6	3 ph; 25A; 600V
443	679-1	1 ph; 25A; 100V
443	679-2	1 ph; 25A; 200V
443	679-3	1 ph; 25A; 300V
443	679-4	1 ph; 25A; 400V
443	679-5	1 ph; 25A; 500V
443	679-6	1 ph; 25A; 600V
443	680-1	1 ph; 10A; 100V
443	680-2	1 ph; 10A; 200V
443	680-3	1 ph; 10A; 300V
443	680-4	1 ph; 10A; 400V
443	680-5	1 ph; 10A; 500V
443	680-6	1 ph; 10A; 600V
		DOUBLER OR CENTER-TAP
446	681-1	15.0A; 100V
446	681-2	15.0A; 200V
446	681-3	15.0A; 300V
446	681-4	15.0A; 400V
446	681-5	15.0A; 500V
446	681-6	15.0A; 600V
		FULL WAVE BRIDGE
440	682-1	3 ph; 20A; 100V
440	682-2	3 ph; 20A; 200V
440	682-3	3 ph; 20A; 300V
440	682-4	3 ph; 20A; 400V

PAGE	PART NUMBER	DESCRIPTION
		FULL WAVE BRIDGE
440	682-5	3 ph; 20A; 500V
440	682-6	3 ph; 20A; 600V
443	683-1	1 ph; 20A; 100V
443	683-2	1 ph; 20A; 200V
443	683-3	1 ph; 20A; 300V
443	683-4	1 ph; 20A; 400V
443	683-5	1 ph; 20A; 500V
443	683-6	1 ph; 20A; 600V
443	684-1	1 ph; 10A; 100V
443	684-2	1 ph; 10A; 200V
443	684-3	1 ph; 10A; 300V
443	684-4	1 ph; 10A; 400V
443	684-5	1 ph; 10A; 500V
443	684-6	1 ph; 10A; 600V
		DOUBLE OR CENTER-TAP
446	689-1	15A; 100V
446	689-2	15A; 200V
446	689-3	15A; 300V
446	689-4	15A; 400V
446	689-5	15A; 500V
446	689-6	15A; 600V
		FULL WAVE BRIDGE
440	695-1	3 ph; 15A; 100V
440	695-2	3 ph; 15A; 200V
440	695-3	3 ph; 15A; 300V
440	695-4	3 ph; 15A; 400V
440	695-5	3 ph; 15A; 500V
440	695-6	3 ph; 15A; 600V
440	696-1	3 ph; 15A; 100V
440	696-2	3 ph; 15A; 200V
440	696-3	3 ph; 15A; 300V
440	696-4	3 ph; 15A; 400V
440	696-5	3 ph; 15A; 500V
440	696-6	3 ph; 15A; 600V
448	697-1	1 ph; 2.5A; 100V
448	697-2	1 ph; 2.5A; 200V
448	697-3	1 ph; 2.5A; 300V
448	697-4	1 ph; 2.5A; 400V
448	697-5	1 ph; 2.5A; 500V
448	697-6	1 ph; 2.5A; 600V
448	698-1	1 ph; 2.25A; 100V
448	698-2	1 ph; 2.25A; 200V
448	698-3	1 ph; 2.25A; 300V
448	698-4	1 ph; 2.25A; 400V
448	698-5	1 ph; 2.25A; 500V
448	698-6	1 ph; 2.25A; 600V
450	700-1	3 ph; 2.5A; 100V
450	700-2	3 ph; 2.5A; 200V
450	700-3	3 ph; 2.5A; 300V
450	700-4	3 ph; 2.5A; 400V
450	700-5	3 ph; 2.5A; 500V
450	700-6	3 ph; 2.5A; 600V
450	701-1	3 ph; 2.25A; 100V
450	701-2	3 ph; 2.25A; 200V
450	701-3	3 ph; 2.25A; 300V
450	701-4	3 ph; 2.25A; 400V
450	701-5	3 ph; 2.25A; 500V
450	701-6	3 ph; 2.25A; 600V
452	800-1	3 ph; 40A; 50V
452	800-2	3 ph; 40A; 100V
452	800-3	3 ph; 40A; 125V
452	800-4	3 ph; 40A; 150V
452	801-1	3 ph; 20A; 50V
452	801-2	3 ph; 20A; 100V

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		FULL WAVE BRIDGE
452	801-3	3 ph; 20A; 125V
452	801-4	3 ph; 20A; 150V
455	802-1	1 ph; 35A; 50V
455	802-2	1 ph; 35A; 100V
455	802-3	1 ph; 35A; 125V
455	802-4	1 ph; 35A; 150V
455	803-1	1 ph; 20A; 50V
455	803-2	1 ph; 20A; 100V
455	803-3	1 ph; 20A; 125V
455	803-4	1 ph; 20A; 150V
		DOUBLER OR CENTER-TAP
458	804-1	20A; 50V
458	804-2	20A; 100V
458	804-3	20A; 125V
458	804-4	20A; 150V
461	PMB101	1.0A; 2.5kV
461	PMB102	1.0A; 5.0kV
461	PMB103	1.0A; 7.5kV
461	PMB104	1.0A; 10kV
461	PMB105	1.0A; 15kV
461	PMB106	1.0A; 20kV
461	PMB107	1.0A; 30kV
461	PMB101X	1.0A; 2.5kV
461	PMB102X	1.0A; 5.0kV
461	PMB103X	1.0A; 7.5kV
461	PMB104X	1.0A; 10kV
461	PMB105X	1.0A; 15kV
461	PMB106X	1.0A; 20kV
461	PMB107X	1.0A; 30kV
461	PMB201	2.0A; 2.5kV
461	PMB202	2.0A; 5.0kV
461	PMB203	2.0A; 7.5kV
461	PMB204	2.0A; 10kV
461	PMB205	2.0A; 15kV
461	PMB201X	2.0A; 2.5kV
461	PMB202X	2.0A; 5.0kV
461	PMB203X	2.0A; 7.5kV
461	PMB204X	2.0A; 10kV
461	PMB205X	2.0A; 15kV
		FULL WAVE BRIDGE
463	PMC101	1 ph; 2A; 2.5kV
463	PMC102	1 ph; 2A; 5.0kV
463	PMC103	1 ph; 2A; 7.5kV
463	PMC104	1 ph; 2A; 15kV
463	PMC104	1 ph; 2A; 10kV
463	PMC105	1 ph; 2A; 15kV
463	PMC101X	1 ph; 2A; 2.5kV
463	PMC102X	1 ph; 2A; 5.0kV
463	PMC103X	1 ph; 2A; 7.5kV
463	PMC104X	1 ph; 2A; 10kV
463	PMC105X	1 ph; 2A; 15kV
463	PMC201	1 ph; 4A; 2.5kV
463	PMC202	1 ph; 4A; 5.0kV
463	PMC203	1 ph; 4A; 7.5kV
463	PMC201X	1 ph; 4A; 2.5kV
463	PMC202X	1 ph; 4A; 5.0kV
463	PMC203X	1 ph; 4A; 7.5kV
465	PMD101	3 ph; 3A; 2.5kV
465	PMD102	3 ph; 3A; 5.0kV
465	PMD103	3 ph; 3A; 7.5kV
465	PMD104	3 ph; 3A; 10kV
465	PMD101X	3 ph; 3A; 2.5kV
465	PMD102X	3 ph; 3A; 5.0kV
465	PMD103X	3 ph; 3A; 7.5kV

PAGE	PART NUMBER	DESCRIPTION
		FULL WAVE BRIDGE
465	PMD104X	3 ph; 6A; 2.5kV
465	PMD201	3 ph; 6A; 5.0kV
465	PMD202	3 ph; 3A; 10kV
465	PMD201X	3 ph; 6A; 2.5kV
465	PMD202X	3 ph; 6A; 5.0kV
		DOUBLER OR CENTER-TAP
467	SES5401C	16A; 50V; TO-220
467	SES5402C	16A; 100V; TO-220
467	SES5403C	16A; 150V; TO-220
469	SES5601C	25A; 50V; TO-220
469	SES5602C	25A; 100V; TO-220
469	SES5603C	25A; 150V; TO-220
		FULL WAVE BRIDGE
471	SPA25, J	1 ph; 25A; 100V
471	SPB25, J	1 ph; 25A; 200V
471	SPC25, J	1 ph; 25A; 400V
471	SPD25, J	1 ph; 25A; 600V
		DOUBLER OR CENTER-TAP
473	UES2401	16A, 50V; TO-220
473	UES2402	16A; 100V; TO-220
473	UES2403	16A, 150V; TO-220
475	UES2601	30A; 50V; TO-3
475	UES2602	30A; 100V; TO-3
475	UES2603	30A; 150V; TO-3
477	UES2604	30A; 200V; TO-3
477	UES2605	30A; 300V; TO-3
477	UES2606	30A; 400V; TO-3

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

POWER ZENERS AND TRANSIENT VOLTAGE SUPPRESSORS

PRODUCT SELECTION GUIDE


A


B


CCL

Transient Voltage Suppressors

		Part No.	Stand -Off Voltage V_R (V)	Min. Breakdown Voltage $BV_{(min)}$ @ 1mA (V)	Max. Peak Pulse Current I_{pp} (A)	Max. Clamping Voltage* V_C @ I_{pp} (V)	Peak Power for 1mS (W)
Package Style	A Body	TVS305	5.0	6.0	17	8.7	150
		TVS310	10.0	11.1	8.9	16.8	
		TVS312	12.0	13.8	7.1	21.0	
		TVS315	15.0	16.7	5.9	25	
		TVS318	18.0	20.4	4.9	31	
		TVS324	24.0	28.4	3.6	42	
		TVS328	28.0	30.7	3.2	46	
		TVS348	48.0	54	1.7	82	
		TVS360	60.0	67	1.4	105	
		TVS410	100.0	111	.91	160	
		TVS420	200.0	234	.42	360	
		TVS430	300.0	342	.28	520	
	B Body	TVS505	5.0	6.0	53.7	9.3	500
		TVS510	10.0	11.1	30.3	16.5	
		TVS512	12.0	13.8	23.8	21.0	
		TVS515	15.0	16.7	19.8	25.2	
		TVS518	18.0	20.4	16.3	30.5	
		TVS524	24.0	28.4	11.9	42.0	
		TVS528	28.0	30.7	10.7	46.5	
	CCL Body	1N5610*		33.0	32.0	47.5	1500
		1N5611*		43.7	24.0	63.5	
		1N5612*		54.0	19.0	79.5	
		1N5613*		191.0	5.7	265.0	

*Available in JAN & JANTX

Bi-directional Zeners

	Power	1W	3W	5W
	Package Style	AA		BB
Voltage, V (10% Tolerance)	7.5	UDZ8807	UDZ807	UDZ5807
	8.2	UDZ8808	UDZ808	UDZ5808
	9.1	UDZ8809	UDZ809	UDZ5809
	10	UDZ8810	UDZ810	UDZ5810
	12	UDZ8812	UDZ812	UDZ5812
	15	UDZ8815	UDZ815	UDZ5815
	18	UDZ8818	UDZ818	UDZ5818
	20	UDZ8820	UDZ820	UDZ5820
	24	UDZ8824	UDZ824	UDZ5824
	27	UDZ8827	UDZ827	UDZ5827
	30	UDZ8830	UDZ830	UDZ5830
	33	UDZ8833	UDZ833	UDZ5833
	36	UDZ8836	UDZ836	UDZ5836
	40	UDZ8840	UDZ840	UDZ5840
	45	UDZ8845	UDZ845	UDZ5845
	60	UDZ8860	UDZ860	UDZ5860
	300		UDZ230	UDZ5230
	220		UDZ222	UDZ5222
	100		UDZ210	UDZ5210


AA


BB

POWER ZENERS AND TRANSIENT VOLTAGE SUPPRESSORS


A


B

Power		1W	1.5W	3W	5W	5W	6W	10W
Package Style		**A**	**A‡**	**A‡**	**B**	**B‡**	**CL‡**	**C‡**
VOLTAGE V. (5% Tolerance)†	6.8V	UZ8706	1N4461*	1N5063	UZ4706	1N4954*	UZ7706L	UZ7706
	7.5V	UZ8707	1N4462*	1N5064	UZ4707	1N4955*	UZ7707L	UZ7707
	8.2V	UZ8708	1N4463*	1N5065	UZ4708	1N4956*	UZ7708L	UZ7708
	9.1V	UZ8709	1N4464*	1N5066	UZ4709	1N4957*	UZ7709L	UZ7709
	10V	UZ8710	1N4465*	1N5067	UZ4710	1N4958*	UZ7710L	UZ7710
	11V	UZ8711	1N4466*	1N5068		1N4959*	UZ7711L	UZ7711
	12V	UZ8712	1N4467*	1N4883	UZ4712	1N4960*	UZ7712L	UZ7712
	13V	UZ8713	1N4468*	1N5069	UZ4713	1N4961*	UZ7713L	UZ7713
	14V	UZ8714		1N5070		1N5118	UZ7714L	UZ7714
	15V	UZ8715	1N4469*	1N5071	UZ4715	1N4962*	UZ7715L	UZ7715
	16V	UZ8716	1N4470*	1N5072	UZ4716	1N4963*	UZ7716L	UZ7716
	18V	UZ8718	1N4471*	1N5073	UZ4718	1N4964*	UZ7718L	UZ7718
	20V	UZ8720	1N4472*	1N4884	UZ4720	1N4965*	UZ7720L	UZ7720
	22V	UZ8722	1N4473*	1N5074	UZ4722	1N4966*	UZ7722L	UZ7722
	24V	UZ8724	1N4474*	1N5075	UZ4724	1N4967*	UZ7724L	UZ7724
	27V	UZ8727	1N4475*	1N5076	UZ4727	1N4968*	UZ7727L	UZ7727
	30V	UZ8730	1N4476*	1N5077	UZ4730	1N4969*	UZ7730L	UZ7730
	33V	UZ8733	1N4477*	1N5078	UZ4733	1N4970*	UZ7733L	UZ7733
	36V	UZ8736	1N4478*	1N5079	UZ4736	1N4971*	UZ7736L	UZ7736
	39V		1N4479*	1N5080	UZ4739	1N4972*		
	40V	UZ8740		1N5081		1N5119	UZ7740L	UZ7740
	43V		1N4480*	1N5082	UZ4743	1N4973*		
	45V	UZ8745		1N5083		1N5120	UZ7745L	UZ7745
	47V		1N4481*	1N5084	UZ4747	1N4974*		
	50V	UZ8750		1N5085		1N5121	UZ7750L	UZ7750
	51V		1N4482*	1N5086	UZ4751	1N4975*		
	56V	UZ8756	1N4483*	1N5087	UZ4756	1N4976*	UZ7756L	UZ7756
	60V	UZ8760		1N5088		1N5122	UZ7760L	UZ7760
	62V		1N4484	1N5089	UZ4762	1N4977*		
	68V		1N4485	1N5090	UZ4768	1N4978*		
PULSE POWER **		100W	140W	230W	720W	900W	2000W	2000W

* Available as JAN, JANTX, & JANTXV
** For 100 μsec pulse width
‡ Unitrode fused-in-glass construction
† 10% and 20% tolerance also available.

CL

C

Power		1W	1.5W	3W	5W	5W	6W	10W
Package Style		**A**	**A‡**	**A‡**	**B**	**B‡**	**CL‡**	**C‡**
VOLTAGE V_z (5% Tolerance)†	70V	UZ8770		1N5091		1N5123	UZ7770L	UZ7770
	75V	UZ8775	1N4486	1N5092	UZ4775	1N4979*	UZ7775L	UZ7775
	80V	UZ8780		1N5093		1N5124	UZ7780L	UZ7780
	82V		1N4487	1N5094	UZ4782	1N4980*		
	90V	UZ8790		1N4096		1N5125	UZ7790L	UZ7790
	91V		1N4488	1N4095	UZ4791	1N4981*		
	100V	UZ8110	1N4489	1N4097	UZ4110	1N4982*	UZ7110L	UZ7110
	110V	UZ8111		1N5096	UZ4111	1N4983*		
	120V	UZ8112		1N5097	UZ4112	1N4984*		
	130V	UZ8113		1N5098	UZ4113	1N4985*		
	140V	UZ8114		1N5099				
	150V	UZ8115		1N4098	UZ4115	1N4986*		
	160V	UZ8116		1N5100	UZ4116	1N4987*		
	170V	UZ8117		1N5101		1N5127		
	180V	UZ8118		1N5102	UZ4118	1N4988*		
	190V	UZ8119		1N5103		1N5128		
	200V	UZ8120		1N5104	UZ4120	1N4989*		
	220V			1N5105		1N4990*		
	240V			1N5106		1N4991*		
	260V			1N5107		1N5129		
	270V			1N5108		1N4992*		
	280V			1N5109		1N5130		
	300V			1N5110		1N4993*		
	320V			1N5111		1N5131		
	330V			1N5112		1N4994*		
	340V			1N5113		1N5132		
	360V			1N5114		1N4995*		
	380V			1N5115		1N5133		
	390V			1N5116		1N4996*		
	400V			1N5117		1N5134		
PULSE POWER **		100W	140W	230W	720W	900W	2000W	2000W

* Available as JAN, JANTX, & JANTXV
** For 100 μsec pulse width
‡ Unitrode fused-in-glass construction
† 10% and 20% tolerance also available.

POWER ZENERS
1.5 Watt, Military

1N4461-1N4496
JAN, JANTX & JANTXV

FEATURES
- 5 Times Greater Surge Rating than JAN1N3016 Series
- Low Reverse Current: to 50nA
- ¼ Size of Conventional 1 Watt Zeners

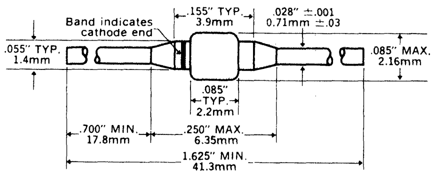
DESCRIPTION
Fused-in-glass, metallurgically bonded 1.5 watt zeners, qualified to MIL-S-19500/406.

ABSOLUTE MAXIMUM RATINGS

Zener Voltage, V_Z	6.8 to 200V
Continuous Current	See Table
Surge Current (8.3ms)	See Table
Surge Power	See Graph
Power	See Lead Temperature Derating Curve
Storage and Operating Temperature	−65°C to +175°C

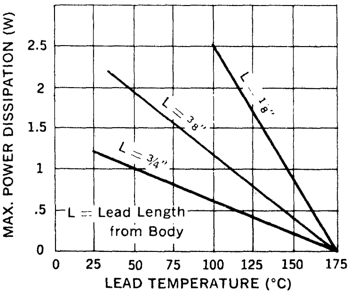
MECHANICAL SPECIFICATIONS

JAN, JANTX & JANTXV 1N4461-1N4496

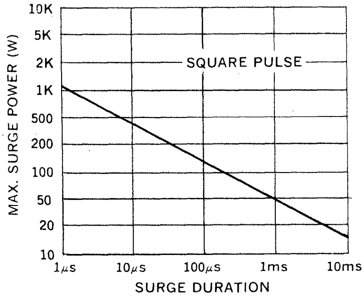


BODY A

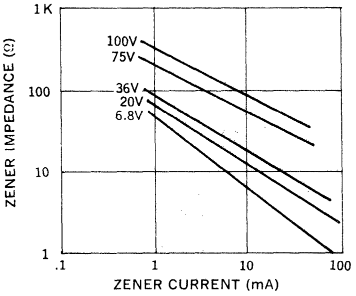
Power Dissipation vs. Lead Temperature Derating Curve



Max. Surge Power vs. Surge Duration



Typical Zener Impedance vs. Zener Current



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UNITRODE

Type	Electrical Specifications at 25°C									Maximum Ratings	
	Nominal Zener Voltage † V_Z @ I_{ZT}	Test Current I_{ZT}	Max. Zener Impedance §			Voltage ** Regulation ΔBV Max	Maximum Reverse Leakage Current			Maximum Cont. Current I_{ZM}	Maximum Surge Current ‡ I_S
			Z_Z @ I_{ZT}	Z_{ZK} @ I_{ZK}	I_{ZK}		I_R @ V_R	V_R			
±5% Tolerance	Volts	mA	Ohms	Ohms	mA	Volts	μA	Volts		mA	Amps
1N4461	6.8	37	2.5	200	1.0	.30	5.0	4.08		210	5.0
1N4462	7.5	34	2.5	400	.5	.35	1.0	4.50		191	4.5
1N4463	8.2	31	3.0	400	.5	.40	.50	4.92		174	3.9
1N4464	9.1	28	4.0	500	.5	.45	.30	5.46		157	3.4
1N4465	10	25	5.0	500	.25	.50	.30	8.0		143	3.0
1N4466	11	23	6.0	550	.25	.55	.30	8.8		130	2.6
1N4467	12	21	7.0	550	.25	.60	.20	9.6		119	2.4
1N4468	13	19	8.0	550	.25	.65	.10	10.4		110	2.2
1N4469	15	17	9.0	600	.25	.75	.05	12.0		95	1.8
1N4470	16	15.5	10.0	600	.25	.80	.05	12.8		90	1.6
1N4471	18	14	11.0	650	.25	.83	.05	14.4		79	1.4
1N4472	20	12.5	12.0	650	.25	.95	.05	16.0		71	1.2
1N4473	22	11.5	14	650	.25	1.0	.05	17.6		65	1.1
1N4474	24	10.5	16	700	.25	1.1	.05	19.2		60	.90
1N4475	27	9.5	18	700	.25	1.3	.05	21.6		53	.80
1N4476	30	8.5	20	750	.25	1.4	.05	24.0		48	.75
1N4477	33	7.5	25	800	.25	1.5	.05	26.4		43	.66
1N4478	36	7.0	27	850	.25	1.7	.05	28.8		40	.60
1N4479	39	6.5	30	900	.25	1.8	.05	31.2		37	.54
1N4480	43	6.0	40	950	.25	1.9	.05	34.4		33	.48
1N4481	47	5.5	50	1000	.25	2.1	.05	37.6		30	.45
1N4482	51	5.0	60	1100	.25	2.3	.05	40.8		28	.42
1N4483	56	4.5	70	1300	.25	2.5	.05	44.8		26	.39
1N4484	62	4.0	80	1500	.25	2.7	.05	49.6		23	.35
1N4485	68	3.7	100	1700	.25	3.0	.05	54.4		21	.32
1N4486	75	3.3	130	2000	.25	3.3	.05	60.0		19	.29
1N4487	82	3.0	160	2500	.25	3.6	.05	65.6		17	.26
1N4488	91	2.8	200	3000	.25	4.0	.05	72.8		16	.23
1N4489	100	2.5	250	3100	.25	4.4	.25	80.0		14	.20
1N4490	110	2.0	300	4000	.25	5.0	.25	88.0		13	.19
1N4491	120	2.0	400	4500	.25	5.5	.25	96.0		12	.18
1N4492	130	1.9	500	5000	.25	6.0	.25	104		11	.16
1N4493	150	1.7	700	6000	.25	7.0	.25	120		9.5	.14
1N4494	160	1.6	1000	6500	.25	8.0	.25	128		8.9	.12
1N4495	180	1.4	1300	7000	.25	10.0	.25	144		7.9	.10
1N4496	200	1.2	1500	8000	.25	12.0	.25	160		7.2	.08

† All Zener voltages are measured with an automated test set using a 35 millisecond test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§ Zener impedance is derived from the 60 cycle AC Voltage created when AC current with RMS value of 10% of DC Zener test current is superimposed on the test current.

** ΔBV is obtained by measuring the voltage change when the test current is changed from 10% to 50% of Iz max under DC conditions. During this measurement the leads are heat sunk .375 inch from the body and maintained at 25°C.

‡ Ratings shown are for peak sinusoidal surge current of 8.3 ms duration, non-repetitive. The 8.3 ms square pulse rating is 71% of the value shown. Rating exceeds JEDEC Registered Specification.

POWER ZENERS
5 Watt, Military

1N4954- 1N4995
JAN, JANTX & JANTXV
1N4996

FEATURES
- 2 Times Greater Surge Rating than Conventional 10 Watt Zeners
- Small Physical Size

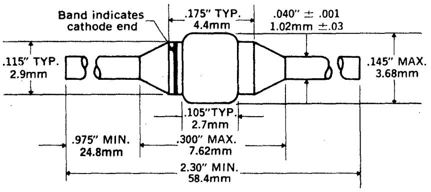
DESCRIPTION
Fused-in-glass, metallurgically-bonded 5 watt zeners, qualified to MIL- S -19500/356.

ABSOLUTE MAXIMUM RATINGS

Zener Voltage, V_Z	6.8 to 390V
Continuous Current	See Table
Surge Current (8.3ms)	See Table
Surge Power	See Graph
Power	See Lead Temperature Derating Curve
Storage and Operating Temperature	−65°C to +175°C

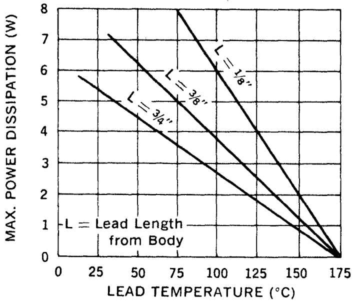
MECHANICAL SPECIFICATIONS

1N4954- 1N4955 JAN, JANTX & JANTXV ,1N4996

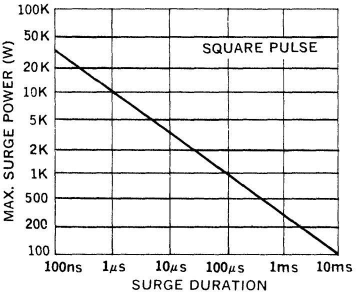


BODY B

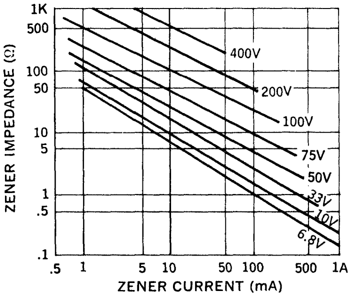
Power Dissipation vs. Lead Temperature Derating Curve



Max. Surge Power vs. Surge Duration



Typical Zener Impedance vs. Zener Current



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UNITRODE

Electrical Specifications at 25°C										Maximum Ratings	
Type	Nominal Zener Voltage† V_Z @ I_{ZT}	Test Current I_{ZT}	Maximum Zener Impedance § Z_Z @ I_{ZT}	Maximum Zener Impedance § Z_{ZK}†† @ I_{ZK} = 1mA	Voltage Regulation ΔBV §§	Maximum Reverse Leakage Current I_R††	Maximum Reverse Leakage Current I_R	Maximum Reverse Leakage Current V_R	Maximum Temperature Coeff. T_C @ I_{ZT}	Maximum Continuous Current ★ I_{ZM}	Maximum Surge Current‡ I_S
±5% Tolerance	Volts	mA	Ohms	Ohms	Volts	μA		Volts	%/°C	mA	Amps
1N4954*	6.8	175	1.0	1000	0.7	150	300	5.2	.05	700	40
1N4955*	7.5	175	1.5	800	0.7	100	200	5.7	.06	630	32
1N4956*	8.2	150	1.5	600	0.7	50	100	6.2	.06	580	24
1N4957*	9.1	150	2.0	400	0.7	25	50	6.9	.06	520	22
1N4958*	10.0	125	2.0	125	0.8	25	25	7.6	.07	475	20
1N4959*	11	125	2.5	130	0.8	10	15	8.4	.07	430	19
1N4960*	12	100	2.5	140	0.8	10	10	9.1	.07	395	18
1N4961*	13	100	3.0	145	0.8	10	10	9.9	.08	365	16
1N4962*	15	75	3.5	150	1.0	5	5	11.4	.08	315	12
1N4963*	16	75	3.5	155	1.1	5	5	12.2	.08	294	10
1N4964*	18	65	4.0	160	1.2	5	5	13.7	.085	264	9.0
1N4965*	20	65	4.5	165	1.5	2	2	15.2	.085	237	8.0
1N4966*	22	50	5.0	170	1.8	2	2	16.7	.085	216	7.0
1N4967*	24	50	5.0	175	2.0	2	2	18.2	.090	198	6.5
1N4968*	27	50	6.0	180	2.0	2	2	20.6	.090	176	6.0
1N4969*	30	40	8	190	2.5	2	2	22.8	.090	158	5.5
1N4970*	33	40	10	200	2.8	2	2	25.1	.095	144	5.0
1N4971*	36	30	11	220	3.0	2	2	27.4	.095	132	4.5
1N4972*	39	30	14	230	3.0	2	2	29.7	.095	122	4.0
1N4973*	43	30	20	240	3.3	2	2	32.7	.095	110	3.5
1N4974*	47	25	25	250	3.5	2	2	35.8	.095	100	3.2
1N4975*	51	25	27	270	4.0	2	2	38.8	.095	92	3.0
1N4976*	56	20	35	320	4.4	2	2	42.6	.095	84	2.8
1N4977*	62	20	42	400	5.0	2	2	47.1	.100	76	2.5
1N4978*	68	20	50	500	5.5	2	2	51.7	.100	70	2.2
1N4979*	75	20	55	620	6.0	2	2	56.0	.100	63.0	2.0
1N4980*	82	15	80	720	6.6	2	2	62.2	.100	58.0	1.8
1N4981*	91	15	90	760	7.5	2	2	69.2	.100	52.5	1.6
1N4982*	100	12	110	800	8.0	2	2	76.0	.100	47.5	1.4
1N4983*	110	12	125	1000	9.0	2	2	83.6	.100	43.0	1.2
1N4984*	120	10	170	1150	10	2	2	91.2	.100	39.5	1.00
1N4985*	130	10	190	1250	11	2	2	98.8	.105	36.6	0.80
1N4986*	150	8	330	1500	13	2	2	114.0	.105	31.6	0.75
1N4987*	160	8	350	1650	14	2	2	121.6	.105	29.4	0.70
1N4988*	180	5	450	1750	16	2	2	136.8	.110	26.4	0.60
1N4989*	200	5	500	1850	18	2	2	152	.110	23.6	0.50
1N4990*	220	5	550	2000	19	2	2	167	.115	21.6	0.50
1N4991*	240	5	650	2050	22	2	2	182	.115	19.8	0.40
1N4992*	270	5	800	2100	25	2	2	206	.120	17.5	0.35
1N4993*	300	4	950	2150	28	2	2	228	.120	15.6	0.30
1N4994*	330	4	1175	2200	32	2	2	251	.120	14.4	0.25
1N4995*	360	3	1400	2300	35	2	2	274	.120	13.0	0.22
1N4996	390	3	1800	2500	40	2	2	297	.120	12.0	0.20

* Available as JAN, JANTX & JANTXV.

† All zener voltages are measured with an automated test set using a 35 msec test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§ Zener impedance is derived from the 60-cycle voltage created when AC current with RMS value of 10% of DC zener test current is superimposed on the test current.

§§ ΔBV is obtained by measuring the voltage change when the test current is changed from 10% to 50% of Iz max under DC conditions. During this measurement the leads are heat sunk .375 inch from the body and maintained at 25°C.

★ Maximum current based on 5 Watt Rating. See lead temperature derating curves for proper mounting methods.

‡ Figures shown are for peak sinusoidal surge current of 8.3 msec duration, non-repetitive. The 8.3 ms square pulse rating is 71% of the value shown.

†† These specifications apply only to JAN and JANTX

POWER ZENERS

Transient Suppressor Diodes

JAN & JANTX 1N5610-1N5613

FEATURES

- 1500 Watts for 1ms Pulse Power Capability
- Small Physical Size
- Designed to be Used in Mil-Std-704A Applications

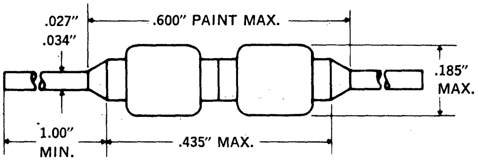
DESCRIPTION

Zener diodes with high surge capability qualified to MIL-S-19500/434. 1N5555 series in DO-13 package and 1N5610 series on double C body for ultimate reliability in repetitive surge applications.

ABSOLUTE MAXIMUM RATINGS (at 25°C except where otherwise noted)

	1N5610	1N5611	1N5612	1N5613
Zener Voltage	See Electrical Specifications			
Forward Surge Current	200A	200A	200A	200A
Zener Surge Current, at 25°C	32.0A	24.0A	19.0A	5.7A
Surge Current, at 150°C	5.5A	4.8A	3.2A	1.0A
Surge Power	See Graph			
Storage and Operating Temperature	—65°C to +175°C			

JAN & JANTX 1N5610-1N5613



Polarity: Cathode indicated by band.
Weight: 1.5 gram (approximate).
Mounting Position: Any. **Leads:** Tinned Copper.
Marking: Type number marked on unit.

Double C BODY

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	Min. Zener Voltage § Vz @ ImA	Max. Zener Voltage† Vz @ Is		Max. Reverse Leakage Current I_R @ V_R		Max. Forward Voltage‡ @ 100 Amps	Typical Temperature Coefficient
	Volts	Volts	Amps	μA	Volts	Volts	%/°C
1N5610*	33.0	47.5	32.0	5.0	30.5	4.8	.093
1N5611*	43.7	63.5	24.0	5.0	40.3	4.8	.094
1N5612*	54.0	79.5	19.0	5.0	49.0	4.8	.096
1N5613*	191.0	265.0	5.7	5.0	175.0	4.8	.100

Notes: * Available as JAN and JANTX.

§ Duration of applied current ≤ 300ms, duty cycle ≤ 2%.

† Utilizing a pulse which decays exponentially to 50% of the peak value in 1ms. See graph entitled "Pulse Waveform."

‡ Peak Sinusoidal surge current of 8.3ms duration, non-repetitive.

APPLICATIONS

Voltage transients can be suppressed with series elements, shunt elements, or a combination of both. These elements may be passive or active. For low and medium power applications, a series resistor and zener clamp offer several attractive features:

1. Simplicity of design
2. High reliability
3. Fast response time

The 1N5610 series of surge suppressors will suppress the following transients defined by *MIL-S-704A* without the use of any series limiting resistance beyond that provided by the source:

1. All 600V transients (category #1 on chart below)
2. All 80V transients except those generated by the main voltage regulator (category #2 on chart below)
3. The overvoltage transients generated by the *main voltage regulator* (category #3 on chart below) will also be suppressed by the 1N5610 series if:
    a. A 20 ohm series limiting resistor is used, or
    b. No series resistance is used but the zener is protected within 500 μs by using, for example, an SCR crowbar

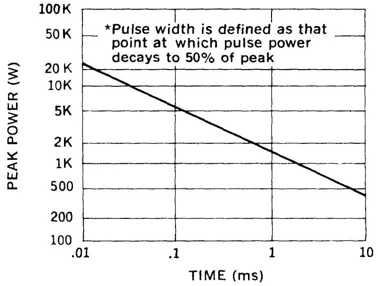
The above statements are based on the source impedances and dv/dt characteristics as given in ARINC* Specification #413. This report entitled "Guidance for Aircraft Electrical Power Utilization and Transient Protection" serves to further define *MIL-STD-704A* for large aircraft electrical systems.

Category	Source of Transient	Maximum Amplitude	Duration	Min. Source Impedance	dv/dt
1.	Inductive Switching	600 V	≤ 10 μs	50 ohms	
2.	BUS Switching	80 V	≤ 10 ms	15 ohms	
3.	Main Voltage Regulator	80 V	≥ 10 ms	0.2 ohms	50V/ms

These Surge Suppressors are useful in a variety of other applications where semiconductor devices must function reliably in an environment subject to extremely high but short term surges.

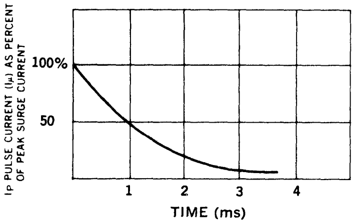
* ARINC stands for Aeronautical Radio, Inc. (Annapolis, Maryland 21401)

Peak Power Rating vs. Pulse Width*

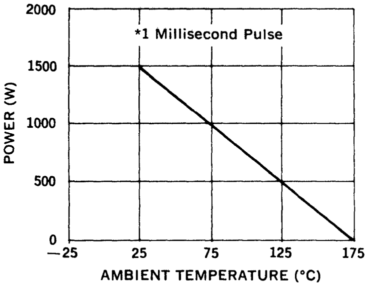


*Pulse width is defined as that point at which pulse power decays to 50% of peak

Pulse Waveform



Peak Power Rating* vs. Ambient Temperature



*1 Millisecond Pulse

TRANSIENT VOLTAGE SUPPRESSORS

TVS305-TVS430
TVS505-TVS528

FEATURES

- Up to 500W for 1mS Pulse Power Capability
- Clamping Time in Picoseconds
- Direct Applicability for all popular Microprocessors and IC families
- Metallurgically bonded assembly system to assure long term reliability
- Miniature glass encased hermetically sealed package

DESCRIPTION

Unitrode's TVS series of transient voltage suppressors feature oxide passivated zener type chips with full-faced metallurgical bonds on both sides to achieve high surge capability and negligible electrical degradation under repeated surge conditions. The series is especially useful in protecting microprocessor, MOS, CMOS, TTL, Schottky TTL, ECL, I²L and linear integrated circuits from spurious transient disturbances.

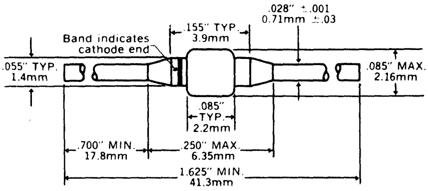
ABSOLUTE MAXIMUM RATINGS @ 25°C

	TVS305-TVS430	TVS505-TVS528
Stand-off Voltage, V_R	5 to 300V	5.0V to 28.0V
Peak Pulse Power (1mS)*	150W	500W
Forward Surge Current (8.3mS half sinewave)	15A	50A
Peak Pulse Current	See Table	See Table
Breakdown Voltage	See Table	See Table
Power, Continuous	3W	5W
Storage and Operating Temperature	−65 to +175°C	−65 to +175°C

*See Figures 3 and 4 for Peak Pulse Power vs Pulse Duration.

MECHANICAL SPECIFICATIONS

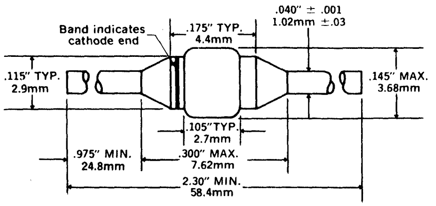
TVS305 Series



BODY A

MECHANICAL SPECIFICATIONS

TVS505 Series



BODY B

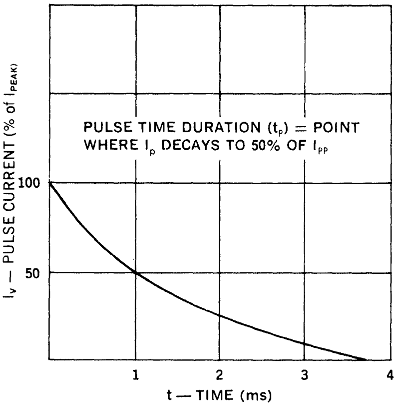
UNITRODE

ELECTRICAL SPECIFICATIONS @ 25°C

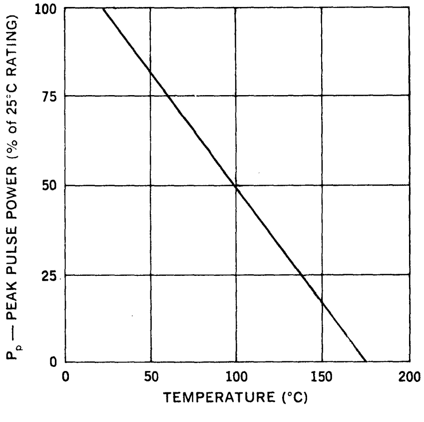
TVS Part No.	Stand -Off Voltage V_R	Min. Breakdown Voltage $BV_{(min)}$ @ 1mA	Max. Leakage Current I_R @ V_R	Max. Peak Pulse Current* I_{PP}	Max. Clamping Voltage* V_C @ I_{PP}	Max. Clamping Voltage* V_C @ 1A	Max. Clamping Voltage* V_C @ 5A	10A
	V	V	μA	A	V	V	V	
TVS305	5.0	6.0	50	17	8.7	—	—	—
TVS310	10.0	11.1	2	8.9	16.8	—	—	—
TVS312	12	13.8	1	7.1	21.0	—	—	—
TVS315	15	16.7	1	5.9	25	—	—	—
TVS318	18	20.4	1	4.9	31	—	—	—
TVS324	24	28.4	1	3.6	42	—	—	—
TVS328	28	30.7	1	3.2	46	—	—	—
TVS348	48	54	1	1.7	82	—	—	—
TVS360	60	67	1	1.4	105	—	—	—
TVS410	100	111	1	.91	160	—	—	—
TVS420	200	234	1	.42	360	—	—	—
TVS430	300	342	1	.28	520	—	—	—
TVS505	5.0	6.0	300	53.7	9.3	7.4	—	7.9
TVS510	10.0	11.1	5	30.3	16.5	13.2	—	14.4
TVS512	12.0	13.8	5	23.8	21.0	16.5	—	18.5
TVS515	15.0	16.7	5	19.8	25.2	19.7	—	22.2
TVS518	18.0	20.4	5	16.3	30.5	23.8	26.0	—
TVS524	24.0	28.4	5	11.9	42.0	32.4	37.0	—
TVS528	28.0	30.7	5	10.7	46.5	35.9	41.0	—

*For 1mS pulse: see Figure 1.

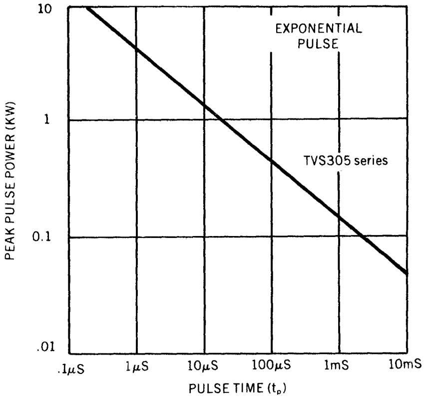
1. **Pulse Waveform**



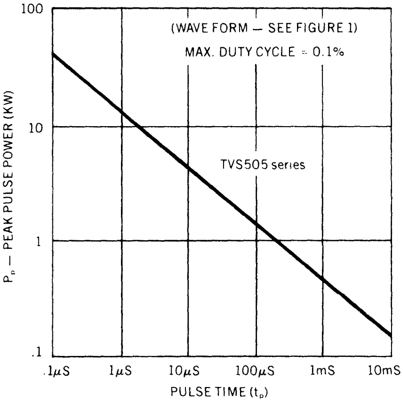
2. **Derating Curve**



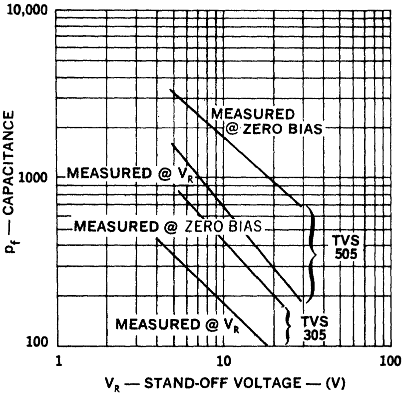
3. Peak Pulse Power vs. Pulse Duration



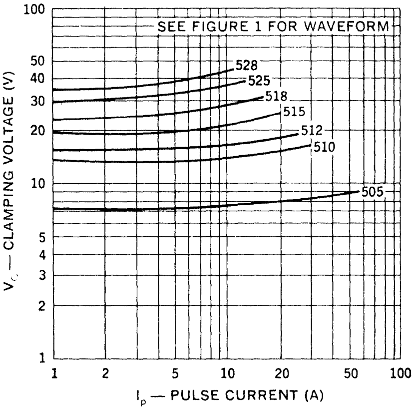
4. Peak Pulse Power vs. Pulse Duration



5. Capacitance vs. Stand-Off Voltage



6. Clamping Voltage vs. Pulse Current



CHOOSING AND SPECIFYING THE PROPER TVS

The following terms are generally used in specifying Transient Voltage Suppressors (TVS):

1. Stand-off Voltage (V_R) is the highest reverse voltage at which the TVS will be non-conducting.
2. Minimum Breakdown Voltage (BV min) is the reverse voltage at which the TVS conducts 1 milli-amp. This is the point where the TVS begins to limit the transient.
3. Maximum Clamping Voltage (V_C max) is the maximum voltage the TVS will allow during a transient "spike."

Figure 7 graphically shows all three terms.

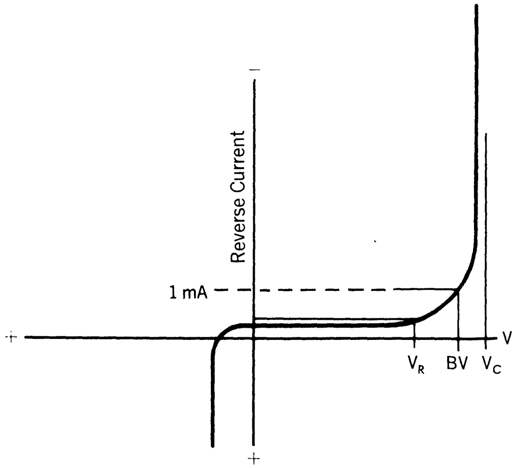


Figure 7

The three most important factors in choosing the appropriate TVS for an application in their order of importance are:

1. Pulse power (P_P) — Choose the TVS series that will handle the Transient Pulse Power. Transient Pulse Power is equal to the clamping voltage (V_C) times the peak pulse current (i_{PP}). The pulse duration vs. pulse power graph on the TVS data sheet can then be used to determine the maximum allowable pulse duration. (Figure 3 or 4).
2. Standoff voltage (V_R) — From the TVS series selected, choose the device with the stand-off voltage equal to or greater than the normal circuit operating voltage.
3. Maximum Clamping Voltage (V_{CMAX}) — Determine the clamping voltage of the device chosen for the transient given and be sure it is below the voltage that might damage any components.

For further information see Unitrode Application Note U-79, "Guidelines for Using Transient Voltage Suppressors."

AC POWER ZENERS
1, 3, 5, and 6 Watt Types

UDZ807 SERIES
UDZ5807 SERIES
UDZ7807 SERIES
UDZ8807 SERIES

FEATURES
- Zener Characteristics in Both Directions
- 7.5 to 300V
- High Surge Ratings
- Small Physical Size

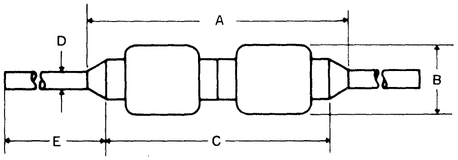
DESCRIPTION
These devices consist of two fused-in-glass zeners brazed anode-to-anode to provide zener action in both directions.

ABSOLUTE MAXIMUM RATINGS

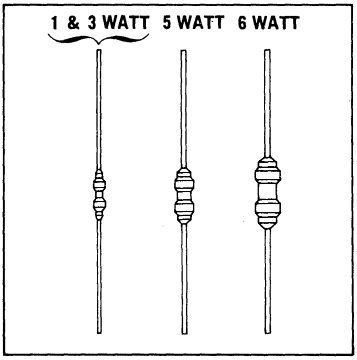
Zener Voltage	7.5 to 300V
Continuous Current	See Tables
Surge Current (8.3ms)	See Tables
Surge Power	See Graph
Power	See Data Sheets for Related Series (UZ8807, UZ807, UZ5807, and UZ7807)
Storage and Operating Temperature	—65°C to +175°C

MECHANICAL SPECIFICATIONS

UDZ807 SERIES UDZ5807 SERIES UDZ7807 SERIES UDZ8807 SERIES



MARKING: "D," followed by last 3 to 4 digits and part number. *Example: 7.5 volt ±10%, 1 watt type would be marked: "D8807".*



Dimensions

1 Watt UDZ8807 Series	3 Watt UDZ807 Series	5 Watt UDZ5807 Series	6 Watt UDZ7807 Series
A. .475″ max.	A. .450″ max.	A. .500″ max.	A. .600″ max.
B. .104″ max.	B. .085″ max.	B. .145″ max.	B. .185″ max.
C. .300″ typical	C. .275″ typical	C. .325″ typical	C. .430″ typical
D. .028″ ± .001″	D. .028″ ± .001″	D. .040″ ± .001″	D. .040″ ± .001″
E. .975″ min.	E. .700″ min.	E. .975″ min.	E. .925″ min.

	Electrical Specifications at 25°C						Maximum Ratings**	
Type	Nominal Zener Voltage† V_Z @ I_{ZT}	Test Current I_{ZT}	Max. Zener Imped § Z_Z @ I_{ZT}	Maximum Leakage Current	@ Reverse Voltage ±10%	±5%	Maximum Cont. Current I_{ZM}	Maximum Surge Current‡ I_S
±10% Tolerance*	Volts	mA	Ohms	μA	Volts	Volts	mA	Amps
1 WATT ZENERS — Specifications apply for both directions.								
UDZ8807	7.5	34	6	50	4.9	5.2	125	5
UDZ8808	8.2	31	7	30	5.4	5.7	115	4.5
UDZ8809	9.1	28	8	10	5.9	6.2	105	3.9
UDZ8810	10	25	8.5	3	6.6	6.9	95	3.37
UDZ8812	12	23	9	1	8.6	9.1	85	2.25
UDZ8815	15	17	14	0.5	10.8	11.4	63	1.65
UDZ8818	18	14	20	0.5	12.9	13.7	52	1.12
UDZ8820	20	12.5	23	0.5	14.4	15.2	47	1.12
UDZ8824	24	10.5	25	0.5	17.3	18.2	40	0.825
UDZ8827	27	9.5	35	0.5	19.4	20.6	35	0.825
UDZ8830	30	8.5	40	0.5	21.6	22.8	31	0.825
UDZ8833	33	7.5	45	0.5	23.7	25.1	28	0.675
UDZ8836	36	7.0	50	0.5	25.9	27.4	26	0.562
UDZ8840	40	6.5	62	0.5	28.8	30.4	24	0.562
UDZ8845	45	6	75	0.5	32.4	34.2	22	0.450
UDZ8860	60	4	125	0.5	43.2	45.6	15	0.337
3 WATT ZENERS — Specifications apply for both directions.								
UDZ807	7.5	75	3	500	4.9	5.2	400	10
UDZ808	8.2	75	4	300	5.4	5.7	360	8
UDZ809	9.1	75	4	200	5.9	6.2	330	7
UDZ810	10	75	5	100	6.6	6.9	300	5
UDZ812	12	65	5	10	8.6	9.1	250	4
UDZ815	15	50	6	10	10.8	11.4	200	3
UDZ818	18	40	8	5	12.9	13.7	170	2
UDZ820	20	40	9	5	14.4	15.2	150	2
UDZ824	24	30	10	5	17.3	18.2	125	1.5
UDZ827	27	25	12	1	19.4	20.6	110	1.5
UDZ830	30	25	15	1	21.6	22.8	100	1.5
UDZ833	33	20	21	1	23.7	25.1	90	1.2
UDZ836	36	20	21	1	25.9	27.4	85	1
UDZ840	40	20	27	1	28.8	30.4	75	1
UDZ845	45	15	37	1	32.4	34.7	65	0.8
UDZ860	60	10	70	1	43.2	45.6	50	0.6
UDZ210	100	5	175	1	72	76	30	0.4
UDZ222	220	3	325	1	158.4	167.2	15	0.1
UDZ230	300	3	1900	1	216	228	10	0.07

*For ±5% voltage tolerance change the 3rd number from the right from 8 to 7 or from 2 to 1. i.e. UDZ8807 to UDZ8707, UDZ210 to UDZ110, etc.

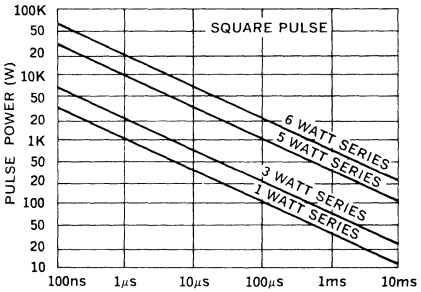
†All zener voltages are measured with an automated test set using a 35ms test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§Zener impedance is derived from the 60-cycle voltage created when AC current with RMS value of 10% of DC zener test current is superimposed on the test current.

**D.C. Ratings are based on the lead temperature conditions shown in the data sheets covering the UDZ8807, UDZ807, UDZ5807, and UDZ7807 series devices. Other conditions will affect the power ratings of all the families except the 1 watt zener family. However, the surge values given apply for any mounting conditions including printed circuit board mounting.

‡Figures shown are for peak sinusoidal surge current of 8.3ms duration using 60 cycle AC. The 8.3ms square pulse rating is 71% of the value shown.

Typical Reverse Surge Power vs. Surge Duration



For Sinusoidal Pulse, Peak Value
is 1.4 Times Value Shown

Type	Electrical Specifications at 25°C						Maximum Ratings**	
	Nominal Zener Voltage† V_Z @ I_{ZT}	Test Current I_{ZT}	Max. Zener Imped § Z_Z @ I_{ZT}	Maximum Leakage Current	@ Reverse Voltage ±10%	±5%	Maximum Cont. Current I_{ZM}	Maximum Surge Current‡ I_S
±10% Tolerance*	Volts	mA	Ohms	μA	Volts	Volts	mA	Amps
5 WATT ZENERS — Specifications apply for both directions.								
UDZ5807	7.5	175	1.8	500	4.9	5.2	620	40
UDZ5808	8.2	150	1.8	400	5.4	5.7	570	32
UDZ5809	9.1	150	2.5	200	5.9	6.2	510	24
UDZ5810	10	125	2.5	100	6.6	6.9	470	22
UDZ5812	12	100	2.5	50	8.6	9.1	385	18
UDZ5815	15	75	3.5	15	10.8	11.4	300	12
UDZ5818	18	65	4	10	12.9	13.7	255	9
UDZ5820	20	65	4.5	10	14.4	15.2	220	8
UDZ5824	24	50	5	10	17.3	18.2	180	6.5
UDZ5827	27	50	6	10	19.4	20.6	155	6
UDZ5830	30	40	8	10	21.6	22.8	140	5.5
UDZ5833	33	40	10	5	23.7	25.1	130	5
UDZ5836	36	30	11	5	25.9	27.4	120	4.5
UDZ5840	40	30	14	5	28.8	30.4	105	4
UDZ5845	45	30	20	5	32.4	34.2	95	3.5
UDZ5860	60	20	40	5	43.2	45.6	75	2.5
UDZ5210	100	10	100	5	72	76	45	1.4
UDZ5222	220	5	550	5	158.4	167.2	20	0.5
UDZ5230	300	5	950	5	216	228	15	0.25
6 WATT ZENERS — Specifications apply for both directions.								
UDZ7807	7.5	325	0.9	1000	4.9	5.2	1250	50
UDZ7808	8.2	300	1.0	800	5.4	5.7	1150	41
UDZ7809	9.1	275	1.2	200	5.9	6.2	1020	31
UDZ7810	10	250	1.2	150	6.6	6.9	950	29
UDZ7812	12	200	1.3	75	8.6	9.1	770	17
UDZ7815	15	150	2.0	30	10.8	11.4	600	17
UDZ7818	18	130	3.5	20	12.9	13.7	500	13
UDZ7820	20	120	4.0	20	14.4	15.2	440	12
UDZ7824	24	100	5.0	20	17.3	18.2	360	10
UDZ7827	27	90	6.0	20	19.4	20.6	310	9
UDZ7830	30	80	8.0	20	21.6	22.8	280	8.5
UDZ7833	33	70	10	10	23.9	25.1	260	7.5
UDZ7836	36	60	12	10	25.9	27.4	240	7
UDZ7840	40	60	15	10	28.8	30.4	210	6.4
UDZ7845	45	50	20	10	32.4	34.2	180	5.5
UDZ7860	60	40	35	10	43.2	45.6	150	3.7
UDZ7210	100	20	90	10	72	76	90	2.3

*For ±5% voltage tolerance change the 3rd number from the right from 8 to 7 or from 2 to 1. i.e. UDZ8807 to UDZ8707, UDZ210 to UDZ110, etc.

†All zener voltages are measured with an automated test set using a 35ms test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§Zener impedance is derived from the 60-cycle voltage created when AC current with RMS value of 10% of DC zener test current is superimposed on the test current.

**D.C. Ratings are based on the lead temperature conditions shown in the data sheets covering the UDZ8807, UDZ807, UDZ5807, and UDZ7807 series devices. Other conditions will affect the power ratings of all the families except the 1 watt zener family. However, the surge values given apply for any mounting conditions including printed circuit board mounting.

‡Figures shown are for peak sinusoidal surge current of 8.3ms duration using 60 cycle AC. The 8.3ms square pulse rating is 71% of the value shown.

POWER ZENERS
3 Watt

UZ706 SERIES
UZ806 SERIES

FEATURES
- 10 Times Greater Surge Rating than Conventional 1 Watt Types
- Small Physical Size

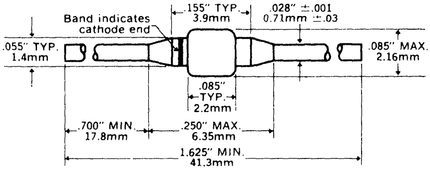
DESCRIPTION
Fused-in-glass metallurgically bonded 3 watt zener diodes.

ABSOLUTE MAXIMUM RATINGS

Zener Voltage, V_Z	6.8 to 400V
Continuous Current	See Table
Surge Current (8.3ms)	See Table
Surge Power	See Graph
Power	See Lead Temperature Derating Curve
Storage and Operating Temperature	—65°C to +175°C

MECHANICAL SPECIFICATIONS

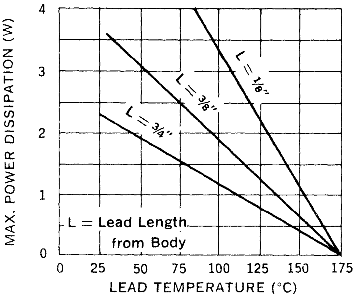
UZ706 SERIES UZ806 SERIES



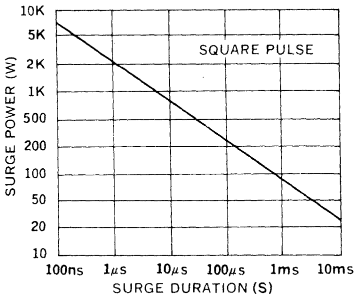
UZ Prefix is identified by a Blue or Red Cathode Band

BODY A

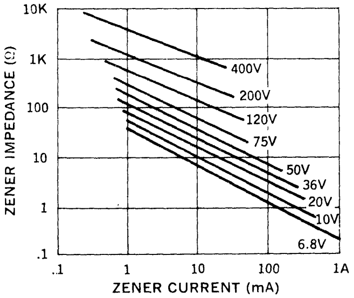
Power Dissipation vs. Lead Temperature Derating Curve



Surge Power vs. Surge Duration



Typical Zener Impedance vs. Zener Current



UNITRODE

Type*		Electrical Specifications at 25°C							Maximum Ratings	
		Nominal Zener Voltage † V_Z @ I_{ZT}	Test Current I_{ZT}	Max. Zener Impedance § Z_Z @ I_{ZT}	Maximum Reverse Leakage Current I_R @ V_R	± 5% V_R	± 10% V_R	Typ. Temp. Coefficient T_C @ I_{ZT}	Maximum Continuous Current ★ I_{ZM}	Maximum Surge Current‡ I_S
±5% Tolerance	Jedec** Registration	Volts	mA	Ohms	µA	Volts	Volts	%/°C	mA	Amps
UZ706	1N5063	6.8	75	2	500	5.2	4.9	.04	440	10.0
UZ707	1N5064	7.5	75	2	300	5.7	5.4	.04	400	8.0
UZ708	1N5065	8.2	75	3	200	6.2	5.9	.05	360	7.0
UZ709	1N5066	9.1	75	3	100	6.9	6.6	.05	330	6.0
UZ710	1N5067	10.0	75	4	40	7.6	7.2	.06	300	5.0
UZ712	1N4883	12	65	5	10	9.1	8.6	.07	250	4.0
UZ713	1N5069	13	50	6	10	9.9	9.3	.07	230	4.0
UZ714	1N5070	14	50	6	10	10.6	10.1	.07	210	4.0
UZ715	1N5071	15	50	6	10	11.4	10.8	.07	200	3.0
UZ716	1N5072	16	50	7	5	12.2	11.5	.07	185	3.0
UZ718	1N5073	18	40	8	5	13.7	12.9	.08	170	2.0
UZ720	1N4884	20	40	9	5	15.2	14.4	.08	150	2.0
UZ722	1N5074	22	30	10	5	16.7	15.8	.08	135	2.0
UZ724	1N5075	24	30	10	5	18.2	17.3	.08	125	1.5
UZ727	1N5076	27	25	12	1	20.6	19.4	.09	110	1.5
UZ730	1N5077	30	25	15	1	22.8	21.6	.090	100	1.5
UZ733	1N5078	33	20	21	1	25.1	23.7	.090	90	1.2
UZ736	1N5079	36	20	21	1	27.4	25.9	.090	85	1.0
UZ740	1N5081	40	20	27	1	30.4	28.8	.095	75	1.0
UZ745	1N5083	45	15	37	1	34.2	32.4	.095	65	0.8
UZ750	1N5085	50	15	50	1	38.0	36.0	.095	60	0.8
UZ756	1N5087	56	10	70	1	42.6	40.3	.095	55	0.7
UZ760	1N5088	60	10	70	1	45.7	43.2	.095	50	0.6
UZ770	1N5091	70	10	90	1	53.3	50.5	.095	45	0.6
UZ775	1N5092	75	10	100	1	56.0	54.0	.095	40	0.5
UZ780	1N5093	80	10	115	1	60.8	57.7	.095	35	0.4
UZ790	1N4096	90	8.0	150	1	68.5	64.8	.095	30	0.4
UZ110	1N4097	100	5.0	175	1	76.0	72.0	.100	30	0.4
UZ111	1N5096	110	5.0	250	1	83.6	79.2	.100	25	0.3
UZ112	1N5097	120	5.0	325	1	91.2	86.4	.100	25	0.2
UZ113	1N5098	130	5.0	375	1	98.8	93.6	.100	20	0.20
UZ114	1N5099	140	5.0	550	1	106	101	.100	20	0.20
UZ115	1N4098	150	5.0	650	1	114	108	.100	20	0.20
UZ116	1N5100	160	4.0	700	1	122	115	.100	20	0.15
UZ117	1N5101	170	4.0	750	1	129	122	.100	18	0.15
UZ118	1N5102	180	4.0	850	1	137	129	.100	18	0.10
UZ119	1N5103	190	4.0	900	1	144	137	.100	15	0.10
UZ120	1N5104	200	4.0	950	1	152	144	.100	15	0.10
UZ122	1N5105	220	3.0	1100	1	167	158	.100	15	0.09
UZ124	1N5106	240	3.0	1300	1	182	173	.105	12	0.09
UZ126	1N5107	260	3.0	1500	1	198	187	.105	12	0.08
UZ128	1N5109	280	3.0	1700	1	213	202	.105	10	0.08
UZ130	1N5110	300	3.0	1900	1	228	216	.105	10	0.07
UZ132	1N5111	320	2.0	2100	1	243	230	.105	9	0.07
UZ134	1N5113	340	2.0	2400	1	258	245	.110	9	0.06
UZ136	1N5114	360	2.0	2700	1	274	259	.110	8	0.06
UZ138	1N5115	380	2.0	3000	1	289	274	.110	8	0.06
UZ140	1N5117	400	2.0	3500	1	304	288	.110	7	0.06

* Specify 20% voltage tolerance by changing first numeral of type number from 7 to 9. (UZ709 becomes UZ909) or from 1 to 3 (UZ111 becomes UZ311).

Specify 10% voltage tolerance by changing first numeral of type number from 7 to 8. (UZ709 becomes UZ809) or from 1 to 2 (UZ111 becomes UZ211).

** Jedec registration applies to ±5% tolerance zeners only.

† All zener voltages are measured with an automated test set using a 35 ms test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§ Zener impedance is derived from the 60-cycle AC voltage created when AC current with RMS value of 10% of DC zener test current is superimposed on the test current.

★ Maximum current based on 3 watt rating. See lead temperature derating curves for proper mounting methods.

‡ Figures shown are for a peak sinusoidal surge current of 8.3ms duration using 60 cycle AC. The 8.3ms square pulse rating is 71% of the value shown.

POWER ZENERS
5 Watt, Industrial

UZ4706 SERIES
UZ4806 SERIES

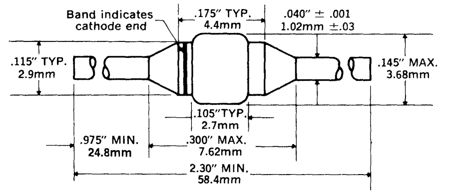
FEATURES
- 2 Times Greater Surge Rating than Plastic Types
- Small Physical Size
- Impervious to Moisture

DESCRIPTION
Fused-in-glass 5 watt zeners with the same electrical specs as the 1N5342-1N5388 series.

ABSOLUTE MAXIMUM RATINGS
Zener Voltage, V_Z	6.8 to 200V
Continuous Current	See Table
Surge Current (8.3ms)	See Table
Surge Power	See Graph
Power	See Lead Temperature Derating Curve
Storage and Operating Temperature	−65°C to +175°C

MECHANICAL SPECIFICATIONS

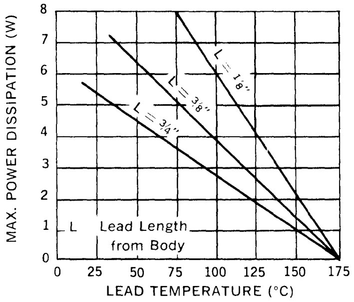
UZ4706 SERIES UZ4806 SERIES



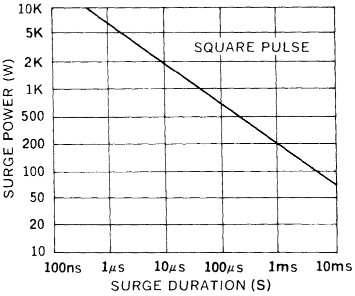
UZ Prefix is identified by a Blue or Red Cathode Band

BODY B

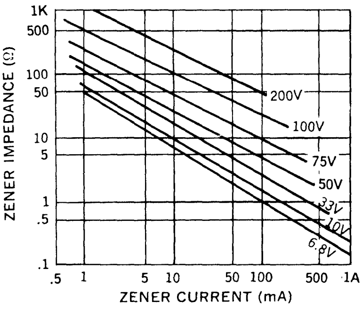
Power Dissipation vs. Lead Temperature Derating Curve



Surge Power vs. Surge Duration



Typical Zener Impedance vs. Zener Current



UNITRODE

Type		Electrical Specifications at 25°C							Maximum Ratings	
		Nominal Zener Voltage † V_Z @ I_{ZT}	Test Current I_{ZT}	Max. Zener Impedance §		Reverse Voltage			Maximum Cont. Current I_{ZM}	Maximum Surge Current ‡ I_S
				Z_Z @ I_{ZT}	Z_{ZK} @ I_{ZK} = ImA	Maximum Leakage Current	@ Reverse Voltage ±10%	±5%		
±5% Tolerance	±10% Tolerance	Volts	mA	Ohms	Ohms	µA	Volts	Volts	mA	Amps
UZ4706	UZ4806	6.8	175	1	1000	500	4.9	5.2	675	32
UZ4707	UZ4807	7.5	175	1.5	800	400	5.4	5.7	620	26.5
UZ4708	UZ4808	8.2	150	1.5	600	200	5.9	6.2	570	19.2
UZ4709	UZ4809	9.1	150	2	400	100	6.6	6.9	510	17.6
UZ4710	UZ4810	10	125	2	125	75	7.2	7.6	470	16
UZ4712	UZ4812	12	100	2.5	140	50	8.6	9.1	385	14.4
UZ4713	UZ4813	13	100	3	145	25	9.3	9.9	350	12.8
UZ4715	UZ4815	15	75	3.5	150	15	10.8	11.4	300	9.6
UZ4716	UZ4816	16	75	3.5	155	10	11.5	12.2	275	8
UZ4718	UZ4818	18	65	4	160	10	12.9	13.7	255	7.2
UZ4720	UZ4820	20	65	4.5	165	10	14.4	15.2	220	6.4
UZ4722	UZ4822	22	50	5	170	10	15.8	16.7	195	5.6
UZ4724	UZ4824	24	50	5	175	10	17.3	18.2	180	5.2
UZ4727	UZ4827	27	50	6	180	10	19.4	20.6	155	4.8
UZ4730	UZ4830	30	40	8	190	10	21.6	22.8	140	4.4
UZ4733	UZ4833	33	40	10	200	5	23.7	25.1	130	4.0
UZ4736	UZ4836	36	30	11	220	5	25.9	27.4	120	3.6
UZ4739	UZ4839	39	30	14	230	5	28.1	29.7	105	3.2
UZ4743	UZ4843	43	30	20	240	5	31	32.7	100	2.8
UZ4747	UZ4847	47	25	25	250	5	33.8	35.8	96	2.6
UZ4751	UZ4851	51	25	27	270	5	36.7	38.8	85	2.4
UZ4756	UZ4856	56	20	35	320	5	40.3	42.6	81	2.2
UZ4762	UZ4862	62	20	42	400	5	44.6	47.1	73	2.0
UZ4768	UZ4868	68	20	50	500	5	49.0	51.7	61	1.8
UZ4775	UZ4875	75	20	55	620	5	54.0	56	60	1.6
UZ4782	UZ4882	82	15	80	720	5	59.0	62.2	55	1.4
UZ4791	UZ4891	91	15	90	760	5	65.5	69.2	50	1.3
UZ4110	UZ4210	100	12	100	800	5	72.0	76.0	45	1.1
UZ4111	UZ4211	110	12	125	1000	5	79.2	83.6	40	1.0
UZ4112	UZ4212	120	10	170	1150	5	86.4	91.2	38	.8
UZ4113	UZ4213	130	10	190	1250	5	93.6	98.8	35	.64
UZ4115	UZ4215	150	8	330	1500	5	108	114.0	31	.60
UZ4116	UZ4216	160	8	350	1650	5	115	121.6	30	.56
UZ4118	UZ4218	180	5	450	1750	5	129	136.8	25	.48
UZ4120	UZ4220	200	5	500	1850	5	144	152.0	22	.40

Maximum V_F @ 1.0 Amp = 1.2 Volts for all types

†All zener voltages are measured with an automated test set using a 35 ms test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§Zener impedance is derived from the 60-cycle voltage created when AC current with RMS value of 10% of DC zener test current is superimposed on the test current.

‡Figures shown are for peak sinusoidal surge current of 8.3 ms duration using 60 cycle AC.
The 8.3ms square pulse rating is 71% of the value shown.

POWER ZENERS
5 Watt

UZ5706 SERIES
UZ5806 SERIES

FEATURES
- 2 Times Greater Surge Rating than Conventional 10 Watt Zeners
- Small Physical Size

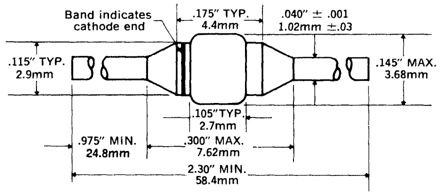
DESCRIPTION
Fused-in-glass, metallurgically-bonded 5 watt zeners.

ABSOLUTE MAXIMUM RATINGS

Zener Voltage, V_Z	6.8 to 400V
Continuous Current	See Table
Surge Current (8.3ms)	See Table
Surge Power	See Graph
Power	See Lead Temperature Derating Curve
Storage and Operating Temperature	—65°C to +175°C

MECHANICAL SPECIFICATIONS

UZ5706 SERIES UZ5806 SERIES

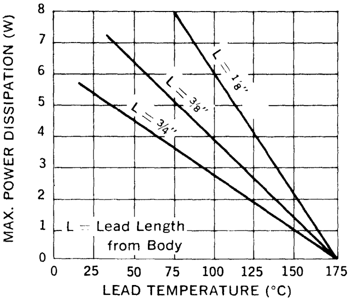


UZ Prefix is identified by a Blue or Red Cathode Band

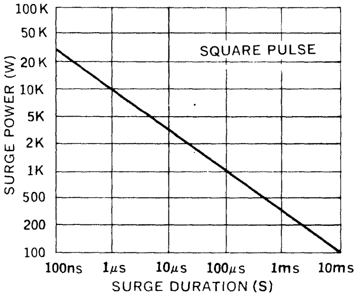
BODY B

IX

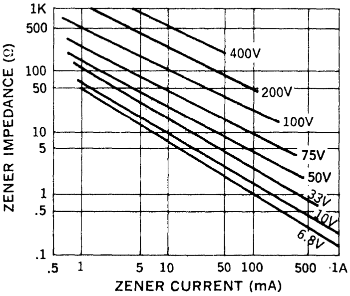
Power Dissipation vs. Lead Temperature Derating Curve



Surge Power vs. Surge Duration



Typical Zener Impedance vs. Zener Current



UNITRODE

Type *		Electrical Specifications at 25°C							Maximum Ratings	
		Nominal Zener Voltage †	Test Current	Max. Zener Impedance §	Maximum Reverse Leakage Current			Typ. Temp. Coeff.	Maximum Continuous Current ★	Maximum Surge Current ‡
		V_Z @ I_{ZT}	I_{ZT}	Z_Z @ I_{ZT}	I_R	± 5% V_R	± 10% V_R	T_C @ I_{ZT}	I_{ZM}	I_S
±5% Tolerance	±10% Tolerance	Volts	mA	Ohms	µA	Volts	Volts	%/°C	mA	Amps
UZ5706	UZ5806	6.8	175	1.0	500	5.2	4.9	.05	675	40
UZ5707	UZ5807	7.5	175	1.5	400	5.7	5.4	.06	620	32
UZ5708	UZ5808	8.2	150	1.5	200	6.2	5.9	.06	570	24
UZ5709	UZ5809	9.1	150	2.0	100	6.9	6.6	.06	510	22
UZ5710	UZ5810	10.0	125	2.0	75	7.6	7.2	.07	470	20
UZ5712	UZ5812	12	100	2.5	50	9.1	8.6	.07	385	18
UZ5713	UZ5813	13	100	3.0	25	9.9	9.3	.08	350	16
UZ5714	UZ5814	14	100	3.0	20	10.6	10.1	.08	320	14
UZ5715	UZ5815	15	75	3.5	15	11.4	10.8	.08	300	12
UZ5716	UZ5816	16	75	3.5	10	12.2	11.5	.08	275	10
UZ5718	UZ5818	18	65	4.0	10	13.7	12.9	.085	255	9.0
UZ5720	UZ5820	20	65	4.5	10	15.2	14.4	.085	220	8.0
UZ5722	UZ5822	22	50	5.0	10	16.7	15.8	.085	195	7.0
UZ5724	UZ5824	24	50	5.0	10	18.2	17.3	.090	180	6.5
UZ5727	UZ5827	27	50	6.0	10	20.6	19.4	.090	155	6.0
UZ5730	UZ5830	30	40	8	10	22.8	21.6	.09	140	5.5
UZ5733	UZ5833	33	40	10	5	25.1	23.7	.09	130	5.0
UZ5736	UZ5836	36	30	11	5	27.4	25.9	.095	120	4.5
UZ5740	UZ5840	40	30	14	5	30.4	28.8	.095	105	4.0
UZ5745	UZ5845	45	30	20	5	34.2	32.4	.095	95	3.5
UZ5750	UZ5850	50	25	25	5	38.0	36.0	.095	85	3.0
UZ5756	UZ5856	56	20	35	5	42.6	40.3	.095	80	2.8
UZ5760	UZ5860	60	20	40	5	45.7	43.2	.100	75	2.5
UZ5770	UZ5870	70	20	50	5	53.3	50.5	.100	65	2.3
UZ5775	UZ5875	75	15	55	5	56.0	54.0	.100	60	2.0
UZ5780	UZ5880	80	15	80	5	60.8	57.7	.100	55	1.8
UZ5790	UZ5890	90	15	90	5	68.5	64.8	.100	50	1.6
UZ5110	UZ5210	100	10	100	5	76.0	72.0	.100	45	1.4
UZ5111	UZ5211	110	10	125	5	83.6	79.2	.100	40	1.2
UZ5112	UZ5212	120	10	170	5	91.2	86.4	.100	38	1.0
UZ5113	UZ5213	130	10	190	5	98.8	93.6	.105	35	0.80
UZ5114	UZ5214	140	8	230	5	106.0	101.0	.105	33	0.80
UZ5115	UZ5215	150	8	330	5	114.0	108.0	.105	31	0.75
UZ5116	UZ5216	160	8	350	5	122.0	115.0	.105	30	0.70
UZ5117	UZ5217	170	8	380	5	129.0	122.0	.105	27	0.65
UZ5118	UZ5218	180	5	450	5	137	129	.110	25	0.60
UZ5119	UZ5219	190	5	470	5	144	137	.110	24	0.55
UZ5120	UZ5220	200	5	500	5	152	144	.110	22	0.50
UZ5122	UZ5222	220	5	550	5	167	158	.115	20	0.45
UZ5124	UZ5224	240	5	650	5	182	173	.115	18	0.40
UZ5126	UZ5226	260	5	750	5	198	187	.120	17	0.35
UZ5128	UZ5228	280	4	850	5	213	202	.120	16	0.30
UZ5130	UZ5230	300	4	950	5	228	216	.120	15	0.25
UZ5132	UZ5232	320	4	1100	5	243	230	.120	14	0.24
UZ5134	UZ5234	340	4	1200	5	258	245	.120	13	0.23
UZ5136	UZ5236	360	3	1400	5	274	259	.120	12	0.22
UZ5138	UZ5238	380	3	1500	5	289	274	.120	12	0.21
UZ5140	UZ5240	400	3	1800	5	304	288	.120	11	0.20

Temperature Range: Operating and Storage −65°C to +175°C.

* Specify 20% tolerance by changing the second numeral of type number from 8 to 9 (UZ5809 becomes UZ5909) or from 2 to 3 (UZ5211 becomes UZ5311).

† All zener voltages are measured with an automated test set using a 35 millisecond test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§ Zener impedance is derived from the 60-cycle AC voltage created when AC current with RMS value of 10% of DC zener test current is superimposed on the test current.

★ Maximum current based on 5 watt rating. See lead temperature derating curves for proper mounting methods.

‡ Figures shown are for a peak sinusoidal surge current of 8.3ms duration using 60 cycle AC. The 8.3ms square pulse rating is 71% of the value shown.

Several of the above types now have JEDEC 1N type numbers. The following cross-reference table lists the appropriate 1N numbers; specifications are same as above.

JEDEC #	UNITRODE TYPE	JEDEC #	UNITRODE TYPE	JEDEC #	UNITRODE TYPE
1N5118	UZ5714	1N5124	UZ5780	1N5130	UZ5128
1N5119	UZ5740	1N5125	UZ5790	1N5131	UZ5132
1N5120	UZ5745	1N5126	UZ5114	1N5132	UZ5134
1N5121	UZ5750	1N5127	UZ5117	1N5133	UZ5138
1N5122	UZ5760	1N5128	UZ5119	1N5134	UZ5140
1N5123	UZ5770	1N5129	UZ5126		

POWER ZENERS
6 Watt, Military, 10 Watt Military

UZ7706L and UZ7806L SERIES
UZ7706 and UZ7806 SERIES

FEATURES
- High Surge Rating
- Small Physical Size
- Leaded and Stud Packages Available

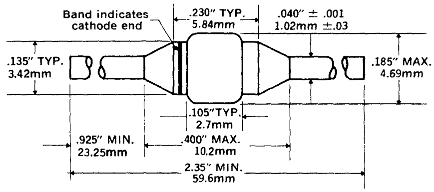
DESCRIPTION
Fused-in-glass, metallurgically bonded 6 watt leaded zeners and 10 watt stud-type zeners.

ABSOLUTE MAXIMUM RATINGS

Zener Voltage, V_Z		6.8 to 100V
Continuous Current		See Table
Surge Current (8.3ms)		See Table
Surge Power		See Graph
Power	UZ7706L & UZ7806L	See Lead Temperature Derating Curve
	UZ7706 & UZ7806 @100°C Case	10W
Storage and Operating Temperature		—65°C to +175°C

MECHANICAL SPECIFICATIONS

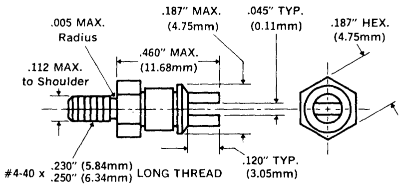
UZ7706L and UZ7806L SERIES



UZ Prefix is identified by a Blue or Red Cathode Band

BODY C — Lead Mount

UZ7706 and UZ7806 SERIES



POLARITY: Cathode to Stud is standard. Reverse polarity denoted by "R" suffix.

FINISH: Metal parts gold plated per MIL-G-45204, Type II.

WEIGHT: 1.5 grams (max.)

INSTALLATION PRECAUTIONS: Maximum unlubricated stud torque: 28 inch-ounces. Do not use a screwdriver in the turret slot for installation purposes, or damage may result.

UZ Prefix is identified by a Blue or Red Cathode Band

BODY C — Stud Mount

Type *		Electrical Specifications at 25°C							Maximum Ratings	
		Nominal Zener Voltage † V_Z @ I_{ZT}	Test Current I_{ZT}	Max. Zener Impedance § Z_Z @ I_{ZT}	Maximum Reverse Leakage Current			Typ. Temp. Coeff. T_C @ I_{ZT}	Maximum Continuous Current ★ I_{ZM}	Maximum Surge Current ‡ I_S
					I_R @ V_R	± 5% V_R	± 10% V_R			
±5% Tolerance	±10% Tolerance	Volts	mA	Ohms	µA	Volts	Volts	%/°C	mA	Amps
UZ7706	UZ7806	6.8	350	0.6	1000	5.2	4.9	.04	1350	50
UZ7707	UZ7807	7.5	325	0.7	800	5.7	5.4	.04	1250	41
UZ7708	UZ7808	8.2	300	0.8	200	6.2	5.9	.05	1150	31
UZ7709	UZ7809	9.1	275	1.0	150	6.9	6.6	.05	1020	29
UZ7710	UZ7810	10.0	250	1.0	100	7.6	7.2	.06	950	26
UZ7712	UZ7812	12	200	1.3	75	9.1	8.6	.07	770	23
UZ7713	UZ7813	13	200	1.5	50	9.9	9.3	.07	700	21
UZ7714	UZ7814	14	175	1.5	40	10.6	10.1	.07	640	20
UZ7715	UZ7815	15	150	2.0	30	11.4	10.8	.07	600	17
UZ7716	UZ7816	16	150	2.5	20	12.2	11.5	.07	550	15
UZ7718	UZ7818	18	130	3.5	20	13.7	12.9	.08	500	13
UZ7720	UZ7820	20	120	4.0	20	15.2	14.4	.08	440	12
UZ7722	UZ7822	22	100	4.5	20	16.7	15.8	.08	390	11
UZ7724	UZ7824	24	100	5.0	20	18.2	17.3	.08	360	10
UZ7727	UZ7827	27	90	6.0	20	20.6	19.4	.09	310	9
UZ7730	UZ7830	30	80	8	20	22.8	21.6	.090	280	8.5
UZ7733	UZ7833	33	70	10	10	25.1	23.7	.090	260	7.5
UZ7736	UZ7836	36	60	12	10	27.4	25.9	.090	240	7.0
UZ7740	UZ7840	40	60	15	10	30.4	28.8	.095	210	6.4
UZ7745	UZ7845	45	50	20	10	34.2	32.4	.095	180	5.5
UZ7750	UZ7850	50	50	22	10	38.0	36.0	.095	170	4.6
UZ7756	UZ7856	56	40	30	10	42.6	40.3	.095	160	4.1
UZ7760	UZ7860	60	40	35	10	45.6	43.2	.095	150	3.7
UZ7770	UZ7870	70	35	40	10	53.2	50.4	.095	130	3.3
UZ7775	UZ7875	75	30	45	10	56.0	54.0	.095	120	3.1
UZ7780	UZ7880	80	30	60	10	60.8	57.6	.095	110	2.9
UZ7790	UZ7890	90	25	75	10	68.4	64.8	.095	100	2.6
UZ7110	UZ7210	100	20	90	10	76.0	72.0	.100	90	2.3

Power Rating: Stud Mounted: 10 Watts at 100°C Case derate linerally to zero at 175°C Case.
Lead Mounted: See lead temperature derating curve.
Temperature Range: Operating and storage —65°C to 175°C.

* Specify 20% tolerance by changing the second numeral of type number from 8 to 9 (UZ7809 becomes UZ7909) or from 2 to 3 (UZ7210 becomes UZ7310). Specify leaded version by adding an L suffix (UZ7809 becomes UZ7809L).

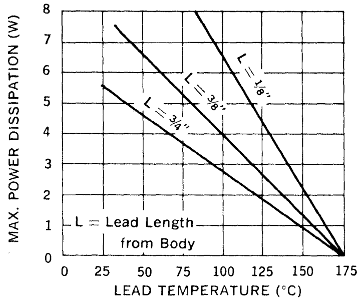
† All zener voltages are measured with an automated test set using a 35 msec test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§ Zener impedance is derived from the 60-cycle voltage created when AC current with RMS value of 10% of DC zener test current is superimposed on the test current.

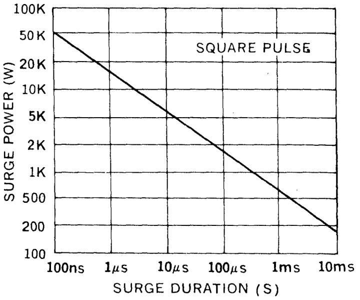
★ Ratings Based on 100°C Case temperature.

‡ Figures shown are for a peak sinusoidal surge current of 8.3ms duration, non-repetitive. The 8.3ms square pulse rating is 71% of the value shown.

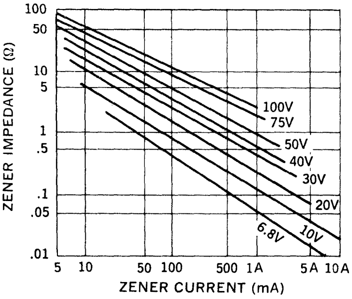
Power Dissipation vs. Lead Temperature Derating Curve



Surge Power vs. Surge Duration



Typical Zener Impedance vs. Zener Current



POWER ZENERS

1 Watt, Industrial

UZ8706 SERIES
UZ8806 SERIES

FEATURES

- High Surge Ratings
- A Quarter the Size of Conventional 1 Watt Zeners
- Impervious to Moisture

DESCRIPTION

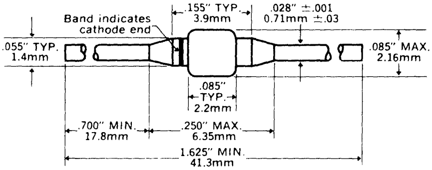
One watt zener diodes, hermetically sealed in glass.

ABSOLUTE MAXIMUM RATINGS

Zener Voltage, V_Z	6.8 to 200V
Continuous Current	See Table
Surge Current (8.3ms)	See Table
Surge Power	See Graph
Power	See Lead Temperature Derating Curve
Storage and Operating Temperature	—65°C to +175°C

MECHANICAL SPECIFICATIONS

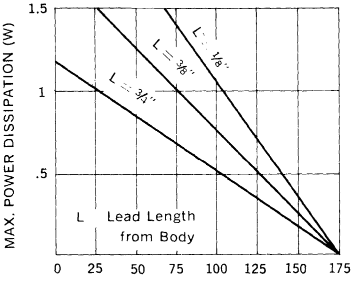
UZ8706 SERIES UZ8806 SERIES



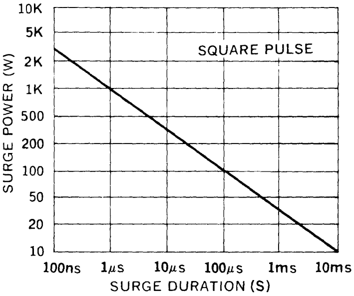
UZ Prefix is identified by a Blue or Red Cathode Band

BODY A

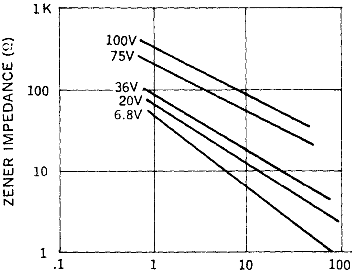
Power Dissipation vs. Lead Temperature Derating Curve



Surge Power vs. Surge Duration



Typical Zener Impedance vs. Zener Current



UNITRODE

Type		Electrical Specifications at 25°C							Maximum Ratings	
		Nominal Zener Voltage †	Test Current	Max. Zener Impedance §	Maximum Reverse Leakage Current			Typ. Temp. Coefficient	Maximum Continuous Current ★	Maximum Surge Current ‡
						± 5%	± 10%			
		V_Z @ I_{ZT}	I_{ZT}	Z_Z @ I_{ZT}	I_R @ V_R	V_R	V_R	T.C. @ I_{ZT}	I_{ZM}	I_S
± 5% Tolerance	± 10% Tolerance	Volts	mA	Ohms	µA	Volts	Volts	%/°C	mA	Amps
UZ 8706	UZ 8806	6.8	37	3.5	50	5.2	4.9	0.04	140	5.00
UZ 8707	UZ 8807	7.5	34	4.0	30	5.7	5.4	0.04	125	4.50
UZ 8708	UZ 8808	8.2	31	4.5	10	6.2	5.9	0.05	115	3.90
UZ 8709	UZ 8809	9.1	28	5.0	3.0	6.9	6.6	0.05	105	3.37
UZ 8710	UZ 8810	10	25	7.0	2.0	7.6	7.2	0.06	95	2.77
UZ 8712	UZ 8812	12	23	9.0	1.0	9.1	8.6	0.07	85	2.25
UZ 8713	UZ 8813	13	21	10	0.5	9.9	9.3	0.07	80	2.25
UZ 8714	UZ 8814	14	19	12	0.5	10.6	10.1	0.07	74	2.25
UZ 8715	UZ 8815	15	17	14	0.5	11.4	10.8	0.07	63	1.65
UZ 8716	UZ 8816	16	15.5	16	0.5	12.1	11.5	0.07	60	1.65
UZ 8718	UZ 8818	18	14.0	20	0.5	13.7	12.9	0.08	52	1.12
UZ 8720	UZ 8820	20	12.5	22	0.5	15.2	14.4	0.08	47	1.12
UZ 8722	UZ 8820	22	11.5	23	0.5	16.7	15.8	0.08	43	1.12
UZ 8724	UZ 8824	24	10.5	25	0.5	18.2	17.3	0.08	40	0.825
UZ 8727	UZ 8827	27	9.5	35	0.5	20.5	19.4	0.09	35	0.825
UZ 8730	UZ 8830	30	8.5	40	0.5	22.8	21.6	0.09	31	0.825
UZ 8733	UZ 8833	33	7.5	45	0.5	25.1	23.7	0.09	28	0.675
UZ 8736	UZ 8836	36	7.0	50	0.5	27.3	25.9	0.09	26	0.562
UZ 8740	UZ 8840	40	6.5	62	0.5	30.4	28.8	0.095	24	0.562
UZ 8745	UZ 8845	45	6.0	75	0.5	34.2	32.4	0.095	22	0.450
UZ 8750	UZ 8850	50	5.0	85	0.5	38.0	36.0	0.095	20	0.450
UZ 8756	UZ 8856	56	4.5	110	0.5	42.5	40.3	0.095	17	0.390
UZ 8760	UZ 8860	60	4.0	125	0.5	45.6	43.2	0.095	15	0.337
UZ 8770	UZ 8870	70	3.7	150	0.5	53.2	50.4	0.095	14	0.337
UZ 8775	UZ 8875	75	3.3	175	0.5	57.0	54.0	0.095	12	0.277
UZ 8780	UZ 8880	80	3.0	200	0.5	60.8	57.6	0.095	11	0.225
UZ 8790	UZ 8890	90	2.8	250	0.5	68.4	64.8	0.095	10	0.225
UZ 8110	UZ 8210	100	2.5	350	0.5	76.0	72.0	0.10	9.5	0.225
UZ 8111	UZ 8211	110	2.3	450	0.5	83.6	79.2	0.10	8.5	0.165
UZ 8112	UZ 8212	120	2.0	550	0.5	91.2	86.4	0.10	8.0	0.112
UZ 8113	UZ 8213	130	1.9	700	0.5	98.8	93.6	0.10	7.2	0.112
UZ 8114	UZ 8214	140	1.8	850	0.5	106	100	0.10	6.8	0.112
UZ 8115	UZ 8215	150	1.7	1000	0.5	114	108	0.10	6.3	0.112
UZ 8116	UZ 8216	160	1.6	1100	0.5	121	115	0.10	5.9	0.082
UZ 8117	UZ 8217	170	1.5	1200	0.5	129	122	0.10	5.6	0.082
UZ 8118	UZ 8218	180	1.4	1300	0.5	137	129	0.10	5.2	0.056
UZ 8119	UZ 8219	190	1.3	1400	0.5	144	137	0.10	5.0	0.056
UZ 8120	UZ 8220	200	1.2	1500	0.5	152	144	0.10	4.7	0.056

†All zener voltages are measured with an automated test set using a 35 millisecond test time. Longer or shorter test times will have a corresponding effect on the measured value due to heating effects.

§Zener impedance is derived from the 60-cycle AC voltage created when AC current with RMS value of 10% of DC zener test current is superimposed on the test current.

★Ratings are based on free air. T_A is 25°C. For use at 1.5 watts see derating curve.

‡Figures shown are for a peak sinusoidal surge current of 8.3 ms duration using 60 cycle AC. The 8.3 ms square pulse rating is 71% of the value shown.

POWER ZENERS & TRANSIENT VOLTAGE SUPPRESSORS

PART NUMBER INDEX

PAGE	PART NUMBER	DESCRIPTION
		ZENER
499	1N4096	3.0W; 5%
499	1N4097	3.0W; 5%
499	1N4098	3.0W; 5%
*	1N4321	1.0W; 10%
486	1N4461-1N4496, J, JTX, JTXV	1.5W; 5%
499	1N4883-1N4884	3.0W; 5%
488	1N4954-1N4995, J, JTX, JTXV	5.0W; 5%
488	1N4996	5.0W; 5%
499	1N5063-1N5117	3.0W; 5%
503	1N5118-1N5134	5.0W; 5%
		TRANSIENT VOLTAGE SUPPRESSOR
490	1N5610, J, JTX	33V
490	1N5611, J, JTX	43.7V
490	1N5612, J, JTX	54V
490	1N5613, J, JTX	191V
492	TVS305-TVS360	150W
492	TVS410-TVS430	150W
492	TVS505-TVS528	500W
		ZENER
496	UDZ210-UDZ240	Bidirectional; 3W; 10%
496	UDZ707-UDZ790	Bidirectional; 3W; 5%
496	UDZ807-UDZ890	Bidirectional; 3W; 10%
496	UDZ5707-UDZ5790	Bidirectional; 5W; 5%
496	UDZ5807-UDZ5890	Bidirectional; 5W; 10%
496	UDZ8210-UDZ8220	Bidirectional; 1W; 10%
496	UDZ8707-UDZ8791	Bidirectional; 1W; 5%
496	UDZ8807-UDZ8891	Bidirectional; 1W; 10%
499	UZ110-UZ119	3W; 5%
499	UZ120-UZ140	3W; 5%
499	UZ210-UZ219	3W; 10%
499	UZ220-UZ240	3W; 10%
499	UZ706-UZ760	3W, 5%
499	UZ770-UZ790	3W; 5%
499	UZ806-UZ860	3W; 10%
499	UZ870-UZ890	3W; 10%
501	UZ4110-UZ4120	5W; 5%
501	UZ4210-UZ4220	5W; 10%
501	UZ4706-UZ4791	5W; 5%
501	UZ4806-UZ4891	5W; 10%
503	UZ5110-UZ5119	5W; 5%
503	UZ5120-UZ5240	5W; 5%
503	UZ5210-UZ5240	5W; 10%
503	UZ5310-UZ5340	5W; 20%
503	UZ5706-UZ5760	5W; 5%
503	UZ5770-UZ5790	5W; 5%
503	UZ5806-UZ5860	5W; 10%
503	UZ5870-UZ5890	5W; 10%
503	UZ5970-UZ5990	5W; 20%
505	UZ7110	10W; 5%
505	UZ7110L	6W; 5%
505	UZ7210	10W; 10%
505	UZ7210L	6W; 10%
505	UZ7706-UZ7750	10W; 5%
505	UZ7706L-UZ7750L	6W; 5%
505	UZ7756-UZ7790	10W; 5%
505	UZ7756L-UZ7790L	6W; 5%
505	UZ7806-UZ7850	10W; 10%
505	UZ7806L-UZ7850L	6W; 10%
505	UZ7856-UZ7890	10W; 10%
505	UZ7856L-UZ7890L	6W, 10%
507	UZ8110-UZ8120	1W; 5%
		ZENER
507	UZ8210-UZ8220	1W; 10%
507	UZ8706-UZ8790	1W; 5%
507	UZ8806-UZ8890	1W; 10%
*	UZS306-UZS440	3W; 5%
*	UZS506-UZS640	3W; 10%

*Contact Unitrode for specifications and ratings.
Legend: J — JAN JTX — JANTX JTXV — JANTXV

THYRISTORS (SCRs, TRIACs & PUTs)

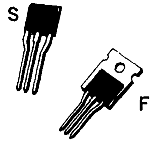
PRODUCT SELECTION GUIDE

SCRs

15-25A/200-800V

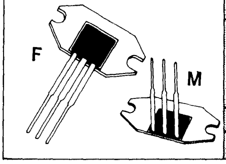
Features:
- Diffused design
- Center gate construction
- Isolated case
- Hard glass passivation
- High dv/dt
- Low power dissipation
- High surge current capability

PACKAGE L7



$I_{T\,(RMS)}$		15A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	L7R08152	S, F
	400	L7R08154	S, F
	600	L7R08156	S, F
	800	L7R08158	S, F
I_{GT}		15mA	
I_H		25mA	

PACKAGE L2



$I_{T\,(RMS)}$		25A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	L2R06252	S, B, F, M
	400	L2R06254	S, B, F, M
	600	L2R06256	S, B, F, M
	800	L2R06258	S, B, F, M
I_{GT}		25mA	
I_H		50mA	

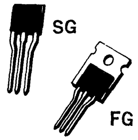
SCRs

FAST TURN-OFF INVERTER TYPE

Specifically designed for use in inverter and high pulse current applications.

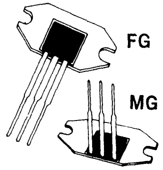
Features:
- Fast turn-off time
- High pulse capability
- High dv/dt and di/dt ratings
- Cost effective package design
- Isolated case

PACKAGE L7



$I_{T\,(RMS)}$		5A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	L7R08052	SG, FG
	400	L7R08054	SG, FG
	600	L7R08056	SG, FG
	800	L7R08058	SG, FG
I_{GT}		40mA	
I_H		50mA	
t_q		<10μS	

PACKAGE L2

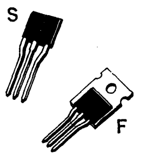


$I_{T\,(RMS)}$		10A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	L2R06102	SG, BG, FG, MG
	400	L2R06104	SG, BG, FG, MG
	600	L2R06106	SG, BG, FG, MG
	800	L2R06108	SG, BG, FG, MG
I_{GT}		70mA	
I_H		175mA	
t_q		<8μS	

TRIACs

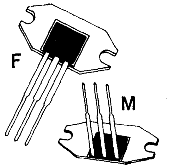
10-40A/200-800V
Features:
- Diffused design
- Center gate construction
- Isolated case
- Hard glass passivation
- High dv/dt
- Low power dissipation
- High surge current capability

PACKAGE L7



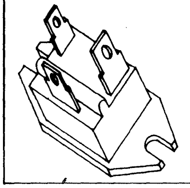
$I_{T\ (RMS)}$		10A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	L7B08102	S, F
	400	L7B08104	S, F
	600	L7B08106	S, F
	800	L7B08108	S, F
I_{GT}		Quadrant 1, 3	30mA
		Quadrant 2, 4	50mA
I_H		30mA	

PACKAGE L2



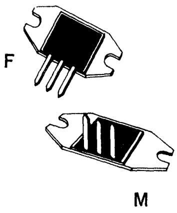
$I_{T\ (RMS)}$		20A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	L2B06202	S, B, F, M
	400	L2B06204	S, B, F, M
	600	L2B06206	S, B, F, M
	800	L2B06208	S, B, F, M
I_{GT}		Quadrant 1, 3	50mA
		Quadrant 2, 4	80mA
I_H		50mA	

PACKAGE L3



$I_{T\ (RMS)}$		25A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	CSB20	None
	400	CSB40	None
	600	CSB60	None
I_{GT}		Quadrant 1, 3	50mA
		Quadrant 2, 4	80mA
I_H		50mA	

PACKAGE L1



$I_{T\ (RMS)}$		30A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	L1B04302	S, B, F, M
	400	L1B04304	S, B, F, M
	600	L1B04306	S, B, F, M
	800	L1B04308	S, B, F, M
I_{GT}		Quadrant 1, 3	80mA
		Quadrant 2, 4	120mA
I_H		60mA	

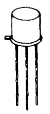
$I_{T\ (RMS)}$		40A	
		Part Number	Part No. Suffix
Repetitive Peak Off-State Voltage V_{DRM} (V)	200	L1B05402	S, B, F, M
	400	L1B05404	S, B, F, M
	600	L1B05406	S, B, F, M
	800	L1B05408	S, B, F, M
I_{GT}		Quadrant 1, 3	80mA
		Quadrant 2, 4	120mA
I_H		90mA	

A PART NUMBER SUFFIX MUST BE SPECIFIED WHEN ORDERING

SUFFIX	DESCRIPTION
S, SG	— SOLDERABLE BACK, STRAIGHT LEADS
B, BG	— SOLDERABLE BACK, PREBENT LEADS
F, FG	— FLANGE MOUNTED, STRAIGHT LEADS
M, MG	— FLANGE MOUNTED, PREBENT LEADS

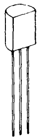
THYRISTORS (SCRs, TRIACs & PUTs)

PRODUCT SELECTION GUIDE



TO-18

SCR		$I_{T(RMS)}$	.5A			
	V_{DRM} (V)	30		2N3027*	2N3030*	ID100
		60	AA114	2N3028*	2N3031*	ID101
		100		2N3029*	2N3032*	ID102
		150				ID103
		200	AA116			ID104
		300	AA110			ID105
		400	AA111			ID106
		I_{GT}	200μA	200μA	20μA	200μA
		I_H	2mA	5mA	4mA	5mA



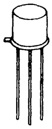
TO-92

SCR		$I_{T(RMS)}$	.8A	
	V_{DRM} (V)	30	2N5060	IP100
		60	2N5061	IP101
		100	2N5062	IP102
		150	2N5063	IP103
		200	2N5064	IP104
		300	2N6564	IP105
		400	2N6565	IP106
		I_{GT}	.2μA TYP.	.2μA TYP.
		I_H	5mA	5mA

SCR (High Voltage)		$I_{T(RMS)}$	1.0A	
	V_{DRM} (V)	100	2N6681	IP200
		200	2N6682	IP202
		400	2N6683	IP204
		600	2N6684	IP206
		800	2N6685	IP208
		I_{GT}	30μA (TYP) 200μA	
		I_H	5mA	

TO-9

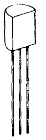
SCR		$I_{T(RMS)}$	1.25A	
	V_{DRM} (V)	30	2N1876	2N1870A**
		60	2N1877	2N1871A**
		100	2N1878	2N1872A**
		150	2N1879	2N1873A
		200	2N1880	2N1874A**
		I_{GT}	20μA	200μA
		I_H	3mA	5mA



TO-39

TO-5

SCR		$I_{T(RMS)}$	1.6A			
	V_{DRM} (V)	30			2N2322	
		60	AD100	2N2323A***	2N2323***	ID200
		100	AD101	2N2324A***	2N2324***	ID201
		150		2N2325A	2N2325	ID202
		200	AD102	2N2326A***	2N2326***	ID203
		300	AD103	2N2328A***	2N2328***	ID300
		400	AD104		2N2329***	ID301
		I_{GT}	2μA	20μA	200μA	200μA
		I_H	2mA	2mA	2mA	3mA



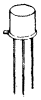
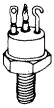
TO-92

TRIAC		$I_{T(RMS)}$	.8A
	V_{DRM} (V)	200	IB202
		400	IB204
		600	IB206
		I_{GT}	Quadrant 1,3 5mA†
			Quadrant 2,4 10mA
		I_H	15mA

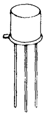
*Available as JAN and JANTX types.
**Available as JAN type.
***Available as JAN, JANTX, JANTXV types.
†3mA available from factory

THYRISTORS (SCRs, TRIACs & PUTs) PRODUCT SELECTION GUIDE

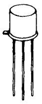
ULTRAFAST SWITCHING

 **TO-18**	**SCR**	V_{DRM} (V)	$I_{T(RMS)}$	**.4A**	
			60V	GA200 GA300	GA200A GA300A
			100V	GA201 GA301	GA201A GA301A
			t_{on}	20ns (TYP.)	20nS (TYP.)
			t_q	2.0μS	.5μS
 **TO-59**	**SCR**	V_{DRM} (V)	$I_{T(RMS)}$	**6A**	
			60V	GB200 GB300	GB200A GB300A
			100V	GB201 GB301	GB201A GB301A
			t_{on}	20ns (TYP.)	20nS (TYP.)
			t_q	2.0μS	.5μS

RADIATION HARDENED SCRs

 **TO-18**	On-State Current $I_{T(RMS)}$		0.4A
	Package Style		**TO-18**
	REPETITIVE PEAK OFF-STATE VOLTAGE, V_{DRM} and REVERSE VOLTAGE, V_{RRM}	30V	GA100
		60V	GA101
		80V	GA102
	Key Parameters		I_{GT} (Post $3X10^{14}$ NVT) 20mA
			I_H (Post $3X10^{14}$ NVT) 30mA

PUTs — PROGRAMMABLE UNIJUNCTION TRANSISTORS

 **TO-18**	Peak Recurrent Forward Current		8A	
	Package Style		**TO-18**	
	MIN. VALLEY CURRENT, I_V MAX. PEAK POINT CURRENT, I_P	$I_V = 25\mu A$ @ $R_G = 10K$ $I_P = .15\mu A$ @ $R_G = 1Meg$	U13T2	CONSULT FACTORY
		$I_V = 70\mu A$ @ $R_G = 10K$ $I_P = 2\mu A$ @ $R_G = 1Meg$	U13T1	
		$I_V = lmA$ @ $R_G = 200\Omega$ $I_P = .15\mu A$ @ $R_G = 1Meg$	2N6120	
		$I_V = 1.5mA$ @ $R_G = 200\Omega$ $I_P = 2\mu A$ @ $R_G = 1Meg$	2N6119 2N6137*	
	Forward and Reverse Voltage; V_{AK}, V_{AKR}		40V	100V

 **TO-92**	Peak Recurrent Forward Current		5A	2A
	Package Style		**TO-92**	**TO-92**
	MIN. VALLEY CURRENT, I_V MAX. PEAK POINT CURRENT, I_P	$I_V = 25\mu A$ @ $R_G = 10K$ $I_P = .15\mu$ @ $R_G = 1Meg$	P13T2	
		$I_V = 70\mu$ @ $R_G = 10K$ $I_P = 2\mu A$ @ $R_G = 1Meg$	P13T1	
		$I_V = 1mA$ @ $R_G = 200\Omega$ $I_P = .15\mu$ @ $R_G = 1Meg$		2N6028
		$I_V = 1.5mA$ @ $R_G = 200\Omega$ $I_P = 2\mu A$ @ $R_G = 1Meg$		2N6027
	Forward and Reverse Voltage; V_{AK}, V_{AKR}		40V	

* Available as JAN and JANTX types.

GLASS PASSIVATED SOLDERABLE CHIPS

(Only Available Through Factory)

TRIAC
Features
- Hard glass passivation
- Solderable contacts
- Center gate geometry

$I_{T(RMS)}$	V_{DRM}	I_{GT} Maximum	Type*
10A		80mA	B0810**
20A	200-600V	100mA	B0620**
30A		120mA	B0430**
40A		150mA	B0540**

SCRs
Features
- Hard glass passivation
- Solderable contacts
- Center gate geometry

$I_{T(RMS)}$	V_{DRM}	I_{GT} Maximum	Type*
15A		25mA	R0815**
	200-600V		
25A		25mA	R0625**
55A		40mA	R0555**

*Current ratings are at operating temperature of 65°C as measured on the substrate immediately adjacent to the chip. (Equivalent to case temperature in a packaged unit.) Current rating at 65°C derates linearly to zero at a operating temperature of 110°C.

**Add suffix 20, 40, 60 to depict voltages 200V, 400V, 600V respectively.

Design Comments

1. Chips available in 5/95 solder or 60/40 solder. Call factory for additional information.
2. Chips are supplied with metal contact clips (unattached).

SCRs
1.25 Amp, Planar

2N1870A-2N1874A

FEATURES
- Available as Either "JAN" or Standard Types
- Operating D.C. Current Range: 5 to 1250mA
- Pulse Currents: to 30A
- Voltage Ratings: to 200V
- Maximum Trigger Current: 0.2mA
- Maximum Trigger Voltage: 0.8V
- All Leads Isolated from Case
- Maximum θ_{J-C}: 20°C/W

DESCRIPTION
These are premium PNPN controlled switches intended for use in applications requiring a high degree of reliability assurance. The JAN types are specified under MIL-S-19500/198, and are included in MIL-STD-701 as recommended types for military usage.

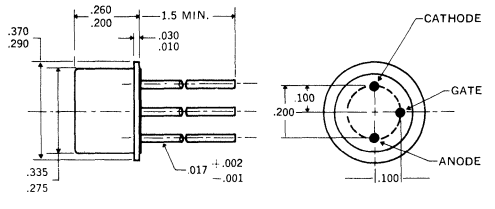
This series is useful in a wide variety of applications including: safety, arming and detonating circuits; timing and programming circuits; protective and warning circuits; driving relays; driving indicator lamps, encoding and decoding circuits; replacing relays, thyratrons, and magamps; servo motor control; pulse generation; plus many others.

ABSOLUTE MAXIMUM RATINGS

	2N1870A JAN2N1870A	2N1871A JAN2N1871A	2N1872A JAN2N1872A	2N1873A —	2N1874A JAN2N1874A
Repetitive Peak Off-State Voltage, V_{DRM}	30V	60V	100V	150V	200V
Repetitive Peak Reverse Voltage, V_{RRM}	30V	60V	100V	150V	200V
D.C. On-State Current, I_T					
100°C Ambient	250mA				
100°C Case	1.25A				
Repetitive Peak On-State Current, I_{TRM}	up to 30A				
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	15A				
Peak Gate Current, I_{GM}	250mA				
Average Gate Current, $I_{G(AV)}$	25mA				
Reverse Gate Voltage, V_{GR}	5V				
Thermal Resistance, Junction to Case, $R\theta_{J-C}$	20°C/W				
Operating and Storage Temperature Range	−65°C to +150°C				

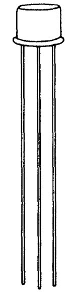
MECHANICAL SPECIFICATIONS

2N1870A-2N1874A



Dimensions in inches.

TO-9



UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)†

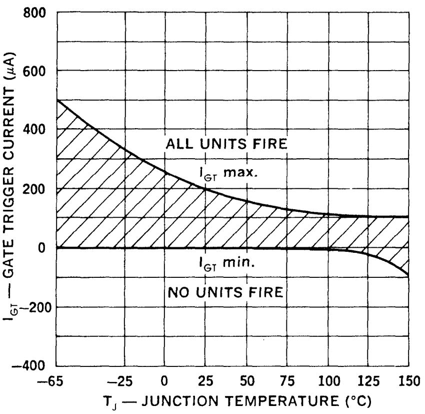
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Subgroup 1 (Visual and Mechanical)						
Subgroup 2 (25°C Tests)						
Off-State Current	I_{DRM}	—	0.5	10	μA	$R_{GK} = 1K, V_{DRM} = +$ Rating
Reverse Current	I_{RRM}	—	0.5	10	μA	$R_{GK} = 1K, V_{RRM} = -$ Rating
Gate Trigger Voltage	V_{GT}	0.4	0.55	0.8	V	$R_{GS} = 100$ ohms, $V_D = 5V$
Gate Trigger Current	I_{GT}	—	30	200	μA	$R_{GS} > 10K$ ohms, $V_D = 5V$
On-State Voltage	V_{TM}	—	1.8	2.5	V	$I_{TM} = 2A$ (pulse test)
Off-State Voltage — Critical of Rise	dv_c/dt	100	—	—	V/μs	Specified test circuit
Reverse Gate Current	I_{GR}	—	0.5	10	μA	$V_{GRM} = 5V$, anode open
Holding Current	I_H	0.3	—	5.0	mA	$I_G = -150\mu A, V_D = 5V$
Subgroup 3 (125°C Tests)						
High Temp. Off-State Current	I_{DRM}	—	15	100	μA	$R_{GK} = 1K, V_{DRM} = +$ Rating
High Temp. Reverse Current	I_{RRM}	—	15	100	μA	$R_{GK} = 1K, V_{RRM} = -$ Rating
High Temp. Gate Non-Trigger Voltage	V_{GD}	0.2	—	—	V	$R_{GS} = 100$ ohms, $V_D = 5V$
High Temp. Holding Current	I_H	0.2	—	—	mA	$I_G = -150\mu A, V_D = 5V$
Subgroup 4 (—65°C Tests)						
Low Temp. Gate Trigger Voltage	V_{GT}	—	—	1.0	V	$R_{GK} = 100$ ohms, $V_D = 5V$
Low Temp. Gate Trigger Current	I_{GT}	—	—	500	μA	$R_{GK} > 10K$ ohms, $V_D = 5V$
Low Temp. Holding Current	I_H	—	—	15	mA	$I_G = -150\mu A, V_{AA} = 5V$

†All values in this table are JEDEC registered.

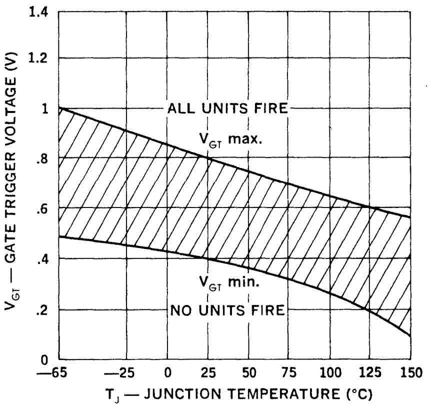
Note: Voltage ratings apply over the full operating temperature range, provided the gate is connected to the cathode through a resistor, 1 K or smaller, or other adequate gate bias is used.

Triggering and Bias Stabilization

1. **Gate Trigger Current**

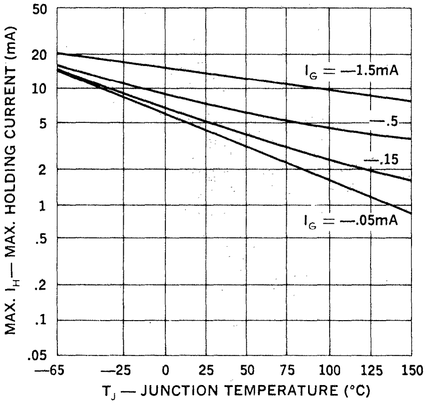


2. **Gate Trigger Voltage**

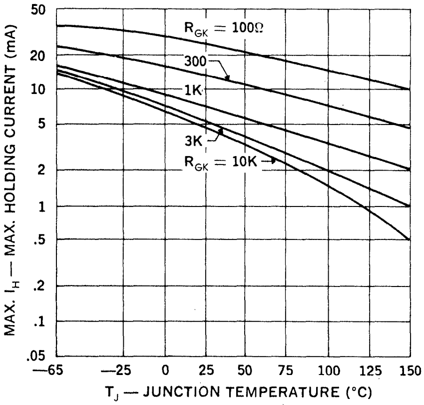


Holding Current

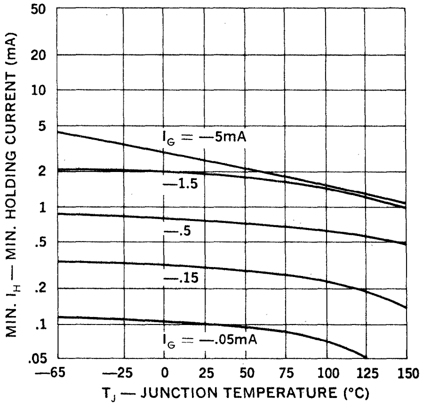
1. Max. Holding Current (Current Bias)



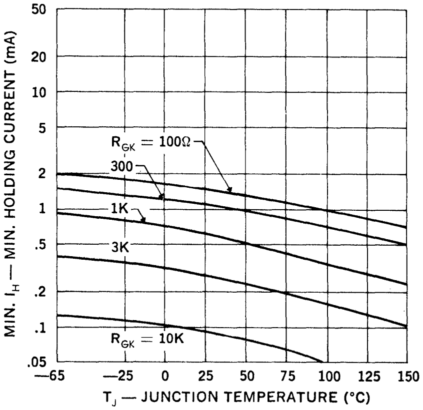
2. Max. Holding Current (Resistor Bias)



3. Min. Holding Current (Current Bias)

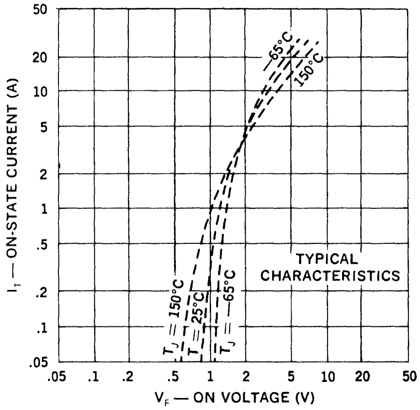


4. Min. Holding Current (Resistor Bias)

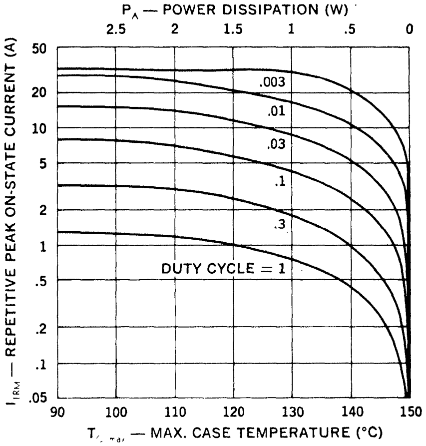


Current Ratings — Thermal Design

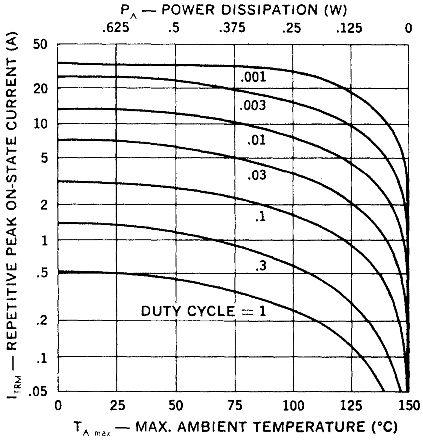
1. On-State Current vs. Voltage



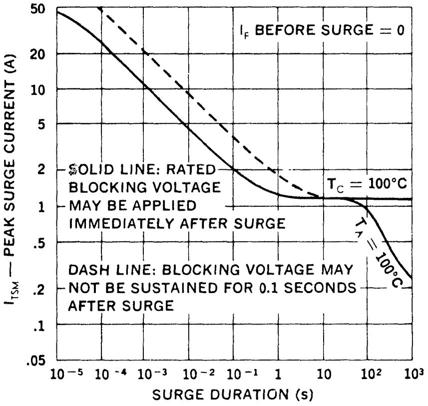
2. Peak Current vs. Case Temperature



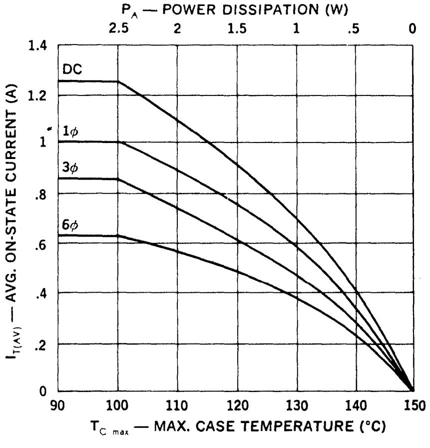
3. Peak Current vs. Ambient Temperature



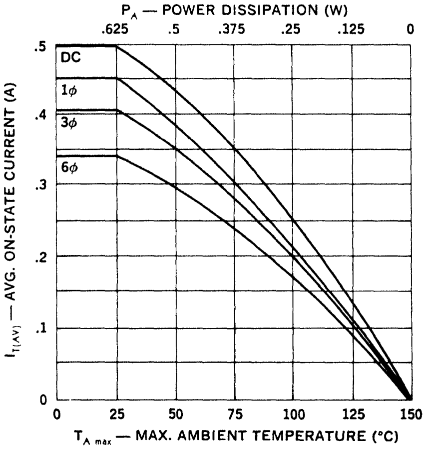
4. Surge Current vs. Time



5. Average Current vs. Case Temperature



6. Average Current vs. Ambient Temperature



SCRs

1.25 Amp, Planar

2N1875-2N1880

FEATURES

- Operating D.C. Current Range: 10-1250mA
- Peak Pulse Current: to 30A
- Maximum Gate Current to Fire: 20μA
- Firing Voltage: .52±.08V
- Voltage Ratings: to 200V
- "Turn-on" Time: Typically 0.1μs
- Low On Voltage: 2.5V Maximum at 2A

DESCRIPTION

This high sensitivity series, featuring very precise control of triggering characteristics, is particularly useful for timing and time delay circuits, voltage limit detectors, high gain static switching, logic circuits, pulse and sweep generators, and related applications.

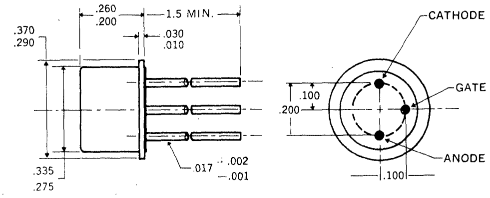
This series is available in a TO-9 package, with all leads isolated from the case, providing a maximum thermal resistance of 20°C/Watt between junction and case.

ABSOLUTE MAXIMUM RATINGS

	2N1875	2N1876	2N1877	2N1878	2N1879	2N1880
Repetitive Peak Off-State Voltage, V_{DRM}	15V	30V	60V	100V	150V	200V
Repetitive Peak Reverse Voltage, V_{RRM}	15V	30V	60V	100V	150V	200V
D.C. On-State Current, I_T						
100°C Ambient	250mA					
100°C Case	1.25A					
Repetitive Peak On-State Current, I_{TRM}	up to 30A					
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	15A					
Peak Gate Current, I_{GM}	250mA					
Average Gate Current, $I_{G(AV)}$	25mA					
Reverse Gate Voltage, V_{GR}	5V					
Thermal Resistance, Junction to Case, $R\theta_{J-C}$	20°C/W					
Operating and Storage Temperature Range	—65°C to +150°C					

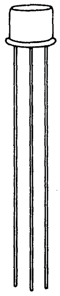
MECHANICAL SPECIFICATIONS

2N1875-2N1880



Dimensions in inches.

TO-9



UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)†

Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Subgroup 1 (Visual and Mechanical)						
Subgroup 2 (25°C Tests)						
Off-State Current	I_{DRM}	—	0.5	5	μA	V_{DRM} = Rating, R_{GK} = 1K
Reverse Current	I_{RRM}	—	0.5	10	μA	V_{RRM} = Rating
Reverse Gate Current	I_{GR}	—	0.5	10	μA	V_{GR} = 2V
Gate Trigger Current	I_{GT}	—	5	20	μA	V_D = 5V, R_{GS} = 10K
Gate Trigger Voltage	V_{GT}	.44	.52	.60	V	V_D = 5V, R_{GS} = 100Ω
Anode Trigger Current (Note 2)	I_{AT}	—	100	—	μA	V_D = 5V
On-State Voltage	V_T	0.8	1.8	2.5	V	I_T = 2A (Pulse Test)
Holding Current	I_H	0.3	1.0	3	mA	I_G = −150μA, V_{AA} = 5V
Subgroup 3 (25°C Tests)						
Turn-on Time	t_{on}	—	0.1	—	μs	I_G = 20mA
Turn-off Time	t_{off}	—	0.5	—	μs	I_T = .5A
Gate Trigger — on Pulse Width	$t_{pg(on)}$	—	0.5	—	μs	V_D = 30V
Circuit Commutated Turn-off Time	t_q	—	10	—	μs	I_T = .5A, i_R = .5A, R_{GK} = 1K
Subgroup 4 (125°C Tests)						
High Temp. Off-State Current	I_{DRM}	—	5	20	μA	V_D = Rating, R_{GK} = 1K
High Temp. Reverse Current	I_{RRM}	—	15	100	μA	V_{RRM} = Rating

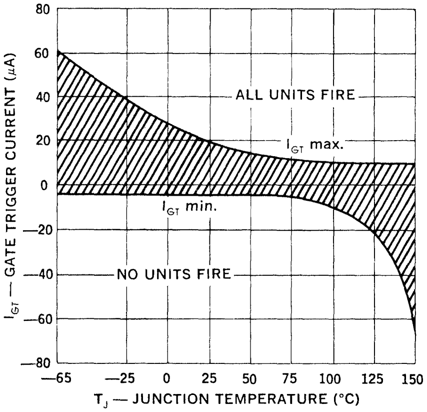
Note: 1. Voltage ratings apply over the operating temperature range, provided the gate is connected to the cathode through an appropriate resistor, or adequate gate bias is used.

2. For a maximum limit of 50μA, use suffix "—1" and drop "2N". Example: 1877-1.

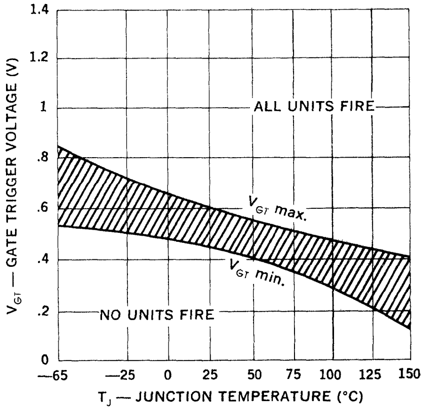
† All values in this table are JEDEC registered.

TRIGGERING AND BIAS STABILIZATION

1. Gate Trigger Current



2. Gate Trigger Voltage



SCRs

1 Amp, Planar

2N1881-2N1885

FEATURES

- One Cycle Surge Current: 15A
- Voltage Ratings: to 200V
- Low "On-Voltage": 2V Max. at 1A
- Operation: to 150°C Junction Temperature
- All Leads Isolated for Design Flexibility

DESCRIPTION

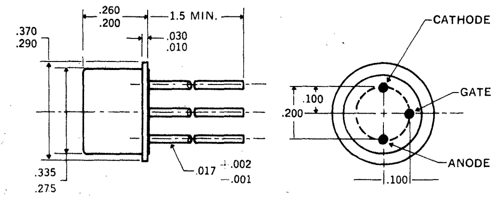
These types are useful in AC and DC static switching, proportioning control, relay and thyratron replacement, DC to AC converters, servo motor driving, protective circuits, and related applications.
This series is available in a TO-9 package, with all leads isolated from the case, providing a maximum thermal resistance of 20°C/Watt between junction and case.

ABSOLUTE MAXIMUM RATINGS

	2N1881	2N1882	2N1883	2N1884	2N1885
Repetitive Peak Off-State Voltage, V_{DRM}	30V	60V	100V	150V	200V
Repetitive Peak Reverse Voltage, V_{RRM}	30V	60V	100V	150V	200V
D.C. On-State Current, I_T					
100°C Ambient	250mA				
100°C Case	1.0A				
Repetitive Peak On-State Current, I_{TRM}	up to 30A				
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	15A				
Peak Gate Current, I_{GM}	250mA				
Average Gate Current $I_{G(AV)}$	25mA				
Reverse Gate Voltage, V_{GR}	3V				
Thermal Resistance, Junction to Case, $R\theta_{J-C}$	20°C/W				
Operating and Storage Temperature Range	—65°C to +150°C				

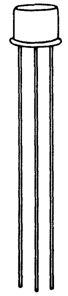
MECHANICAL SPECIFICATIONS

2N1881-2N1885



Dimensions in inches.

TO-9



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)†

Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Subgroup 1 (Visual and Mechanical)						
Subgroup 2 (25°C Tests)						
Off-State Current	I_{DRM}	—	0.5	10	μA	$R_{GK} = 1K$, V_{DRM} = Rating
Reverse Current	I_{RRM}	—	0.5	10	μA	$R_{GK} = 1K$, V_{RRM} = Rating
Reverse Gate Current	I_{GR}	—	0.5	10	μA	$V_{GRM} = 2V$
Gate Trigger Current	I_{GT}	—	0.2	2	mA	$R_{GS} = 10K$, $V_D = 5V$
Gate Trigger Voltage	V_{GT}	0.40	1	2	V	$R_{GS} = 100\Omega$, $V_D = 5V$
On-State Voltage	V_T	—	1.5	2	V	$I_T = 1A$ (pulse test)
Holding Current	I_H	—	2	—	mA	$I_G = -150\mu A$, $V_D = 5V$
Anode Trigger Current	I_{AT}	—	0.5	—	mA	$R_{GS} = 10K$, $V_D = 5V$
Subgroup 3 (25°C Tests)						
Turn-on Time	t_{on}	—	0.2	—	μs	$I_G = 20mA$, $I_T = 0.5A$, $V_D = 30V$
Gate Trigger — on Pulse Width	t_{pg} (on)	—	1	—	μs	$I_G = 20mA$, $I_T = 0.5A$, $V_D = 30V$
Turn-off Time	t_{off}	—	1	—	μs	$I_T = 1A$, $I_R = IA$, $R_{GK} = IK$
Circuit Commutated Turn-off Time	t_q	—	10	—	μs	$I_T = 1A$, $I_R = IA$, $R_{GK} = IK$
Subgroup 3 (125°C Tests)						
High Temp. Off-State Current	I_{DRM}	—	15	200	μA	$R_{GK} = 1K$, V_{DRM} = Rating
High Temp. Reverse Current	I_{RRM}	—	15	200	μA	$R_{GK} = 1K$, V_{RRM} = Rating

† All values in this table are JEDEC registered.

Note: Voltage ratings apply over the operating temperature range, provided the gate is connected to the cathode through an appropriate resistor, or adequate gate bias is used.

SCRs
1.6 Amp, Planar

2N2322-2N2329
2N2323A-2N2328A

FEATURES
- Available as JAN & JANTX Types
- 1.6A D.C. Current
- Peak Currents: to 30A
- Voltage Ratings: to 400V
- 20μA Max. Trigger Current ("A" types)
- 0.6V Max. Trigger Voltage ("A" types)

DESCRIPTION
These are premium thyristor switches intended for use in high performance industrial, military and space applications requiring a high degree of reliability assurance. This series is useful in a wide variety of applications including timing and programming circuits, protective and warning circuits, driving relays, driving indicator lamps, encoding and decoding circuits, replacing relays, thyratrons, and magamps, servo motor control, pulse generation, plus many others. The high surge current rating (15A - 1 cycle) makes this series particularly useful for squib firing.

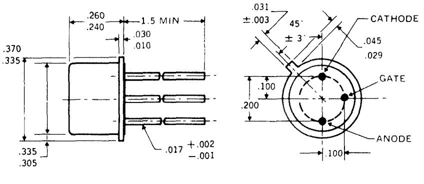
The following JAN and JANTX types are specified under Mil-S-19500/276A and are included in Mil-STD-701 as recommended types for military usage:

ABSOLUTE MAXIMUM RATINGS

	2N2322	2N2323 JAN2N2323 JANTX2N2323 2N2323A JAN2N2323A JANTX2N2323A	2N2324 JAN2N2324 JANTX2N2324 2N2324A JAN2N2324A JANTX2N2324A	2N2325 2N2325A	2N2326 JAN2N2326 JANTX2N2326 2N2326A JAN2N2326A JANTX2N2326A	2N2327 2N2327A	2N2328 JAN2N2328 JANTX2N2328 2N2328A JAN2N2328A JANTX2N2328A	2N2329 JAN2N2329 JANTX2N2329
Repetitive Peak Off-State Voltage, V_{DRM}	25V	50V	100V	150V	200V	250V	300V	400V
Repetitive Peak Reverse Voltage, V_{RRM}	25V	50V	100V	150V	200V	250V	300V	400V
Non-Repetitive Peak Reverse Voltage, V_{RSM} (< 5ms)	40V	75V	150V	225V	300V	350V	400V	500V
D.C. On-State Current, I_T								
80°C Ambient	300mA							
85°C Case	1.6A							
One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	15A							
Repetitive Peak On-State Current, I_{TM}	30A							
Gate Power Dissipation, P_{GM}	0.1W							
Gate Power Dissipation, $P_{GM(AV)}$	0.01W							
Peak Gate Current, I_{GM}	100mA							
Peak Gate Voltage, Forward and Reverse	6V							
Reverse Gate Current, I_{GR}	3mA							
Storage Temperature Range	−65°C to +150°C							
Operating Temperature Range	−65°C to +125°C							

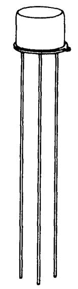
MECHANICAL SPECIFICATIONS

2N2322-2N2329 2N2323A-2N2328A

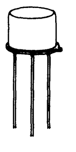


Dimensions in inches. **TO-39 has .5" lead length**

TO-5



TO-39



Non JAN types available in TO-39 package

ELECTRICAL SPECIFICATIONS

Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Visual and Mechanical						MIL-STD-750, Method 2071
25°C						
Off-State Current	I_{DRM}	—	0.1	10	μA	V_{DRM} = Rating, R_{GK} = 1K (2K for "A" Types)
Reverse Current	I_{RRM}	—	0.1	10	μA	V_{RRM} = Rating, R_{GK} = 1K (2K for "A" Types)
Gate Trigger Current	I_{GT}					
"A" Types		—	2	20	μA	V_D = 6V, R_L = 100Ω
non-"A" Types		—	50	200	μA	V_D = 6V, R_L = 100Ω
Gate Trigger Voltage	V_{GT}					
"A" Types		0.35	0.52	0.60	V	V_D = 6V, R_{GK} = 2K, R_L = 100Ω
non-"A" Types		0.35	0.55	0.80	V	V_D = 6V, R_{GK} = 1K, R_L = 100Ω
On-State Voltage	V_{TM}	—	2.0	2.2	V	I_{TM} = 4A (pulse test)
Holding Current	I_H	—	0.3	2.0	mA	V_D = 6V, R_{GK} = 1K (2K for "A" Types)
Reverse Gate Current	I_{GR}	—	1	200*	μA	V_{GR} = 6V
Delay Time	t_d	—	0.6	—	μs	I_G = 10mA, I_T = 1A, V_D = 30V
Rise Time	t_r	—	0.4	—	μs	I_G = 10mA, I_T = 1A, V_D = 30V
Circuit Commutated Turn-Off Time	t_q	—	20	—	μs	I_T = 1A, I_R = 1A, R_{GK} = 1K
125°C						
Off-State Current	I_{DRM}	—	1	100	μA	V_{DRM} = Rating, R_{GK} = 1K (2K for "A" Types)
Reverse Current	I_{RRM}	—	1	100	μA	V_{RRM} = Rating, R_{GK} = 1K (2K for "A" Types)
Gate Trigger Voltage	V_{GT}	0.1	0.3	—	V	V_D = Rated V_D, R_{GK} = 1K (2K for "A" Types)
Holding Current	I_H					
"A" Types		0.1†	—	—	mA	V_D = 6V, R_{GK} = 2K
non-"A" Types		0.15†	—	—	mA	V_D = 6V, R_{GK} = 1K
Off-State Voltage — Critical Rate of Rise	dv/dt					
"A" Types		0.7*			V/μs	V_D = Rating, R_{GK} = 2K
non-"A" Types		1.8*			V/μs	V_D = Rating, R_{GK} = 1K
−65°C						
Off-State Current	I_{DRM}	—	.05	5.0*	μA	V_{DRM} = Rating, R_{GK} = 1K (2K for "A" Types)
Reverse Current	I_{RRM}	—	.05	5.0*	μA	V_{RRM} = Rating, R_{GK} = 1K (2K for "A" Types)
Gate Trigger Current	I_{GT}					
"A" Types		—	50	75	μA	V_D = 6V, R_L = 100Ω
non-"A" Types		—	100	350	μA	V_D = 6V, R_L = 100Ω
Gate Trigger Voltage	V_{GT}					
"A" Types		—	0.7	0.8*	V	V_D = 6V, R_{GK} = 2K, R_L = 100Ω
				0.9†	V	V_D = 6V, R_{GK} = 2K, R_L = 100Ω
non-"A" Types		—	0.75	1.0	V	V_D = 6V, R_{GK} = 1K, R_L = 100Ω
Holding Current	I_H	—	—	3.0†	mA	V_D = 6V, R_{GK} = 1K (2K for "A" Types)

* JAN and JANTX Types only.
† Industrial Types only.

JAN and JANTX Acceptance Tests

100% Screening TX-Types

High Temperature Storage
Temperature Cycling
Constant Acceleration
Fine & Gross Hermetic Seal
Electrical Test
Burn-in
Electrical Test

Group B Tests

Subgroup 1 — Reverse Gate Current
Surge Current
Non-Repetitive Reverse Voltage

Subgroup 2 — Low Temp. Reverse Blocking Current
Low Temp. Forward Blocking Current
Low Temp. Gate Trigger Voltage
Low Temp. Gate Trigger Current

Subgroup 3 — Temperature Cycling
Thermal Shock
Moisture Resistance
Solderability

Subgroup 4 — Blocking Life Test

Group C Tests

Subgroup 1 — Physical Dimensions

Subgroup 2 — Shock
Constant Acceleration
Vibration, Variable Frequency

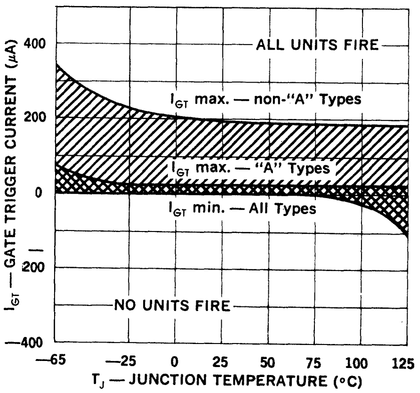
Subgroup 3 — Barometric Pressure, Reduced

Subgroup 4 — Salt Atmosphere

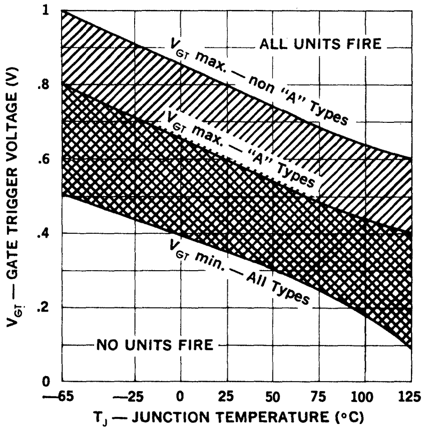
Subgroup 5 — Terminal Strength

Subgroup 6 — Intermittent Operating Life Test

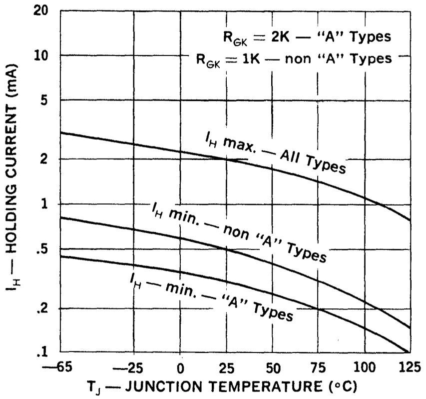
Gate Trigger Current



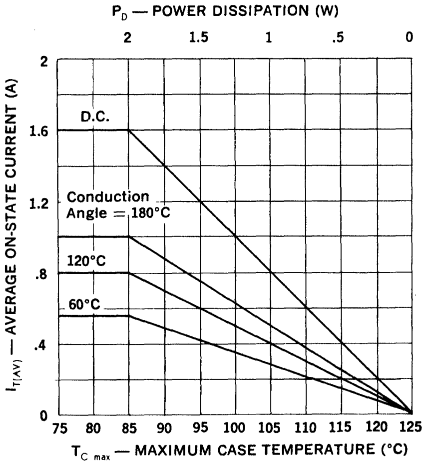
Gate Trigger Voltage



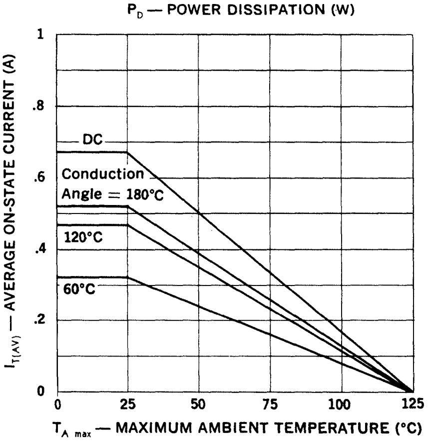
Holding Current



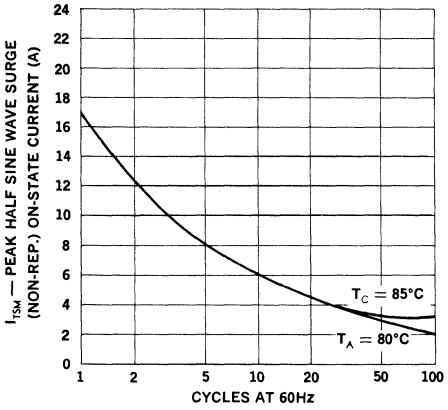
Average Current vs. Case Temperature



Average Current vs. Ambient Temperature



Surge Current



SCRs

0.5 Amp, Planar

JAN & JANTX 2N3027-2N3032

FEATURES

- JAN and JANTX Types Available
- Fully Characterized for "Worst Case" Design
- Passivated Planar Construction for Maximum Reliability and Parameter Uniformity
- Low On-State Voltage and Fast Switching at High Current Levels
- Typical Turn-On Time: 0.12μs
- Typical Recovery Time: 0.7μs
- Pulse Currents: to 30A

DESCRIPTION

The 2N3027 series of planar SCRs (controlled switches) are intended for use in military and space applications requiring a high degree of reliability. They offer a unique combination of extremely fast switching, precise triggering, high pulse power, small size, intrinsic parameter stability, and high radiation tolerance.

The JAN and JANTX types are specified under MIL-S-19500/419, and are included in MIL-STD-701 as recommended types for military usage.

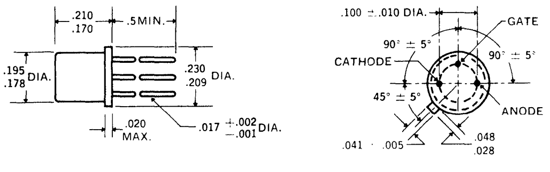
ABSOLUTE MAXIMUM RATINGS

	JAN & JANTX 2N3027 JAN & JANTX 2N3030	JAN & JANTX 2N3028 JAN & JANTX 2N3031	JAN & JANTX 2N3029 JAN & JANTX 2N3032
Repetitive Peak Off-State Voltage, V_{DRM}	30V	60V	100V
Repetitive Peak Reverse Voltage, V_{RRM}	30V	60V	100V
D.C. On-State Current, I_T			
100°C Case	500mA		
75°C Ambient	250mA		
Repetitive Peak On-State Current, I_{TRM}	30A		
Surge (Non-Rep.) On-State Current, I_{TSM}			
50ms	5A		
8ms	8A		
Peak Gate Current, I_{GM}	250mA		
Average Gate Current, $I_{G(AV)}$	25mA		
Reverse Gate Voltage	5V		
Reverse Gate Current	3mA		
Storage Temperature Range	−65°C to +200°C		
Operating Temperature Range	−65°C to +150°C		

Note: Blocking voltage ratings apply over the operating temperature range, provided the gate is connected to the cathode through an appropriate resistor, or adequate gate bias is used. (See section on bias stabilization.)

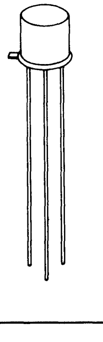
MECHANICAL SPECIFICATIONS

JAN & JANTX 2N3027-2N3032



Dimensions in inches.

TO18



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)
2N3027 — 2N3028 — 2N3029

Parameter	Symbol	Min.	Typical	Max.	Units	Test Conditions
SUBGROUP 1						MIL-STD-750
Visual and Mechanical	—	—	—	—	—	Method 2071
SUBGROUP 2 (25°C Tests)						
Off-State Current	I_{DRM}	—	.002	0.1	μA	$R_{GK} = 1K$, $V_{DRM} =$ Rating
Reverse Current	I_{RRM}	—	.002	0.1	μA	$R_{GK} = 1K$, $V_{RRM} =$ Rating
Reverse Gate Voltage	V_{GR}	5	8	—	V	$I_{GR} = 0.1mA$
Gate Trigger Current	I_{GT}	−5	8	200	μA	$R_{GS} = 10K$, $V_D = 5V$
Gate Trigger Voltage	V_{GT}	.40	.55	.80	V	$R_{GS} = 100\Omega$, $V_D = 5V$
On-State Voltage	V_T	0.8	1.2	1.5	V	$i_T = 1A$ (pulse test)
Holding Current	I_H	0.3	0.7	5.0	mA	$R_{GK} = 1K$, $V_D = 5V$
SUBGROUP 3 (25°C Tests)						
Off-State Voltage — Critical Rate of Rise	dv_c/dt	30	60	—	v/μs	$R_{GK} = 1K$, $V_D = 30V$
Gate Trigger-on Pulse Width	$t_{pg\,(on)}$	—	.07	0.2	μs	$I_G = 10mA$, $I_T = 1A$, $V_{DM} = 30V$
Delay Time	t_d	—	.08	—	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Rise Time	t_r	—	.04	—	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Circuit Commutated Turn-off Time	t_q	—	0.7	2.0	μs	$I_T = 1A$, $i_R = 1A$, $R_{GK} = 1K$
SUBGROUP 4 (150°C Tests)						
High Temp. Off-State Current	I_{DRM}	—	2	20	μA	$R_{GK} = 1K$, $V_{DRM} =$ Rating
High Temp. Reverse Current	I_{RRM}	—	20	50	μA	$R_{GK} = 1K$, $V_{RRM} =$ Rating
High Temp. Gate Trigger Voltage	V_{GT}	.10	.15	0.6	V	$R_{GS} = 100\Omega$, $V_D = 5V$
High Temp. Holding Current	I_H	.05	.20	1.0	mA	$R_{GK} = 1K$, $V_D = 5V$
SUBGROUP 5 (−65°C Tests)						
Low Temp. Gate Trigger Voltage	V_{GT}	0.6	0.75	1.1	V	$R_{GS} = 100\Omega$, $V_D = 5V$
Low Temp. Gate Trigger Current	I_{GT}	0	150	1.2	mA	$R_{GS} = 10K$, $V_D = 5V$
Low Temp. Holding Current	I_H	0.5	3.5	10	mA	$R_{GK} = 1K$, $V_D = 5V$

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)
2N3030 — 2N3031 — 2N3032

Parameter	Symbol	Min.	Typical	Max.	Units	Test Conditions
SUBGROUP 1						MIL-STD-750
Visual and Mechanical	—	—	—	—	—	Method 2071
SUBGROUP 2 (25°C Tests)						
Off-State Current	I_{DRM}	—	.002	0.1	μA	$R_{GK} = 1K$, $V_{DRM} =$ Rating
Reverse Current	I_{RRM}	—	.002	0.1	μA	$R_{GK} = 1K$, $V_{RRM} =$ Rating
Reverse Gate Voltage	V_{GR}	5	8	—	V	$I_{GR} = 0.1mA$
Gate Trigger Current	I_{GT}	−5		20	μA	$R_{GS} = 10K$, $V_D = 5V$
Gate Trigger Voltage	V_{GT}	0.44		0.6	V	$R_{GS} = 100\Omega$, $V_D = 5V$
On-State Voltage	V_T	0.8	1.2	1.5	V	$i_T = 1A$ (pulse test)
Holding Current	I_H	0.3	1.0	4.0	mA	$R_{GK} = 1K$, $V_D = 5V$
SUBGROUP 3 (25°C Tests)						
Off-State Voltage — Critical Rate of Rise	dv_c/dt	30	60	—	v/μs	$R_{GK} = 1K$, $V_D = 30V$
Gate Trigger-on Pulse Width	t_{pg} (on)	—	.05	0.1	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Delay Time	t_d	—	0.1	—	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Rise Time	t_r	—	.05	—	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Circuit Commutated Turn-off Time	t_q	—	0.7	2.0	μs	$I_T = 1A$, $i_R = 1A$, $R_{GK} = 1K$
SUBGROUP 4 (150°C Tests)						
High Temp. Off-State Current	I_{DRM}	—	2	20	μA	$R_{GK} = 1K$, $V_{DRM} =$ Rating
High Temp. Reverse Current	I_{RRM}	—	20	50	μA	$R_{GK} = 1K$, $V_{RRM} =$ Rating
High Temp. Gate Trigger Voltage	V_{GT}	.10	.15	0.4	V	$R_{GS} = 100\Omega$, $V_D = 5V$
High Temp. Holding Current	I_H	.05	.30	2.0	mA	$R_{GK} = 1K$, $V_D = 5V$
SUBGROUP 5 (−65°C Tests)						
Low Temp. Gate Trigger Voltage	V_{GT}	0.44	0.8	0.95	V	$R_{GS} = 100\Omega$, $V_D = 5V$
Low Temp. Gate Trigger Current	I_{GT}	0	0.4	0.5	mA	$R_{GS} = 10K$, $V_D = 5V$
Low Temp. Holding Current	I_H	0.5	5.0	8	mA	$R_{GK} = 1K$, $V_D = 5V$

High Reliability Processing

The 2N3027-2N3032 series provides a complete range of high reliability processing from the standard devices that undergo extensive electrical testing, through JAN and JANTX levels. 100% processing, Group B, and Group C tests for JAN and JANTX devices is shown below. For further details, see MIL-S-19500/419(EL).

100% Screening TX-Types

High Temperature Storage
Temperature Cycling
Constant Acceleration
Fine & Gross Hermetic Seal
Electrical Test
Burn-in
Electrical Test

Group B Tests

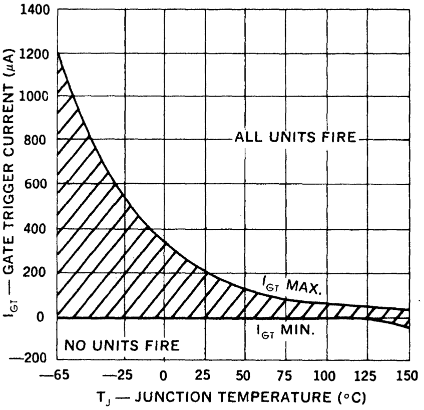
Subgroup 1 — Physical Dimensions
Subgroup 2 — Solderability
Temperature Cycling
Thermal Shock
Constant Acceleration
Moisture Resistance
Subgroup 3 — Surge Current
Subgroup 4 — Blocking Life Test
Subgroup 5 — Storage Life Test
Subgroup 6 — Operating Life Test

Group C Tests

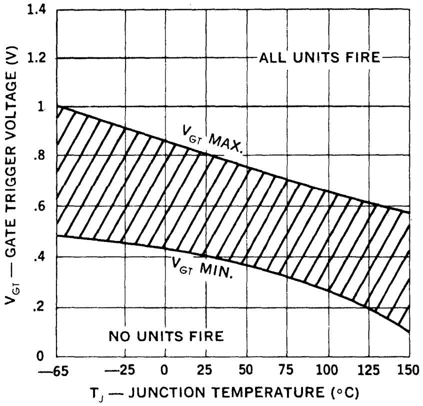
Subgroup 1 — Shock
Vibration, Variable Frequency
Subgroup 2 — Salt Atmosphere
Subgroup 3 — Terminal Strength
Subgroup 4 — High Temp. Anode Voltage — Critical rate or rise
Subgroup 5 — Storage Life Test
Subgroup 6 — Operating Life Test

TYPICAL CHARACTERISTICS
2N3027 — 2N3028 — 2N3029

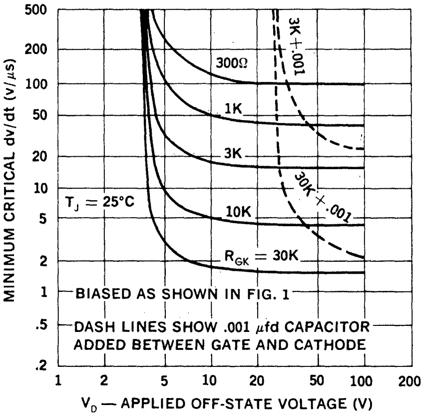
1 Gate Trigger Current



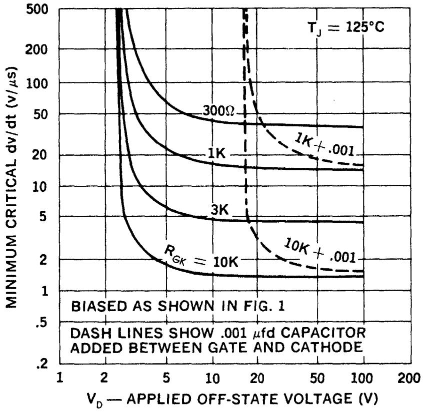
2 Gate Trigger Voltage



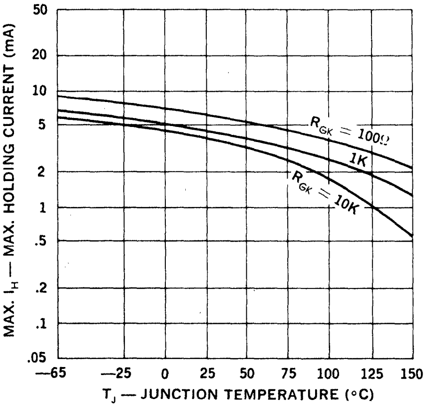
3 Min. Critical dv/dt (25°C — R Bias)



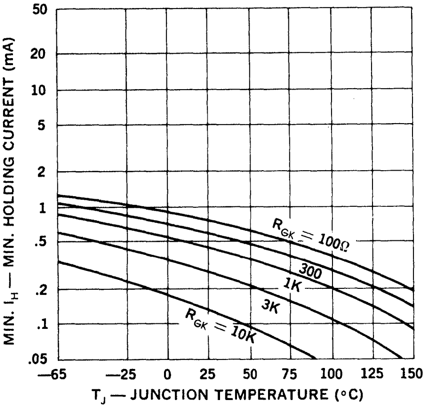
4 Min. Critical dv/dt (125°C — R Bias)



5 Max. Holding Current (Resistor Bias)

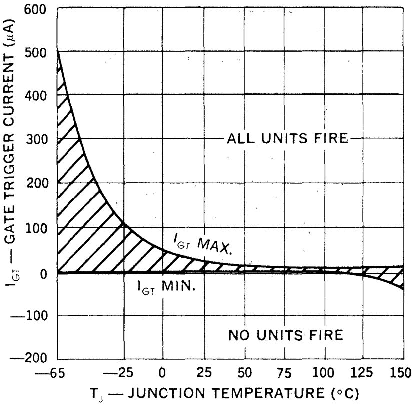


6 Min. Holding Current (Resistor Bias)

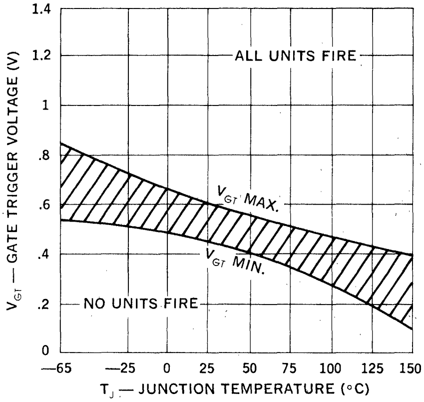


TYPICAL CHARACTERISTICS
2N3030 — 2N3031 — 2N3032

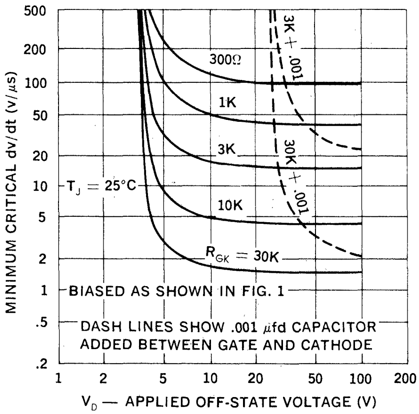
1 **Gate Trigger Current**



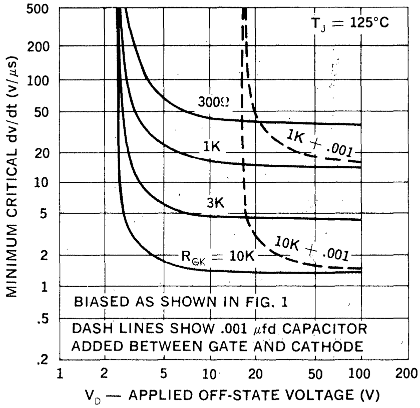
2 **Gate Trigger Voltage**



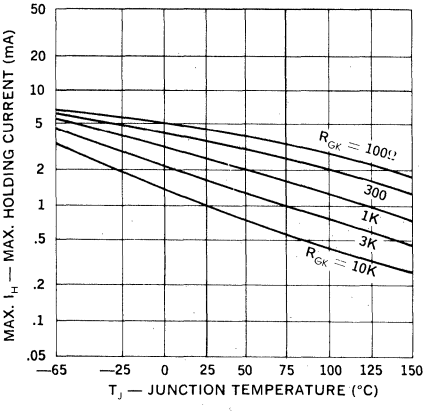
3 **Min. Critical dv/dt (25°C — R Bias)**



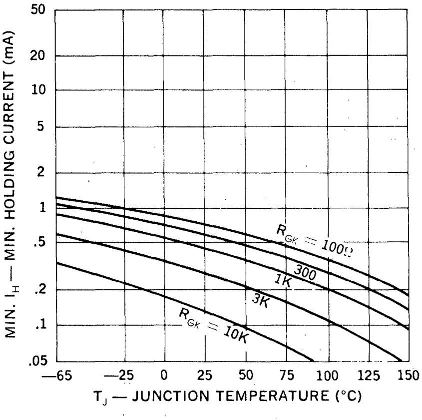
4 **Min. Critical dv/dt (125°C — R Bias)**



5 **Max. Holding Current (Resistor Bias)**

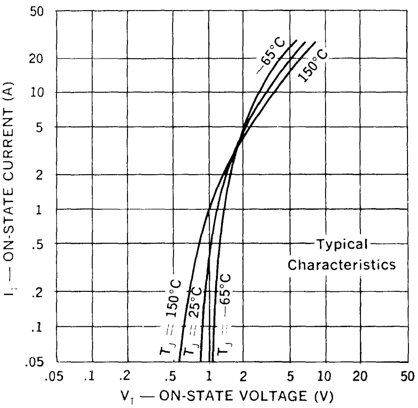


6 **Min. Holding Current (Resistor Bias)**

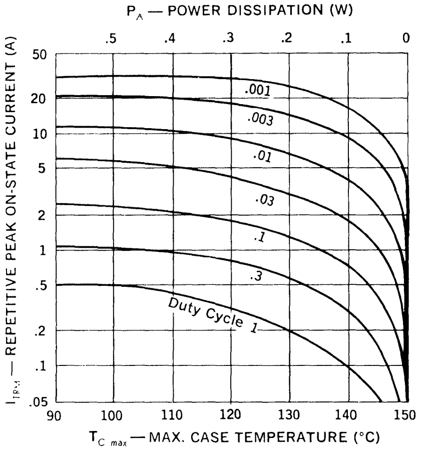


CURRENT RATINGS

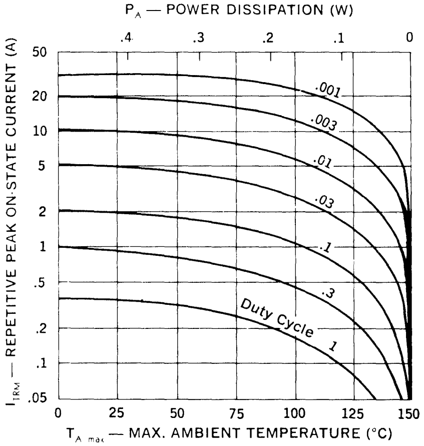
C1 Forward on Current vs. Voltage



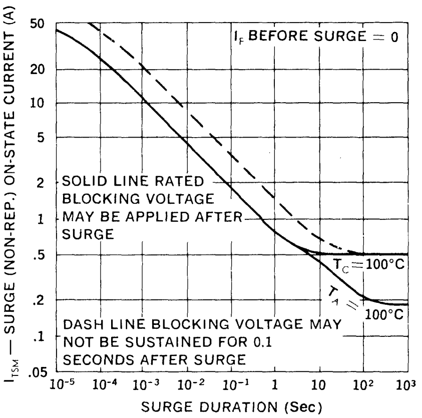
C2 Peak Current vs. Case Temperature



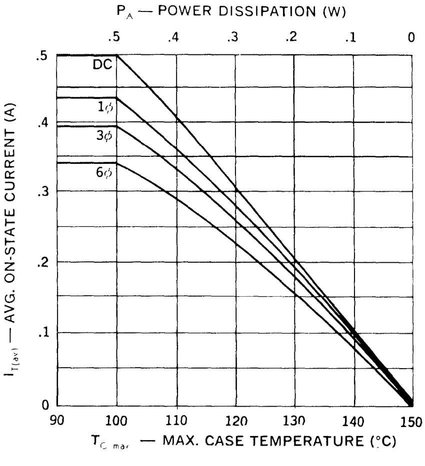
C3 Peak Current vs. Ambient Temperature TO-18 Ratings (see note)



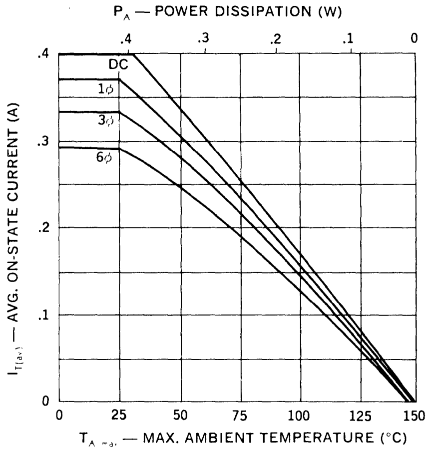
C4 Surge Current vs. Time



C5 Average Current vs. Case Temperature

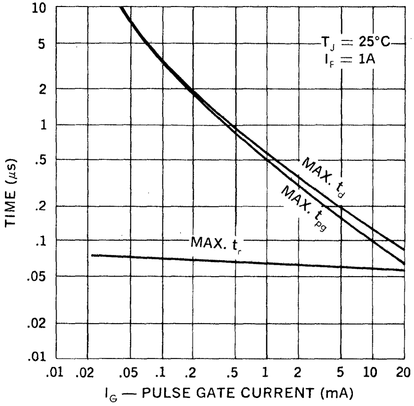


C6 Average Current vs. Ambient Temperature TO-18 Ratings (see note)

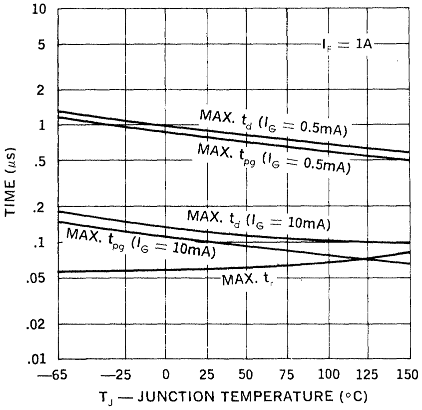


SWITCHING SPEEDS

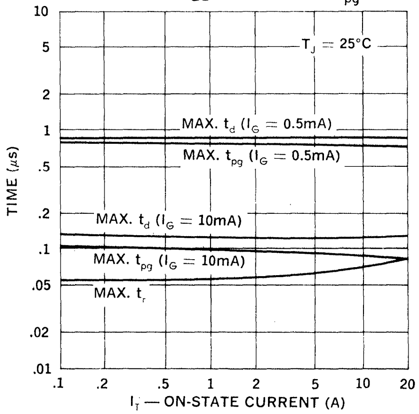
S1 Maximum Delay Time t_d, Rise Time t_r, and Gate Trigger Pulse Width t_{pg} (on)



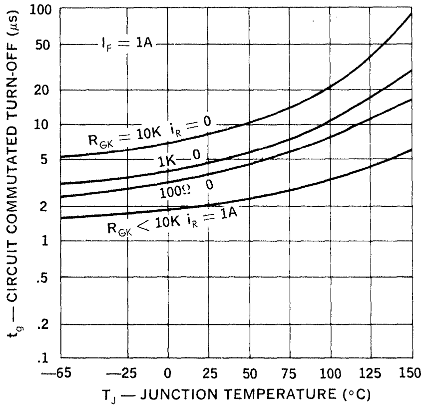
S2 Maximum Delay Time t_d, Rise Time t_r, and Gate Trigger Pulse Width t_{pg} (on)



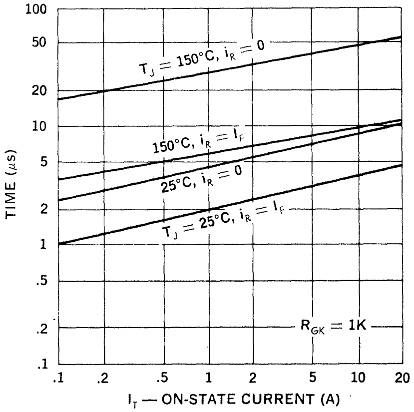
S3 Maximum Delay Time t_d, Rise Time t_r, and Gate Trigger Pulse Width t_{pg} (on)



S4 Maximum Circuit Commutated Turn-off Time t_q



S5 Maximum Circuit Commutated Turn-off Time t_q



SCRs

.8 Amp RMS, Plastic

2N5060-2N5064

FEATURES

- Voltage Ratings: to 200V
- Forward Current: 0.8A RMS
- Surge Current: 6A, 8ms
- Gate Sensitivity: 200μa max.
- Planar Passivated Process
- TO-92 Plastic Package

DESCRIPTION

This plastic series features very fast switching performance, low forward voltage drop and a high degree of reliability and parameter stability. All units are fully planar passivated and are packaged in a rugged TO-92 case, constructed from a special epoxy compound that features excellent moisture resistance providing stable performance under high humidity conditions and good thermal transfer characteristics.

TYPICAL APPLICATIONS

Lamp Driving
Relay Driving
Relay Replacement
Alarm Systems
Counters

Process Controls
Pressure Controls
Display Systems
Touch Switches

Remote Controls
High Current SCR Driving
Timers
Temperature Controls

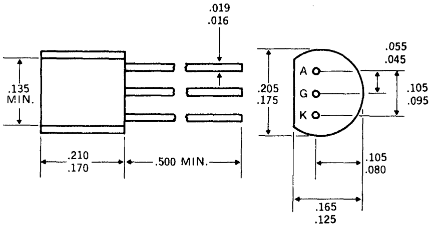
and many other current sensing and control applications.

ABSOLUTE MAXIMUM RATINGS

	2N5060	2N5061	2N5062	2N5063	2N5064
Repetitive Peak Off-State Voltage, V_{DRM}	30V	60V	100V	150V	200V
Repetitive Peak Reverse Voltage, V_{RRM}	30V	60V	100V	150V	200V
On-State Current, $I_{T(RMS)}$	0.8A				
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	6A				
Peak Gate Current, I_{GM}	1.0A				
Peak Gate Power, P_{GM}	1W				
Average Gate Power $P_{G(AV)}$	0.01W				
Reverse Gate Voltage, V_{GR}	6V				
Storage Temperature Range	−65°C to +150°C				
Operating Temperature Range	−65°C to +125°C				

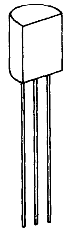
MECHANICAL SPECIFICATIONS

2N5060-2N5064



Dimensions in inches.

TO92



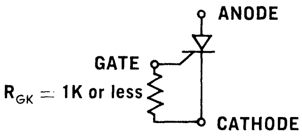
ELECTRICAL SPECIFICATIONS (at 25°C unless noted

Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	0.1	1.0	μA	V_{DRM} = Rating R_{GK} = 1KΩ
		—	—	50	μA	V_{DRM} = Rating, T = 125°C
Reverse Current	I_{RRM}	—	0.1	1.0	μA	V_{RRM} = Rating R_{GK} = 1KΩ
		—	—	50	μA	V_{RRM} = Rating, T = 125°C
Gate Trigger Current	I_{GT}	—	—	200	μA	V_D = 7V, R_L = 100 ohms R_{GS} = 10KΩ
		—	—	350	μA	V_D = 7V, R_L = 100 ohms, T = –65°C
Gate Trigger Voltage	V_{GT}	—	0.6	0.8	V	V_D = 7V, R_L = 100 ohms R_{GS} = 10KΩ
		—	—	1.2	V	V_D = 7V, R_L = 100 ohms, T = –65°C
		0.1	—	—	V	V_D = Rating, R_L = 100 ohms, T = 125°C
Peak On-State Voltage	V_{TM}	—	1.2	1.7	V	I_{TM} = 1 Amp Pulse
Holding Current	I_H	—	0.7	5.0	mA	V_D = 7V, T = 25°C
		—	—	10.0	mA	V_D = 7V, T = –65°C
Critical Rate of Rise — Off-State Voltage	dv/dt	—	75	—	V/μs	V_D = Rated
Turn-on Time	t_{on}	—	0.1	—	μs	I_G = 10mA, I_T = 1A, V_D = 30V
Circuit Commutated Turn-off Time	t_q	—	8	—	μs	I_T = I_R = 1A

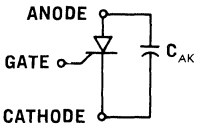
Note: Blocking voltage ratings apply over the full operating temperature range, provided the gate is connected to the cathode through a resistor, 1000 ohms or smaller, or other adequate bias is used.

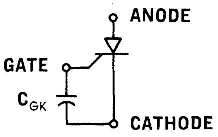
DESIGN CONSIDERATIONS

1. The 2N5060 Series SCRs are guaranteed to block their rated voltage over the rated operating temperature when a resistance of 1000 ohms or less is connected from gate to cathode as shown.

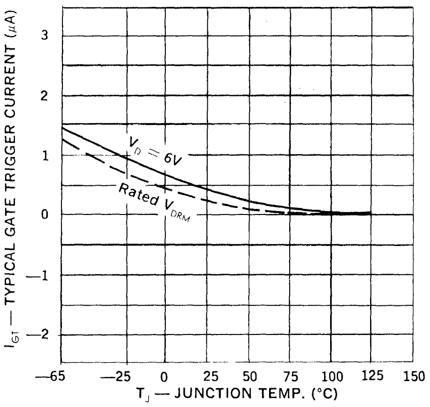


2. In cases where the SCR may be subjected to fast rising anode voltages a capacitor can be connected between anode or gate and cathode as shown, to serve as protection against dv/dt firing.

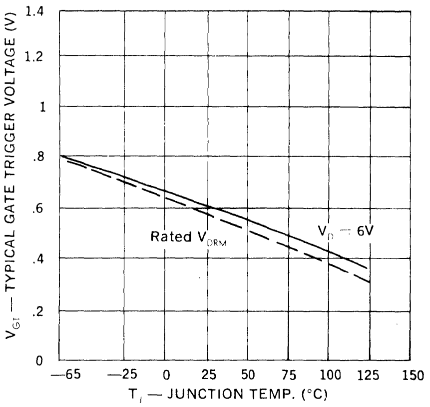




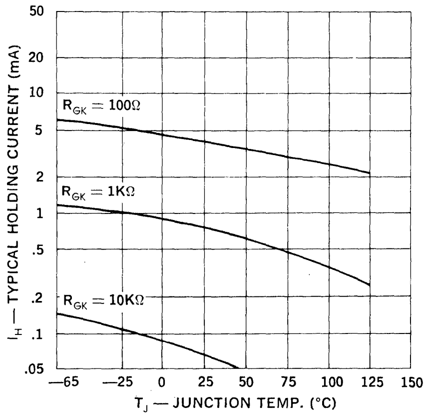
Gate Trigger Current vs. Junction Temp.



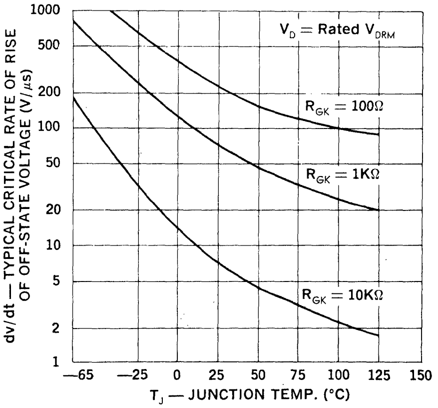
Gate Trigger Voltage vs. Junction Temp.



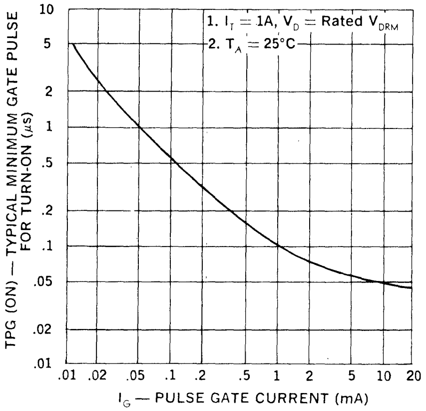
Holding Current vs. Junction Temp.



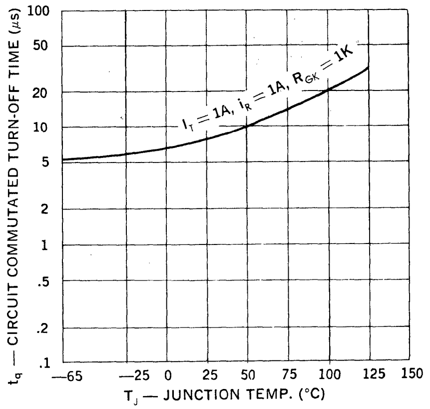
dv/dt vs. Junction Temp.



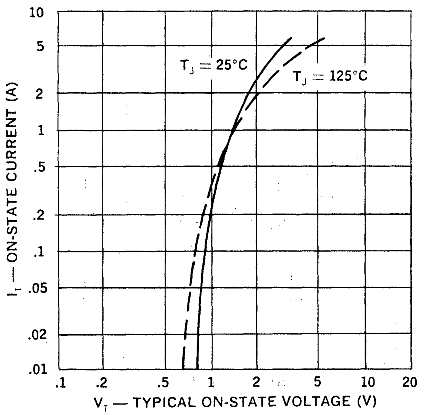
Gate Pulse For Turn-On vs. Pulse Gate Current



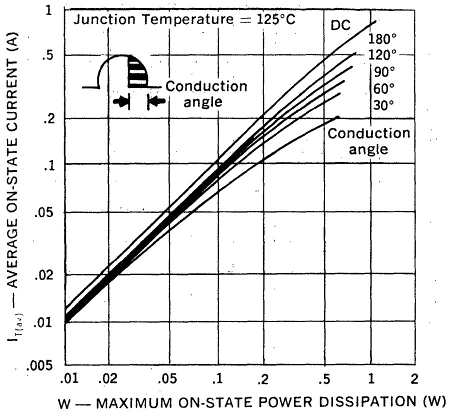
Forward Blocking Recovery Time vs. Junction Temp.



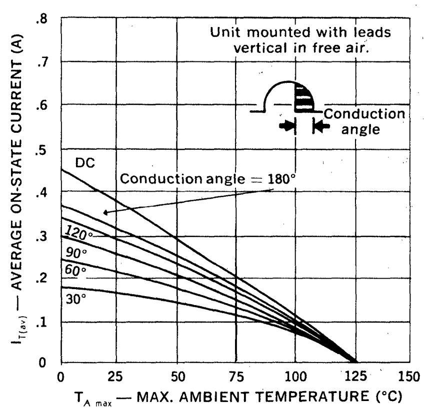
Current vs. On-State Voltage



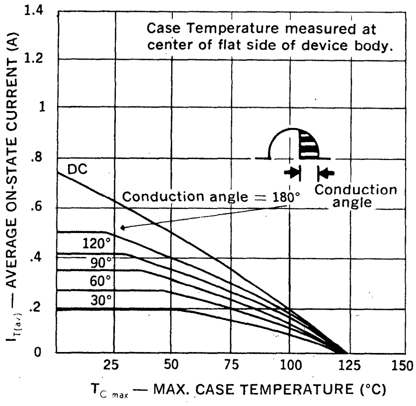
Current vs. Power Dissipation



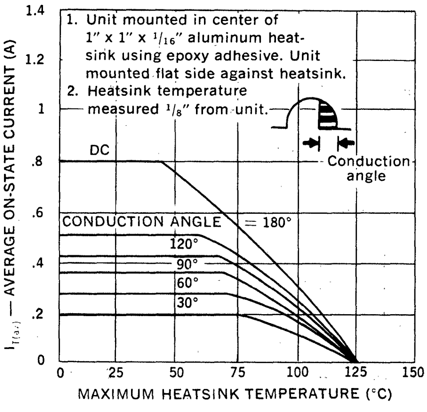
Current vs. Ambient Temp.



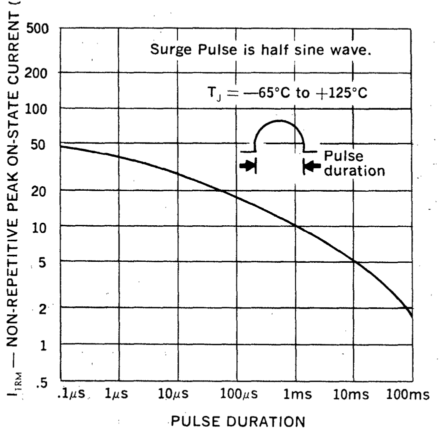
Current vs. Case Temp.



Current vs. Heatsink Temp.



Surge Rating vs. Pulse Duration



SCRs
1.6 Amp, Planar

2N5724-2N5728

FEATURES

- Maximum Gate Trigger Current: 20μA
- Closely Controlled Gate Trigger Voltage: .44 to .6V
- Operating Current Range: 2mA to 1.6A
- Voltage Ratings: to 400V
- Low On-State Voltage
- Specified for dv/dt and Switching Time

DESCRIPTION

These devices are intended for general purpose usage in Military/aerospace or severe industrial environments. Major design parameters are specified at the temperature extremes, thus permitting worst case design on the basis of guaranteed values. These devices undergo 100% preconditioning, which includes high temperature storage and temperature cycling followed by a fine leak test as a regular part of the manufacturing procedure.

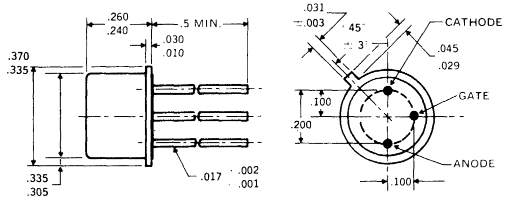
The high voltage types of the 2N5724 series are especially useful as pulse modulator switches in low to medium power pulse modulator applications. Specific parameters such as rise time, delay time, holding current, and recovery time can be selected for optimum performance in a pulse modulator circuit.

ABSOLUTE MAXIMUM RATINGS

	2N5724	2N5725	2N5726	2N5727	2N5728
Repetitive Peak Off-State Voltage, V_{DRM}	60V	100V	200V	300V	400V
Repetitive Peak Reverse Voltage, V_{RRM}	60V	100V	200V	300V	400V
Non-Repetitive Peak Off-State Voltage, V_{DSM}			500V		
D.C. On-State Current, I_T					
75°C Ambient			450mA		
85°C Case			1.6A		
Repetitive Peak On-State Current, I_{TRM}			up to 30A		
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}			15A		
Peak Gate Current, I_{GM}			250mA		
Average Gate Current, $I_{G(AV)}$			25mA		
Reverse Gate Current, I_{GR}			3mA		
Reverse Gate Voltage, V_{GR}			6V		
Operating and Storage Temperature Range			−65°C to +150°C		

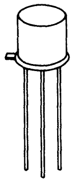
MECHANICAL SPECIFICATIONS

2N5724-2N5728



Dimensions in inches.

TO-39



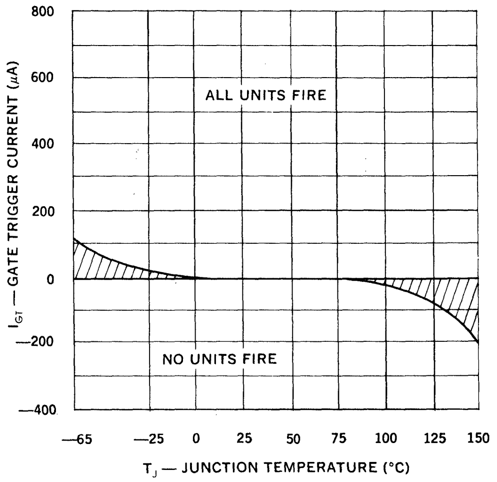
ELECTRICAL SPECIFICATIONS

Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
SUBGROUP 1						
Visual and Mechanical	—	—	—	—	—	
SUBGROUP 2 (25°C TESTS)						
Off-State Current	I_{DRM}	—	.05	0.1	μA	$R_{GK} = 1K$, $V_{DRM} =$ Rating
Reverse Current	I_{RRM}	—	.05	0.1	μA	$R_{GK} = 1K$, $V_{RRM} =$ Rating
Reverse Gate Voltage	V_{GR}	5	8	—	V	$I_{GR} = 0.1mA$
Gate Trigger Current	I_{GT}	—	2	20	μA	$R_{GS} = 10K$, $V_D = 5V$
Gate Trigger Voltage	V_{GT}	0.44	0.5	0.6	V	$R_{GS} = 100\Omega$, $V_D = 5V$
On-State Voltage	V_T	—	2.3	2.5	V	$I_T = 5A$ (pulse test)
Holding Current	I_H	0.3	0.8	2.0	mA	$R_{GK} = 1K$, $V_D = 5V$
SUBGROUP 3 (25°C TESTS)						
Off-State Voltage — Critical Rate of Rise	dv/dt	100	150	—	v/μs	$R_{GK} = 1K$, $V_D = 30V$
Gate Trigger — on Pulse Width	t_{pg} (on)	—	0.1	0.5	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Delay Time	t_d	—	0.1	—	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Rise Time	t_r	—	0.3	—	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Circuit Commutated Turn-off Time						
2N5724, 2N5725, 2N5726,	t_q	—	15	30	μs	$I_T = 1A$, $i_R = 1A$, $R_{GK} = 1K$
2N5727, 2N5728		—	30	50	μs	
SUBGROUP 4 (150°C TESTS)						
High Temp. Off-State Current	I_{DRM}	—	50	200	μA	$R_{GK} = 1K$, $V_{DRM} =$ Rating
High Temp. Reverse Current	I_{RRM}	—	80	200	μA	$R_{GK} = 1K$, $V_{RRM} =$ Rating
High Temp. Gate Trigger Voltage	V_{GT}	0.10	0.15	—	V	$R_{GS} = 100\Omega$, $V_D = 5V$
High Temp. Holding Current	I_H	0.10	0.15	—	mA	$R_{GK} = 1K$, $V_D = 5V$
SUBGROUP 5 (—65°C TESTS)						
Low Temp. Gate Trigger Voltage	V_{GT}	—	0.7	0.9	V	$R_{GS} = 100\Omega$, $V_D = 5V$
Low Temp. Gate Trigger Current	I_{GT}	—	50	125	μA	$R_{GS} = 10K$, $V_D = 5V$
Low Temp. Holding Current	I_H	—	1.2	3.0	mA	$R_{GK} = 1K$, $V_D = 5V$

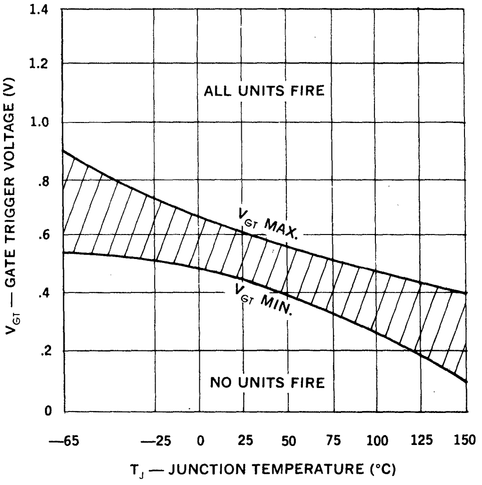
Note 1 See rating curves for full rating information.

Note 2 Blocking voltage ratings apply over the full operating temperature range, provided the gate is connected to the cathode through a resistor, 1K or smaller, or other adequate gate bias is used.

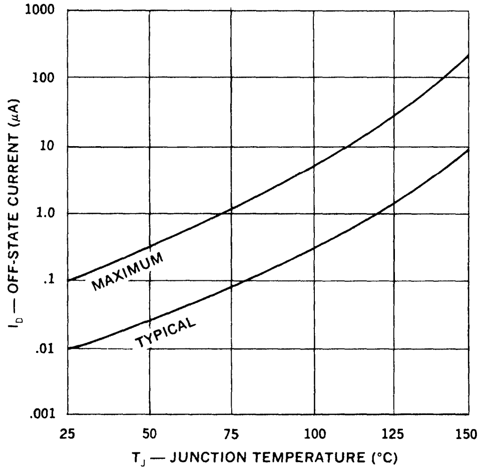
Gate Trigger Current



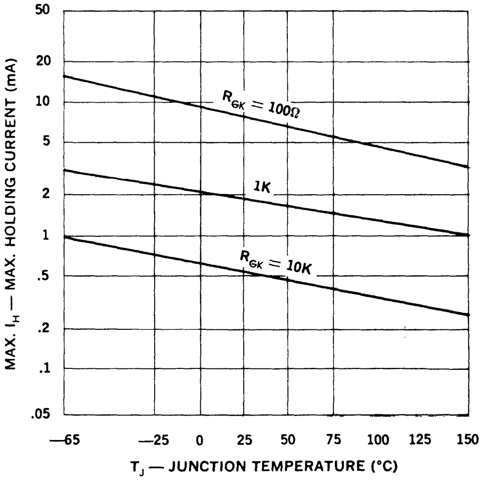
Gate Trigger Voltage



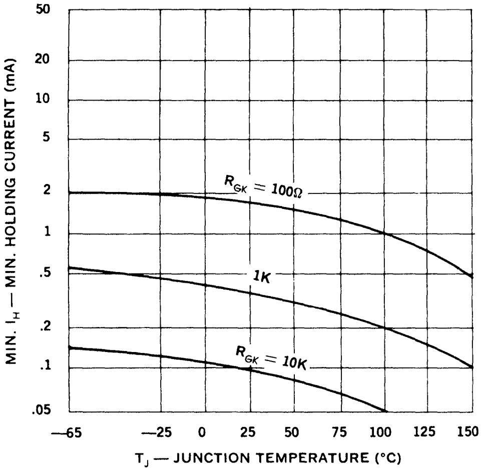
Off-State Current



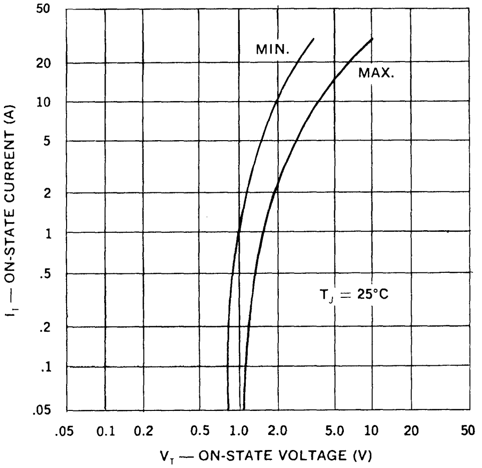
Max. Holding Current



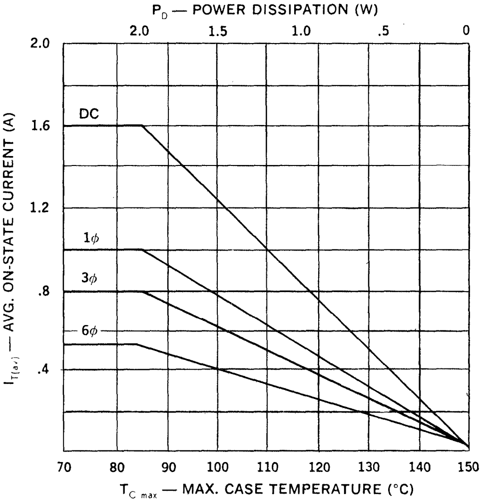
Min. Holding Current



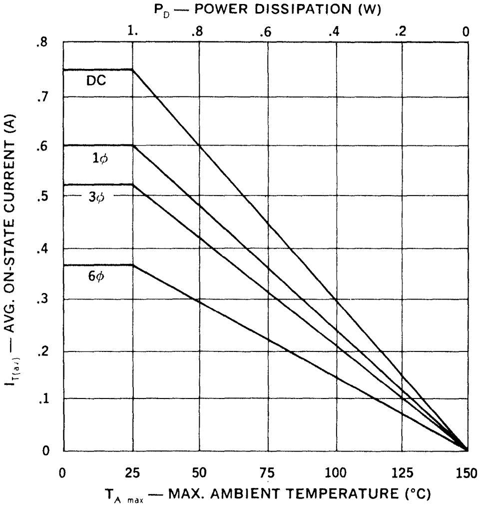
On-State Current vs. Voltage



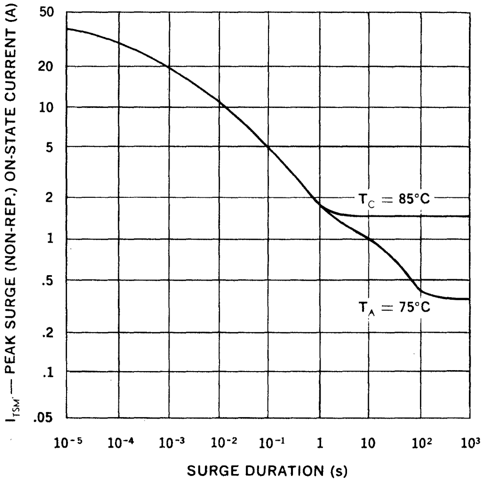
Avg. Current vs. Case Temperature



Avg. Current vs. Ambient Temperature



Surge Current



PUTs

Planar, TO-92, Plastic

2N6027-2N6028

FEATURES

- TO-92 Plastic Package
- Maximum Peak Current: 150nA
- Minimum Valley Current: 1.5mA
- Peak Forward Current: 5A
- Programmable Eta, R_{BB}, I_P and I_V
- Planar Passivated Construction for Maximum Reliability and Parameter Uniformity

DESCRIPTION

The Unitrode Programmable Unijunction Transistor is today's preferred device for low cost timing circuits, oscillators, sensing circuits and a wide range of other applications where a variable voltage level threshold is desired. Functionally equivalent to standard unijunction transistors, the Unitrode PUT offers the distinct advantage of versatile programming. External resistors can be added to meet the designer's needs in programming the Eta, R_{BB}, I_P, and I_V functions. For additional information see Unitrode Application Note U-66.

TYPICAL FEATURES

Programmable Turn-on
Programmable Turn-off
Low Leakage Current
High Output Pulse

TYPICAL APPLICATIONS

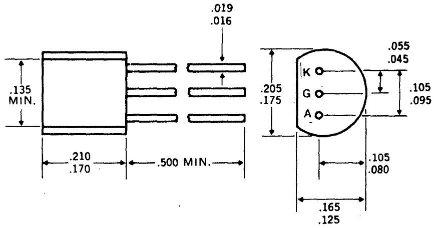
SCR Triggers	Delay Circuits
Timing Circuits	Sampling Circuits
Oscillators	Relay Drivers
Sweep Circuits	Smoke Detectors

ABSOLUTE MAXIMUM RATINGS

Anode-to-Cathode Voltage, V_{AK}	±40V
Gate-to-Cathode Forward Voltage, V_{GK}	40V
Gate-to-Anode Reverse Voltage, V_{GAR}	40V
Gate-to-Cathode Reverse Voltage, V_{GKR}	−5V
Peak Recurrent Forward Current	
20µs, 1% Duty Cycle	2A
100µs, 1% Duty Cycle	1A
Peak Non-recurrent Forward Current, 10µs	5A
Power Dissipation	
25°C Ambient	375mW
Derating Factor	5mW/°C
Storage Temperature	−55°C to +125°C
Operating Temperature Range	−55°C to +100°C

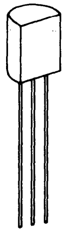
MECHANICAL SPECIFICATIONS

2N6027-2N6028



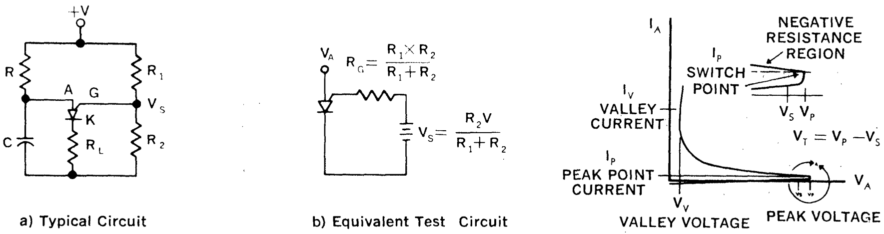
Dimensions in inches.

TO-92



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	Fig.	2N6027		2N6028		Units	Test Conditions
			Min.	Max.	Min.	Max.		
Peak Current	I_P	1	— —	2 5	— —	0.15 1.0	μA μA	$R_G = 1M\Omega$, $V_S = 10V$ $R_G = 10k\Omega$, $V_S = 10V$
Valley Current	I_V	1	— 70 1.5	50 — —	— 25 1.0	25 — —	μA μA mA	$R_G = 1M\Omega$, $V_S = 10V$ $R_G = 10k\Omega$, $V_S = 10V$ $R_G = 200\Omega$, $V_S = 10V$
Offset Voltage	V_T	1	0.2 0.2	0.6 1.6	0.2 0.2	0.6 0.6	V V	$R_G = 10k\Omega$, $V_S = 10V$ $R_G = 1M\Omega$, $V_S = 10V$
Gate-to-Anode Leakage	I_{GAO}	2	— —	10 100	— —	10 100	nA nA	T = 25°C, $V_S = 40V$ T = 75°C, $V_S = 40V$
Gate-to-Cathode Leakage	I_{GKS}	3	—	100	—	100	nA	$V_S = 40V$
Forward Voltage	V_F	4	—	1.5	—	1.5	V	$I_F = 50mA$
Pulse Output Voltage	V_O	5	6	—	6	—	V	
Pulse Output Rise Time	t_r	5	—	80	—	80	ns	



a) Typical Circuit

b) Equivalent Test Circuit

Figure 1

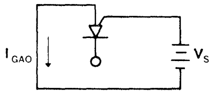


Figure 2

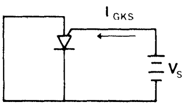


Figure 3

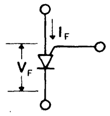


Figure 4

Note: Conditions for oscillation

$$\frac{V_{BB} - V_P}{R} > I_P$$

$$\frac{V_{BB} - V_V}{R} < I_V$$

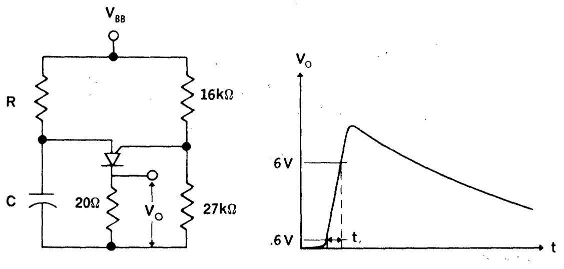
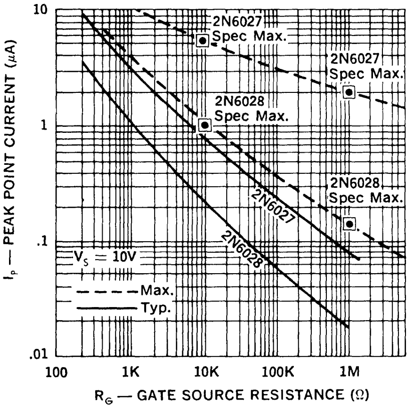
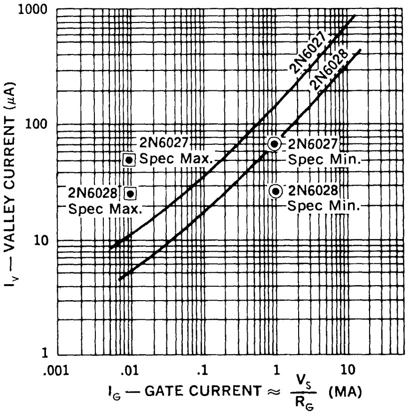


Figure 5

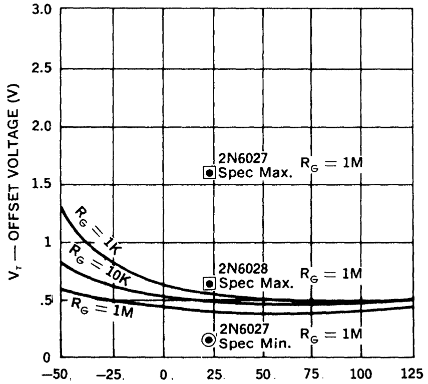
Peak Point Current vs. Gate Source Resistance



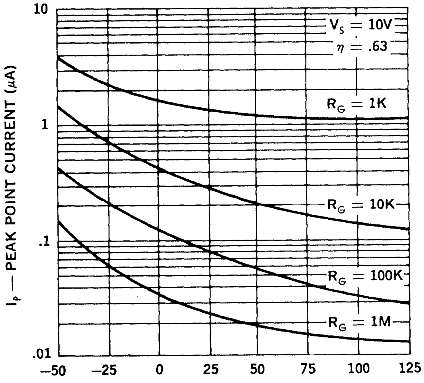
Valley Current vs. Gate Current



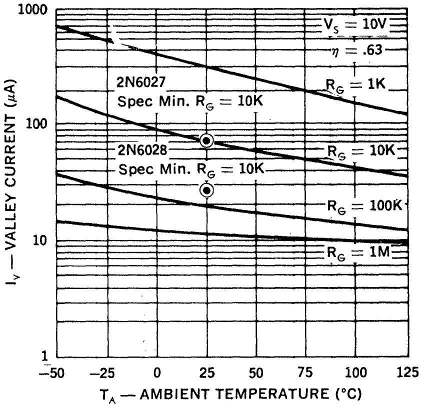
Offset Voltage vs. Ambient Temperature



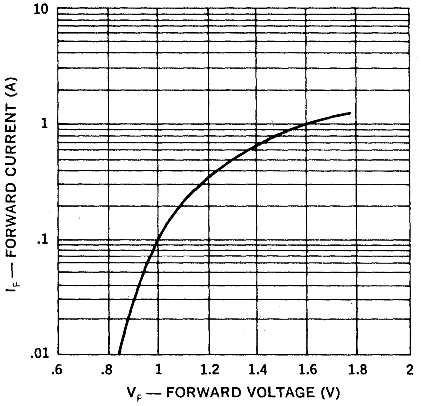
Peak Point Current vs. Ambient Temperature



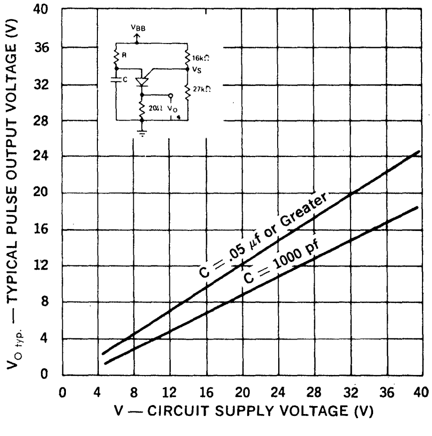
Valley Current vs. Ambient Temperature



Forward Current vs. Forward Voltage



Typical Pulse Output vs. Circuit Supply Voltage



PUTs

Planar, TO-18, Hermetic

2N6119-2N6120

FEATURES

- Hermetically Sealed TO-18 Metal Can
- Programmable Eta, R_{BB}, I_P and I_V
- Maximum Peak Point Current: 150nA
- Minimum Valley Current to 1.5mA
- Nano-Amp Leakage
- Passivated Planar Construction for Maximum Reliability and Parameter Uniformity

DESCRIPTION

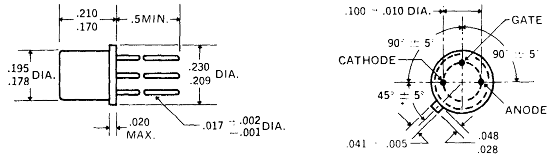
Functionally equivalent to standard unijunction transistors, Unitrode's Programmable Unijunction Transistors offer the distinct advantage of versatile programming. External resistors can be added to meet the designer's needs in programming Eta, R_{BB}, I_P and I_V functions. This series also features a hermetically sealed TO-18 package for optimum reliability in all environmental conditions. Applications include pulse and timing circuits, SCR trigger circuits, relaxation oscillators and sensing circuits. For additional information see Unitrode Application Note U-66.

ABSOLUTE MAXIMUM RATINGS

Anode-to-Cathode Voltage, V_{AK}	±40V
Gate-to-Cathode Forward Voltage, V_{GK}	40V
Gate-to-Anode Reverse Voltage, V_{GAR}	40V
Gate-to-Cathode Reverse Voltage, V_{GKR}	−5V
Peak Recurrent Forward Current	
10μs, 1% Duty Cycle	8A
100μs, 1% Duty Cycle	5A
Power Dissipation	
25°C Ambient	400mW
Derating Factor	3.2mW/°C
Storage Temperature	−55°C to +125°C
Operating Temperature Range	−55°C to +125°C

MECHANICAL SPECIFICATIONS

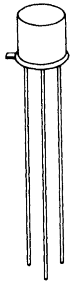
2N6119-2N6120



GATE CONNECTED TO CASE

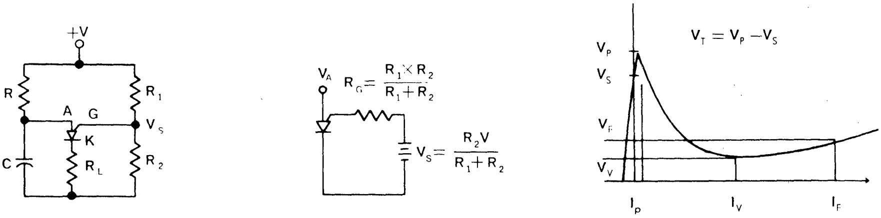
Dimensions in inches.

TO-18



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	Fig.	2N6119		2N6120		Units	Test Conditions
			Min.	Max.	Min.	Max.		
Peak Current	I_P	1	— —	5 2	— —	1.0 0.15	μA μA	$R_G = 10k, V_S = 10V$ $R_G = 1$ Meg.
Valley Current	I_V	1	70 — 1.5	— 50 —	25 — 1.0	— 25 —	μA μA mA	$R_G = 10k, V_S = 10V$ $R_G = 1$ Meg. $R_G = 200\Omega$
Offset Voltage	V_T	1	0.2 0.2	0.6 1.6	0.2 0.2	0.6 0.6	V V	$R_G = 10k, V_S = 10V$ $R_G = 1$ Meg.
Gate-to-Anode Leakage	I_{GAO}	2	— —	10 100	— —	10 100	nA nA	$T = 25°C, V_S = 40V$ $T = 75°C$
Gate-to-Cathode Leakage	I_{GKS}	3	—	100	—	100	nA	$V_S = 40V$
Forward Voltage	V_F	4	—	1.0	—	1.0	V	$I_F = 50mA$
Pulse Output Voltage	V_o	5	9	—	9	—	V	
Pulse Output Rate of Rise	t_r	5	—	80	—	80	ns	



a) Typical Circuit

b) Equivalent Test Circuit

c) Characteristic Curve

Figure 1

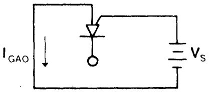


Figure 2

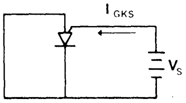


Figure 3

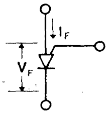


Figure 4

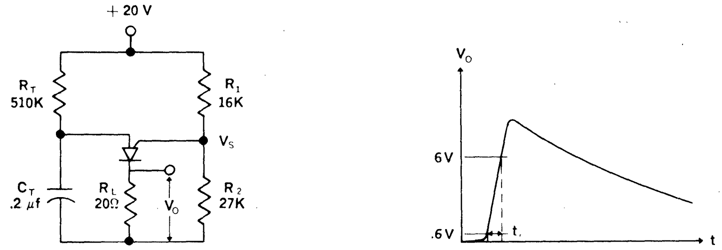
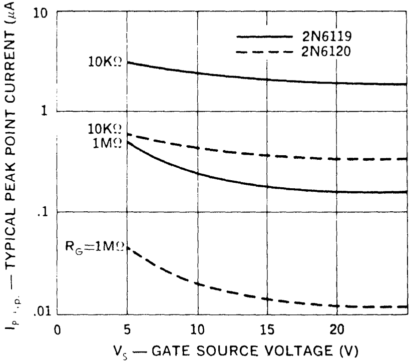
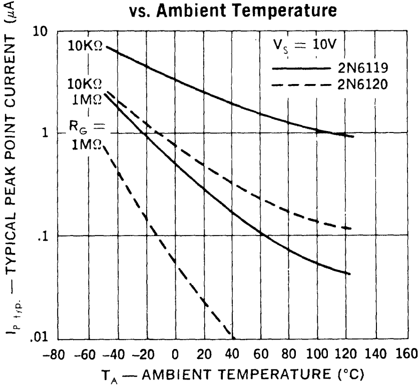


Figure 5

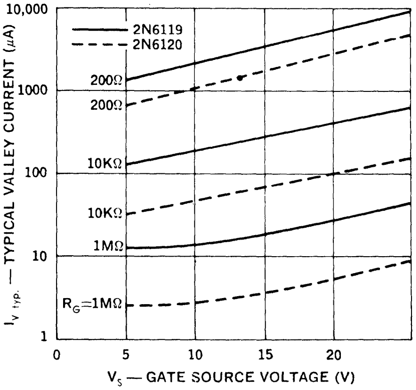
Typical Peak Point Current vs. Gate Source Voltage



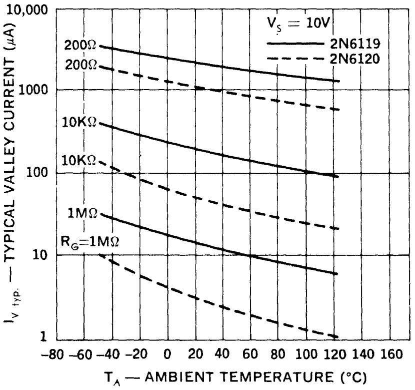
Typical Peak Point Current vs. Ambient Temperature



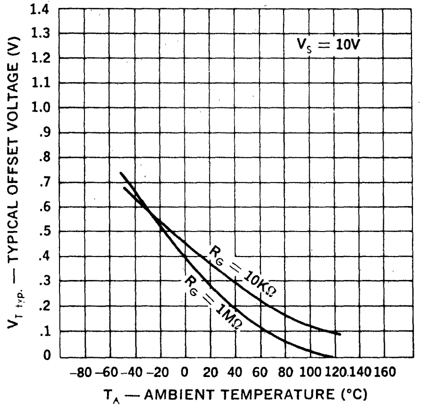
Typical Valley Current vs. Gate Source Voltage



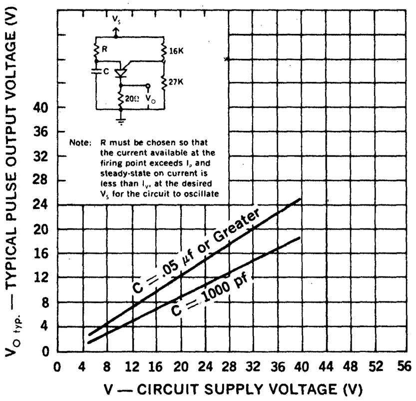
Typical Valley Current vs. Ambient Temperature



Typical Offset Voltage vs. Ambient Temperature

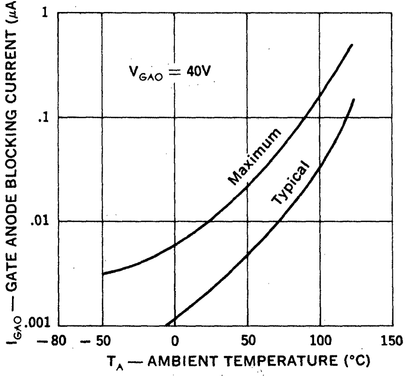


Typical Pulse Output vs. Circuit Supply Voltage

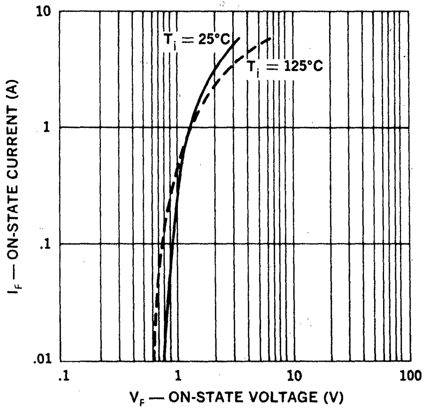


Note: R must be chosen so that the current available at the firing point exceeds I_P and steady-state on current is less than I_V, at the desired V_S for the circuit to oscillate

Gate-Anode Blocking Current vs. Ambient Temperature



Typical On-State Current vs. Voltage



PUTs

2N6137-2N6138

Military, Planar, TO-18, Hermetic

FEATURES

- Available as JAN and JAN TX types
- −55°C to +125°C Temperature Range for Timing and Oscillator Circuits
- $I_P \leqslant 10\mu A$ at $T = -55°C$
  $I_V \geqslant 40\mu A$ at $T = +125°C$
- Programmable η, R_{BB}, I_P and I_V
- Peak Recurrent Current: of 5A
- Low On-State Voltage Drop
- Hermetically Sealed Metal Case and Planar Passivated Construction for Maximum Reliability and Parameter Stability.

DESCRIPTION

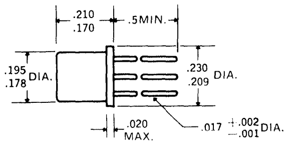
The Programmable Unijunction Transistor is functionally equivalent to a standard unijunction transistor with the advantage that external resistors can be used to program η, R_{BB}, I_P, and I_V, depending upon the designer's needs. The Unitrode device, in addition to allowing programmable versatility, is completely planar passivated and packaged in a TO-18 hermetically sealed package, which offers an order of magnitude improvement in inherent reliability over many similar devices. Applications include pulse and timing circuits, SCR trigger circuits, relaxation oscillators, and sensing circuits. For further application information see Unitrode Application Note U-66.

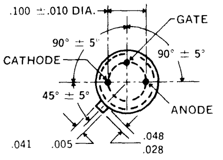
ABSOLUTE MAXIMUM RATINGS

	2N6137	2N6138
Anode-to-Cathode Forward Voltage, V_{AK}	40V	100V
Anode-to-Cathode Reverse Voltage, V_{AKR}	40V	100V
Gate-to-Cathode Forward Voltage, V_{GK}	40V	100V
Gate-to-Anode Reverse Voltage, V_{GAR}	40V	100V
Gate-to-Cathode Reverse Voltage, V_{GKR}	5V	5V
Peak Recurrent Forward Current, 10μs 1% Duty Cycle	5A	5A
Peak Gate Current, I_{GM}	250mA	250mA
Average Gate Current, $I_{G(AV)}$	50mA	50mA
Power Dissipation		
25°C Ambient	300mW	300mW
Derating Factor	2.4mW/°C	2.4mW/°C
Storage Temperature Range	−55°C to +125°C	
Operating Temperature Range	−55°C to +125°C	

MECHANICAL SPECIFICATIONS

2N6137-2N6138

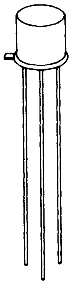




GATE CONNECTED TO CASE

Dimensions in inches.

TO-18

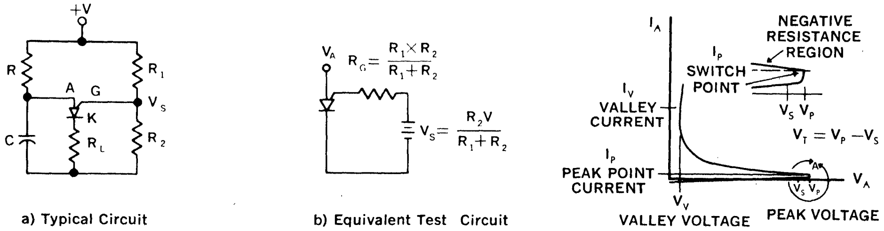


UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)†

Test	Symbol	Figure	Minimum	Typical	Maximum	Units	Test Conditions
SUBGROUP 1 Visual and Mechanical	—	—	—	—	—	—	—
SUBGROUP 2							
Gate-anode blocking current	I_{GAO}	2	—	2	10	nA	V_{GA} = Rating
Gate-cathode blocking current	I_{GKS}	3	—	5	100	nA	V_{GK} = Rating
SUBGROUP 3							
Peak-point anode current	I_P	1	— —	1 2.5	2 5	μA μA	R_G = 1 Meg R_G = 10K } V_S = 10V
Peak-point offset voltage	V_T	1	0.2 0.2	0.26 0.35	1.6 0.6	V V	R_G = 1 Meg R_G = 10K } V_S = 10V
Valley-point anode current	I_V	1	— 70 1.5	15 200 2	50 — —	μA μA mA	R_G = 1 Meg R_G = 10K } V_S = 10V R_G = 200Ω
SUBGROUP 4							
Forward on-state voltage	V_F	4	—	0.85	1.0	V	I_F = 50mA
Peak pulse voltage	V_o	5	9	12	—	V	
Peak pulse voltage rise time	t_r	5	—	50	80	ns	
SUBGROUP 5							
Gate-anode blocking current (125°C Test)	I_{GAO}	2	—	150	500	nA	V_{GA} = Rating
Valley-point anode current (125°C Test)	I_V	1	40	100	—	μA	R_G = 10K, V_S = 10V
Peak-point anode current (—55°C Test)	I_P	1	—	7.5	10	μA	R_G = 10K, V_S = 10V

† All values in table are JEDEC registered



a) Typical Circuit

b) Equivalent Test Circuit

Figure 1

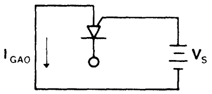


Figure 2

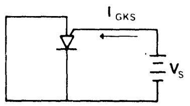


Figure 3

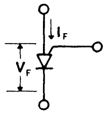


Figure 4

Note: Conditions for oscillation

$$\frac{V_{BB} - V_P}{R} > I_P$$

$$\frac{V_{BB} - V_V}{R} < I_V$$

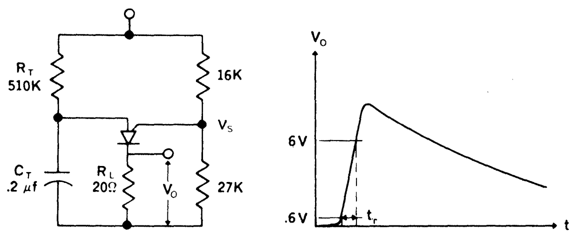
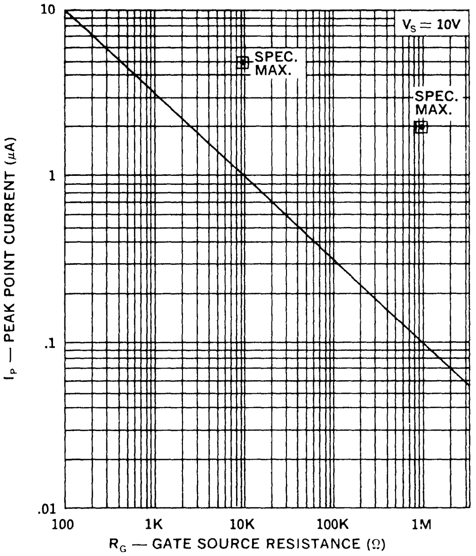
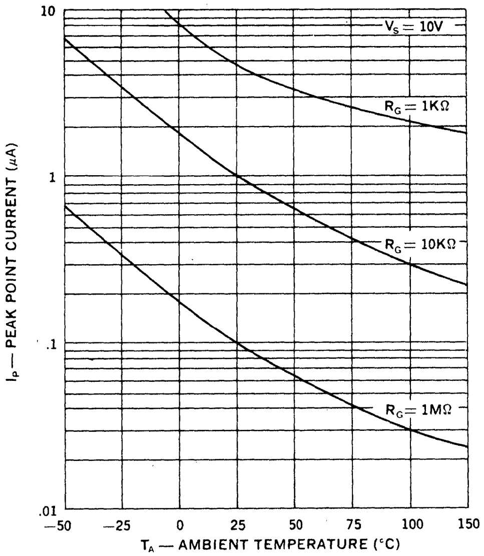


Figure 5

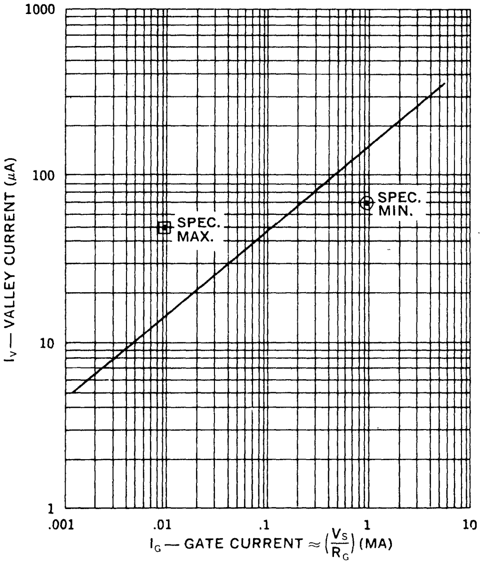
Peak Point Current vs. Gate Source Resistance



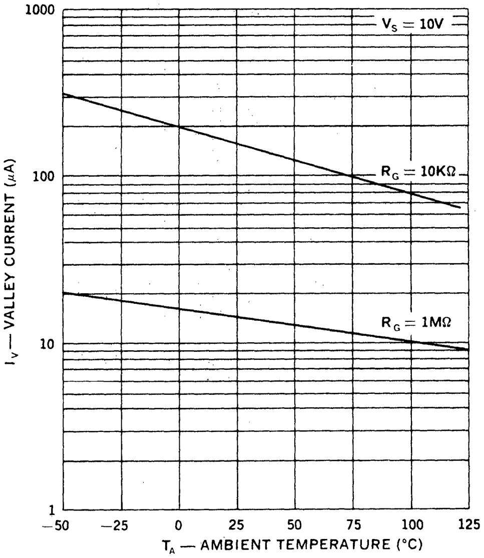
Peak Point Current vs. Ambient Temperature



Valley Current vs. Gate Current

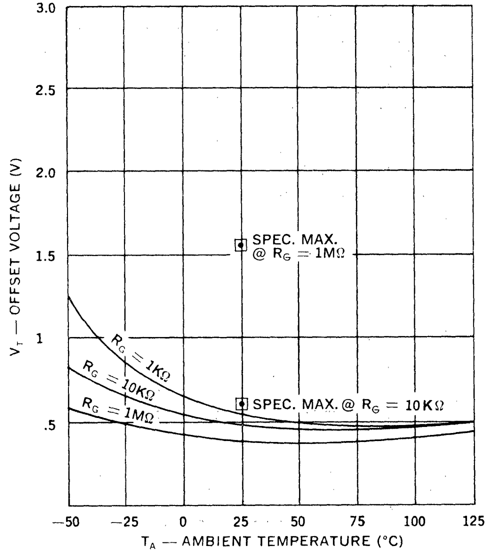


Valley Current vs. Ambient Temperature

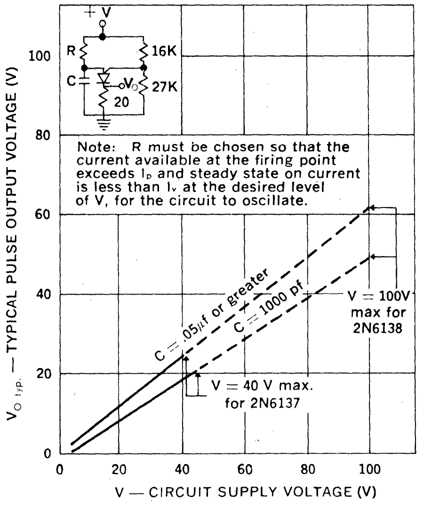


X

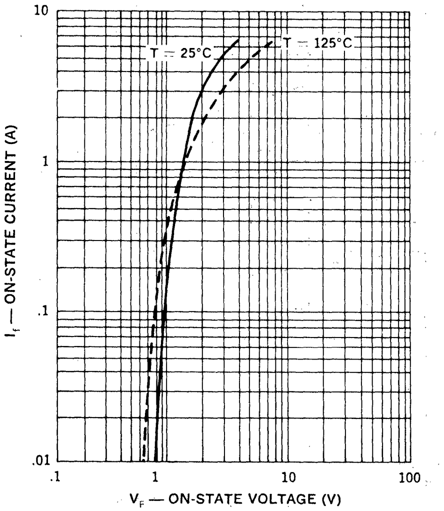
Offset Voltage vs. Ambient Temperature



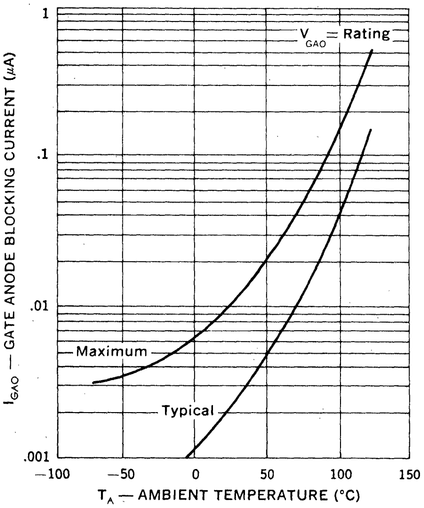
Typical Pulse Output Voltage vs. Circuit Supply Voltage



Typical Current vs. On-State Voltage



Gate-Anode Blocking Current vs. Ambient Temperature



SCRs

.8 Amp RMS, Plastic

2N6564-2N6565

FEATURES

- Voltage Ratings: to 400V
- Forward Current: 0.8A RMS
- Surge Current: 6A, 8ms
- Gate Sensitivity: 200μa max.
- Planar Passivated Process
- TO-92 Plastic Package

DESCRIPTION

This plastic series features very fast switching performance, low forward voltage drop and a high degree of reliability and parameter stability. All units are fully planar passivated and are packaged in a rugged TO-92 case, constructed from a special epoxy compound that features excellent moisture resistance providing stable performance under high humidity conditions and good thermal transfer characteristics.

TYPICAL APPLICATIONS

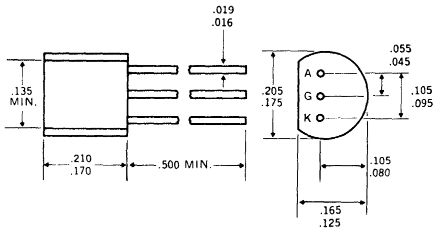
Lamp Driving
Relay Driving
Relay Replacement
Alarm Systems
Counters
Process Controls
Pressure Controls
Display Systems
Touch Switches
Remote Controls
High Current SCR Driving
Timers
Temperature Controls
and many other current sensing and control applications.

ABSOLUTE MAXIMUM RATINGS

	2N6564	2N6565
Repetitive Peak Off-State Voltage, V_{DRM}	300V	400V
Repetitive Peak Reverse Voltage, V_{RRM}	300V	400V
On-State Current, $I_{T(RMS)}$, @ $T_C = 70°C$	0.8A	
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	6A	
Peak Gate Current, I_{GM}	1.0A	
Peak Gate Power, P_{GM}	1W	
Average Gate Power $P_{G(AV)}$	0.01W	
Reverse Gate Voltage, V_{GR}	6V	
Storage Temperature Range	−65°C to +150°C	
Operating Temperature Range	−65°C to +125°C	

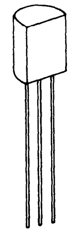
MECHANICAL SPECIFICATIONS

2N6564-2N6565



Dimensions in inches.

TO92



UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted, $R_{GK} = 1000$ ohms)

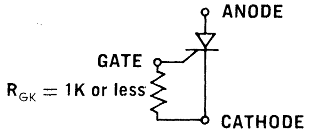
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	— —	0.1 —	1.0 100	μA μA	V_{DRM} = Rating V_{DRM} = Rating, T = 125°C*
Reverse Current	I_{RRM}	— —	0.1 —	1.0 100	μA μA	V_{RRM} = Rating V_{RRM} = Rating, T = 125°C*
Gate Trigger Current	I_{GT}	— —	— —	200 350	μA μA	V_D = 6V, R_L = 100 ohms V_D = 6V, R_L = 100 ohms, T = −65°C*
Gate Trigger Voltage	V_{GT}	— — 0.1	0.6 — —	0.8 1.2 —	V V V	V_D = 6V, R_L = 100 ohms V_D = 6V, R_L = 100 ohms, T = −65°C* V_D = Rating, R_L = 100 ohms, T = 125°C*
Peak On-State Voltage	V_{TM}	—	1.0	1.7	V	I_{TM} = 1.2 Amp Pulse*
Holding Current	I_H	— —	0.7 —	5.0 10.0	mA mA	V_D = 6V, T = 25°C V_D = 6V, T = −65°C*
Critical Rate of Rise — Off-State Voltage	dv/dt	—	75	—	V/μs	V_D = Rating
Turn-on Time	t_{on}	—	0.5	1.5	μs	I_G = 10mA, I_T = 1A, V_D = Rating*
Circuit Commutated Turn-off Time	t_q	—	15	—	μs	$I_T = I_R$ = 1A

Note: Blocking voltage ratings apply over the full operating temperature range, provided the gate is connected to the cathode through a resistor, 1000 ohms or smaller, or other adequate bias is used.

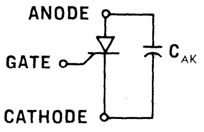
*Indicates JEDEC Registered data.

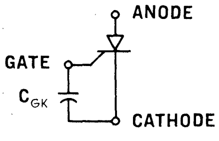
DESIGN CONSIDERATIONS

1. The 2N6564 Series SCRs are guaranteed to block their rated voltage over the rated operating temperature when a resistance of 1000 ohms or less is connected from gate to cathode as shown.



2. In cases where the SCR may be subjected to fast rising anode voltages a capacitor can be connected between anode or gate and cathode as shown, to serve as protection against dv/dt firing.





SCRs
1.0 Amp RMS, Plastic
800V

2N6681
2N6682
2N6683
2N6684
2N6685

FEATURES:
- Forward Current: 1.0A RMS
- Voltage Ratings: to 800V
- High Surge Current: 15A, 8mS
- Gate Sensitivity: 30μA Typical
- Hard Glass Passivated Junction
- Economical TO-92 Package

TYPICAL APPLICATIONS:
Ground fault interrupters
Photo flash circuits
Ignition/Ignitor circuits
Relay drivers
Relay replacement
Gate drivers for high current SCRs
Lamp driving
Off-line appliance controls

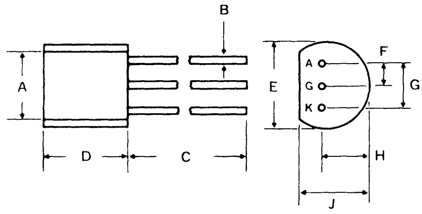
DESCRIPTION:
This plastic PNPN device is rated at 1.0 Amp RMS maximum on-state current, with rated voltages up to 800 volts. All units in this series offer full hard glass passivation with sensitivity especially targeted for good transient immunity. Supplied in an economical TO-92 package, this device is well suited for many high volume applications.

MAXIMUM RATINGS

	2N6681	2N6682	2N6683	2N6684	2N6685
Repetitive Peak Off-State Voltage, V_{DRM}	100V	200V	400V	600V	800V
Repetitive Peak Reverse Voltage, V_{RRM}	100V	200V	400V	600V	800V
On-State Current, I_T RMS At 60°C Case, 180° Conduction Sinewave			1.0A		
Surge (Non-Rep.) On-State Current, I_{TSM}			15A		
Peak Gate Current, I_{GM}			1.0A		
Peak Gate Power, P_{GM}			1W		
Average Gate Power P_G (AV.)			0.01W		
Reverse Gate Voltage, V_{GR}			6V		
Storage Temperature Range			−55°C to +150°C		
Operating Temperature Range (2N6681-2N6683)			−55°C to +110°C		
Operating Temperature Range (2N6684-2N6685)			−55°C to + 85°C		

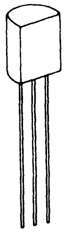
MECHANICAL SPECIFICATIONS

2N6681-5 SERIES



	inches	millimeters
A	.135 MIN.	3.43 MIN.
B	.019 - .016	.48 - .41
D	.210 - .170	5.33 - 4.32
C	.500 MIN.	12.7 MIN.
E	.205 - .175	5.21 - 4.45
J	.165 - .125	4.19 - 3.18
F	.055 - .045	1.40 - 1.14
G	.105 - .095	2.67 - 2.41
H	.105 - .080	2.67 - 2.03

TO-92



12/79 (Formerly IP200 Series)

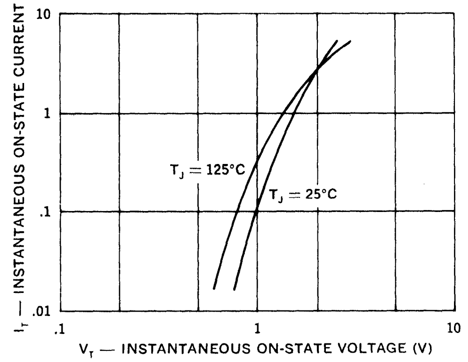
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

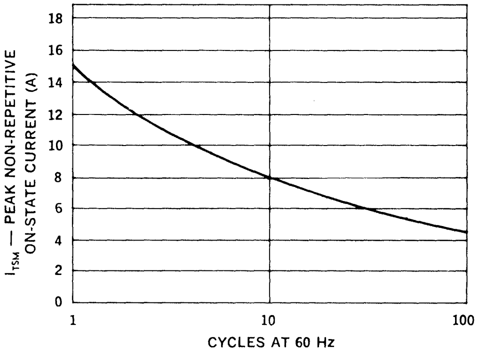
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	100	μA	V_{DRM} = Rating, R_{GK}= 1K, T*= 110°C
Reverse Current	I_{RRM}	—	—	100	μA	V_{RRM} = Rating, R_{GK}= 1K, T* = 110°C
Gate Trigger Current	I_{GT}	—	30	200	μA	$V_D = 6V$, $R_{GS} = 10K$
Gate Trigger Voltage	V_{GT}	— — 0.1	0.6 — —	0.8 1.2 —	V V V	$V_D = 6V$, $R_{GS} = 100\Omega$ $V_D = 6V$, $R_{GS} = 100\Omega$, T = – 55°C $V_D = 6V$, $R_{GS} = 100\Omega$, T = 125°C
Peak On-State Voltage	V_{TM}	—	—	1.5	V	I_{TM} = 1 Amp Pulse
Holding Current	I_{HX}	— —	0.7 —	5.0 10.0	mA mA	R_{GK} = 1K, T = 25°C R_{GK} = 1K, T = –55°C
Critical Rate of Rise — Off-State Voltage	dv/dt	—	20	—	V/μs	V_D = Rating, R_{GK} = 1K, T = 100°C

*For 2N6684, 2N6685 T = 90°C

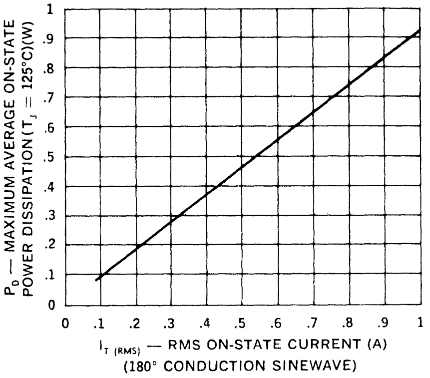
Maximum On-State Characteristics



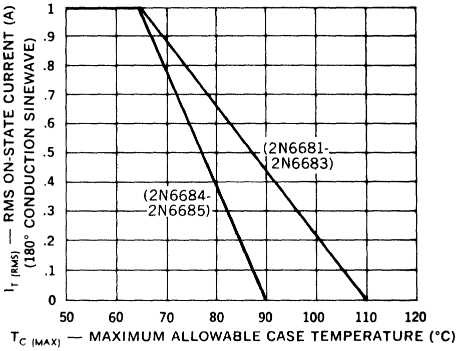
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



Maximum On-State Power Dissipation (60Hz)



Maximum Allowable Case Temperature vs. On-State Current (60Hz)



SCRs
.5A, Planar

AA100-AA104
AA107-AA111
AA114-AA118

FEATURES
- Maximum Gate Trigger Current: 2, 20 or 200μA
- Tight Gate Trigger Voltage Range: .44 to .6V
- Voltage Ratings: to 400V
- Specified for dv/dt and Switching Time

DESCRIPTION
This data sheet describes Unitrode's AA Series 0.5A SCRs designed for low-current sensing applications. Units are available in a complete range of blocking voltages from 60 to 400 volts.

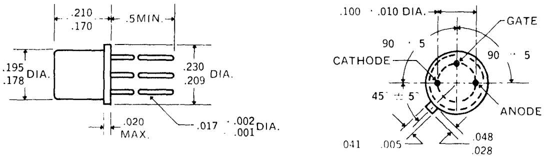
The AA100 series offers a maximum gate trigger current of 2.0 microamps making it the most sensitive device of its type. The AA107 series has a maximum I_{GT} of 20μA while this parameter is specified at 200μA for the AA114 series.

ABSOLUTE MAXIMUM RATINGS

	AA100 **AA107** **AA114**	**AA101** **AA108** **AA115**	**AA102** **AA109** **AA116**	**AA103** **AA110** **AA117**	**AA104** **AA111** **AA118**
Repetitive Peak Off-State Voltage, V_{DRM}	60V	100V	200V	300V	400V
Repetitive Peak Reverse Voltage, V_{RRM}	60V	100V	200V	300V	400V
Non-Repetitive Peak Reverse Voltage, V_{RSM}	80V	150V	300V	400V	500V
Non-Repetitive Peak Off-State Voltage, V_{DSM}	500V				
D.C. On-State Current, I_T					
75°C Ambient	250mA				
100°C Case	500mA				
Repetitive Peak On-State Current, I_{TRM}	up to 30A				
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	5A				
Peak Gate Current, I_{GM}	250mA				
Average Gate Current, $I_{G(AV)}$	25mA				
Reverse Gate Voltage V_{GR}	6V				
Operating and Storage Temperature Range	−65°C to +150°C				

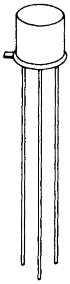
MECHANICAL SPECIFICATIONS

AA100-AA104 AA107-AA111 AA114-AA118



Dimensions in inches.

TO-18

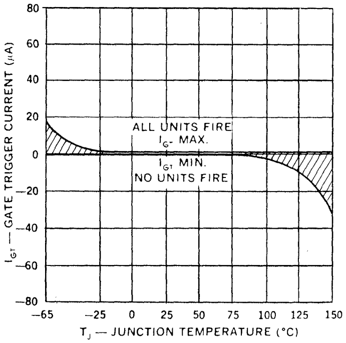


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

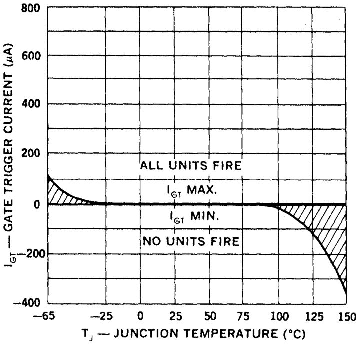
Parameter	Symbol	Min.	Typical	Max.	Units	Test Conditions
SUBGROUP 1 Visual & Mechanical	—	—	—	—	—	—
SUBGROUP 2 (25°C TESTS)						
Off-State Current	I_{DRM}	—	.01	0.1	μA	$R_{GK} = 1K, V_{DRM} =$ Rating
Reverse Current	I_{RRM}	—	.01	0.1	μA	$R_{GK} = 1K, V_{RRM} =$ Rating
Reverse Gate Current	I_{GR}	—	0.1	0.2	μA	$V_{GR} = 2V$
Gate Trigger Current	I_{GT}					$R_{GS} = 10K, V_D = 5V$
AA100-104		—	0.2	2.0	μA	
AA107-111		—	2.0	20	μA	
AA114-118		—	20	200	μA	
Gate Trigger Voltage	V_{GT}	0.44	0.52	0.60	V	$R_{GS} = 100\Omega, V_D = 5V$
On-State Voltage	V_T	—	1.1	1.5	V	$I_T = 1.0$ A (pulse)
Holding Current	I_H	0.3	0.5	2.0	mA	$R_{GK} = 1K$
SUBGROUP 3 (25°C TESTS)						
Off-State Voltage — Critical Rate of Rise	dv/dt	50	100	—	V/μs	$R_{GK} = 1K, V_D = 30V$
Gate Trigger — on Pulse Width	t_{pg} (on)	—	0.5	2.0	μs	$I_G = 10mA, I_T = 1A, V_D = 30V$
Delay Time	t_d	—	0.6	—	μs	$I_G = 10mA, I_T = 1A, V_D = 30V$
Rise Time	t_r	—	0.4	—	μs	$I_G = 10mA, I_T = 1A, V_D = 30V$
Circuit Commutated Turn-off Time	t_q	—	20	50	μs	$I_T = 1A, I_R = 1A, R_{GK} = 1K$
SUBGROUP 4 (125°C TESTS)						
Off-State Current	I_{DRM}	—	10	20	μA	$R_{GK} = 1K, V_{DRM} =$ Rating
Reverse Current	I_{RRM}	—	30	100	μA	$R_{GK} = 1K, V_{RRM} =$ Rating
Gate Trigger Voltage	V_{GT}	0.15	0.2	—	V	$R_{GS} = 100\Omega, V_D = 5V$
Holding Current	I_H	0.2	0.4	1.5	mA	$R_{GK} = 1K$

Note: Blocking voltage ratings apply over the full operating temperature range, provided the gate is connected to the cathode through a resistor, 1000 ohms or smaller, or other adequate bias is used.

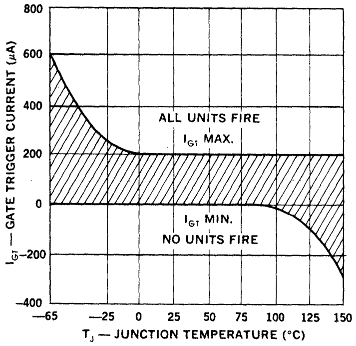
Gate Trigger Current
AA100 Series



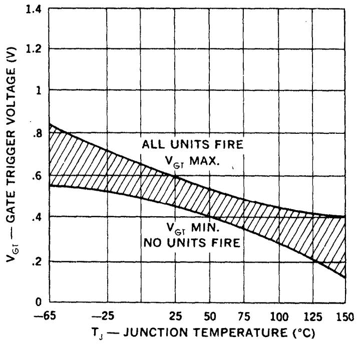
Gate Trigger Current
AA107 Series



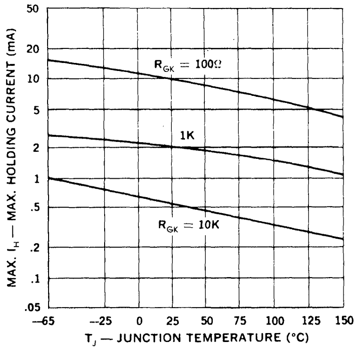
Gate Trigger Current
AA114 Series



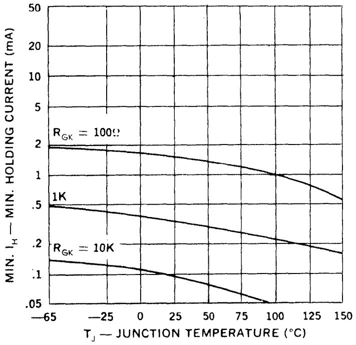
Gate Trigger Voltage



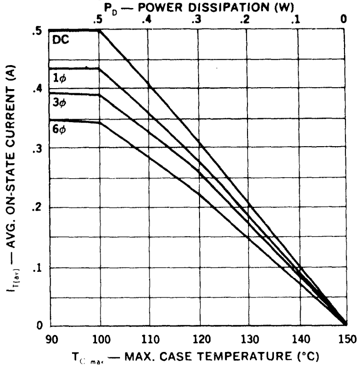
Max. Holding Current



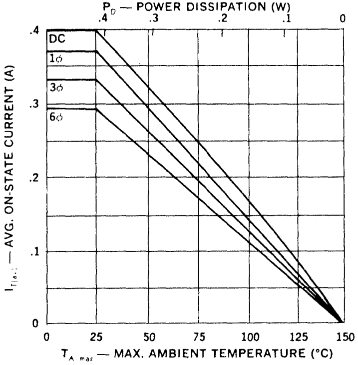
Min. Holding Current



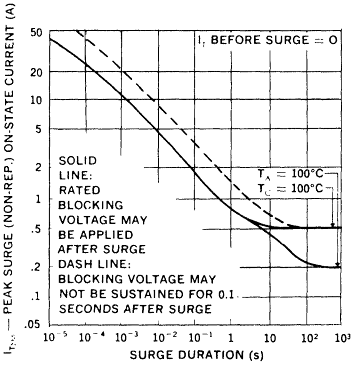
Avg. Current vs. Case Temperature



Avg. Current vs. Ambient Temperature



Surge Current



SCRs
1.6 Amp, Planar

AD100-AD104
AD107-AD111
AD114-AD118

FEATURES
- Maximum Gate Trigger Current: 2, 20 or 200μA
- Tight Gate Trigger Voltage Range: .44 to .6V
- Voltage Ratings: to 400V
- Specified for dv/dt and Switching Time

DESCRIPTION
This data sheet describes Unitrode's AD Series 1.6A SCRs designed for medium-current control and sensing applications. Units are available in a complete range of blocking voltages from 60 to 400 volts.

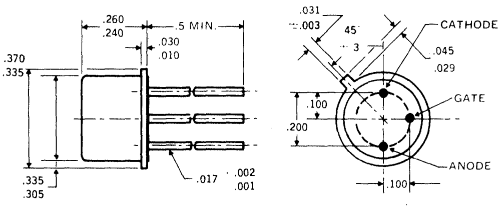
The AD100 series offers a maximum gate trigger current of 2.0 microamps making it the most sensitive device of its type. The AD107 series has a maximum I_{GT} of 20μA while this parameter is specified at 200μA for the AD114 series.

ABSOLUTE MAXIMUM RATINGS

	AD100 AD107 AD114	AD101 AD108 AD115	AD102 AD109 AD116	AD103 AD110 AD117	AD104 AD111 AD118
Repetitive Peak Off-State Voltage, V_{DRM}	60V	100V	200V	300V	400V
Repetitive Peak Reverse Voltage, V_{RRM}	60V	100V	200V	300V	400V
Non-Repetitive Peak Reverse Voltage, V_{RSM}	80V	150V	300V	400V	500V
Non-Repetitive Peak Off-State Voltage, V_{DSM}			500V		
D.C. On-State Current, I_T					
75°C Ambient			450mA		
85°C Case			1.6A		
Repetitive Peak On-State Current, I_{TRM}			up to 30A		
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}			15A		
Peak Gate Current, I_{GM}			250mA		
Average Gate Current, $I_{G(AV)}$			25mA		
Reverse Gate Voltage, V_{GR}			6V		
Operating and Storage Temperature Range			−65°C to +150°C		

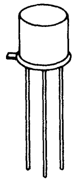
MECHANICAL SPECIFICATIONS

AD100-AD104 AD107-AD111 AD114-AD118



Dimensions in inches.

TO-39



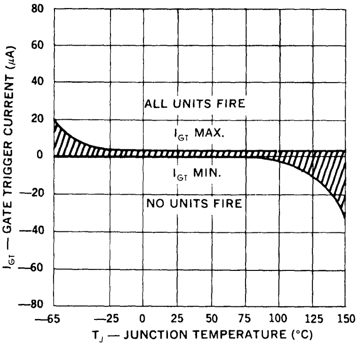
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

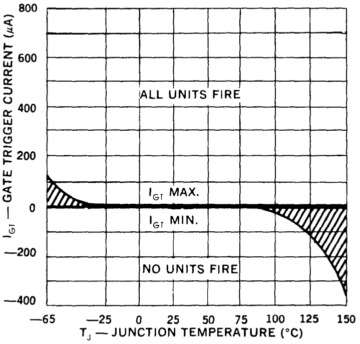
Parameter	Symbol	Min.	Typical	Max.	Units	Test Conditions
SUBGROUP 1						
Visual & Mechanical	—	—	—	—	—	
SUBGROUP 2 (25°C TESTS)						
Off-State Current	I_{DRM}	—	.01	0.1	μA	$R_{GK} = 1K$, $V_{DRM} =$ Rating
Reverse Current	I_{RRM}	—	.01	0.1	μA	$R_{GK} = 1K$, $V_{RRM} =$ Rating
Reverse Gate Current	I_{GR}	—	0.1	0.2	μA	$V_{GR} = 2V$
Gate Trigger Current	I_{GT}					$R_{GS} = 10K$, $V_D = 5V$
AD100-104		—	0.2	2.0	μA	
AD107-111		—	2.0	20	μA	
AD114-118		—	20	200	μA	
Gate Trigger Voltage	V_{GT}	0.44	0.52	0.60	V	$R_{GS} = 100\Omega$, $V_D = 5V$
On-State Voltage	V_T	—	1.1	1.5	V	$I_T = 1.0$ Amp (pulse)
Holding Current	I_H	0.3	0.5	2.0	mA	$R_{GK} = 1K$
SUBGROUP 3 (25°C TESTS)						
On-State Voltage-Critical Rate of Rise	dv/dt	50	100	—	V/μs	$R_{GK} = 1K$, $V_D = 30V$
Gate Trigger-on Pulse Width	t_{pg} (on)	—	0.5	2.0	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Delay Time	t_d	—	0.6	—	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Rise Time	t_r	—	0.4	—	μs	$I_G = 10mA$, $I_T = 1A$, $V_D = 30V$
Circuit Commutated Turn-off Time	t_q	—	20	50	μs	$I_T = 1A$, $I_R = 1A$, $R_{GK} = 1K$
SUBGROUP 4 (125°C TESTS)						
Off-State Current	I_{DRM}	—	10	100	μA	$R_{GK} = 1K$, $V_{DRM} =$ Rating
Reverse Current	I_{RRM}	—	30	100	μA	$R_{GK} = 1K$, $V_{RRM} =$ Rating
Gate Trigger Voltage	V_{GT}	0.15	0.2	—	V	$R_{GS} = 100\Omega$, $V_D = 5V$
Holding Current	I_H	0.2	0.4	1.5	mA	$R_{GK} = 1K$

Note: Blocking voltage ratings apply over the full operating temperature range, provided the gate is connected to the cathode through a resistor, 1000 ohms or smaller, or other adequate bias is used.

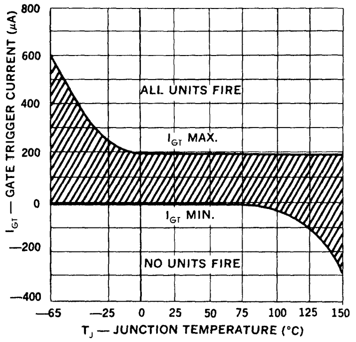
Gate Trigger Current
AD100 Series



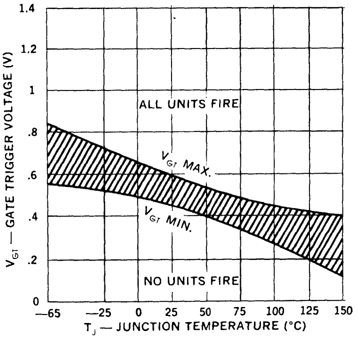
Gate Trigger Current
AD107 Series



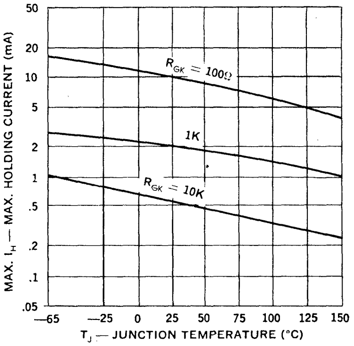
Gate Trigger Current
AD114 Series



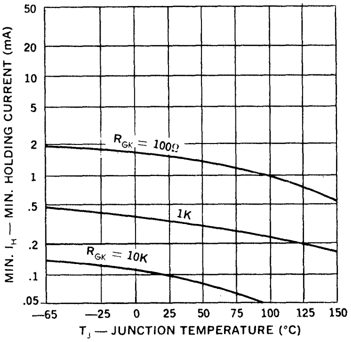
Gate Trigger Voltage



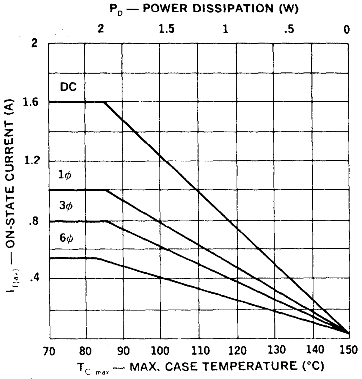
Max. Holding Current



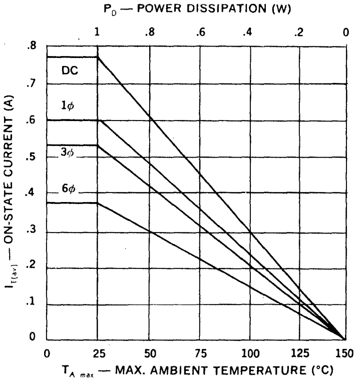
Min. Holding Current



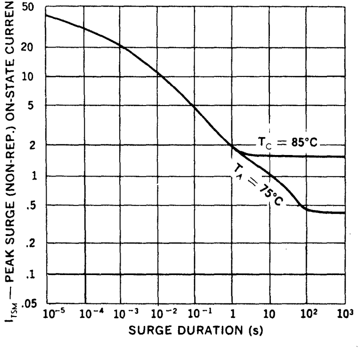
Avg. Current vs. Case Temperature



Avg. Current vs. Ambient Temperature



Surge Current



TRIACs

25 Amp RMS, 600V, ChipStrate® Quick Connect Terminals

CSB20
CSB40
CSB60

FEATURES

- Voltage Ratings: 200V-600V
- Hard-Glass Passivated Junction
- Isolated Case
- Quick Connect Terminals

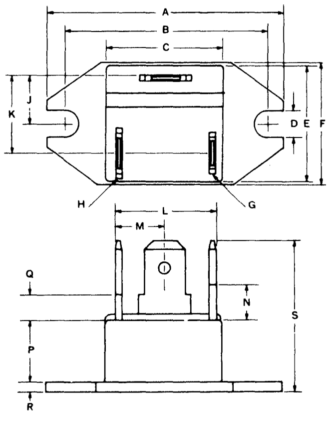
DESCRIPTION

The Unitrode ChipStrate CSB20 series Triac has been designed specifically for the appliance and industrial controls market. Standard quick connect terminals allow for simple solderless connections, ideally suited to production line techniques. The heart of this device is the exclusive ChipStrate assembly with proven reliability, incorporating a copper heat spreader, a BeO substrate for lowest thermal resistance, and a one piece lead frame construction for mechanical strength and optimum power handling capability. All Unitrode ChipStrate Triacs are isolated from the mounting flange.

ABSOLUTE MAXIMUM RATINGS

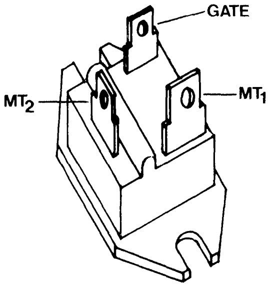
	CSB20	CSB40	CSB60
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V
On-State Current $I_{T(RMS)}$ (at $T_C = 65°C$ and conduction angle of 360°)		25A	
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}		250A	
Peak Gate Power, P_{GM}		16W	
Average Gate Power, $P_{G(AV)}$		0.5W	
Rate of On-State Current, di/dt (at $V_{DM} = V_{DRM}$, $I_{GT} = 175mA$, $t_r = 0.1\mu s$)		125 A/μs	
Storage Temperature Range		−40°C to +150°C	
Operating Temperature Range		−40°C to +110°C	
Isolation Voltage, Flange to Terminal		2500V RmS	

CSB60 CSB40 CSB20



	DIMENSIONS	
	(Inches)	Metric
A	1.395	35.43 mm
B	1.187	30.15 mm
C	.675	17.15 mm
D	.156 (TYP.)	3.96 mm (TYP.)
E	.675	17.15 mm
F	.700	17.78 mm
G	.187 WIDE X .032 THICK (GATE)	4.75 mm WIDE X 0.81 mm THICK (GATE)
H	.250 WIDE X .032 THICK (MT1)	6.35 mm WIDE X 0.81 THICK (MT1)
J	.290	7.37 mm
K	.442	11.23 mm
L	.580	14.73 mm
M	.290	7.37 mm
N	.218	5.54 mm
P	.360	9.14 mm
Q	.156 (2 PLACES)	3.96 mm (2 PLACES)
R	.050	1.27 mm
S	.875 (TYP.)	22.23 mm

L3

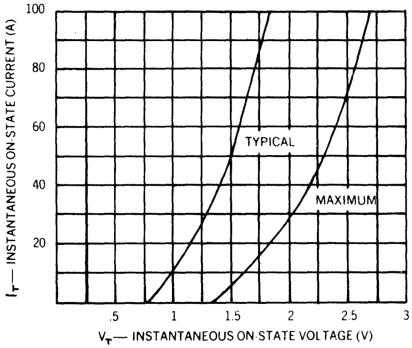


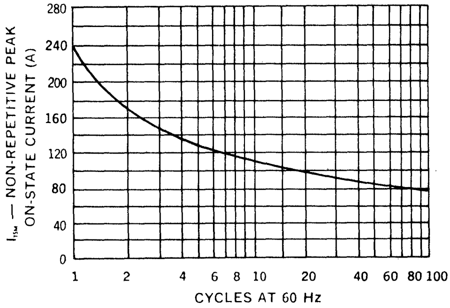
ChipStrate® is a registered trademark of Unitrode Corporation.

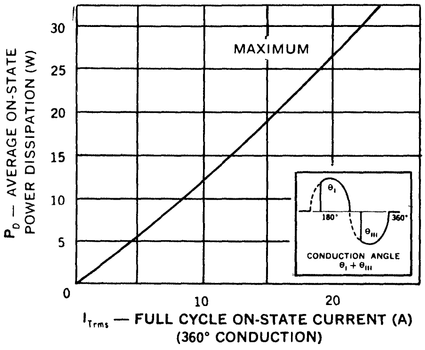
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

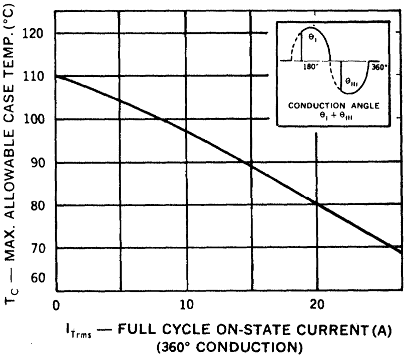
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	2.0	mA	V_{DRM} = Rating, T_C = 100°C
Gate Trigger Current	I_{GT}	— —	— —	50 80	mA	V_D = 12V Quadrants 1, 3 (+ +, — —) V_D = 12V Quadrants 2, 4 (+ —, — +)
Gate Trigger Voltage	V_{GT}	—	—	2.5	V	V_D = 12V
Peak On-State Voltage	V_{TM}	—	—	1.9	V	I_{TM} = 28A Peak
Holding Current	I_H	—	—	50	mA	V_D = 12V
Critical Rate of Rise — Off-State Voltage	dv/dt	20	50	—	V/µS	V_{DRM} = Rating, T_C = 100°C
Critical Rate of Rise — Commutated Off-State Voltage	$dv/dt_{(c)}$	3	10	—	V/µS	I_T = Rating, V_{DRM} = Rating, T_C = 65°C
Steady State Thermal Resistance*	$R\theta_{JC}$	—	—	1.1	°C/W	Steady State

* Junction-to-Case


On-State Characteristics


Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions


Maximum Conduction Power Dissipation vs. On-State Current (50 or 60HZ)


Maximum Allowable Case Temp. vs. On-State Current (50 or 60HZ)

SCRs
Nuclear Radiation Resistant, Planar

GA100
GA101
GA102

FEATURES

- Optimized for Radiation Resistance
- Fully Characterized for "Worst Case" Design
- Post Radiation Design Limits Specified
- Passivated Planar Construction for Maximum Reliability and Parameter Uniformity
- Pulse Currents: to 30A
- Max. Trigger Current 20mA after 3 X 10^{14} NVT
- Max. Holding Current 30mA after 3 X 10^{14} NVT

DESCRIPTION

The GA100 Series of Radiation Hard SCRs have been designed to provide significantly greater radiation tolerance than conventional SCRs or Transistors with the same current handling ability. This Series is capable of operation after exposure to 10^{15} NVT.

The radiation resistant characteristics of the GA100 series devices make them particularly desirable for use under radiation environments in squib firing circuits; inverters and converters; pulse generators; relay drivers; and modulator discharge switches.

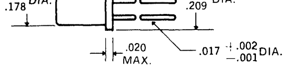
ABSOLUTE MAXIMUM RATINGS

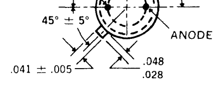
	GA100	GA101	GA102
Repetitive Peak Off-State Voltage, V_{DRM}	30V	60V	80V
D.C. On-State Current, I_T			
75°C Ambient	200mA		
100°C Case	400mA		
Repetitive Peak On-State Current, I_{TRM}	up to 30A		
Surge (non-rep.) On-State Current, I_{TSM} (Sq. Pulse-50ms)	5A		
Peak Gate Current, I_{GM}	250mA		
Average Gate Current, $I_{G(AV)}$	25mA		
Reverse Gate Voltage, V_{GR}	5V		
Reverse Gate Current, I_{GR}	3mA		
Storage Temperature Range	−65°C to +200°C		
Operating Temperature Range	−65°C to +150°C		

X

MECHANICAL SPECIFICATIONS

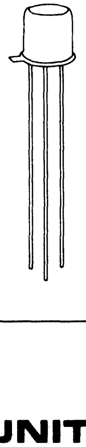
GA100 GA101 GA102





Dimensions in inches.

TO-18



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

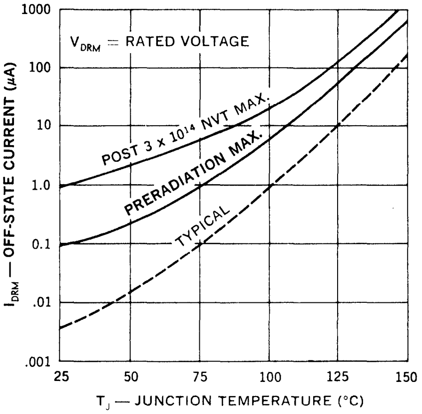
Test	Symbol	Preradiation Limits			Post 3 x 10^{14} NVT Design Limits		Units	Test Conditions
		Min.	Typ.	Max.	Min.	Max.		
SUBGROUP 1 Visual and Mechanical	—	—	—	—	—	—	—	MIL-STD-750 Method 2071
SUBGROUP 2 (25°C Tests)								
Off-State Current	I_{DRM}	—	.005	0.1	—	1.0	μA	$R_{GK} = 220\Omega$, V_{DRM} = Rating
Reverse Gate Current	I_{GR}	—	.01	0.1	—	1.0	μA	$V_{GR} = 2V$
Input Trigger Current (Note 2)	I_{ST}	1.8	2.3	3.5	—	20	mA	$R_{GK} = 220\Omega$, $V_D = 5V$
Gate Trigger Voltage	V_{GT}	0.4	0.5	0.7	—	1.5	V	$R_{GK} = 220\Omega$, $V_D = 5V$
On-State Voltage	V_T	0.8	1.1	1.5	—	3.0	V	i_T = 1A (pulse test)
Holding Current	I_H	0.3	0.7	10	—	30	mA	$R_{GK} = 220\Omega$
SUBGROUP 3 (25°C Tests)								
Off-State Voltage-Critical Rate of Rise	dv_c/dt	20	40	—	—	—	v/μs	$R_{GK} = 220\Omega$, $V_D = 30V$
Gate Trigger-on Pulse Width	t_{pg} (on)	—	.02	.05	—	0.1	μs	$I_G = 25mA$, $I_T = 1A$, $V_D = 30V$
Delay Time	t_d	—	.02	—	—	—	μs	$I_G = 25mA$, $I_T = 1A$, $V_D = 30V$
Rise Time	t_r	—	.05	—	—	—	μs	$I_G = 25mA$, $I_T = 1A$, $V_D = 30V$
Circuit Commutated Turn-off Time	t_q	—	1.5	2.5	—	1.0	μs	$I_T = 1A$, $i_R = 1A$, $R_{GK} = 220\Omega$
SUBGROUP 4 (125°C Tests)								
High Temp Off-State Current	I_{DRM}	—	10	100	—	100	μA	$R_{GK} = 220\Omega$, V_{DRM} = Rating
High Temp Gate Trigger Voltage	V_{GT}	0.1	.17	—	0.1	—	V	$R_{GK} = 220\Omega$, $V_D = 5V$

Notes: 1. Off-State voltage ratings apply over the operating temperature range provided the gate is connected to the cathode through an appropriate resistor, or other adequate bias is used.
2. Total Input Trigger Current, including current required by 220Ω gate bias resistance.

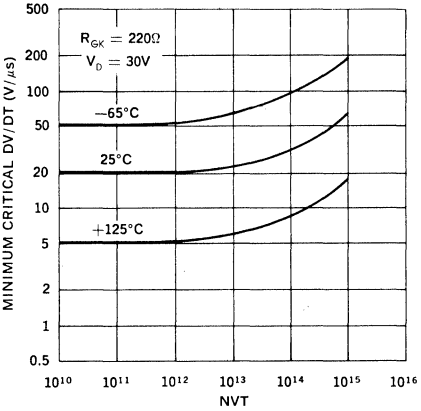
DESIGN CONSIDERATIONS

1. Curve 1 shows the off-state current, I_{DRM} of the SCR as a function of temperature. I_{DRM} is increased by radiation damage, but is not a design consideration at the recommended gate bias levels.
   In order to optimize for radiation tolerance, reverse blocking capability has not been retained as a design feature. Devices with reverse blocking capability can be provided.
2. Minimum critical dv/dt levels are defined in Curve 2. The dv/dt capability is improved after radiation because of reduced triggering sensitivity. dv/dt is therefore a design consideration only prior to radiation.
3. Curves 3 and 4 show the limits of Gate Trigger Voltage and Total Input Trigger Current prior to radiation. Maximum design limits after a total radiation dosage of 3 x 10^{14} NVT is also shown. Curves 5 and 6 show the maximum limits of Gate Trigger Voltage and Total Input Trigger Currents as a junction of neutron dosage. The minimum level of Trigger current prior to radiation is established by the shunting effect of a 220 ohm resistor between gate and cathode. After radiation the device is less sensitive and Total Trigger Current will increase to a level relatively independent of the bias resistance. The 220 ohm resistor is recommended since it raises the minimum preradiation trigger current to a level that is closer to the past radiation limit and minimizes the percentage change in this parameter.
4. Current ratings shown in Curves 10, 11, and 12 apply after the device has been subjected to 3 x 10^{14} NVT. Current ratings prior to radiation are greater than the values indicated.
5. Gamma radiation produces a reversible ionization (leakage) current within the device which is directly proportional to the Gamma flux level. When the Gamma flux level is in the range of 10 to 100 Roentgens per microsecond for burst durations greater than 1 microsecond, the device will self trigger ON. For the radiation bursts associated with nuclear explosions, the Gamma flux level will invariably cause device triggering at radiation levels significantly below the levels that would produce detectable permanent device damage due to cumulative neutron dosage. In applications where the burst effect triggering cannot be tolerated, it is necessary to reset the device after the radiation burst. Special circuit approaches such as additional SCRs to crowbar or otherwise cancel the output function may be used.

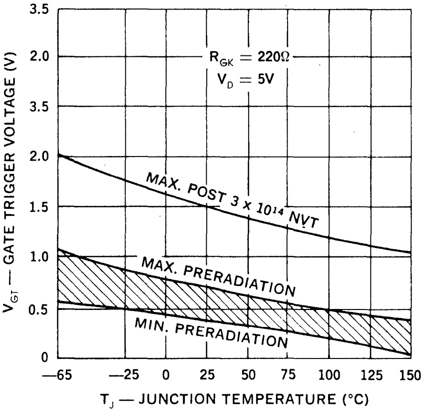
1. Off-State Current



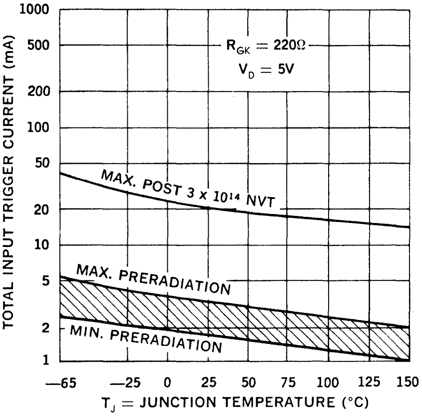
2. Minimum Critical DV/DT vs. Neutron Dosage



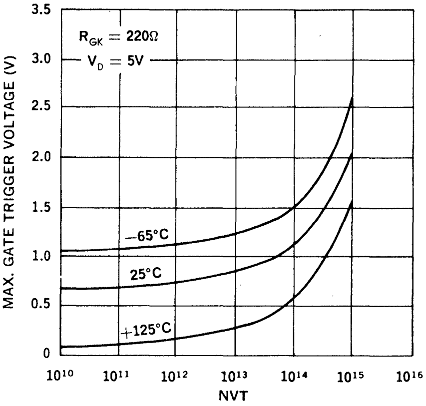
3. Gate Trigger Voltage



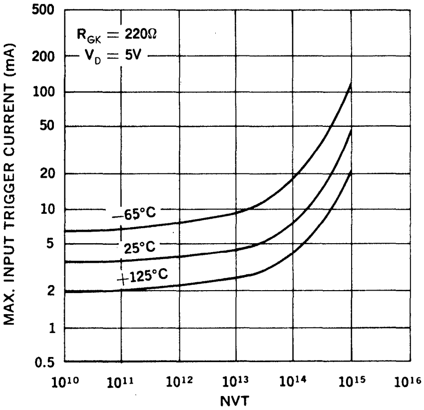
4. Input Trigger Current



5. Max. Gate Trigger Voltage vs. Neutron Dosage

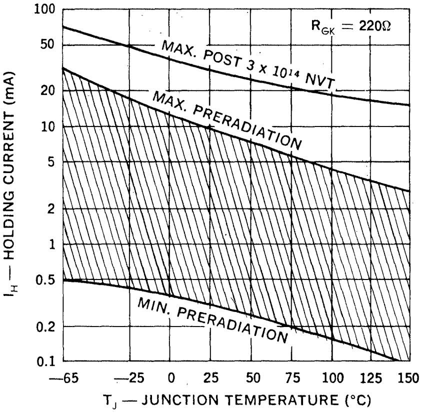


6. Max. Input Trigger Current vs. Neutron Dosage

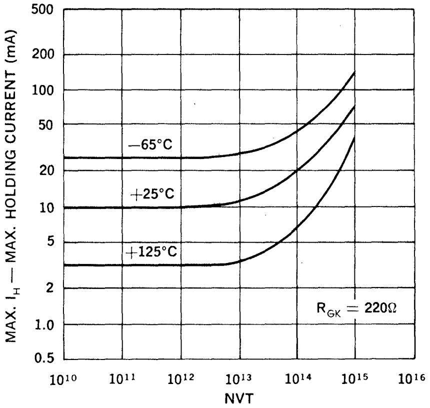


X

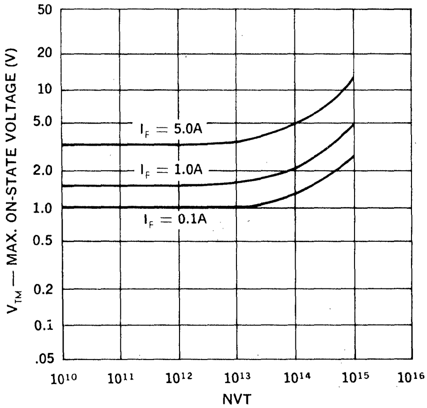
7. **Holding Current**



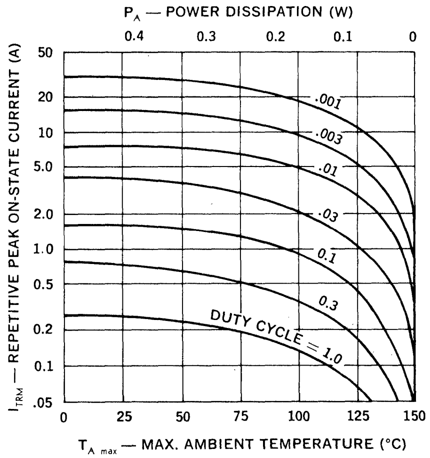
8. **Max. Holding Current vs. Neutron Dosage**



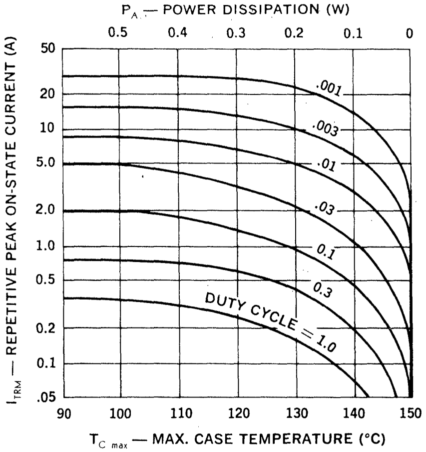
9. **Max. On-State Voltage vs. Neutron Dosage**



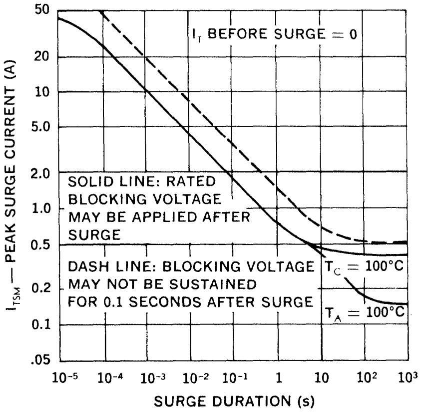
10. **Peak Current vs. Ambient Temperature**



11. **Peak Current vs. Case Temperature**



12. **Surge Current vs. Time**



SCRs

Nanosecond Switching, Planar

GA200 GB200
GA200A GB200A
GA201 GB201
GA201A GB201A

FEATURES

- Rise Time: 10ns
- Delay Time: 10ns
- Recovery Time: 0.5 μs
- Pulse Current: to 100A
- Turn-on with 20ns, 10 mA Gate Pulse

DESCRIPTION

The Unitrode Nanosecond Thyristor Switch combines the turn-on speed of logic level transistors with the high current switching capability inherent in SCRs. With this device engineers can now design circuits capable of switching pulse currents of 1A in less than 10ns or up to 30A in less than 20ns.

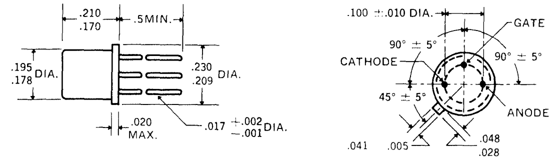
The GA/GB200 series is specifically designed for use as switching elements in high speed, low-to-medium power radar pulse modulators. Other applications include switching elements for phased array radars, laser pulse drivers, harmonic wave-form generators, line drivers and high current replacements for avalanche transistors. For applications requiring higher voltage levels, Unitrode has developed several "series string" circuits which allow the series connection of virtually an unlimited number of devices for voltages as high as 2000V with no significant decrease in speed. These circuits are described in Unitrode Design Note #14.

ABSOLUTE MAXIMUM RATINGS

	GA200 GA200A	GA201 GA201A	GB200 GB200A	GB201B
Repetitive Peak Off-State Voltage, V_{DRM}	60V	100V	60V	100V
Repetitive Peak On-State Current, I_{TRM}	up to 100A		up to 100A	
D.C. On-State Current, I_T				
70°C Ambient	200mA		—	
70°C Case	400mA		6A	
Peak Gate Current, I_{GM}	250mA		250mA	
Average Gate Current, $I_{G(AV)}$	25mA		50mA	
Reverse Gate Current, I_{GR}	3mA		3mA	
Reverse Gate Voltage, V_{GR}	5V		5V	
Storage Temperature Range	−65°C to +200°C			
Operating Temperature Range	−65°C to +150°C			

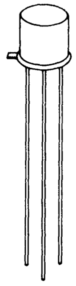
MECHANICAL SPECIFICATIONS

GA200 GA200A GA201 GA201A

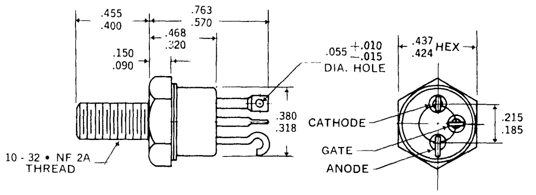


Dimensions in inches.

TO-18



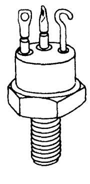
GB200 GB200A GB201 GB201A



Dimensions in inches.

NOTE: Anode connected to case.

TO-59



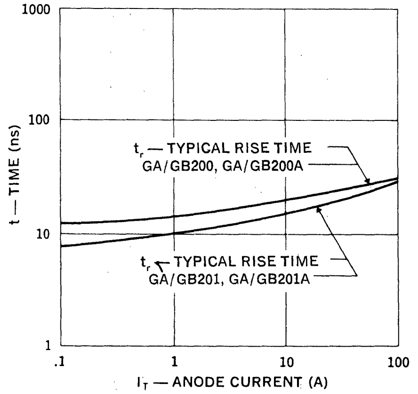
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Delay Time	t_d	—	20	30	ns	$I_G = 20mA, I_T = 1A$
		—	10	—	ns	$I_G = 30mA, I_T = 1A$
Rise Time GA200, 200A, GB200, 200A	t_r	—	15	25	ns	$V_D = 60V, I_T = 1A$ (1)
		—	25	—	ns	$V_D = 60V, I_T = 30A$ (1)
Rise Time GA201, 201A, GB201, 201A	t_r	—	10	20	ns	$V_D = 100V, I_T = 1A$ (1)
		—	20	—	ns	$V_D = 100V, I_T = 30A$ (1)
Gate Trigger on Pulse Width	$t_{pg(on)}$	—	.02	.05	μs	$I_G = 10mA, I_T = 1A$
Circuit Commutated Turn-off Time GA200, 201, GB200, 201	t_q	—	0.8	2.0	μs	$I_T = 1A, I_R = 1A, R_{GK} = 1K$
GA200A, 201A, GB200A, 201A	t_q	—	0.3	0.5	μs	
Off-State Current	I_{DRM}	—	.01	0.1	μA	V_{DRM} = Rating, $R_{GK} = 1K$
		—	20	100	μA	V_{DRM} = Rating, $R_{GK} = 1K$, 150°C
Reverse Current	I_{RRM}	—	1.0	10	mA	$V_{RRM} = 30V, R_{GK} = 1K$ (2)
Reverse Gate Current	I_{GR}	—	.01	0.1	mA	$V_{GRM} = 5V$
Gate Trigger Current	I_{GT}	—	10	200	μA	$V_D = 5V, R_{GS} = 10K$
Gate Trigger Voltage	V_{GT}	0.4	.06	0.75	V	$V_D = 5V, R_{GS} = 100\Omega, T = 25°C$
		0.10	0.2	—	V	$T = +150°C$
On-State Voltage	V_T	—	1.1	1.5	V	$I_T = 2A$
Holding Current	I_H	0.3	2.0	5.0	mA	$V_D = 5V, R_{GS} = 100\Omega, T = 25°C$
		0.05	0.2	—	mA	$T = +150°C$
Off-State Voltage-Critical Rate of Rise	dv/dt	20	40	—	V/μs	$V_D = 30V, R_{GK} = 1K$

Notes: 1. I_G = 10mA; Pulse Test, Duty Cycle <1%.

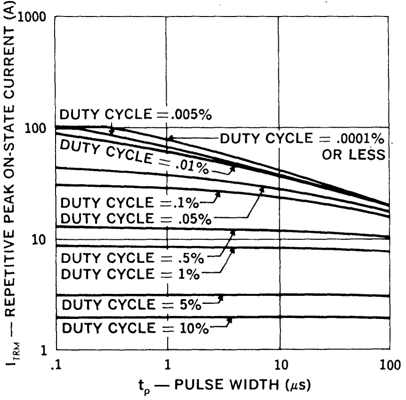
2. Pulse test intended to guarantee reverse anode voltage capability for pulse commutation. Device should not be operated in the Reverse blocking mode on a continuous basis.

Switching Speed (Typical)
GA/GB200 Series



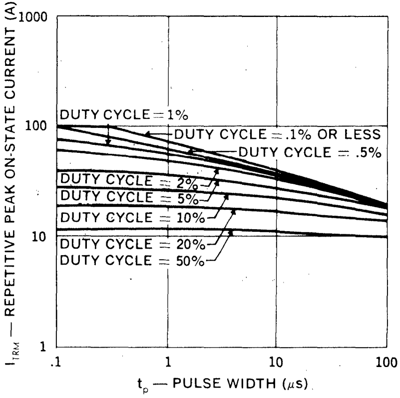
NOTES: 1. V_D = Rated V_{DRM}
2. $T_A = 25°C$
3. $I_G = 20mA$
4. t_d = 20ns TYPICALLY FOR ALL TYPES INDEPENDENT OF ANODE CURRENT

Peak Current vs. Pulse Width
GA200 Series



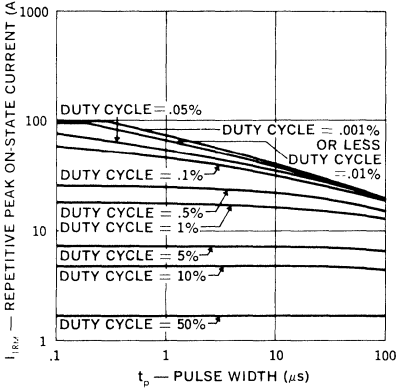
NOTES: 1. DATA BASED ON ON-STATE VOLTAGE GRAPH AT T_j = 150°C. BLOCKING VOLTAGE MAY BE APPLIED IMMEDIATELY AFTER TERMINATION OF CURRENT PULSE.
2. $T_A = 75°C$

Peak Current vs. Pulse Width
GB200 Series



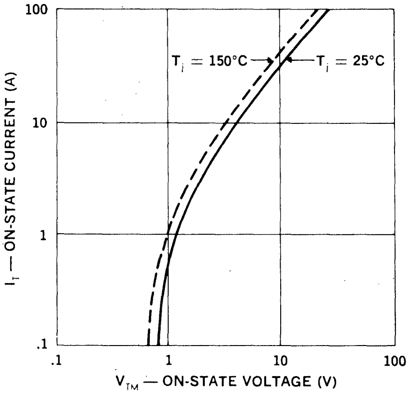
NOTES: 1. DATA BASED ON ON-STATE VOLTAGE GRAPH AT $T_j = 150°C$. BLOCKING VOLTAGE MAY BE APPLIED IMMEDIATELY AFTER TERMINATION OF CURRENT PULSE.
2. $T_C = 75°C$

Peak Current vs. Pulse Width
GB200 Series

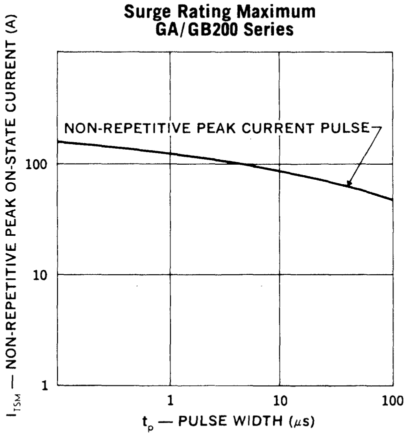


NOTES: 1. DATA BASED ON ON-STATE VOLTAGE GRAPH AT $T_j = 150°C$. BLOCKING VOLTAGE MAY BE APPLIED IMMEDIATELY AFTER TERMINATION OF CURRENT PULSE.
2. $T_A = 75°C$

On-State Current vs. Voltage
GA/GB200 Series



Surge Rating Maximum
GA/GB200 Series



NOTES: 1. BLOCKING VOLTAGE MAY NOT BE APPLIED FOR .001 SEC. AFTER TERMINATION OF SURGE PULSE AS JUNCTION TEMPERATURE WILL EXCEED 150°C.
2. $T_C = 75°C$

SCRs
Commercial Nanosecond Switching, Planar

GA300 GB300
GA300A GB300A
GA301 GB301
GA301A GB301A

FEATURES

- Rise Time: 10ns
- Delay Time: 10ns
- Recovery Time: 0.5μs
- Pulse Current: to 100A
- Turn-on with 20ns, 10mA gate pulse

DESCRIPTION

Unitrode's Nanosecond Thyristor Switch combines the turn-on speed of logic level transistors with the high current switching capability inherent in SCRs. With this device, engineers can now design circuits capable of switching pulse currents of 1A in less than 10ns or up to 30A in less than 20ns.

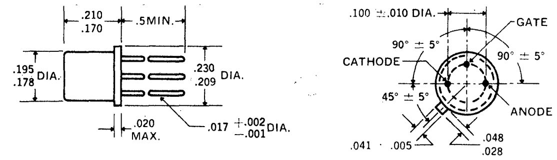
The GA300, GB300 Series is specifically designed for use as the switching element in high speed laser diode pulse drivers. Other applications include electronic crowbars, harmonic wave-form generators, line drivers and general purpose replacements for avalanche transistors. For applications requiring higher voltage levels, Unitrode has developed several "series string" circuits which allow the series connection of an unlimited number of devices for voltages as high as 2000V with no significant decrease in speed. These circuits are described in Unitrode's Design Note #14.

ABSOLUTE MAXIMUM RATINGS

	GA300 **GA300A**	**GA301** **GA301A**	**GB300** **GB300A**	**GB301A** **GB301**
Repetitive Peak Off-State Voltage, V_{DRM}	60V	100V	60V	100V
Repetitive Peak On-State Current, I_{TRM}	up to 100A		up to 100A	
Peak Gate Current, I_{GM}	250mA		250mA	
Average Gate Current, $I_{G(AV)}$	25mA		50mA	
Reverse Gate Current, I_{GR}	3mA		3mA	
Reverse Gate Voltage, V_{GR}	5V		5V	
Storage Temperature Range	−65°C to +150°C			
Operating Temperature Range	0°C to +125°C			

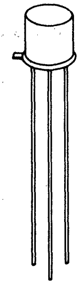
MECHANICAL SPECIFICATIONS

GA300 GA300A GA301 GA301A

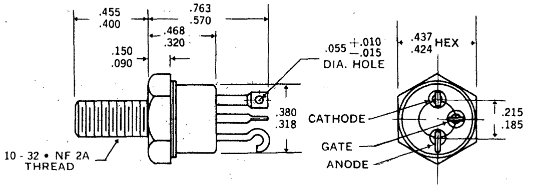


Dimensions in inches.

TO-18



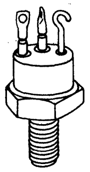
GB300 GB300A GB301 GB301A



Dimensions in inches.

NOTE: Anode connected to case.

TO-59



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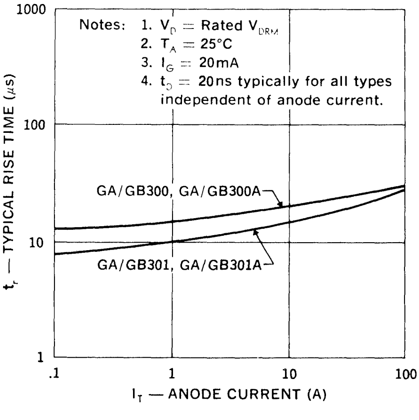
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

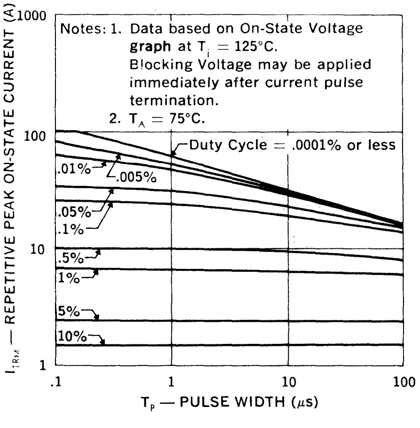
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Delay Time	t_d	—	20 10	30 —	ns	$I_G = 20mA, I_T = 1A$ $I_G = 30mA, I_T = 1A$
Rise Time (Note 1) GA300, 300A, GB300, 300A	t_r	—	15 25	25 —	ns	$V_D = 60V, I_T = 1A$ $V_D = 60V, I_T = 30A$ (Note 1)
Rise Time (Note 1) GA301, 301A, GB301, 301A	t_r	—	10 20	20 —	ns	$V_D = 100V, I_T = 1A$ $V_D = 100V, I_T = 30A$ (Note 1)
Circuit Commutated Turn-off Time GA300, 301, GB300, 301	t_q	—	0.8	2.0	μs	$I_T = 1A, I_R = 1A, R_{GK} = 1K$
GA300A, 301A, GB300A, 301A			0.3	0.5	μs	$I_T = 1A, I_R = 1A, R_{GK} = 1K$
Gate Trigger-on Pulse Width	$t_{pg\ (on)}$	—	0.02	0.05	μs	$I_G = 10mA, I_T = 1A$
Off-state Current	I_{DRM}	— —	0.01 20	0.1 100	μA μA	V_{DRM} = Rating, $R_{GK} = 1K, T = 25°C$ V_{DRM} = Rating, $R_{GK} = 1K, T = 125°C$
Reverse Current (Note 2)	I_{RRM}	—	1.0	10	mA	$V_{RRM} = 30V, R_{GK} = 1K$ (Note 2)
Gate Trigger Voltage	V_{GT}	0.4 0.10	0.6 0.2	0.75 —	V V	$V_D = 5V, R_{GS} = 100\Omega, T = 25°C$ $V_D = 5V, R_{GS} = 100\Omega, T = 125°C$
Gate Trigger Current	I_{GT}	—	10	200	μA	$V_D = 5V, R_{GS} = 10K$
On-state Voltage	V_T	—	1.1	1.5	V	$I_T = 2A$
Off-state Voltage — Critical Rate of Rise	dv/dt	15	30	—	V/μs	$V_D = 30V, R_{GK} = 1K$
Reverse Gate Current	I_{GR}	—	0.01	0.1	mA	$V_{GR} = 5V$
Holding Current	I_H	0.3 0.05	2.0 0.4	5.0 —	mA mA	$V_D = 5V, R_{GK} = 1K, T = 25°C$ $V_D = 5V, R_{GK} = 1K, T = 125°C$

Notes: 1. $I_G = 10mA$; Pulse Test, Duty Cycle < 1%.
2. Pulse test intended to guarantee reverse anode voltage capability for pulse commutation. Device should not be operated in the reverse blocking mode on a continuous basis.

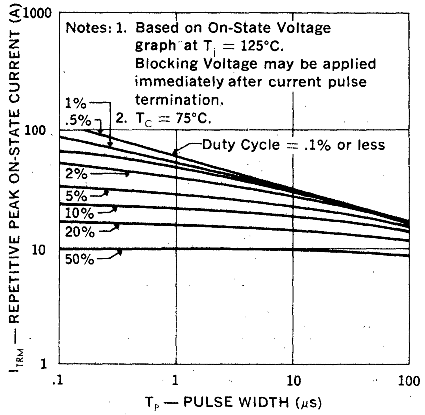
Switching Speed vs. Current
GA/GB300 Series



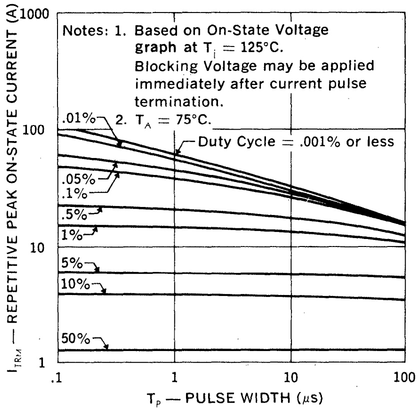
Peak Current vs. Pulse Width
GA300 Series



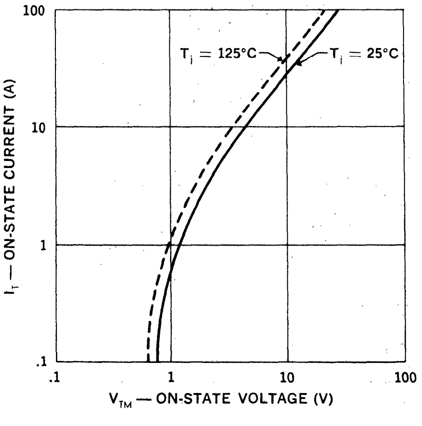
Peak Current vs. Pulse Width
GB300 Series



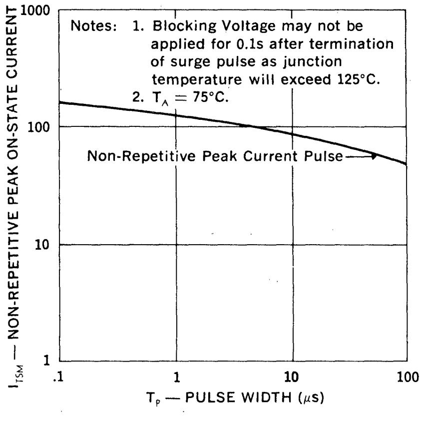
Peak Current vs. Pulse Width
GB300 Series



On-State Voltage vs. Current
GA/GB300 Series



Surge Rating
GA/GB300 Series



TRIAC

.8 Amp. RMS, Plastic TO-92
600V

IB202
IB204
IB206

FEATURES:
- Forward Current: .8A RMS
- Voltage Ratings: to 600V
- High Surge Current: 8A
- Gate Sensitivity: 2mA Typical, 1st & 3rd Quad
- Hard Glass Passivated Junction
- Economical TO-92 Package

TYPICAL APPLICATIONS:
- Appliance Control Circuitry
- Speed Controls
- AC Switches
- Logic to A.C. Interface

DESCRIPTION:
This series of low current triacs is designed specifically for high volume, low cost AC switching applications. Supplied in the economical TO-92 package, these devices feature full hard glass passivated junctions and rugged mesa construction.

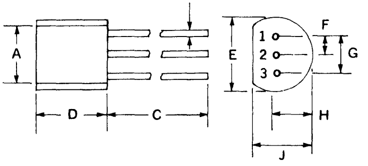
MAXIMUM RATINGS

	IB202	IB204	IB206
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V
Repetitive Peak Reverse Voltage, V_{RRM}	200V	400V	600V
On-State Current, I_T RMS At 65°C Case, 180° Conduction Sinewave		.8A	
Surge (Non-Rep.) On-State Current, I_{TSM}		8A	
Peak Gate Current, I_{GM}		1.0A	
Peak Gate Power, P_{GM}		1W	
Average Gate Power P_G (AV.)		.1W	
Reverse Gate Voltage, V_{GR}		6V	
Storage Temperature Range, $T_{(STG)}$		−55°C to +150°C	
Operating Temperature Range, $T_{(OP)}$		−55°C to +110°C	
Circuit Fusing Consideration, I^2t @ −40 to 100°C, 1.0 to 8.3ms		.25A²S	

X

MECHANICAL SPECIFICATIONS

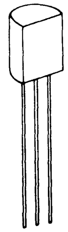
IB202, IB204, IB206 SERIES



	inches	millimeters
A	.135 MIN.	3.43 MIN.
B	.019-.016	.48- .41
C	.500 MIN.	12.7 MIN.
D	.210-.170	5.33-4.32
E	.205-.175	5.21-4.45
F	.055-.045	1.40-1.14
G	.105-.095	2.67-2.41
H	.105-.080	2.67-2.03
J	.165-.125	4.19-3.18

1 — MT2
2 — GATE
3 — MT1

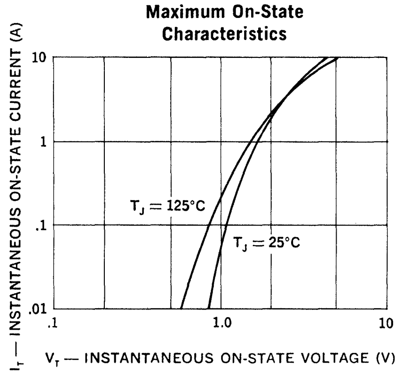
TO-92



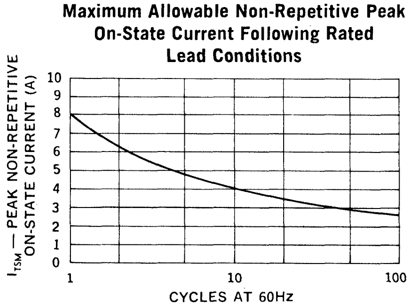
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

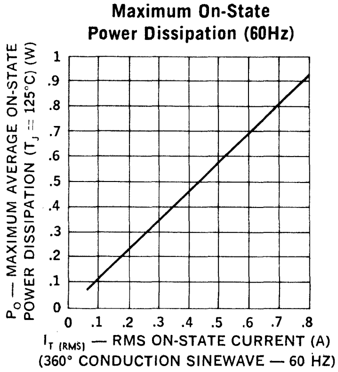
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM} I_{RRM}	— —	— —	.1 .1	mA mA	V_{DRM} = Rating, T_C = 100°C
Gate Trigger Current	I_{GT}	— —	— —	5 10	mA mA	V_D = 12V Quadrants 1, 3 (+ +, — —) V_D = 12V Quadrants 2, 4 (+ —, — +)
Gate Trigger Voltage	V_{GT}	— —	— —	2.0 3.0	V V	V_D = 12V Quadrants 1, 3 (+ +, — —) V_D = 12V Quadrants 2, 4 (+ —, — +)
Peak On-State Voltage	V_{TM}	—	—	1.8	V	I_{TM} = 1.0A Peak
Holding Current	I_H	—	—	15	mA	V_D = 12V
Steady State Thermal Resistance	$R\Theta_{J\text{-}C}$	—	—	50	°C/W	Steady State
Thermal Resistance	$R\Theta_{J\text{-}A}$	—	—	200	°C/W	



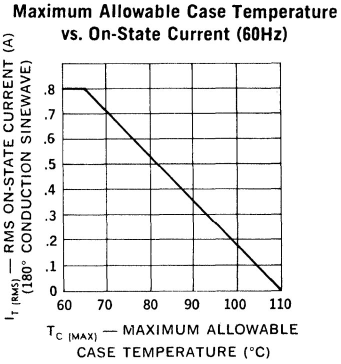
Maximum On-State Characteristics



Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Lead Conditions



Maximum On-State Power Dissipation (60Hz)



Maximum Allowable Case Temperature vs. On-State Current (60Hz)

SCRs

.5 Amp, Planar

ID100-ID106

FEATURES

- Voltage Ratings: to 400V
- Maximum Gate Trigger Current: 200μA
- Hermetically Sealed TO-18 Metal Can
- Planar Passivated Construction

DESCRIPTION

This Data Sheet describes Unitrode's line of hermetically sealed industrial SCRs designed for low-voltage, low-current sensing application. The ID 100 Series is packaged in a TO-18 metal case with Unitrode's unique oxide passivated junctions, offering the highest degree of reliability and parameter stability for any device in its price range.

Typical applications include lamp driving, relay driving, sensor, pulse-generating and timing circuits.

ABSOLUTE MAXIMUM RATINGS

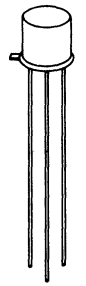
	ID100	ID101	ID102	ID103	ID104	ID105	ID106
Repetitive Peak Off-State Voltage, V_{DRM}	30V	60V	100V	150V	200V	300V	400V
Repetitive Peak Reverse Voltage, V_{RRM}	30V	60V	100V	150V	200V	300V	400V
On-State Current, I_T							
75°C Ambient	250mA						
100°C Case	0.5A						
Repetitive Peak On-State Current, I_{TRM}	6A						
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	up to 30A						
Peak Gate Current, I_{GM}	250mA						
Average Gate Current, $I_{G(AV)}$	25mA						
Reverse Gate Voltage, V_{GR}	6V						
Storage Temperature Range	−65°C to +150°C						
Operating Temperature Range	−65°C to +125°C						

MECHANICAL SPECIFICATIONS

ID100-ID106

Dimensions in inches.

TO-18



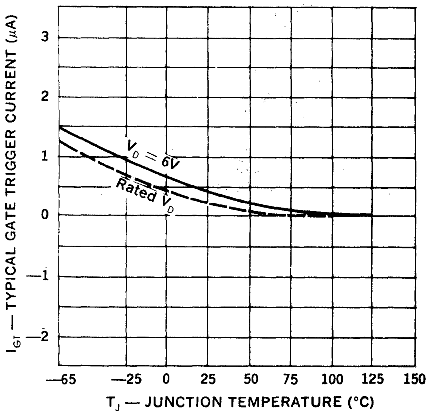
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

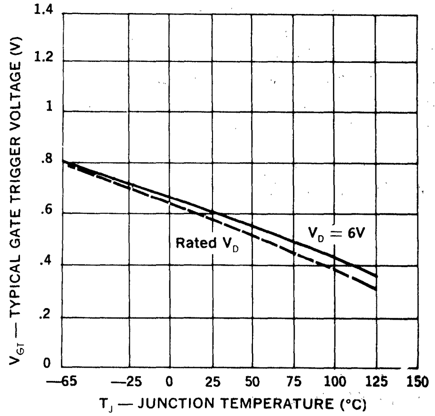
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	— —	5.0 10.0	50 100	μA μA	V_{DRM} = Rating, R_{GK} = 1K, T = 125°C, ID100-ID104 V_{DRM} = Rating, R_{GK} = 1K, T = 125°C, ID105-ID106
Reversing Current	I_{RRM}	— —	10 15	50 100	μA μA	V_{RRM} = Rating, R_{GK} = 1K, T = 125°C, ID100-ID104 V_{RRM} = Rating, R_{GK} = 1K, T = 125°C, ID105-ID106
Gate Trigger Current	I_{GT}	— —	5.0 —	200 500	μA μA	V_D = 5V, R_{GS} = 10K V_D = 5V, R_{GS} = 10K, T = −40°C
Gate Trigger Voltage	V_{GT}	0.4 — 0.10	0.55 — —	0.8 1.0 —	V V V	V_D = 5V, R_{GS} = 100Ω V_D = 5V, R_{GS} = 100Ω, T = −40°C V_D = 5V, R_{GS} = 100Ω, T = 125°C
Peak On-State Voltage	V_{TM}	—	—	1.7	V	I_{TM} = 1 Amp Pulse
Holding Current	I_H	— —	1.0 —	5.0 10.0	mA mA	R_{GK} = 1K R_{GK} = 1K, T = −40°C
Turn-on Time	t_{on}	—	0.5	—	μs	I_G = 10mA, I_T = 1A, V_D = 30V
Circuit Commutated Turn-off Time	t_q	— —	8.0 15.0	— —	μs μs	I_T = I_R = 1A, R_{GK} = 1K, ID100-ID104 I_T = I_R = 1A, R_{GK} = 1K, ID105-ID106

Note: Blocking voltage ratings apply over the full operating temperature range, provided the gate is connected to the cathode through a resistor, 1000 ohms or smaller, or other adequate bias is used.

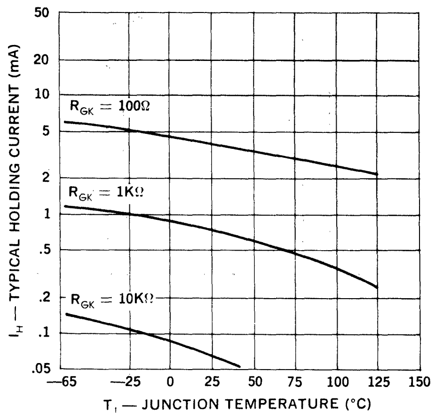
Gate Trigger Current vs. Junction Temp.



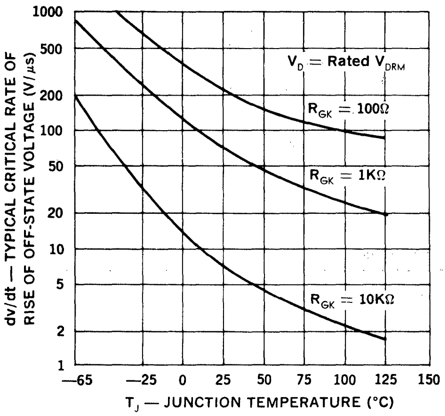
Gate Trigger Voltage vs. Junction Temp.



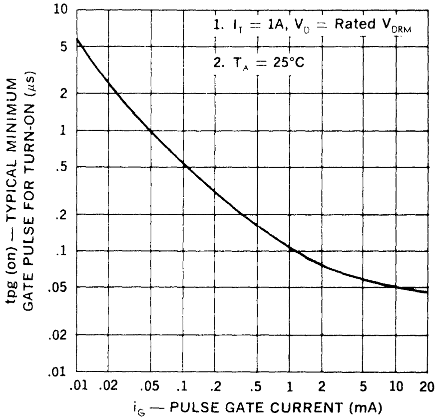
Holding Current vs. Junction Temp.



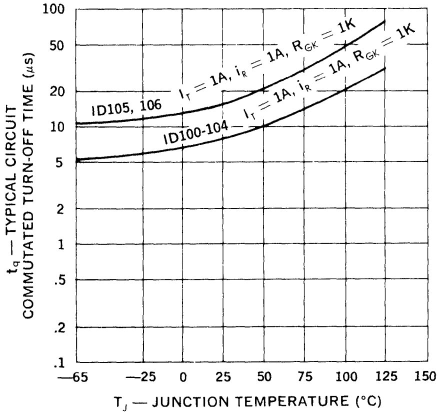
dv/dt vs. Junction Temp.



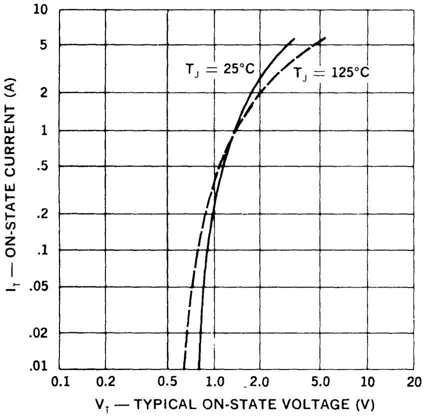
Gate Pulse for Turn-On vs. Pulse Gate Current



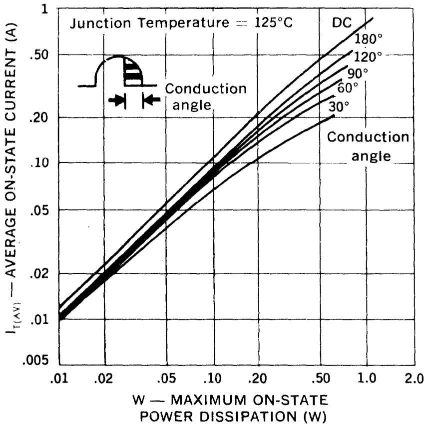
Circuit Commutated Turn-Off Time vs. Junction Temp.



Current vs. On State Voltage



Current vs. Power Dissipation



SCRs
1.6 Amp, Planar

ID200-ID203
ID300-ID301

FEATURES
- Voltage Rating: to 200V
- Max. Gate Trigger Current: 200μA
- Hermetically Sealed Metal Can
- Planar Passivated Construction

DESCRIPTION
This Data Sheet describes Unitrode's line of hermetically sealed industrial SCRs designed for high-voltage, medium-current control applications. The Series is packaged in a TO-39 metal case with Unitrode's unique oxide passivated junctions to ensure reliability and parameter stability.

Typical applications include relay equipment, motor controls, process controllers and pulse generators.

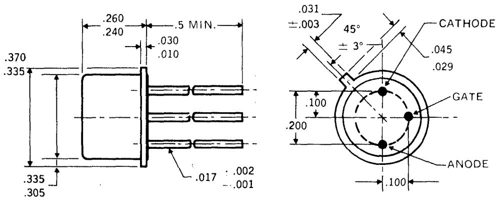
ABSOLUTE MAXIMUM RATINGS

	ID200	ID201	ID202	ID203	ID300	ID301
Repetitive Peak Off-State Voltage, V_{DRM}	50V	100V	150V	200V	300V	400V
Repetitive Peak Reverse Voltage, V_{RRM}	50V	100V	150V	200V	300V	400V
Non-Repetitive Peak Reverse Voltage, V_{RSM} (<5ms)	75V	150V	225V	300V	400V	500V

On-State Current, $I_{T(RMS)}$	
70°C Case	1.6A
75°C Ambient	450mA
Peak One Cycle Surge (Non-Repetitive) On-State Current, I_{TSM}	15A
Repetitive Peak On-State Current, I_{TRM}	up to 30A
Rate of Rise of On-State Current, di/dt	100A/μs
I^2t (for times > 1.5 ms)	0.83A²s
Peak Gate Current, I_{GM}	250mA
Average Gate Current, $I_{G(AV)}$	25mA
Reverse Gate Voltage, V_{GR}	6V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−40°C to +110°C

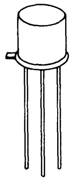
MECHANICAL SPECIFICATIONS

ID200-ID203 ID300-ID301



Dimensions in inches.

TO-39



UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	10	μA	V_{DRM} = Rating, R_{GK} = 1K, T = 25°C
		—	5	100	μA	V_{DRM} = Rating, R_{GK} = 1K, T = 110°C
Reverse Current	I_{RRM}	—	—	10	μA	V_{RRM} = Rating, R_{GK} = 1K, T = 25°C
		—	10	100	μA	V_{RRM} = Rating, R_{GK} = 1K, T = 110°C
Gate Trigger Current	I_{GT}	—	—	200	μA	V_D = 5V, R_{GS} = 10K, T = 25°C
		—	—	500	μA	V_D = 5V, R_{GS} = 10K, T = −40°C
On-State Voltage	V_{GT}	0.4	0.52	0.8	V	V_D = 5V, R_{GS} = 100Ω, T = 25°C
		0.5	0.7	1.0	V	V_D = 5V, R_{GS} = 100Ω, T = −40°C
		0.2	—	—	V	V_D = 5V, R_{GS} = 100Ω, T = 110°C
Peak On — Voltage	V_{TM}	—	—	2.2	V	I_T = 4 Amp Pulse, T = 25°C
Holding Current	I_H	0.3	0.7	3.0	mA	R_{GK} = 1K, T = 25°C
		0.4	—	6.0	mA	R_{GK} = 1K, T = −40°C
		0.2	—	—	mA	R_{GK} = 1K, T = 110°C
Off-State Voltage — Critical Rate of Rise	dv/dt	—	20	—	V/μs	V_{DRM} = Rated, R_{GK} = 1K, T = 110°C
Turn-on Time	t_{on}	—	1.0	—	μs	I_G = 10mA, I_T = I_A, V_D = 30V, T = 25°C
Circuit Commutated Turn-off Time	t_q	—	—	40	μs	I_T = i_R = 1A, R_{GK} = 1K, T = 25°C

Note: Blocking voltage ratings apply over the full operating temperature range, provided the gate is connected to the cathode through a resistor, 1000 ohms or smaller, or other adequate bias is used.

SCRs

IP100-IP104

.8 Amp RMS, Plastic

FEATURES

- Voltage Ratings: to 400V
- Forward Current: 0.8A RMS
- Surge Current: 6A, 8 ms
- Gate Sensitivity: 200 μA max.
- Planar Passivated Process
- TO-92 Plastic Package

DESCRIPTION

This plastic series features very fast switching performance, low forward voltage drop and a high degree of reliability and parameter stability. All units are fully planar passivated and are packaged in a rugged TO-92 case, constructed from a special epoxy compound that features excellent moisture resistance providing stable performance under high humidity conditions and good thermal transfer characteristics.

TYPICAL APPLICATIONS

Lamp Driving
Relay Driving
Relay Replacement
Alarm Systems
Counters

Process Controls
Pressure Controls
Display Systems
Touch Switches
and many other current sensing and control applications.

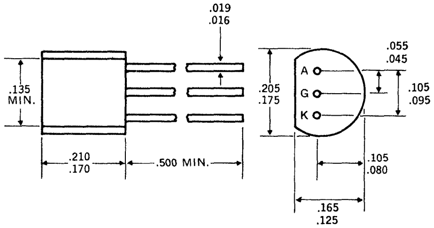
Remote Controls
High Current SCR Driving
Timers
Temperature Controls

ABSOLUTE MAXIMUM RATINGS

	IP100	IP101	IP102	IP103	IP104
Repetitive Peak Off-State Voltage, V_{DRM}	30V	60V	100V	150V	200V
Repetitive Peak Reverse Voltage, V_{RRM}	30V	60V	100V	150V	200V
On-State Current, I_T	0.8A				
Surge (Non-Rep.) On-State Current, I_{TSM}	6A				
Peak Gate Current, I_{GM}	1.0A				
Peak Gate Power, P_{GM}	1W				
Average Gate Power, P_G (Av.)	0.01W				
Reverse Gate Voltage, V_{GR}	6V				
Storage Temperature Range	–65°C to +150°C				
Operating Temperature Range	–65°C to +125°C				

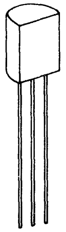
MECHANICAL SPECIFICATIONS

IP100-IP104



Dimensions in inches.

TO-92

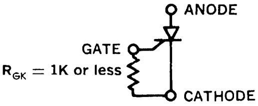


ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

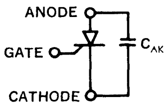
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	— —	0.1 —	1.0 50	μA μA	V_{DRM} = Rating, R_{GK} = 1K V_{DRM} = Rating, R_{GK} = 1K, T = 125°C
Reverse Current	I_{RRM}	— —	0.1 —	1.0 50	μA μA	V_{RRM} = Rating, R_{GK} = 1K V_{RRM} = Rating, R_{GK} = 1K, T = 125°C
Gate Trigger Current	I_{GT}	— —	0.4 —	200 500	μA μA	V_D = 6V, R_{GS} = 10K, V_D = 6V, R_{GS} = 10K, T = –65°C
Gate Trigger Voltage	V_{GT}	— — 0.1	0.6 — —	0.8 1.0 —	V V V	V_D = 6V, R_{GS} = 100Ω V_D = 6V, R_{GS} = 100Ω, T = –65°C V_D = 6V, R_{GS} = 100Ω, T = 125°C
Peak On-State Voltage	V_{TM}	—	1.2	1.7	V	I_{TM} = 1 Amp Pulse
Holding Current	I_{HX}	— —	0.7 —	5.0 10.0	mA mA	R_{GK} = 1K, T = 25°C R_{GK} = 1K, T = –65°C
Critical Rate of Rise — Off-State Voltage	dv/dt	—	75	—	V/μs	V_D = Rating, R_{GK} = 1K,
Turn-on Time	t_{on}	—	0.1	—	μs	I_G = 10mA, $I_{T'}$ = 1A, V_D = 30V
Circuit Commutated Turn-off Time	t_q	—	8.0	—	μs	I_T = I_R = 1A, R_{GK} = 1K

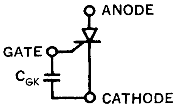
DESIGN CONSIDERATIONS

1. The IP100 Series SCRs are guaranteed to block their rated voltage over their rated operating temperature when a resistance of 1000 ohms or less is connected from gate to cathode as shown.

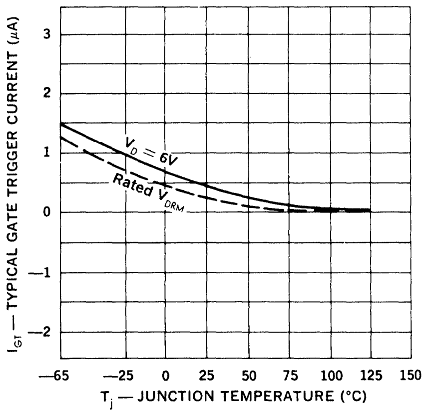


2. In cases where the SCR may be subjected to fast rising anode voltages a capacitor can be connected between anode or gate and cathode as shown, to serve as protection against dv/dt firing.

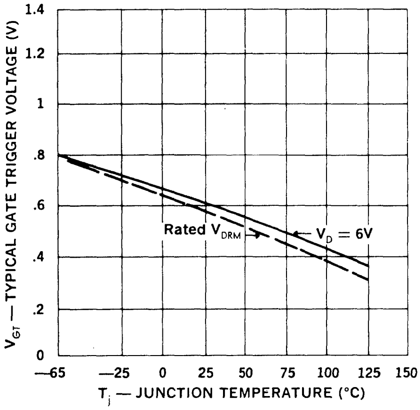


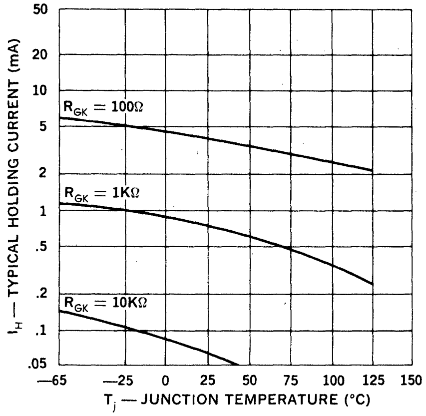


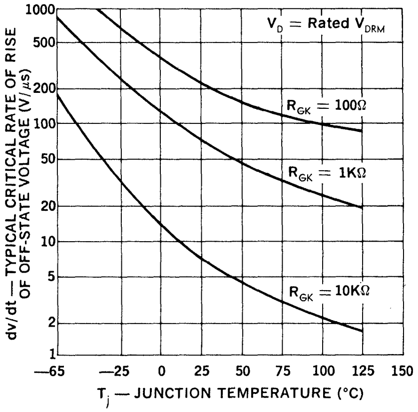
Gate Trigger Current vs. Junction Temp.

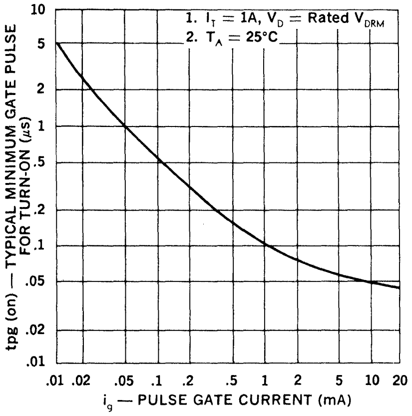


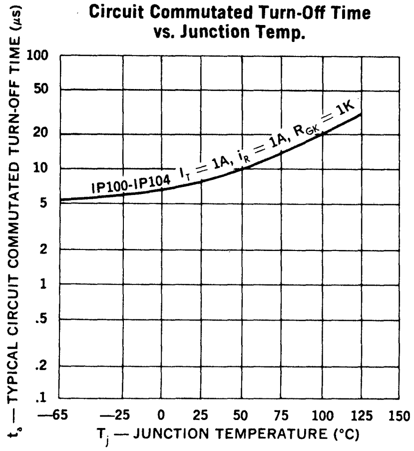
Gate Trigger Voltage vs. Junction Temp.

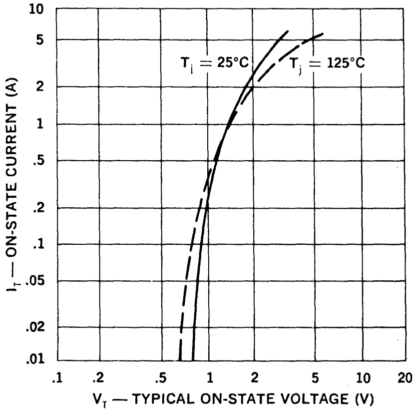


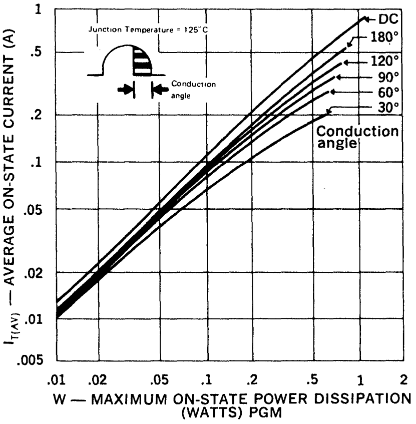

Holding Current vs. Junction Temp.


dv/dt vs. Junction Temp.

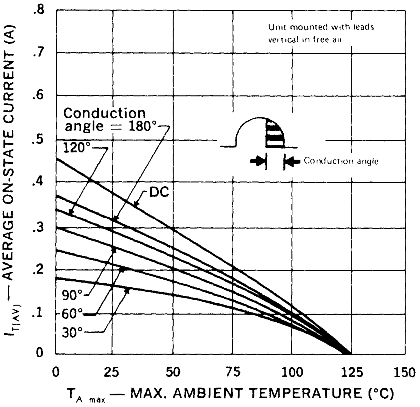

Gate Pulse For Turn-On vs. Pulse Gate Current


Circuit Commutated Turn-Off Time vs. Junction Temp.

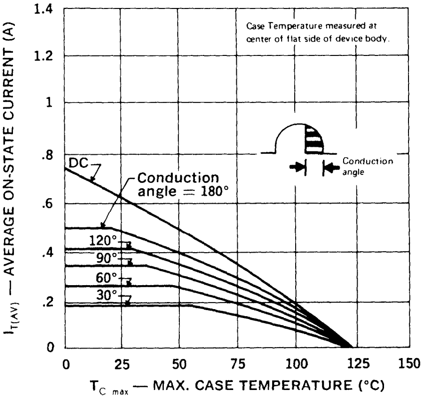

Current vs. On-State Voltage


Current vs. Power Dissipation

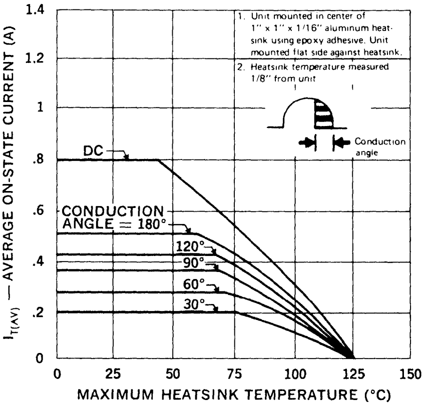
Current
vs. Ambient Temp.



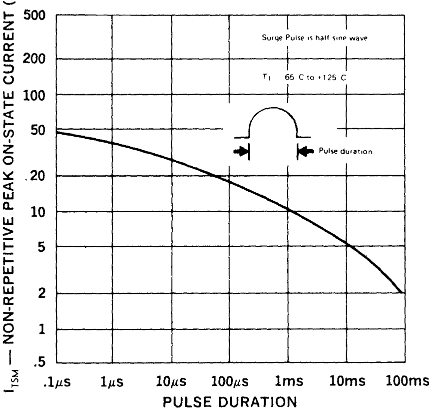
Current
vs. Case Temp.



Current
vs. Heatsink Temp.



Surge Rating
vs. Pulse Duration



X

SCRs

IP105-IP106

.8 Amp RMS, Plastic

FEATURES

- Voltage Ratings: to 400V
- Forward Current: 0.8A RMS
- Surge Current: 6A, 8 ms
- Gate Sensitivity: 200 μA max.
- Planar Passivated Process
- TO-92 Plastic Package

DESCRIPTION

This plastic series features very fast switching performance, low forward voltage drop and a high degree of reliability and parameter stability. All units are fully planar passivated and are packaged in a rugged TO-92 case, constructed from a special epoxy compound that features excellent moisture resistance providing stable performance under high humidity conditions and good thermal transfer characteristics.

TYPICAL APPLICATIONS

Lamp Driving
Relay Driving
Relay Replacement
Alarm Systems
Counters

Process Controls
Pressure Controls
Display Systems
Touch Switches

Remote Controls
High Current SCR Driving
Timers
Temperature Controls

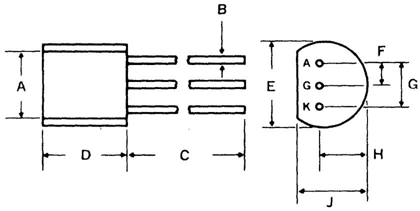
and many other current sensing and control applications.

MAXIMUM RATINGS

	IP105	IP106
Repetitive Peak Off-State Voltage, V_{DRM}	300V	400V
Repetitive Peak Reverse Voltage, V_{RRM}	300V	400V
On-State Current, I_T RMS At 60°C Case, 180° Conduction Sinewave	.8A	
Surge (Non-Rep.) On-State Current, I_{TSM}	6A	
Peak Gate Power, P_{GM}	1W	
Average Gate Power P_G (AV.)	0.01W	
Reverse Gate Voltage, V_{GR}	6V	
Storage Temperature Range	−55°C to +150°C	
Operating Temperature Range	−55°C to +110°C	

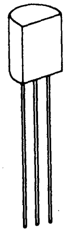
MECHANICAL SPECIFICATIONS

IP105-IP106



	inches	millimeters
A	.135 MIN.	3.43 MIN.
B	.019 - .016	.48 - .41
D	.210 - .170	5.33 - 4.32
C	.500 MIN.	12.7 MIN.
E	.205 - .175	5.21 - 4.45
J	.165 - .125	4.19 - 3.18
F	.055 - .045	1.40 - 1.14
G	.105 - .095	2.67 - 2.41
H	.105 - .080	2.67 - 2.03

TO-92

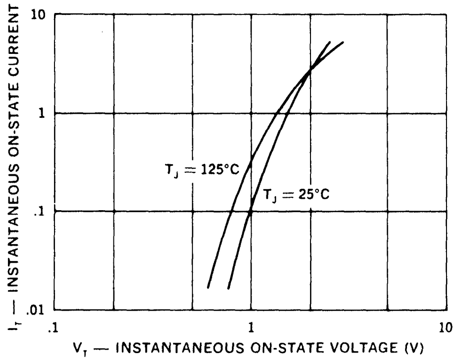


UNITRODE

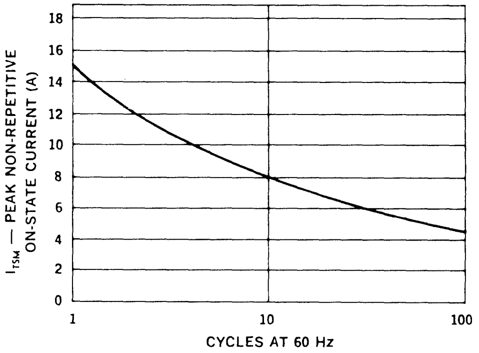
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	100	μA	V_{DRM} = Rating, R_{GK}= 1K, T= 110°C
Reverse Current	I_{RRM}	—	—	100	μA	V_{RRM} = Rating, R_{GK}= 1K, T= 110°C
Gate Trigger Current	I_{GT}	—	10	200	μA	$V_D = 6V, R_{GS} = 10K$
Gate Trigger Voltage	V_{GT}	— — 0.1	0.6 — —	0.8 1.2 —	V V V	$V_D = 6V, R_{GS} = 100\Omega$ $V_D = 6V, R_{GS} = 100\Omega, T = -55°C$ $V_D = 6V, R_{GS} = 100\Omega, T = 125°C$
Peak On-State Voltage	V_{TM}	—	—	1.5	V	$I_{TM} = 1$ Amp Pulse
Holding Current	I_{HX}	— —	0.7 —	5.0 10.0	mA mA	$R_{GK} = 1K, T = 25°C$ $R_{GK} = 1K, T = -55°C$
Critical Rate of Rise — Off-State Voltage	dv/dt	—	75	—	V/μs	V_D = Rating, $R_{GK} = 1K$
Turn-on Time	t_{on}	—	0.5	—	μs	$I_G = 10mA, I_T, = 1A, V_D = 30V$
Circuit Commutated Turn-off Time	t_q	—	15	—	μs	$I_T = I_R = 1A, R_{GK} = 1K$

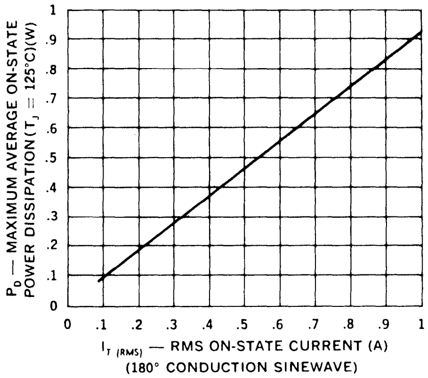
Maximum On-State Characteristics



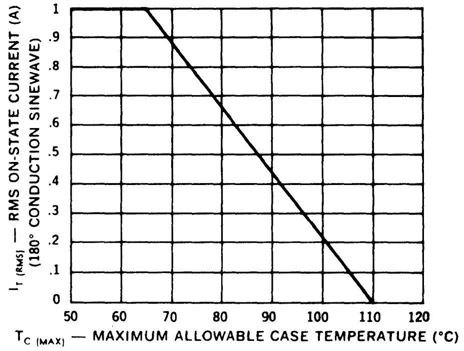
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



Maximum On-State Power Dissipation (60Hz)



Maximum Allowable Case Temperature vs. On-State Current (60Hz)



X

TRIACs

30 Amp RMS, 800V, ChipStrate®

L1BO4302F
L1BO4304F
L1BO4306F
L1BO4308F

FEATURES

- Voltage Ratings: to 800V
- Hard-Glass Passivated Junction
- Miniature Size
- Isolated Case
- Economical Design

DESCRIPTION

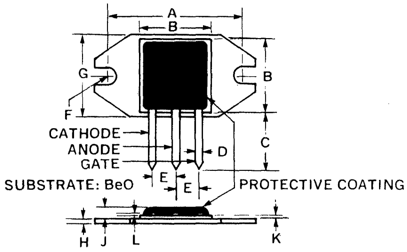
Unitrode ChipStrate power Triacs combine the most advanced hard-glass passivated chips with a metallized ceramic substrate. The resultant ChipStrate provides the economy of an unpackaged chip with the reliability and handling ease of a discrete device.

ABSOLUTE MAXIMUM RATINGS

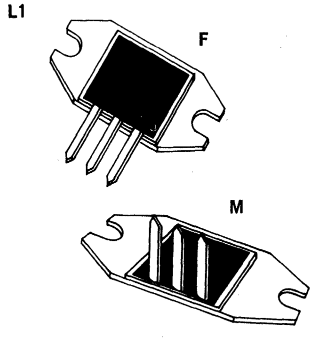
	L1BO4302F	L1BO4304F	L1BO4306F	L1BO4308F
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V	800V
On-State Current $I_{T(RMS)}$ (at $T_C = 80°C$ and conduction angle of 360°)	30A			
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	300A			
Peak Gate Power, P_{GM}	40W			
Average Gate Power, $P_{G(AV)}$	.75W			
Rate of On-State Current, di/dt (at $V_{DM} = V_{DRM}$, $I_{GT} = 200mA$, $t_r = .1\mu s$)	150 A/μs			
Storage Temperature Range	—40°C to +150°C			
Operating Temperature Range	—40°C to +110°C			

MECHANICAL SPECIFICATIONS

L1BO4302F L1BO4304F L1BO4306F L1BO4308F



L1 with Flange		
	INS.	mm
A	1.176 – 1.196	29.87 – 30.38
B	.650	16.51
C	.500 NOM.	12.70 NOM.
D	.060	1.53
E	.200	5.08
F	.078 R. TYP.	.20 R. TYP.
G	.690 – .710	17.52 – 18.04
H	.050	1.27
J	.150	3.81
K	.025	.64
L	.020	.51



PART NO. SUFFIX: When ordering, specify correct part number suffix.

F — (standard package) — FLANGE MOUNTED, STRAIGHT LEADS
M — FLANGE MOUNTED, PREBENT LEADS
S — SOLDERABLE BACK, STRAIGHT LEADS (not shown)
B — SOLDERABLE BACK, PREBENT LEADS (not shown)

1/79 ChipStrate® is a registered trademark of Unitrode Corporation.

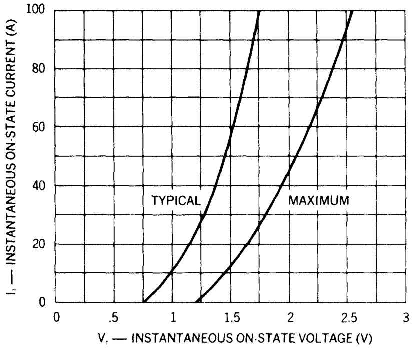
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

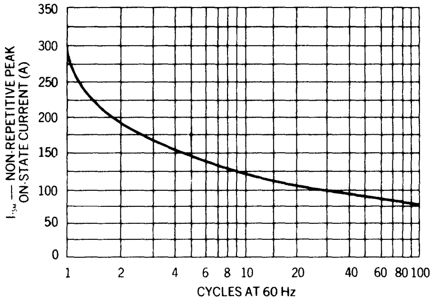
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	4.0	mA	V_{DRM} = Rating T_C = 100°C
Gate Trigger Current	I_{GT}	—	—	80 120	mA	V_D = 12V Quadrant 1, 3 (+ +, − −) V_D = 12V Quadrant 2, 4 (+ −, − +)
Gate Trigger Voltage	V_{GT}	—	—	3.0	V	V_D = 12V
Peak On-State Voltage	V_{TM}	—	—	2.0	V	I_{TM} = 42A Peak
Holding Current	I_H	—	—	60	mA	V_D = 12V
Critical Rate of Rise — Off-State Voltage	dv/dt	40 25 20 10	75 50 40 25	—	V/μS	L1BO4302F L1BO4304F V_{DRM} = Rating, T_C = 100°C L1BO4306F L1BO4308F
Critical Rate of Rise — Commutated Off-State Voltage	$dv/dt_{(c)}$	3	15	—	V/μS	I_T = Rating, V_{DRM} = Rating, T_C = 65°C
Steady State Thermal Resistance*	$R\Theta_{JC}$	—	—	.8	°C/W	Steady State

* Junction-to-Case

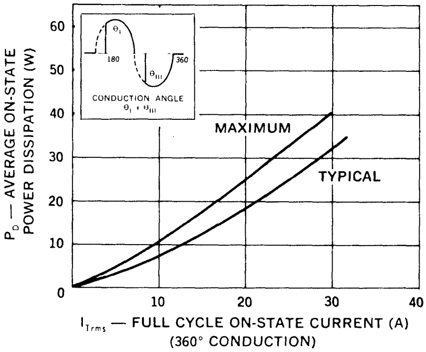
On-State Characteristics



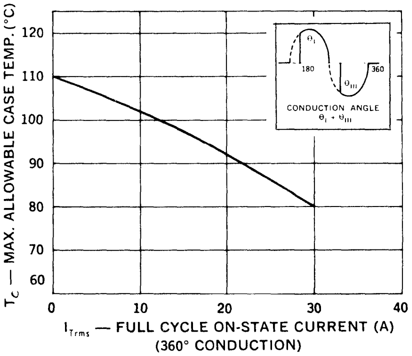
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



Maximum Conduction Power Dissipation vs. On-State Current (50 or 60HZ)



Maximum Allowable Case Temp. vs. On-State Current (50 or 60HZ)



X

RECOMMENDED MOUNTING METHODS

1. Screw Mount Using Standard Flange
2. Solder
3. Thermally Conductive Epoxy
4. Two-Sided Adhesive Electrical Tape
5. P.C. Board Mount (For Low Duty Cycle Applications)

TRIACs
40 Amp RMS, 800V, ChipStrate®

L1BO5402F
L1BO5404F
L1BO5406F
L1BO5408F

FEATURES

- Voltage Ratings: to 800V
- Hard-Glass Passivated Junction
- Miniature Size
- Isolated Case
- Economical Design

DESCRIPTION

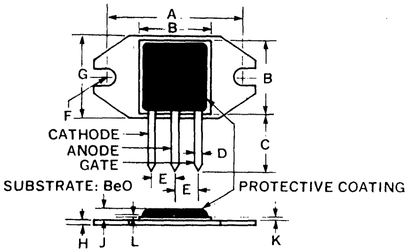
Unitrode ChipStrate power Triacs combine the most advanced hard-glass passivated chips with a metallized ceramic substrate. The resultant ChipStrate provides the economy of an unpackaged chip with the reliability and handling ease of a discrete device.

ABSOLUTE MAXIMUM RATINGS

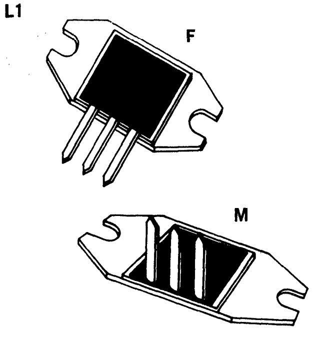
	L1BO5402F	L1BO5404F	L1BO5406F	L1BO5408F
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V	800V
On-State Current $I_{T(RMS)}$ (at $T_C = 80°C$ and conduction angle of 360°)	40A			
Peak One Cycle Surge (Non-Rep.) On-State Current, $I_{T(RMS)}$	400A			
Peak Gate Power, P_{GM}	16W			
Average Gate Power $P_{G(AV)}$	.75W			
Rate of On-State Current, di/dt (at $V_{DM} = V_{DRM}$, $I_{GT} = 250mA$, $t_r = .1\mu s$)	200 A/μs			
Storage Temperature Range	−40°C to +150°C			
Operating Temperature Range	−40°C to +110°C			

MECHANICAL SPECIFICATIONS

L1BO5402F L1BO5404F L1BO5406F L1BO5408F



L1 with Flange		
	INS.	mm
A	1.176 – 1.196	29.87 – 30.38
B	.650	16.51
C	.500 NOM.	12.70 NOM.
D	.060	1.53
E	.200	5.08
F	.078 R. TYP.	.20 R. TYP.
G	.690 – .710	17.52 – 18.04
H	.050	1.27
J	.150	3.81
K	.025	.64
L	.020	.51



PART NO. SUFFIX: When ordering, specify correct part number suffix.

F — (standard package) — FLANGE MOUNTED, STRAIGHT LEADS
M — FLANGE MOUNTED, PREBENT LEADS
S — SOLDERABLE BACK, STRAIGHT LEADS (not shown)
B — SOLDERABLE BACK, PREBENT LEADS (not shown)

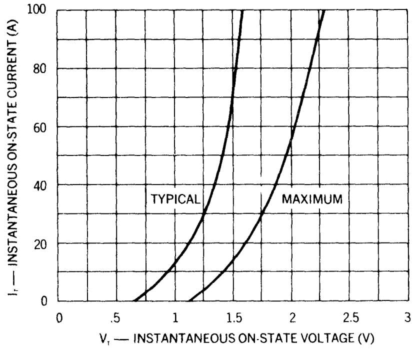
ChipStrate® is a registered trademark of Unitrode Corporation.

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

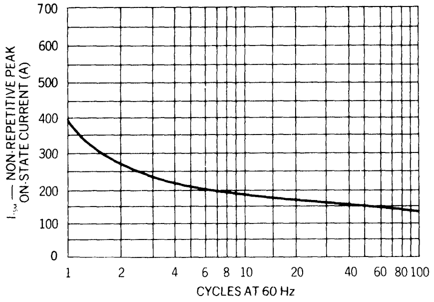
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	4.0	mA	V_{DRM} = Rating, $T_C = 100°C$
Gate Trigger Current	I_{GT}	— —	— —	80 120	mA mA	V_D = 12V Quadrants 1, 3 (+ +, — —) V_D = 12V Quadrants 2, 4 (+ —, — +)
Gate Trigger Voltage	V_{GT}	—	—	3.0	V	$V_D = 12V$
Peak On-State Voltage	V_{TM}	—	—	2.0	V	I_{TM} = 57A Peak
Holding Current	I_H	—	—	90	mA	$V_D = 12V$
Critical Rate of Rise — Off-State Voltage	dv/dt	40 25 20 10	150 100 75 50	— — — —	V/μS	L1BO5402F L1BO5404F L1BO5406F L1BO5408F V_{DRM} = Rating, $T_C = 100°C$
Critical Rate of Rise — Commutated Off-State Voltage	dv/dt$_{(c)}$	4	10	—	V/μS	I_T = Rating, V_{DRM} = Rating, $T_C = 65°C$
Steady State Thermal Resistance*	$R\Theta_{JC}$	—	—	.7	°C/W	Steady State

* Junction-to-Case

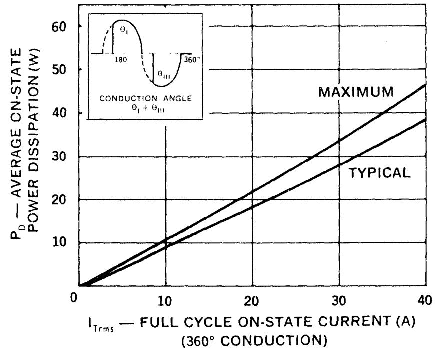
On-State Characteristics



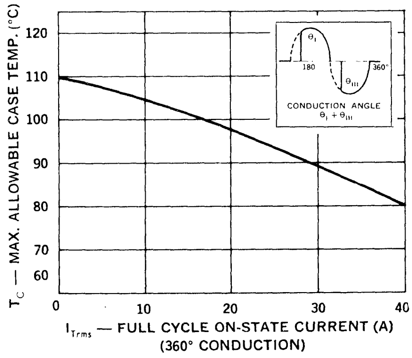
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



Maximum Conduction Power Dissipation vs. On-State Current (50 or 60HZ)



Maximum Allowable Case Temp. vs. On-State Current (50 or 60HZ)



RECOMMENDED MOUNTING METHODS

1. Screw Mount Using Standard Flange
2. Solder
3. Two-Sided Adhesive Electrical Tape
4. P.C. Board Mount (For Low Duty Cycle Applications)

TRIACs
20 Amp RMS, 800V, ChipStrate®

L2BO6202F
L2BO6204F
L2BO6206F
L2BO6208F

FEATURES
- Voltage Ratings: to 800V
- Hard-Glass Passivated Junction
- Miniature Size
- Isolated Case
- Economical Design

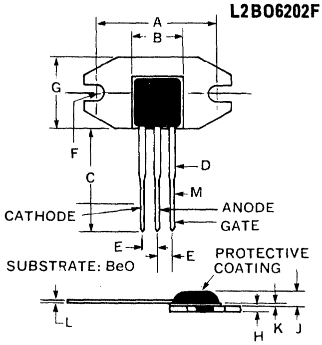
DESCRIPTION
Unitrode ChipStrate power Triacs combine the most advanced hard-glass passivated chips with a metallized ceramic substrate. The resultant ChipStrate provides the economy of an unpackaged chip with the reliability and handling ease of a discrete device.

ABSOLUTE MAXIMUM RATINGS

	L2BO6202F	L2BO6204F	L2BO6206F	L2BO6208F
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V	800V
On-State Current $I_{T(RMS)}$ (at $T_C = 80°C$ and conduction angle of 360°)	20A			
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}	200A			
Peak Gate Power, P_{GM}	16W			
Average Gate Power, $P_{G(AV)}$	.5W			
Rate of On-State Current, di/dt (at $V_{DM} = V_{DRM,}$ $I_{GT} = 175mA$, $t_r = .1\mu s$)	125 A/μs			
Storage Temperature Range	−40°C to +150°C			
Operating Temperature Range	−40°C to +110°C			

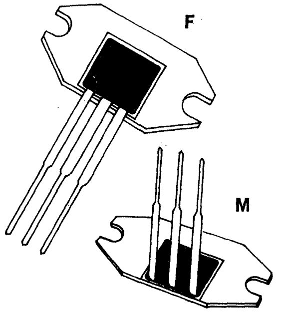
MECHANICAL SPECIFICATIONS

L2BO6202F L2BO6204F L2BO6206F L2BO6208F



L2 with Flange		
	INS.	mm
A	1.176 – 1.196	29.87 – 30.38
B	.500	12.70
C	1.0 NOM.	25.4 NOM.
D	.060	1.53
E	.150	3.81
F	.078 R. TYP.	.20 R. TYP.
G	.690 – 710	17.52 – 18.04
H	.050	1.27
J	.150	3.81
K	.025	.64
L	.020	.51
M	.040	1.02

L2



PART NO. SUFFIX: When ordering, specify correct part number suffix.

F — (standard package) — FLANGE MOUNTED, STRAIGHT LEADS
M — FLANGE MOUNTED, PREBENT LEADS
S — SOLDERABLE BACK, STRAIGHT LEADS (not shown)
B — SOLDERABLE BACK, PREBENT LEADS (not shown)

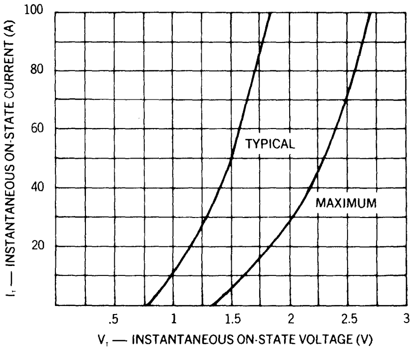
ChipStrate® is a registered trademark of Unitrode Corporation.

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

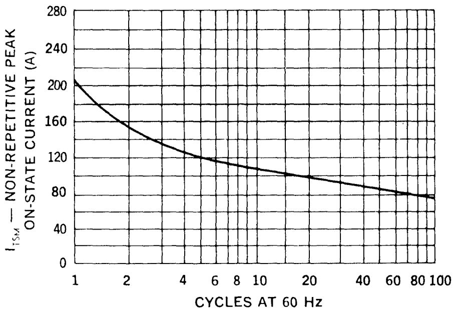
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	2.0	mA	V_{DRM} = Rating, T_C = 100°C
Gate Trigger Current	I_{GT}	— —	— —	50 80	mA	V_D = 12V Quadrants 1, 3 (+ +, — —) V_D = 12V Quadrants 2, 4 (+ —, — +)
Gate Trigger Voltage	V_{GT}	—	—	2.5	V	V_D = 12V
Peak On-State Voltage	V_{TM}	—	—	1.9	V	I_{TM} = 28A Peak
Holding Current	I_H	—	—	50	mA	V_D = 12V
Critical Rate of Rise — Off-State Voltage	dv/dt	30 20 10 10	75 50 30 25	— — — —	V/μS	L2BO6202F L2BO6204F L2BO6206F L2BO6208F V_{DRM} = Rating, T_C = 100°C
Critical Rate of Rise — Commutated Off-State Voltage	dv/$dt_{(c)}$	3	10	—	V/μS	I_T = Rating, V_{DRM} = Rating, T_C = 65°C
Steady State Thermal Resistance*	$R\theta_{JC}$	—	—	1.1	°C/W	Steady State

* Junction-to-Case

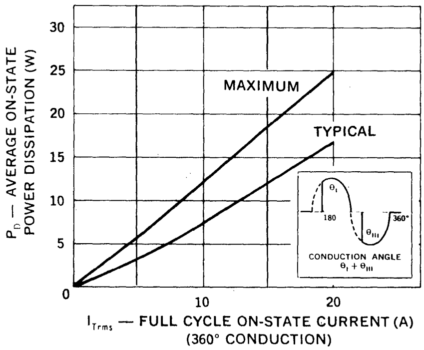
On-State Characteristics



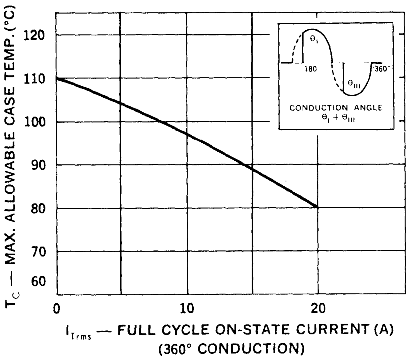
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



Maximum Conduction Power Dissipation vs. On-State Current (50 or 60HZ)



Maximum Allowable Case Temp. vs. On-State Current (50 or 60HZ)



RECOMMENDED MOUNTING METHODS

1. Screw Mount Using Standard Flange
2. Solder
3. Two-Sided Adhesive Electrical Tape
4. P.C. Board Mount (For Low Duty Cycle Applications)

SCRs

10 Amp. RMS 800V ChipStrate® Fast Turn-Off Types

For Inverter and Pulse Applications

L2R06102FG
L2R06104FG
L2R06106FG
L2R06108FG

FEATURES:

- Fast Turn-Off Time
- Shorted Emitter Construction
- High-Current Pulse Capability
- High di/dt and dv/dt Rating
- Center Gate Construction
- Isolated Case
- Economical Design

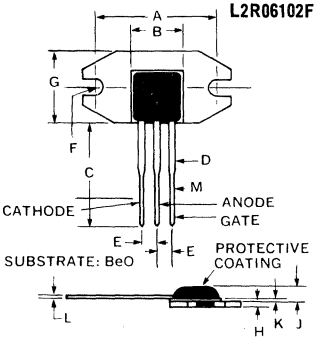
DESCRIPTION:

This series of SCR's is specifically designed for use in inverter and high current pulse applications and exhibits excellent turn-off capability even at much higher currents than their rated values. These devices are made with the most advanced hard glass passivated chips mounted on Unitrode's very economical ChipStrate package.

ABSOLUTE MAXIMUM RATINGS

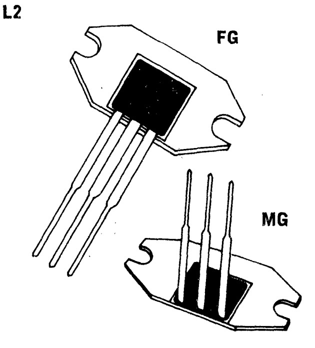
	L2R06102FG	L2R06104FG	L2R06106FG	L2R06108FG
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V	800V
Repetitive Peak Reverse Voltage, V_{RRM}	200V	400V	600V	800V
On-State Current, $I_{T(RMS)}$ (at $T_C = 65°C$ and conduction angle of 180°)	10A			
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM} (60 Hz Sinusoidal)	120A			
Peak Gate Power, P_{GM} (for 10µs Max.)	20W			
Average Gate Power $P_{G(AV)}$	.5W			
Storage Temperature Range	—40°C to +150°C			
Operating Temperature Range	—40°C to +110°C			
Rate of Change of On-State Current di/dt @ V_{DRM}	150 A/µs			
Fusing Current I^2t (T_J = —40 to 100°C t = 1 to 8.3ms)	85 A^2 sec			

MECHANICAL SPECIFICATIONS



L2R06102FG L2R06104FG L2R06106FG L2R06108FG

L2 with Flange		
	INS.	mm
A	1.176 – 1.196	29.87 – 30.38
B	.500	12.70
C	1.0 NOM.	25.4 NOM.
D	.060	1.53
E	.150	3.81
F	.078 R. TYP.	.20 R. TYP.
G	.690 – 710	17.52 – 18.04
H	.050	1.27
J	.150	3.81
K	.025	.64
L	.020	.51
M	.040	1.02



PART NO. SUFFIX: When ordering, specify correct part number suffix.
FG — (standard package) — FLANGE MOUNTED, STRAIGHT LEADS
MG — FLANGE MOUNTED, PREBENT LEADS
SG — SOLDERABLE BACK, STRAIGHT LEADS (not shown)
BG — SOLDERABLE BACK, PREBENT LEADS (not shown)

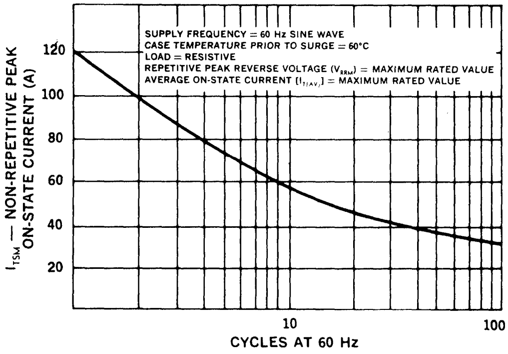
ChipStrate® is a registered trademark of Unitrode Corporation.

UNITRODE

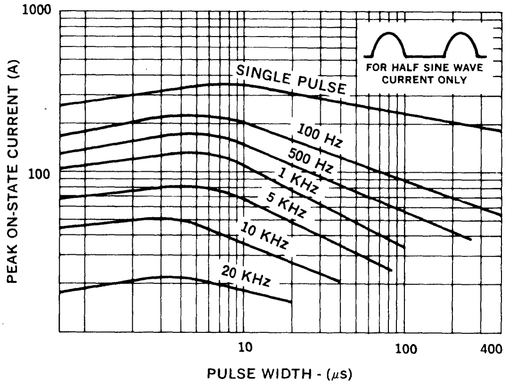
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}		2	4	mA	V_{DRM} = Rating, T_C = 100°C
Reverse Current	I_{RRM}		2	4	mA	V_{RRM} = Rating, T_C = 100°C
Gate Trigger Current	I_{GT}		30	70	mA	V_D = 12V, R_L = 30Ω
Gate Trigger Voltage	V_{GT}		1.2	3	V	V_D = 12V, R_L = 30Ω
Peak On-State Voltage	V_{TM}			10	V	I_{TM} = 100A (Peak)
Holding Current	I_H		130	175	mA	V_D = 12V, Gate Open
Critical Rate of Rise of Off-State Voltage	dv/dt	400			V/μsec	$V_D = V_{DRM,}$ T_C = 80°C
Gate Controlled Turn-On Time, $t_d + t_r$	t_{on}		1.0		μsec	I_T = 2A, I_{GT} = 200mA $V_D = V_{DRM}$
Circuit Commutated Turn-Off Time	t_q		6	8	μsec	Note 1
Thermal Resistance Junction-to-Case	$R_{\theta JC}$			1.3	°C/W	

Note 1 $V_D = V_{DRM,}$ I_T = 100A, PW = 50μsec
V_{RX} = −15V min, V_{GT} = OV (at t_{off})
dv/dt = 100 v/μsec, −5A/μsec
I_{GT} = 100mA, T_C = 80°C

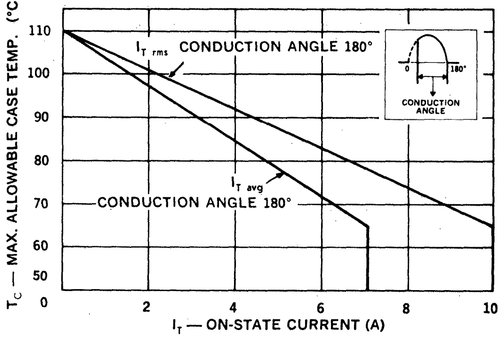


Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions

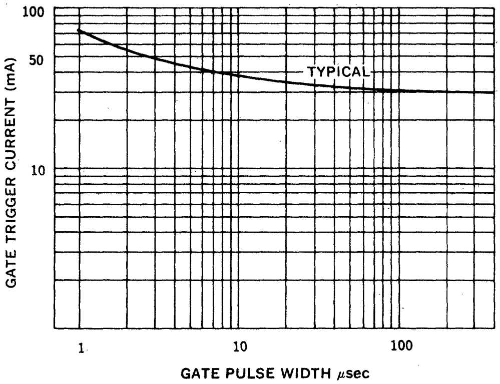


Maximum Allowable Peak On-State Current vs. Pulse Width

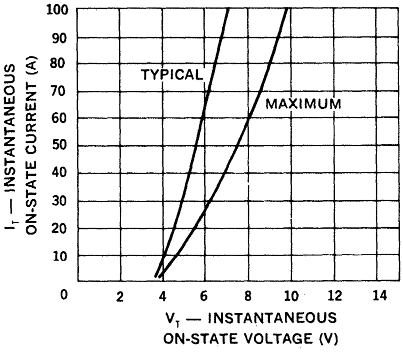
Maximum Allowable Case Temp. vs. On-State Current (50 or 60Hz)



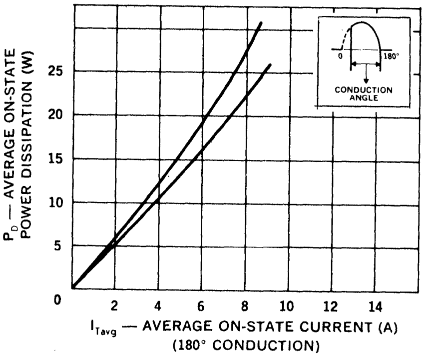
Gate Trigger Current vs. Gate Pulse Width $t_r = 20$ nsec



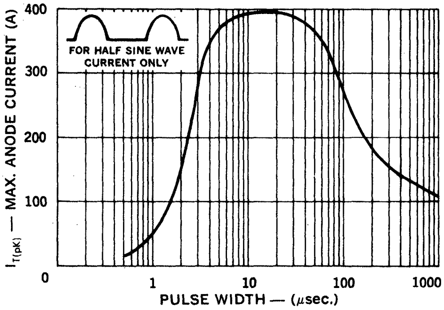
On-State Characteristics



Maximum Conduction Power Dissipation vs. On-State Current (50 or 60Hz)



Maximum Peak Current vs. Pulse Width



SCRs

25 Amp RMS, 800V, ChipStrate®

L2RO6252F
L2RO6254F
L2RO6256F
L2RO6258F

FEATURES

- Voltage Ratings: to 800V
- Hard-Glass Passivated Junction
- Miniature Size
- Isolated Case
- Economical Design

DESCRIPTION

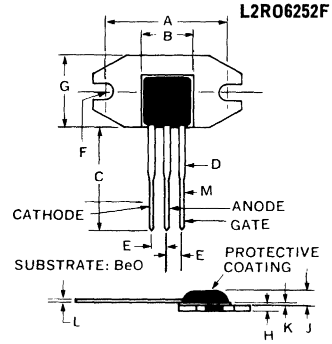
Unitrode ChipStrate power SCRs combine the most advanced hard-glass passivated chips with a metallized ceramic substrate. The resultant ChipStrate provides the economy of an unpackaged chip with the reliability and handling ease of a discrete device.

ABSOLUTE MAXIMUM RATINGS

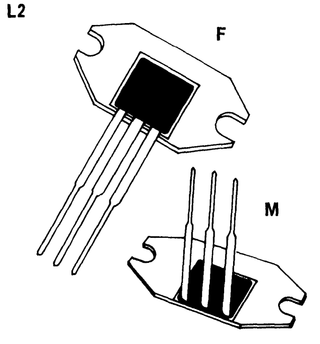
	L2RO6252F	L2RO6254F	L2RO6256F	L2RO6258F
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V	800V
Repetitive Peak Reverse Voltage, V_{RRM}	200V	400V	600V	800V
On-State Current, $I_{T(RMS)}$ (at $T_C = 80°C$ and conduction angle of 180°)		25A		
Peak One Cycle Surge (Non-Rep.) On--State Current, I_{TSM}		250A		
Peak Gate Power, P_{GM}		20W		
Average Gate Power $P_{G(AV)}$		.5W		
Rate of On-State Current, di/dt (at $V_{DM} = V_{DRM,}$ $I_{GT} = 150mA$, $t_r = .5\mu s$)		150 A/μs		
Fusing Current, $I^2{}_t$ (for SCR Protection) $T_j = -40°C$ to 110°C, 1 to 8.3msec		250 A^2s		
Storage Temperature Range		−40°C to +150°C		
Operating Temperature Range		−40°C to +110°C		

MECHANICAL SPECIFICATIONS

L2RO6252F L2RO6254F L2RO6256F L2RO6258F



L2 with Flange		
	INS.	mm
A	1.176 - 1.196	29.87 - 30.38
B	.500	12.70
C	1.0 NOM.	25.4 NOM.
D	.060	1.53
E	.150	3.81
F	.078 R. TYP.	.20 R. TYP.
G	.690 - 710	17.52 - 18.04
H	.050	1.27
J	.150	3.81
K	.025	.64
L	.020	.51
M	.040	1.02



PART NO. SUFFIX: When ordering, specify correct part number suffix.

F — (standard package) — FLANGE MOUNTED, STRAIGHT LEADS
M — FLANGE MOUNTED, PREBENT LEADS
S — SOLDERABLE BACK, STRAIGHT LEADS (not shown)
B — SOLDERABLE BACK, PREBENT LEADS (not shown)

ChipStrate® is a registered trademark of Unitrode Corporation.

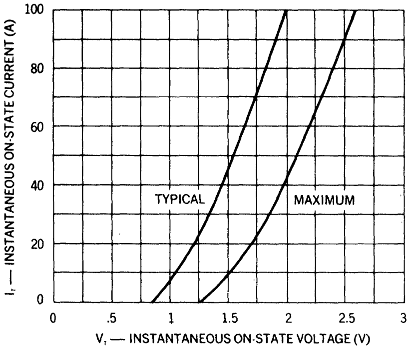
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

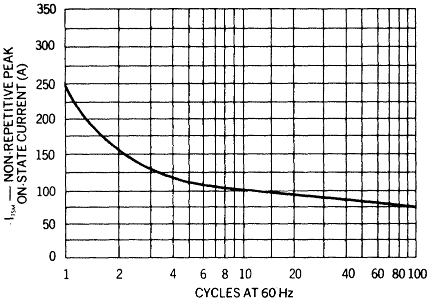
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	2.0	mA	V_{DRM} = Rating, T_C = 100°C
Reverse Current	I_{RRM}	—	—	2.0	mA	V_{RRM} = Rating, T_C = 100°C
Gate Trigger Current	I_{GT}	—	—	25	mA	V_D = 12V
Gate Trigger Voltage	V_{GT}	—	—	2.0	V	V_D = 12V
Peak On-State Voltage	V_{TM}	—	—	2.1	V	I_{TM} = 50A Peak
Holding Current	I_H	—	—	50	mA	V_D = 12V
Critical Rate of Rise — Off-State Voltage	dv/dt	100	200	—	V/µS	V_{DRM} = Rating, T_C = 100°C
Steady State Thermal Resistance*	$R\theta_{JC}$	—	—	1.1	°C/W	Steady State

* Junction-to-Case

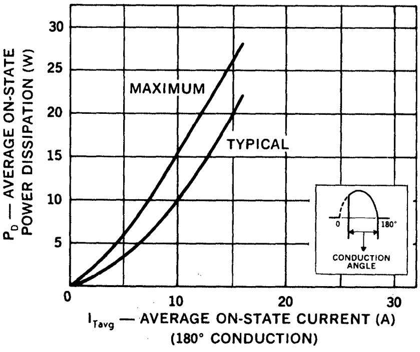
On-State Characteristics



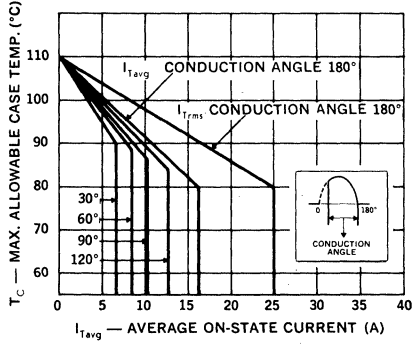
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



Maximum Conduction Power Dissipation vs. On-State Current (50 or 60HZ)



Maximum Allowable Case Temp. vs. On-State Current (50 or 60HZ)



RECOMMENDED MOUNTING METHODS

1. Screw Mount Using Standard Flange
2. Solder
3. Two-Sided Adhesive Electrical Tape
4. P.C. Board Mount (For Low Duty Cycle Applications)

TRIACs
10 Amp RMS, 800V, ChipStrate®

L7BO8102S
L7BO8104S
L7BO8106S
L7BO8108S

FEATURES
- Voltage Ratings: to 800V
- Hard-Glass Passivated Junction
- Miniature Size
- Isolated Case
- Economical Design

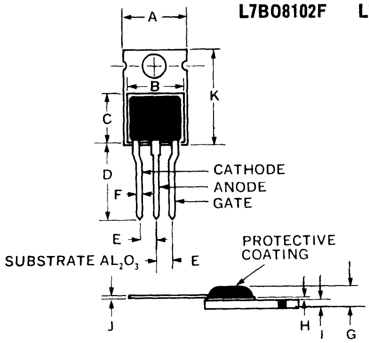
DESCRIPTION
Unitrode ChipStrate power Triacs combine the most advanced hard-glass passivated chips with a metallized ceramic substrate. The resultant ChipStrate provides the economy of an unpackaged chip with the reliability and handling ease of a discrete device.

ABSOLUTE MAXIMUM RATINGS

	L7BO8102S	L7BO8104S	L7BO8106S	L7BO8108S
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V	800V
On-State Current $I_{T(RMS)}$ (at $T_C = 65°C$ and conduction angle of 360°)		10A		
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}		100A		
Peak Gate Power, P_{GM}		16W		
Average Gate Power $P_{G(AV)}$		.5W		
Rate of On-State Current, di/dt (at $V_{DM} = V_{DRM}$, $I_{GT} = 150mA$, $t_r = .1\mu s$)		100 A/μs		
Storage Temperature Range		−40°C to +150°C		
Operating Temperature Range		−40°C to +110°C		

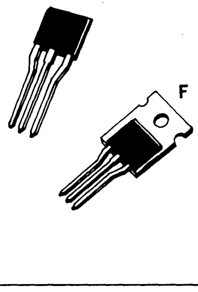
MECHANICAL SPECIFICATIONS

L7BO8102F L7BO8104F L7BO8106F L7BO8108F



L7 with Flange		
	INS.	mm
A	0.4	10.16
B	.350	8.89
C	.300	7.62
D	.500 MIN.	12.70 MIN.
E	.100	2.54
F	.032	.82
G	.150	3.81
H	.015	.39
I	.020	.51
J	.020	.51

L7



PART NO. SUFFIX: When ordering, specify correct part number suffix.

S (standard package) — SOLDERABLE BACK, STRAIGHT LEADS
F — FLANGE MOUNTED, STRAIGHT LEADS

UNITRODE

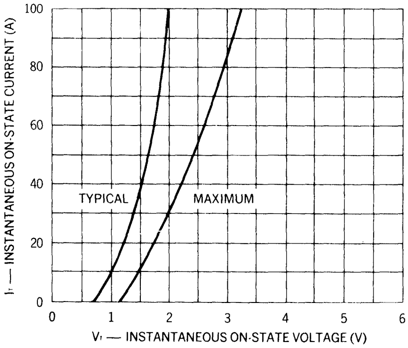
ChipStrate® is a registered trademark of Unitrode Corporation.

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

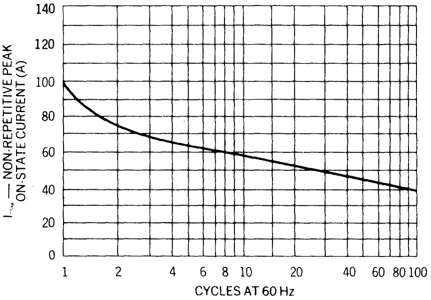
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	2.0	mA	V_{DRM} = Rating, $T_C = 100°C$
Gate Trigger Current	I_{GT}	— —	— —	30 50	mA mA	$V_D = 12V$ Quadrants 1 & 2 (+ +, — —) $V_D = 12V$ Quadrants 3 & 4 (— +, + —)
Gate Trigger Voltage	V_{GT}	—	—	2.0	V	$V_D = 12V$
Peak On-State Voltage	V_{TM}	—	—	1.6	V	I_{TM} = 14A Peak
Holding Current	I_H	—	—	30	mA	$V_D = 12V$
Critical Rate of Rise — Off-State Voltage	dv/dt	30 20 10 10	75 50 30 25	— — — —	V/μS	L7BO8102S L7BO8104S L7BO8106S L7BO8108S V_{DRM} = Rating, $T_C = 100°C$
Critical Rate of Rise — Commutated Off-State Voltage	$dv/dt_{(c)}$	3	10	—	V/μS	I_T = Rating, V_{DRM} = Rating, $T_C = 65°C$
Steady State Thermal Resistance*	$R\theta_{JC}$	—	—	3.0	°C/W	Steady State

*Junction-to-Case

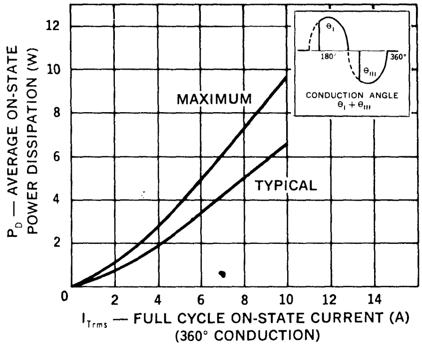
On-State Characteristics



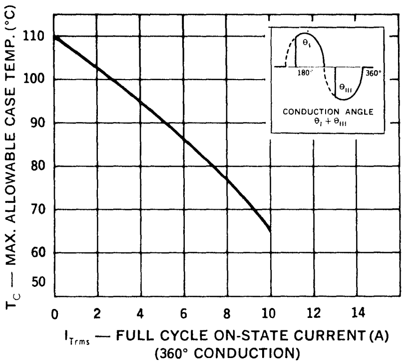
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



Maximum Conduction Power Dissipation vs. On-State Current (50 or 60HZ)



Maximum Allowable Case Temp. vs. On-State Current (50 or 60HZ)



RECOMMENDED MOUNTING METHODS

1. Screw Mount Using Standard Flange
2. Solder
3. Two-Sided Adhesive Electrical Tape
4. P.C. Board Mount (For Low Duty Cycle Applications)

SCRs

5 Amp. RMS 800V ChipStrate® Fast Turn-Off Types

For Inverter and Pulse Applications

L7R08052SG
L7R08054SG
L7R08056SG
L7R08058SG

FEATURES:

- Fast Turn-Off Time
- Shorted Emitter Construction
- High-Current Pulse Capability
- High di/dt and dv/dt Rating
- Center Gate Construction
- Isolated Case
- Economical Design

DESCRIPTION:

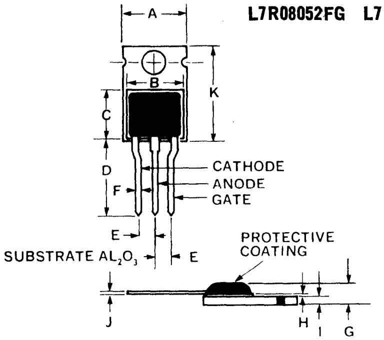
This series of SCR's is specifically designed for use in inverter and high current pulse applications and exhibits excellent turn-off capability even at much higher currents than their rated values. These devices are made with the most advanced hard glass passivated chips mounted on Unitrode's economical ChipStrate package.

ABSOLUTE MAXIMUM RATINGS

	L7R08052SG	L7R08054SG	L7R08056SG	L7R08058SG
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V	800V
Repetitive Peak Reverse Voltage, V_{RRM}	200V	400V	600V	800V
On-State Current, $I_{T(RMS)}$ (at $T_C = 65°C$ and conduction angle of 180°)	5A			
Peak One Cycle (Non-Rep.) On-State Current, I_{TSM} 60 Hz (Sinusoidal)	80A			
Peak Gate Power, P_{GM} (for 10μs Max)	5W			
Average Gate Power, $P_{G(AV)}$	.5W			
Storage Temperature Range	—40°C to +150°C			
Operating Temperature Range	—40°C to +110°C			
Rate of Change of On-State Current di/dt @ V_{DRM}	200 A/μs			
Fusing Current $I^2t(T_J = -40$ to $100°C$ $t = 1$ to $8.3ms)$	60 A^2sec			

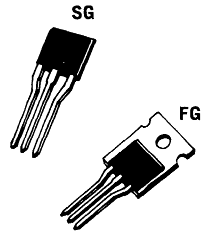
MECHANICAL SPECIFICATIONS

L7R08052FG L7R08054FG L7R08056FG L7R08058FG



L7 with Flange		
	INS.	mm
A	0.4	10.16
B	.350	8.89
C	.300	7.62
D	.500 MIN.	12.70 MIN.
E	.100	2.54
F	.032	.82
G	.150	3.81
H	.015	.39
I	.020	.51
J	.020	.51

L7



PART NO. SUFFIX: When ordering, specify correct part number suffix.
SG (standard package) — SOLDERABLE BACK, STRAIGHT LEADS
FG — FLANGE MOUNTED, STRAIGHT LEADS

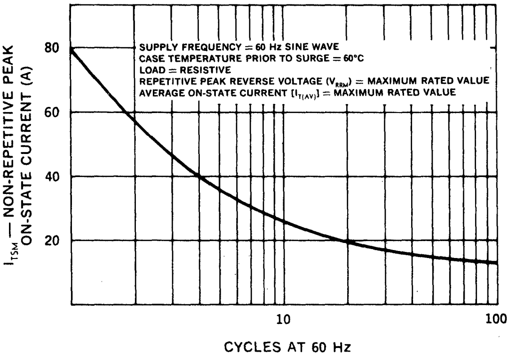
ChipStrate® is a registered trademark of Unitrode Corporation.

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

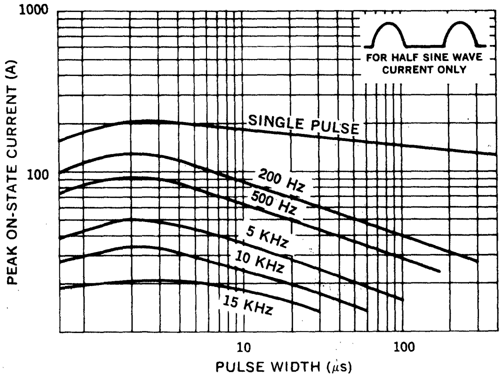
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-state Current	I_{DRM}		0.4	3	mA	V_{DRM} = Rating, $T_C = 100°C$
Reverse Current	I_{RRM}		0.4	2	mA	V_{RRM} = Rating, $T_C = 100°C$
Gate Trigger Current	I_{GT}		20	40	mA	$V_D = 12V$, $R_L = 30\Omega$
Gate Trigger Voltage	V_{GT}		1.5	3.0	V	$V_D = 12V$, $R_L = 30\Omega$
Peak On-state Voltage	V_{TM}		2.0	3.0	V	$I_{TM} = 30A$ (Peak)
Holding Current	I_H		20	50	mA	$V_D = 12V$, Gate open
Critical rate of rise of Off-state Voltage	dv/dt	200	400		V/μsec	$V_D = V_{DRM}$, $T_C = 80°C$
Gate controlled turn-on time (td + tr)	t_{on}		0.7		μsec	$I_T = 2A$, $I_{GT} = 200mA$ $V_D = V_{DRM}$
Circuit commutated turn-off time	t_q		8	10	μsec	Note 1
Thermal Resistance Junction-to-case	$R_{\theta JC}$			7	°C/W	

Note 1 $V_D = V_{DRM}$, $I_T = 20A$, PW = 50μsec
$V_{RX} = -15V$ Min, $V_{GT} = 0V$ (at t_{off})
dv/dt = 100V/μsec, −di/dt = −10A/μsec
$I_{GT} = 100mA$, $T_C = 80°C$

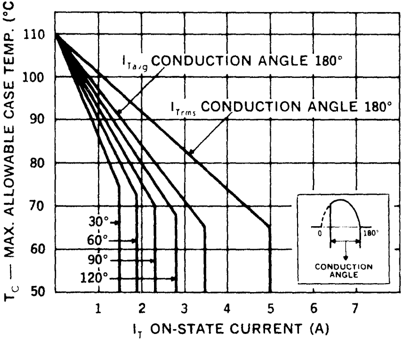
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



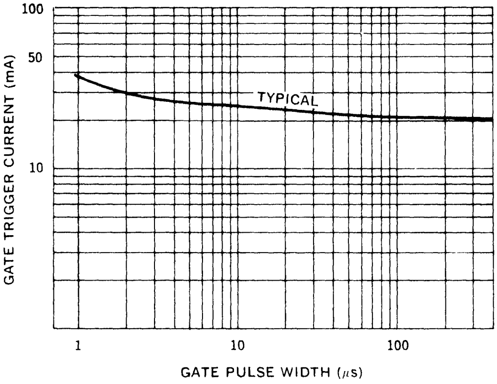
Maximum Allowable Peak On-State Current vs. Pulse Width



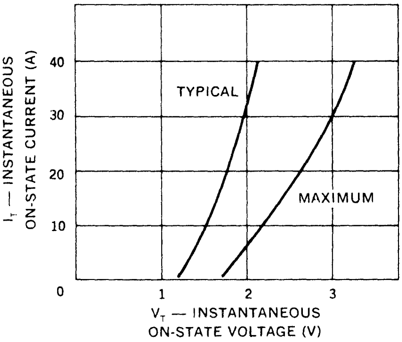
**Maximum Allowable Case Temp.
vs. On-State Current (50 or 60Hz)**



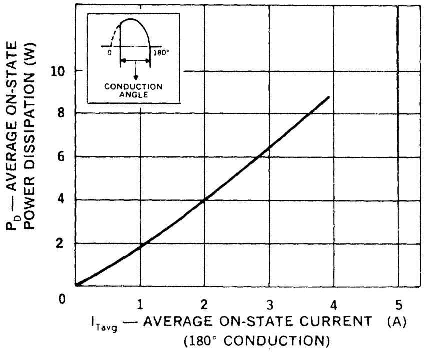
**Gate Trigger Current
vs. Gate Pulse Width tr = 20 nsec**



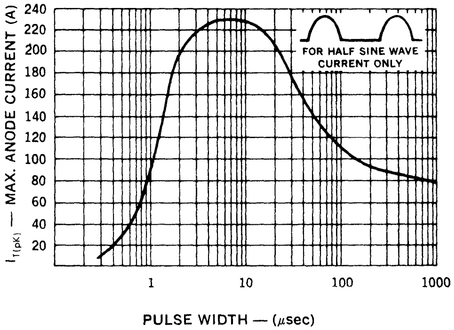
On-State Characteristics



**Maximum Conduction Power Dissipation
vs. On-State Current (50 or 60Hz)**



**Maximum Peak Current
vs. Pulse Width**



X

SCRs

15 Amp RMS, 800V, ChipStrate®

L7RO8152S
L7RO8154S
L7RO8156S
L7RO8158S

FEATURES

- Voltage Ratings: to 800V
- Hard-Glass Passivated Junction
- Miniature Size
- Isolated Case
- Economical Design

DESCRIPTION

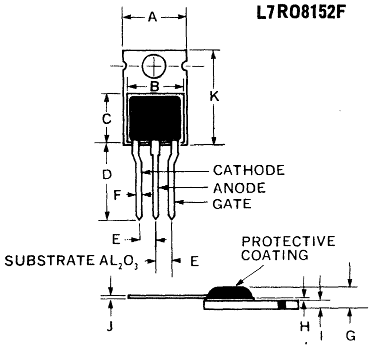
Unitrode ChipStrate power SCRs combine the most advanced hard-glass passivated chips with a metallized ceramic substrate. The resultant ChipStrate provides the economy of an unpackaged chip with the reliability and handling ease of a discrete device.

ABSOLUTE MAXIMUM RATINGS

	L7RO8152S	L7RO8154S	L7RO8156S	L7RO8158S
Repetitive Peak Off-State Voltage, V_{DRM}	200V	400V	600V	800V
Repetitive Peak Reverse Voltage, V_{RRM}	200V	400V	600V	800V
On-State Current, $I_{T(RMS)}$ (at $T_C = 65°C$ and conduction angle of 180°)		15A		
Peak One Cycle Surge (Non-Rep.) On-State Current, I_{TSM}		150A		
Peak Gate Power, P_{GM}		10W		
Average Gate Power, $P_{G(AV)}$		.5W		
Rate of On-State Current, di/dt (at $V_{DM} = V_{DRM}$, $I_{GT} = 100mA$, $t_r = .5\mu s$)		125 A/μs		
Fusing Current, $I^2{}_t$ (for SCR Protection) $T_j = -40°C$ to 110°C, 1 to 8.3msec		150 A²s		
Storage Temperature Range		—40°C to +150°C		
Operating Temperature Range		—40°C to +110°C		

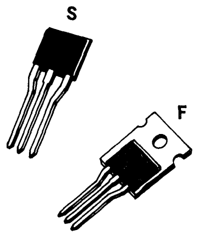
MECHANICAL SPECIFICATIONS

L7RO8152F L7RO8154F L7RO8156F L7RO8158F



L7 with Flange		
	INS.	mm
A	0.4	10.16
B	.350	8.89
C	.300	7.62
D	.500 MIN.	12.70 MIN.
E	.100	2.54
F	.032	.82
G	.150	3.81
H	.015	.39
I	.020	.51
J	.020	.51

L7



PART NO. SUFFIX: When ordering, specify correct part number suffix.
S (standard package) — SOLDERABLE BACK, STRAIGHT LEADS
F — FLANGE MOUNTED, STRAIGHT LEADS

ChipStrate® is a registered trademark of Unitrode Corporation.

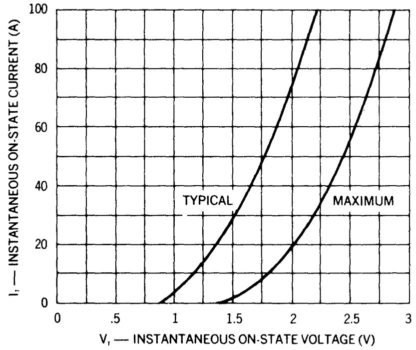
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

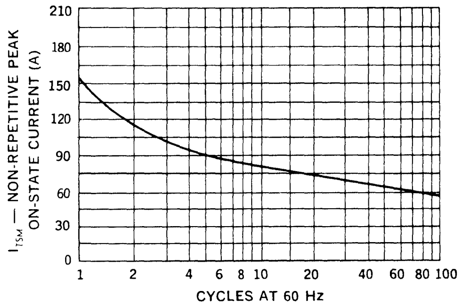
Test	Symbol	Min.	Typical	Max.	Units	Test Conditions
Off-State Current	I_{DRM}	—	—	2.0	mA	V_{DRM} = Rating, T_C = 100°C
Reverse Current	I_{RRM}	—	—	2.0	mA	V_{RRM} = Rating T_C = 100°C
Gate Trigger Current	I_{GT}	—	—	15	mA	V_D = 12V
Gate Trigger Voltage	V_{GT}	—	—	1.5	V	V_D = 12V
Peak On-State Voltage	V_{TM}	—	—	2.1	V	I_{TM} = 25A Peak
Holding Current	I_H	—	—	25	mA	V_D = 12V
Critical Rate of Rise — Off-State Voltage	dv/dt	100	200	—	V/μS	V_{DRM} = Rating, T_C = 100°C
Steady State Thermal Resistance*	$R\Theta_{JC}$	—	—	3.0	°C/W	Steady State

* Junction-to-Case

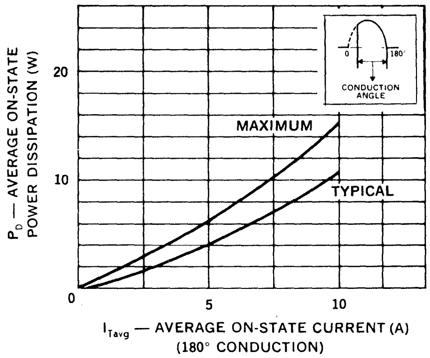
On-State Characteristics



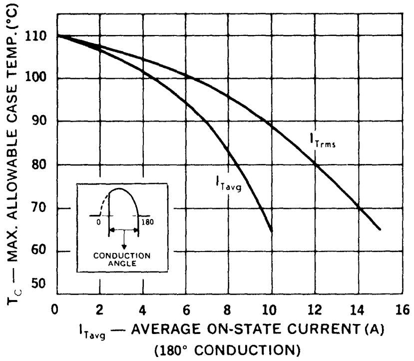
Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions



Maximum Conduction Power Dissipation vs. On-State Current (50 or 60HZ)



Maximum Allowable Case Temp. vs. On-State Current (50 or 60HZ)



RECOMMENDED MOUNTING METHODS

1. Screw Mount Using Standard Flange
2. Solder
3. Two-Sided Adhesive Electrical Tape
4. P.C. Board Mount (For Low Duty Cycle Applications)

PUTs

Planar, TO-92, Plastic

P13T1-P13T2

FEATURES

- TO-92 Plastic Package
- Maximum Peak Current: 0.15 μA
- Minimum Valley Current: 70 μA
- Peak Forward Current: 5A
- Programmable Eta, R_{BB}, I_p and I_V
- Passivated Planar Construction for Maximum Reliability and Parameter Uniformity

DESCRIPTION

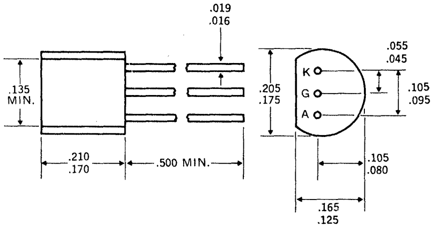
Functionally equivalent to standard unijunction transistors, Unitrode's Programmable Unijunction Transistors offer the distinct advantage of versatile programming. External resistors can be added to meet the designer's needs in programming Eta, R_{BB}, I_P and I_V functions. Applications include pulse and timing circuits, SCR trigger circuits, relaxation oscillators and sensing circuits. For additional information see Unitrode Application Note U-66.

ABSOLUTE MAXIMUM RATINGS

Anode-to-Cathode Voltage, V_{AK}		±40V
Gate-to-Cathode Forward Voltage, V_{GK}		40V
Gate-to-Anode Reverse Voltage, V_{GAR}		40V
Gate-to-Cathode Reverse Voltage, V_{GKR}		−5V
Peak Recurrent Forward Current		
	10μs, 1% Duty Cycle	5A
	100μs, 1% Duty Cycle	1A
Power Dissipation		
	25°C Ambient	375mW
	Derating Factor	5mW/°C
Storage Temperature		−55°C to +150°C
Operating Temperature Range		−55°C to +100°C

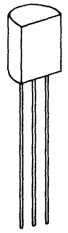
MECHANICAL SPECIFICATIONS

P13T1-P13T2



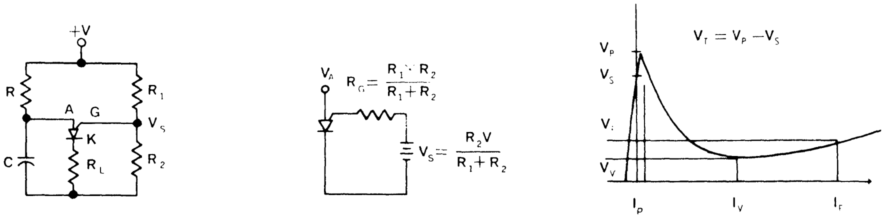
Dimensions in inches.

TO-92



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	Fig.	P13T1 Min.	P13T1 Max.	P13T2 Min.	P13T2 Max.	Units	Test Conditions
Peak Current	I_P	1	— —	5 2	— —	1.0 0.15	μA μA	$R_G = 10k, V_s = 10V$ $R_G = 1\ M\Omega$
Valley Current	I_V	1	70 —	— 50	25 —	— 25	μA μA	$R_G = 10k, V_s = 10V$ $R_G = 1\ M\Omega$
Offset Voltage	V_T	1	0.2 0.2	0.6 1.6	0.2 0.2	0.6 0.6	V V	$R_G = 10k, V_s = 10V$ $R_G = 1\ M\Omega$
Gate-to-Anode Leakage	I_{GAO}	2	— —	10 100	— —	10 100	nA nA	$T = 25°C, V_s = 40V$ $T = 75°C$
Gate-to-Cathode Leakage	I_{GKS}	3	—	100	—	100	nA	$V_s = 40V$
Forward Voltage	V_F	4	—	1.0	—	1.0	V	$I_F = 50mA$
Pulse Output Voltage	V_o	5	9	—	9	—	V	
Pulse Output Rise Time	t_r	5	—	80	—	80	ns	



a) Typical Circuit

b) Equivalent Test Circuit

c) Characteristic Curve

Figure 1

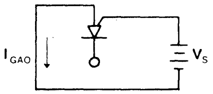


Figure 2

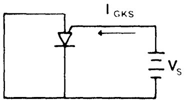


Figure 3

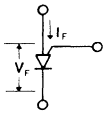


Figure 4

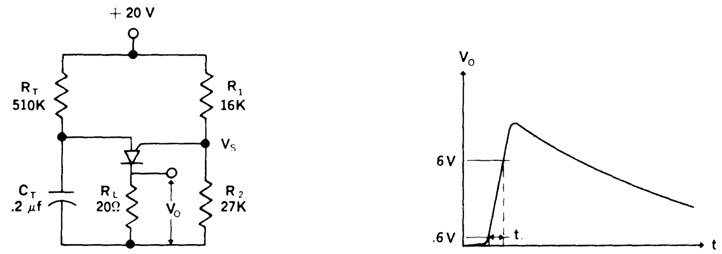
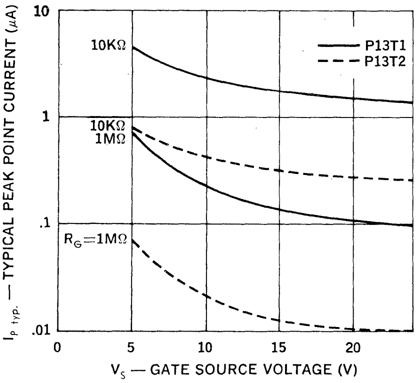
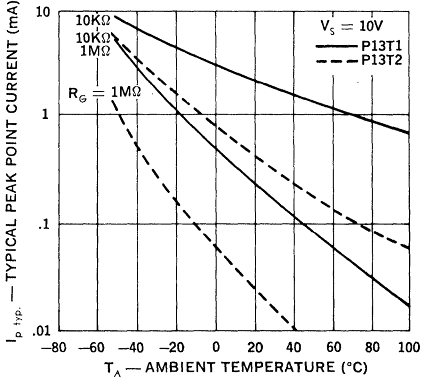


Figure 5

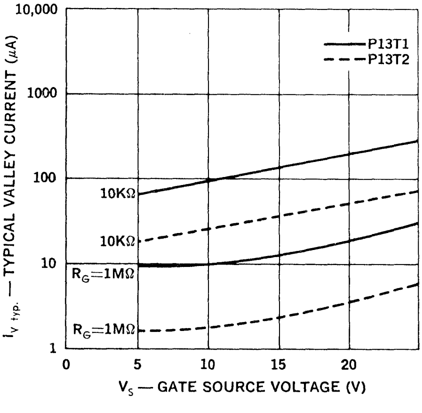
Typical Peak Point Current
vs. Gate Source Voltage



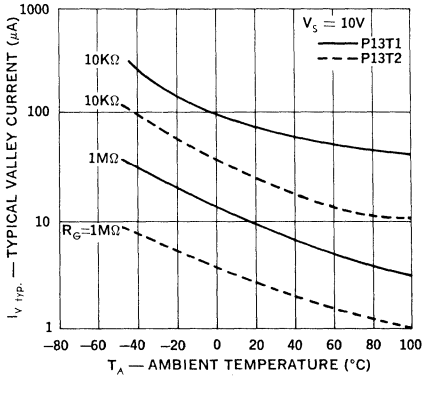
Typical Peak Point Current
vs. Ambient Temperature



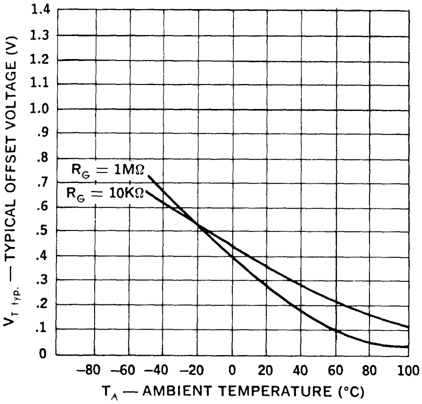
Typical Valley Current
vs. Gate Source Voltage



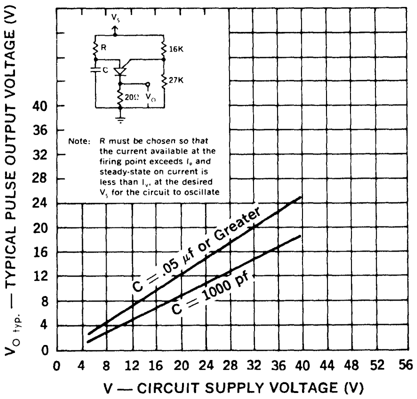
Typical Valley Current
vs. Ambient Temperature



Typical Offset Voltage
vs. Ambient Temperature

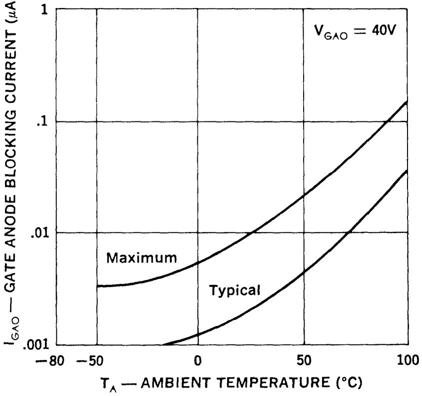


Typical Pulse Output
vs. Circuit Supply Voltage

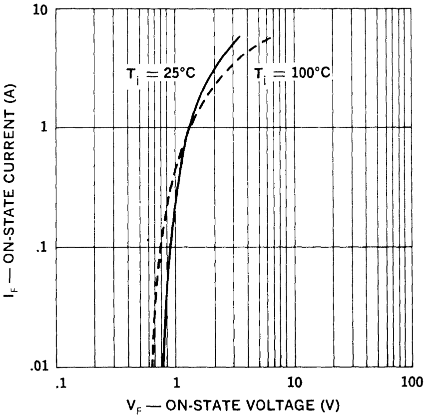


Note: R must be chosen so that the current available at the firing point exceeds I_P and steady-state on current is less than I_V, at the desired V_S for the circuit to oscillate

Gate-Anode Blocking Current
vs. Ambient Temperature



Typical On-State Current vs. Voltage



PUTs

Planar, TO-18 Hermetic

U13T1-U13T2

FEATURES

- Voltage Ratings: to 100V
- Maximum Peak Current: 150nA
- Valley Current: as low as 25 μA
- Low Forward Voltage Drop
- Nano-Amp Leakage
- Hermetically Sealed TO-18 Metal Can

DESCRIPTION

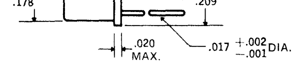
The Unitrode hermetically sealed TO-18 metal can series of programmable unijunction transistors feature blocking voltages to 100V, the highest available to designers. These PUTs are functionally equivalent to standard unijunction transistors, with the added advantages of programming versatility. External resistors can be added to program η, R_{BB}, I_p and I_v, depending upon your design requirements. All units are fully planar passivated. This series features a hermetically sealed TO-18 package for optimum reliability in all environmental conditions. Applications include pulse and timing circuits, SCR trigger circuits, relaxation oscillators, and sensing circuits. For further application information see Unitrode's Application Note U-66.

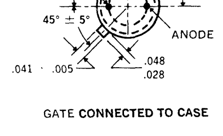
ABSOLUTE MAXIMUM RATINGS

	U13T1 U13T2
Anode-to-Cathode Forward Voltage, V_{AK}	40V
Anode-to-Cathode Reverse Voltage, V_{AKR}	40V
Gate-to-Cathode Forward Voltage, V_{GK}	40V
Gate-to-Anode Reverse Voltage, V_{GAR}	40V
Gate-to-Cathode Reverse Voltage, V_{GKR}	5V
Peak Recurrent Forward Current	
10 μs 1% Duty Cycle	8A
100 μs 1% Duty Cycle	5A
Power Dissipation	
25°C Ambient	400mW
Derating Factor	3.2mW/°C
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	−55°C to +150°C

MECHANICAL SPECIFICATIONS

U13T1-U13T2

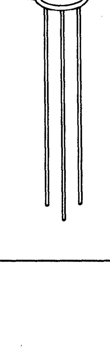




GATE CONNECTED TO CASE

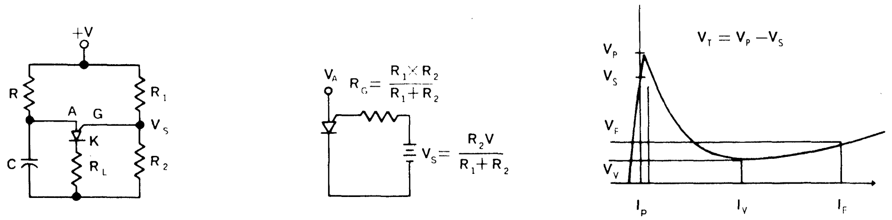
Dimensions in inches.

TO-18



ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Test	Symbol	Fig.	U13T1 Min.	U13T1 Max.	U13T2 Min.	U13T2 Max.	Units	Test Conditions
Peak Current	I_P	1	— —	5 2	— —	1.0 0.15	µA µA	$R_G = 10k, V_s = 10V$ $R_G = 1$ Meg.
Valley Current	I_V	1	70 —	— 50	25 —	— 25	µA µA	$R_G = 10k, V_s = 10V$ $R_G = 1$ Meg.
Offset Voltage	V_T	1	0.2 0.2	0.6 1.6	0.2 0.2	0.6 0.6	V V	$R_G = 10k, V_s = 10V$ $R_G = 1$ Meg.
Gate-to-Anode Leakage	I_{GAO}	2	— —	10 100	— —	10 100	nA nA	$T = 25°C, V_s =$ rating $T = 75°C$
Gate-to-Cathode Leakage	I_{GKS}	3	—	100	—	100	nA	$V_s =$ rating
Forward Voltage	V_F	4	—	1.5	—	1.5	V	$I_F = 50mA$
Pulse Output Voltage	V_o	5	6	—	6	—	V	
Pulse Output Rate of Rise	t_r	5	—	80	—	80	nS	



a) Typical Circuit

b) Equivalent Test Circuit

c) Characteristic Curve

Figure 1

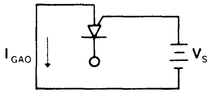


Figure 2

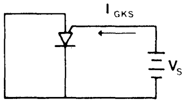


Figure 3

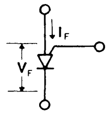


Figure 4

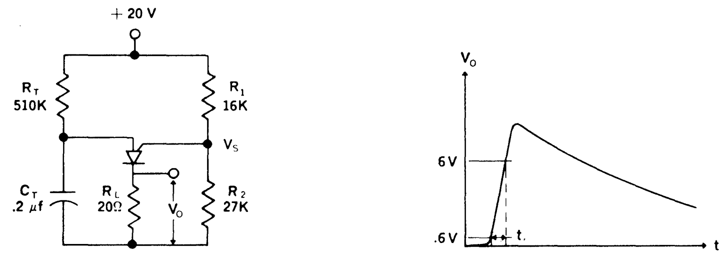


Figure 5

THYRISTORS (SCRs, Triacs, PUTs)

PAGE	PART NUMBER	DESCRIPTION
		SCR
*	2N876	.35A@100°C 15V; TO-18
*	2N877	.35A@100°C 30V; TO-18
*	2N878	.35A@100°C 60V; TO-18
*	2N879	.35A@100°C 100V; TO-18
*	2N880	.35A@100°C 150V; TO-18
*	2N881	.35A@100°C 200V; TO-18
*	2N882	.35A@100°C 300V; TO-18
*	2N883	.35A@100°C 400V; TO-18
*	2N884	.35A@100°C 15V; TO-18
*	2N885	.35A@100°C 30V; TO-18
*	2N886	.35A@100°C 60V; TO-18
*	2N887	.35A@100°C 100V; TO-18
*	2N888	.35A@100°C 150V; TO-18
*	2N889	.35A@100°C 200V; TO-18
*	2N890	.35A@100°C 300V; TO-18
*	2N891	.35A@100°C 400V; TO-18
*	2N948	.26A@125°C 30V; TO-18
*	2N949	.26A@125°C 60V; TO-18
*	2N950	.26A@125°C 100V; TO-18
*	2N951	.26A@125°C 200V; TO-18
*	2N1595	1.0A@80°C 50V; TO-39
*	2N1596	1.0A@80°C 100V; TO-39
*	2N1597	1.0A@80°C 200V; TO-39
*	2N1598	1.0A@80°C 300V; TO-39
*	2N1599	1.0A@80°C 400V; TO-39
*	2N1869	1.25A@100°C 15V; TO-9
518	2N1870A, J	1.25A@100°C 30V; TO-9
518	2N1871A, J	1.25A@100°C 60V; TO-9
518	2N1872A, J	1.25A@100°C 100V; TO-9
518	2N1873A	1.25A@100°C 150V; TO-9
518	2N1874A, J	1.25A@100°C 200V; TO-9
522	2N1875	1.25A@100°C 15V; TO-9
522	2N1876	1.25A@100°C 30V; TO-9
522	2N1877	1.25A@100°C 60V; TO-9
522	2N1878	1.25A@100°C 100V; TO-9
522	2N1879	1.25A@100°C 150V; TO-9
522	2N1880	1.25A@100°C 200V; TO-9
524	2N1881	1.0A@100°C 30V; TO-9
524	2N1882	1.0A@100°C 60V; TO-9
524	2N1883	1.0A@100°C 100V; TO-9
524	2N1884	1.0A@100°C 150V; TO-9
524	2N1885	1.0A@100°C 200V; TO-9
*	2N2009	1.3A@80°C 25V; TO-39
*	2N2010	1.3A@80°C 50V; TO-39
*	2N2011	1.3A@80°C 100V; TO-39
*	2N2012	1.3A@80°C 200V; TO-39
*	2N2013	1.3A@80°C 300V; TO-39
*	2N2014	1.3A@80°C 400V; TO-39
526	2N2322	1.6A@85°C 25V; TO-39
526	2N2323, J, JTX, JTXV	1.6A@85°C 50V; TO-5
526	2N2323A, J, JTX, JTXV	1.6A@85°C 50V; TO-5
526	2N2324, J, JTX, JTXV	1.6A@85°C 100V; TO-5
526	2N2324A, J, JTX, JTXV	1.6A@85°C 100V; TO-5
526	2N2325	1.6A@85°C 150V; TO-39
526	2N2325A	1.6A@85°C 150V; TO-39
526	2N2326, J, JTX, JTXV	1.6A@85°C 200V; TO-5
526	2N2326A, J, JTX, JTXV	1.6A@85°C 200V; TO-5
526	2N2327	1.6A@85°C 250V; TO-39
526	2N2327A	1.6A@85°C 250V; TO-39
526	2N2328, J, JTX, JTXV	1.6A@85°C 300V; TO-5
526	2N2328A, J, JTX, JTXV	1.6A@85°C 300V; TO-5
526	2N2329, J, JTX, JTXV	1.6A@85°C 400V; TO-5
*	2N2344	1.6A@55°C 25V; TO-39
*	2N2345	1.6A@55°C 50V; TO-39
*	2N2346	1.6A@55°C 100V; TO-39
*	2N2347	1.6A@55°C 150V; TO-39
		SCR
*	2N2348	1.6A@55°C 200V; TO-39
*	2N2679	.35A@55°C 30V; TO-18
*	2N2680	.35A@55°C 60V; TO-18
*	2N2681	.35A@55°C 100V; TO-18
*	2N2682	.35A@55°C 200V; TO-18
*	2N2683	.28A@55°C 30V; TO-18
*	2N2684	.28A@55°C 60V; TO-18
*	2N2685	.28A@55°C 100V; TO-18
*	2N2686	.28A@55°C 200V; TO-18
*	2N2687	.28A@55°C 30V; TO-18
*	2N2688	.28A@55°C 60V; TO-18
*	2N2689	.28A@55°C 100V; TO-18
*	2N2690	.28A@55°C 200V; TO-18
*	2N3001	.25A@55°C 30V: TO-18
*	2N3002	.25A@55°C 60V; TO-18
*	2N3003	.25@55°C 100V; TO-18
*	2N3004	.25A@55°C 200V; TO-18
*	2N3005	.25A@55°C 30V; TO-18
*	2N3006	.25A@55°C 60V; TO-18
*	2N3007	.25A@55°C 100V; TO-18
*	2N3008	.25A@55°C 200V; TO-18
529	2N3027, J, JTX	500mA@100°C 30V; TO-18
529	2N3028, J, JTX	500mA@100°C 60V; TO-18
529	2N3029, J, JTX	500mA@100°C 100V;TO-18
529	2N3030, J, JTX	.5@100°C 30V; TO-18
529	2N3031, J, JTX	.5A@100°C 60V; TO-18
529	2N3032, J, JTX	.5A@100°C 100V; TO-18
*	2N3273	2.2A@85°C 100V; TO-39
*	2N3274	2.2A@85°C 200V; TO-39
*	2N3275	2.2A@85°C 300V; TO-39
*	2N3276	2.2A@85°C 400V; TO-39
*	2N3555	1.6A; 30V; TO-39
*	2N3556	1.6A; 60V; TO-39
*	2N3557	1.6A; 100V; TO-39
*	2N3558	1.6A; 200V; TO-39
*	2N3559	1.6A; 30V; TO-39
*	2N3560	1.6A; 60V; TO-39
*	2N3561	1.6A; 100V; TO-39
*	2N3562	1.6A; 200V TO-39
*	2N4108	180mA@25°C 50V; TO-18
*	2N4109	180mA@25° 100V; TO-18
*	2N4110	180mA@25°C 200V; TO-18
*	2N4144	250mA@75°C 15V; TO-18
*	2N4145	250mA@75°C 30V; TO-18
*	2N4146	250mA@75°C 60V; TO-18
*	2N4147	250mA@75°C 100V; TO-18
*	2N4148	250mA@75°C 150V; TO-18
*	2N4149	250mA@75°C 200V; TO-18
*	2N4212	1.0A@85°C 25V; TO-39
*	2N4213	1.0A@85°C 50V; TO-39
*	2N4214	1.0@85°C 100V; TO-39
*	2N4215	1.0A@85°C 150V; TO-39
*	2N4216	1.0A@85°C 200V; TO-39
*	2N4217	1.0A@85°C 250V; TO-39
*	2N4218	1.0A@85°C 300V; TO-39
*	2N4219	1.0A@85°C 400V; TO-39
535	2N5060	0.8A@70° 30V; TO-92
535	2N5061	0.8A@70°C 60V; TO-92
535	2N5062	0.8A@70°C 100V; TO-92
535	2N5063	0.8A@70°C 150V; TO-92
535	2N5064	0.8A@70°C 200V; TO-92
539	2N5724	1.6A@85°C 60V; TO-39
539	2N5725	1.6A@85°C 100V; TO-39
539	2N5726	1.6A@85°C 200V; TO-39
539	2N5727	1.6A@85°C 300V; TO-39
539	2N5728	1.6A@85°C 400V; TO-39

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PAGE	PART NUMBER	DESCRIPTION
		SCR
599	L2R06256F	25A; 600V
599	L2R06258F	25A; 800V
		TRIAC
601	L7B08102S	10A; 200V
601	L7B08104S	10A; 400V
601	L7B08106S	10A; 600V
601	L7B08108S	10A; 800v
		SCR
603	L7R08052SG	5A; 200V; Fast Turn-off
603	L7R08054SG	5A; 400V; Fast Turn-off
603	L7R08056SG	5A; 600V; Fast Turn-off
603	L7R08058SG	5A; 800V; Fast Turn-off
606	L7R08152S	15A; 200V
606	L7R08154S	15A; 400V
606	L7R08156S	15A; 600V
606	L7R08158S	15A; 800V
		PUT
608	P13T1	375mW@25°C 40V; TO-92
608	P13T2	375mW@25°C 40V; TO-92
612	U13T1	400mW@25°C 40V; TO-18
612	U13T2	400mW@25°C 40V; TO-18

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

SWITCHING AND GENERAL PURPOSE DIODES

Type	Reverse Voltage	Forward Voltage	Reverse Recovery Time	Reverse Current @ 25°C	Junction Capacitance	Average Forward Current
1N456	30V	1.0 @ 40mA		25nA		90mA
1N457*	70V	1.0 @ 20mA		25nA		75mA
1N458*	150V	1.0 @ 7mA		25nA		55mA
1N459*	200V	1.0 @ 3mA		25nA		40mA
1N483B**	80V	1.0 @ 100mA		25nA		200mA
1N485B**	200V	1.0 @ 100mA		25nA		200mA
1N645***	270V	1.0 @ 400mA		25nA	20pF	400mA
1N914**	100V	1.0 @ 10mA	5nS	25nA	4pF	75mA
1N3064**	75V	1.0 @ 10mA	4nS	100nA	2pF	75mA
1N3070	200V	1.0 @ 100mA	50nS	100nA	5pF	100mA
1N3595***	150V	.83-1.0 @ 200mA	3μS	1nA	8pF	150mA
1N3600***	75V	.54-.62 @ 1mA	4nS	100nA	2.5pF	200mA
1N4148***	100V	1.0 @ 10mA	4nS	25nA	4pF	200mA
1N4149	75V	1.0 @ 10mA	4nS	25nA	2pF	200mA
1N4150***	75V	.54-.62 @ 1mA	4nS	100nA	2.5pF	200mA
1N4151	75V	1.0 @ 50mA	2nS	50nA	2pF	150mA
1N4152	40V	.49-.52 @ 0.1mA	2nS	50nA	2pF	150mA
1N4153***	75V	.49-.52 @ 0.1mA	2nS	50nA	2pF	150mA
1N4154	35V	1.0 @ 30mA	2nS	100nA	4pF	150mA
1N4305	75V	.5-.575 @ .25mA	2nS	100nA	2pF	150mA
1N4444	70V	.44-.55 @ .1mA		50nA	2pF	200mA
1N4446	75V	1.0 @ 20mA	4nS	25nA	4pF	150mA
1N4447	75V	1.0 @ 20mA	4nS	25nA	2pF	150mA
1N4448	75V	.62-.72 @ 5mA	4nS	25nA	4pF	150mA
1N4449	75V	.63-.73 @ 5mA	4nS	25nA	2pF	150mA
1N4450	40V	.42-.54 @ 0.1mA	4nS	50nA	4pF	200mA
1N4451	40V	.4-.5 @ 0.1mA	4nS	50nA	6pF	200mA
1N4452	40V	.42-.52 @ 0.1mA	50nS	50nA	30pF	200mA
1N4453	30V	.43-.55 @ 0.1mA		50nA	30pF	200mA
1N4454***	75V	1.0 @ 10mA	2nS	100nA	2pF	200mA
1N4500***	80V	.64-.72 @ 10mA	6nS	100nA	4pF	300mA
1N4607	85V	1.1 @ 400mA	10nS	100nA	4pF	400mA

*Available as JAN
**Available as JAN, JANTX
***Available as JAN, JANTX, JANTXV

DIODE
Low Current

1N456
JAN 1N457
JAN 1N458
JAN 1N459

FEATURES

- Metallurgical Bond
- Qualified to MIL-S-19500/193
- Planar Passivated Chip
- DO-7 Package
- Non-JAN Available

DESCRIPTION

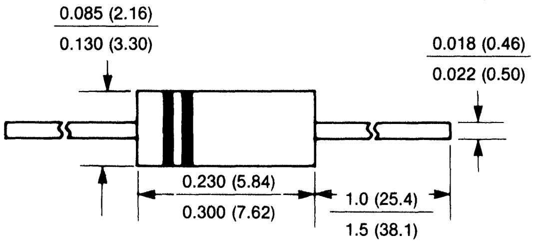
General purpose low current diode with high reliability characteristics

ABSOLUTE MAXIMUM RATINGS, AT 25°C

	1N456	JAN 1N457	JAN 1N458	JAN 1N459
Reverse Working Voltage	25V	60V	125V	175V
Peak Reverse Voltage	30V	70V	150V	200V
Average Output Current	90mA	75mA	55mA	40mA
Surge Current, 8.3mS	700mA	225mA	165mA	120mA
Operating Temperature Range	− 65°C to + 150°C			
Storage Temperature Range	− 65°C to + 200°C			

MECHANICAL SPECIFICATIONS

1N456
JAN 1N457, 1N458, 1N459



Dimensions in inches and (millimeters)

DO-7

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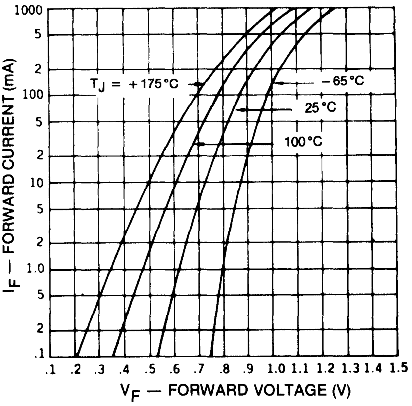
UNITRODE

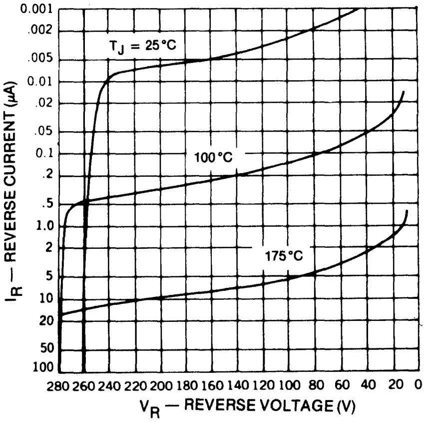
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	Forward Voltage	Reverse Current	Reverse Current @T$_A$ = 150°C	Peak Reverse Voltage @100μA
1N456	1.0V @ 40mA	25nA @ 25V	5μA @ 25V	30V
1N457, J	1.0V @ 20mA	25nA @ 60V	5μA @ 60V	70V
1N458, J	1.0V @ 7mA	25nA @ 125V	5μA @ 125V	150V
1N459, J	1.0V @ 3mA	25nA @ 175V	5μA @ 175V	200V

Typical Forward Voltage vs. Forward Current



Typical Reverse Voltage vs. Reverse Current



DIODE
General Purpose
Low Current

JAN & JANTX 1N483B
JAN & JANTX 1N485B

FEATURES
- Metallurgical Bond
- Qualified to MIL-S-19500/118
- Planar Passivated Chip
- DO-7 Package
- Non-JAN Available

DESCRIPTION
This Series is useful in low current rectifying applications for military, industrial and commercial equipment.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

	1N483B	1N485B
Reverse Breakdown Voltage	80V	200V
Peak Working Voltage	70V	180V

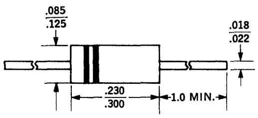
Average Output Current @ $T_A = 25°C$	200mA
$T_A = 150°C$	50mA

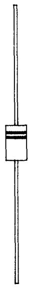
Current Derating 1.2 mAdc/°C from 25°C to 150°C and 1.0 mAdc/°C from 150°C to 200°C

Surge Current, 8.3mSec	2 Amps
Operating Temperature Range	–65°C to +200°C
Storage Temperature Range	–65°C to +200°C

MECHANICAL SPECIFICATIONS

J & JTX 1N483B, 1N485B

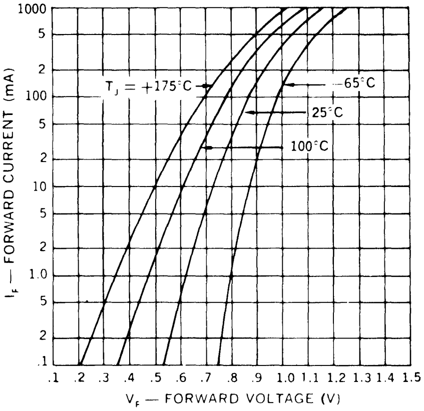




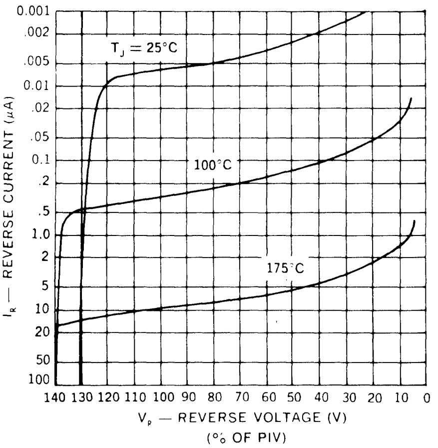
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

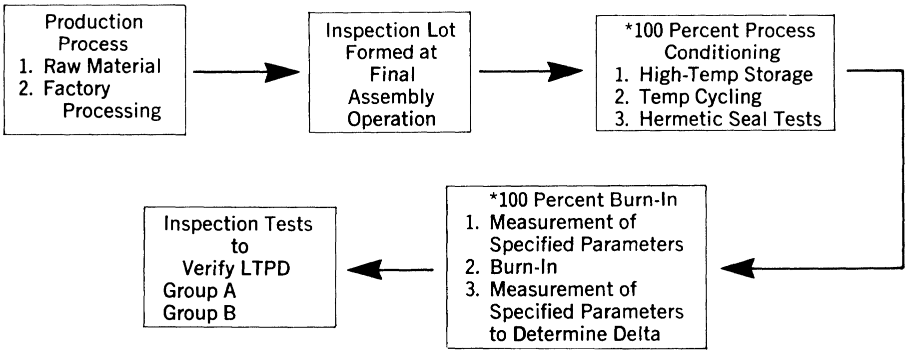
Type	Reverse Current @ 25°C	Reverse Current @ 25°C	Reverse Current @ 150°C	Forward Voltage @ 100mAdc, 8.5msec dc = 2% MAX.
1N483B 1N485B	25nA @ 70Vdc 25nA @ 180Vdc	100 μA(pk) @ 80V(pk) 100 μA(pk) @ 200V(pk)	5.0 μA @ 70Vdc 5.0 μA @ 180Vdc	1.0V(pk)

Forward Voltage vs. Forward Current



Reverse Voltage vs. Reverse Current





*Order of the tests in the blocks shall be performed as shown.

Order of procedure diagrams for TX types only.

RECTIFIERS
High Voltage, Low Current

JAN, JANTX 1N645
JAN, JANTX & JANTXV 1N645-1

FEATURES
- Metallurgical Bond
- Qualified to MIL-S-19500/240
- Planar Passivated Chip
- DO-35 or DO-7 Package
- Non-JAN Available

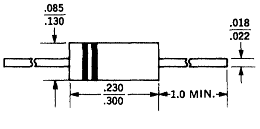
DESCRIPTION
These devices are useful in general purpose low current applications in high reliability and military equipment.

ABSOLUTE MAXIMUM RATINGS AT 25°C

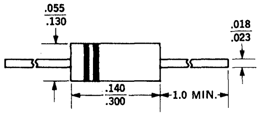
Reverse Breakdown Voltage	270V
Peak Working Voltage	225V
Average Output Current, 25°C	400mA
150°C	150mA
Surge Current, 8.3msec	5A
Operating Temperature Range	—65°C to + 150°C
Storage Temperature Range	—65°C to + 200°C

MECHANICAL SPECIFICATIONS

J, JTX 1N645



J, JTX, & JTXV 1N645-1



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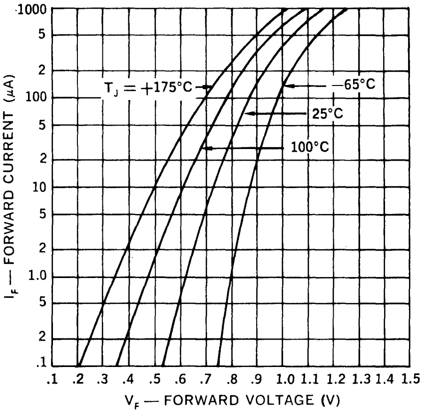
UNITRODE

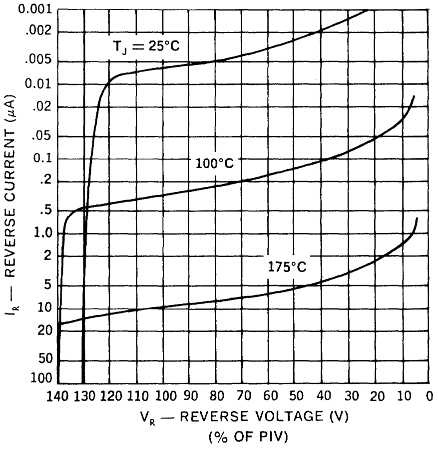
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

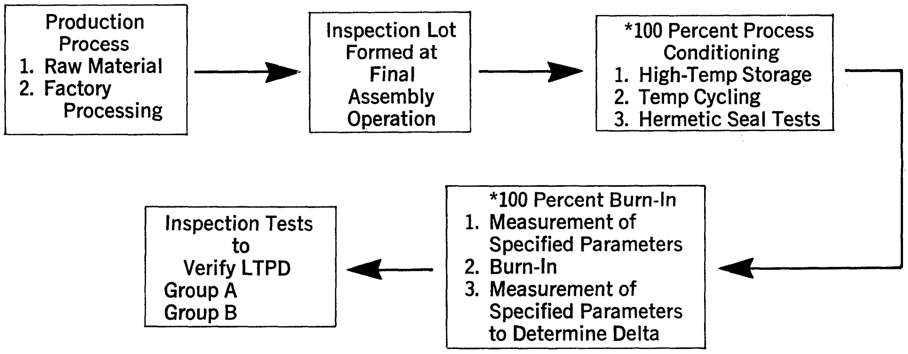
Type	Reverse Current @ 25°C	Reverse Current @ 50°C	Peak Reverse Current @ 25°C	Average Reverse Current @ 150°C	Forward Voltage @ 25°C	Capacitance
1N645	0.025μA @ 225Vdc	15μAdc @ 225Vdc	100μA (pk) @ 270V (pk)	100μAdc @ 225V (pk)	1.0Vdc @ $I_F = 400$mAdc 8.3msec	20 pf $V_R = 4$ Vdc f = 1 MHz $V_{sig} = 50$ mV
1N645-1	0.050μA @ 225Vdc	25μAdc @ 225Vdc	100μA (pk) @ 270V (pk)	100μAdc @ 225V (pk)	1.0Vdc @ $I_F = 400$mAdc 8.3msec	20 pf $V_R = 4$ Vdc f = 1 MHz $V_{sig} = 50$ mV

Forward Voltage vs. Forward Current



Reverse Voltage vs. Reverse Current





*Order of the tests in the blocks shall be performed as shown.

Order of procedure diagrams for TX types only.

COMPUTER DIODE
General Purpose
Switching

JAN, JANTX, 1N914
JAN, JANTX, JANTXV 1N4148
JAN, JANTX, JANTXV 1N4148-1

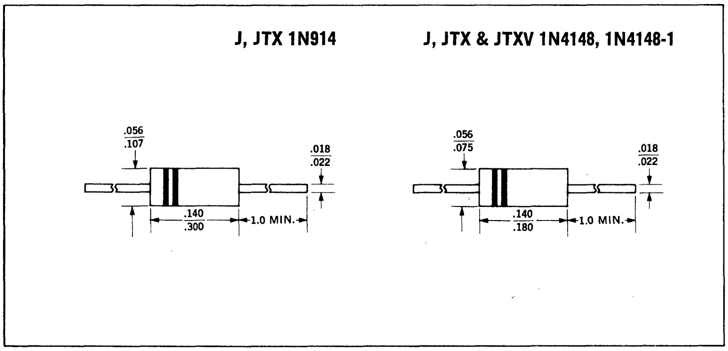
FEATURES
- Metallurgical Bond
- Qualified to MIL-S-19500/116
- Planar Passivated Chip
- DO-35 Package
- Non-JAN Available

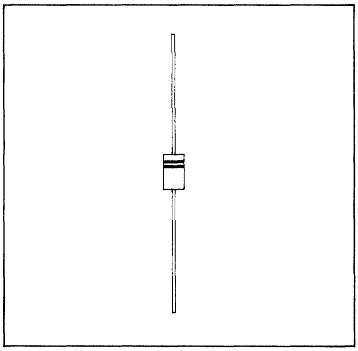
DESCRIPTION
This series is very popular for general purpose switching applications in electronic equipment.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

Reverse Breakdown Voltage	100V
Peak Working Voltage	75V
Average Output Current, 1N914	75mAdc
1N4148	200mAdc
1N4148-1	150mAdc
Surge Current, 8.3msec	500mA
Operating Temperature Range	—65°C to +175°C
Storage Temperature Range	—65°C to +200°C

MECHANICAL SPECIFICATIONS



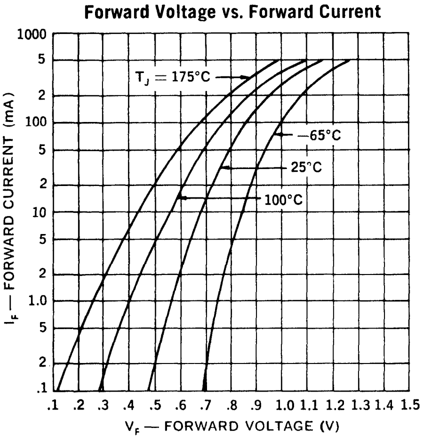


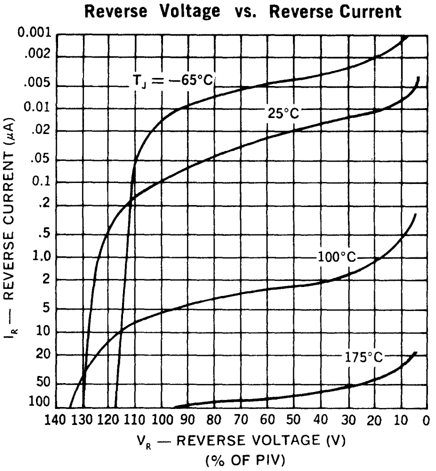
UNITRODE

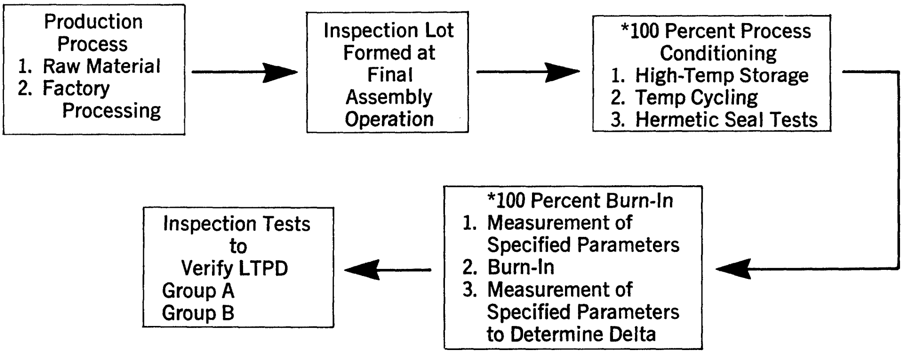
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Reverse Current @ 25°C	Reverse Current @ 25°C	Peak Reverse Current @ 25°C	Reverse Current @ 150°C	Reverse Current @ 150°C
25nAdc @ $V_R = 20$Vdc	5.0μAdc @ $V_R = 75$Vdc	100μA (pk) @ $V_R = 100$V (pk)	50μAdc @ $V_R = 20$Vdc	100μAdc @ $V_R = 75$Vdc

Forward Voltage	Foward Recovery Voltage	Forward Recovery Time	Reverse Recovery Time	Capacitance
1.0Vdc @ $I_F = 10$mAdc	5.0V (pk) @ $I_F = 50$mAdc	20nsec @ $I_F = 50$mAdc	5nsec @ $I_F = I_R = 10$mA $R_L = 100$ ohms	4.0 pf @ $V_R = 0$V, f = 1 MHz $V_{sig} = 50$mV (pk-pk) 2.8 pf @ $V_R = 1.5$V, f = 1 MHz $V_{sig} = 50$mV (pk-pk)







*Order of the tests in the blocks shall be performed as shown.

Order of procedure diagrams for TX types only.

COMPUTER DIODE
General Purpose Switching

JAN & JANTX 1N3064
JAN, JANTX & JANTXV 1N4454
JAN, JANTX & JANTXV 1N4454-1

FEATURES
- Metallurgical Bond
- Qualified to MIL-S-19500/144
- Planar Passivated Chip
- DO-7 or DO-35 Package
- Non-JAN Available

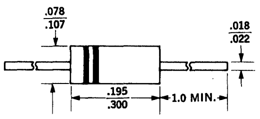
DESCRIPTION
Available in either DO-35 or DO-7 package. Unitrode offers high temperature metallurgical bond, making these devices useful in high reliability applications.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

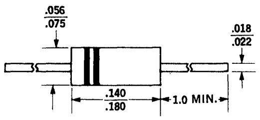
Reverse Breakdown Voltage		75V
Peak Working Voltage		50V
Average Output Current,	1N3064	75mA
	1N4454,-1	200mA
Surge Current, 1sec	1N3064	0.5A
	1N4454,-1	1.0A
Operating Temperature Range		–65°C to +175°C
Storage Temperature Range		–65°C to +200°C

MECHANICAL SPECIFICATIONS

J & JTX 1N3064



J, JTX & JTXV 1N4454, 1N4454-1



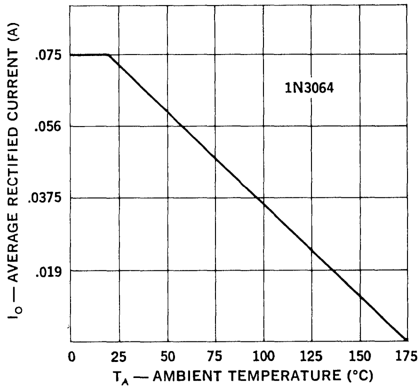
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

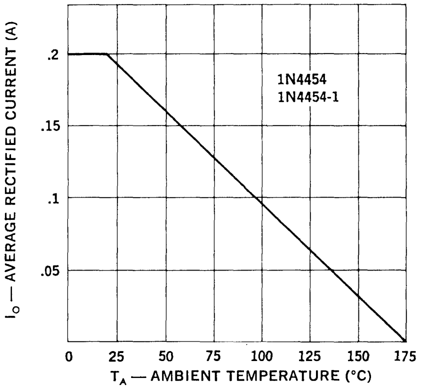
Type	Reverse Current @ 25°C	Reverse Current @ 150°C	Reverse Breakdown Voltage @ −65°C	Reverse Recovery Time	Capacitance
1N3064 1N4454 1N4454-1	0.1μAdc @ $V_R = 50V$	100μAdc @ $V_R = 50V$	75Vdc @ $I_R = 10\mu Adc$	4nsec @ $I_F = I_R = 10mAdc$ $R_L = 100$ ohms $c \leqslant 3pf$	2.0pf @ $V_R = 0$ Vdc, $f = 1$ MHz $v_{sig} = 50mV$ (pk to pk)

Forward Voltage	Forward Recovery Voltage	Forward Recovery Time
1.0 Vdc @ $I_F = 10mAdc$	5.0V (pk) @ $I_F = 100mAdc$ $t_r \leqslant 0.4nsec$	30nsec $I_F = 100mAdc$ $t_r \leqslant 0.4nsec$

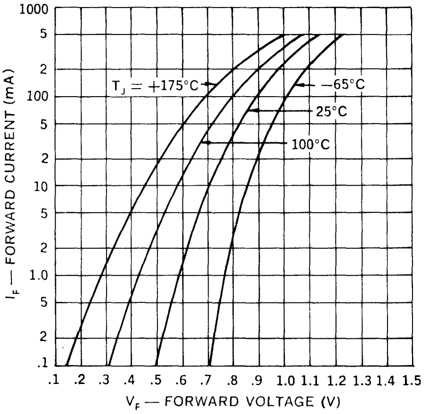
Average Rectified Current vs. Ambient Temperature



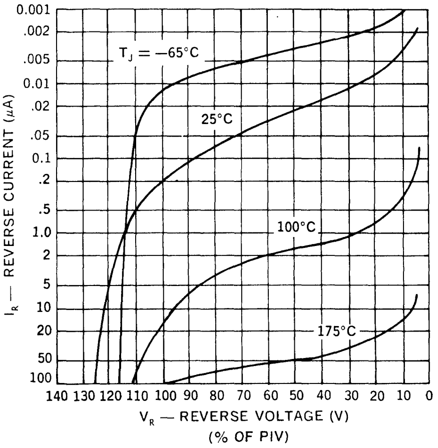
Average Rectified Current vs. Ambient Temperature



Forward Voltage vs. Forward Current



Reverse Voltage vs. Reverse Current



COMPUTER DIODE

1N3070

High Voltage Switching

FEATURES
- Metallurgical Bond
- Planar Passivated
- High Voltage
- DO-35 Package

DESCRIPTION

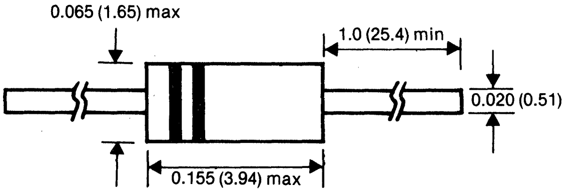
This series offers Metallurgical Bonding and is specifically designed for high voltage applications.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

Reverse Breakdown Voltage	200V
Average Rectified Current	200mAdc
Surge Current, 8.3 mS	500mA
Operating Temperature Range	−65°C to +150°C
Storage Temperature Range	−65°C to +200°C

MECHANICAL SPECIFICATIONS

1N3070



Dimensions in inches and (millimeters)

DO-35

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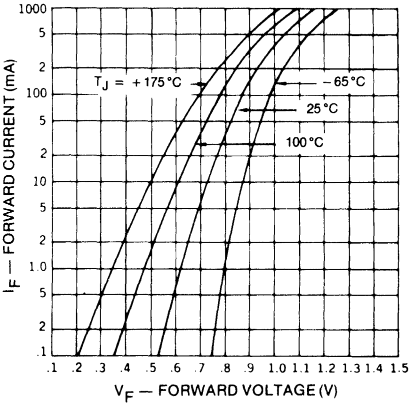
UNITRODE

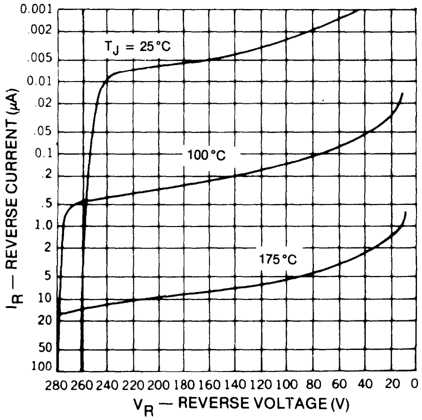
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	Peak Inverse Voltage (V)	Forward Voltage @100mA (V)	Reverse Current (V) (nA)	Reverse Current @ 150°C (V) (μA)	Capacitance 0V (pF)	Reverse Recovery Time (nS)
1N3070	200	1.0	175 100	175 100	5	50

Typical Forward Voltage vs. Forward Current



Typical Reverse Voltage vs. Reverse Current



COMPUTER DIODE
150 mA, Switching

JAN, JANTX, JANTXV 1N3595

FEATURES
- Metallurgical Bond
- Qualified to MIL-S-19500/241
- Planar Passivated Chip
- DO-7 Package
- Non-JAN Available

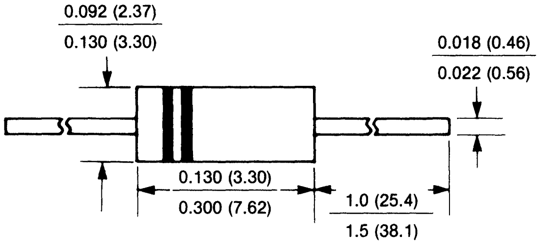
DESCRIPTION
A very useful device for medium current switching applications.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

Peak Reverse Voltage	125V
Reverse Breakdown Voltage	150V
Average Output Current	150mAdc
Surge Current, 1S	500mA
1μS	4A
Operating Temperature Range	−65°C to +150°C
Storage Temperature Range	−65°C to +200°C

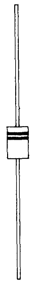
MECHANICAL SPECIFICATIONS

JAN, JANTX, JANTXV 1N3595



Dimensions in inches and (millimeters)

DO-7



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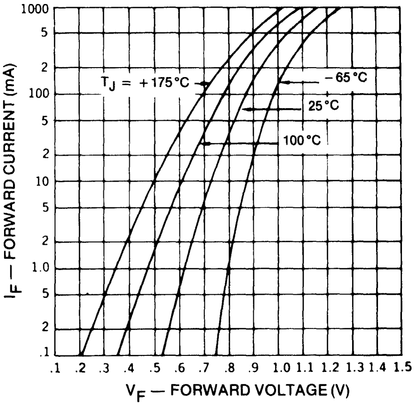
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

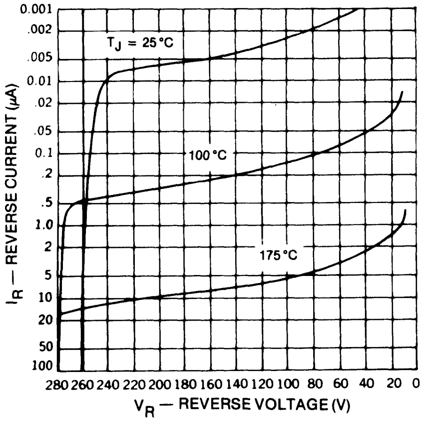
Limits	V_{F_1} I_F = 200mAdc	V_{F_2} I_F = 100mAdc	V_{F_3} I_F = 50mAdc	V_{F_4} I_F = 10mAdc	V_{F_5} I_F = 5mAdc	V_{F_6} I_F = 1mAdc
Min	0.83Vdc	0.79Vdc	0.74Vdc	0.65Vdc	0.60Vdc	0.52Vdc
Max	1.00Vdc	0.92Vdc	0.88Vdc	0.80Vdc	0.75Vdc	0.68Vdc

Limits	I_{R_1} V_R = 125Vdc	I_{R_2} V_R = 30Vdc T_A = 125°C	I_{R_3} V_R = 125Vdc T_A = 125°C	I_{R_4} V_R = 125Vdc T_A = 150°C	C V_R = 0Vdc f = 1MHz	t_{rr} I_F = 10mAdc V_R = 35Vdc
Min	—	—	—	—	—	—
Max	1.0nAdc	0.3μAdc	0.5μAdc	3.0μAdc	8.0pF	3.0μS

Typical Forward Voltage vs. Forward Current



Typical Reverse Voltage vs. Reverse Current



COMPUTER DIODE

200mA
Low Power, Switching

JAN, JANTX & JANTXV 1N3600
JAN, JANTX & JANTXV 1N4150
JAN, JANTX & JANTXV 1N4150-1

FEATURES

- Metallurgical Bond
- Qualified to MIL-S-19500/231
- Planar Passivated Chip
- DO-7 or DO-35 Package
- Non-JAN Available

DESCRIPTION

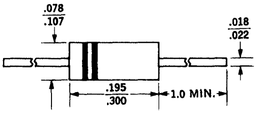
This series of switching diodes is useful in many computer switching applications, for both military and commercial systems.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

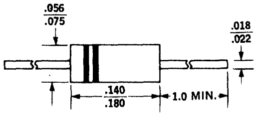
Reverse Breakdown Voltage	75V
Peak Working Voltage	50V
Average Output Current	200mA
Surge Current (1sec)	0.5A
(1μsec)	4.0A
Operating Temperature Range	−65°C to +175°C
Storage Temperature Range	−65°C to +200°C

MECHANICAL SPECIFICATIONS

J, JTX & JTXV 1N3600



J, JTX & JTXV 1N4150, 1N4150-1



UNITRODE

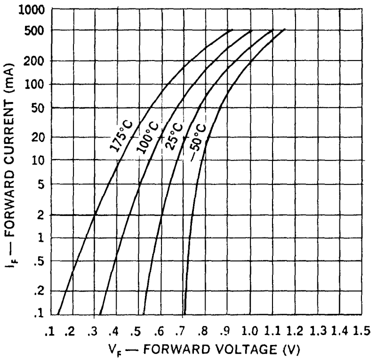
12/79

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

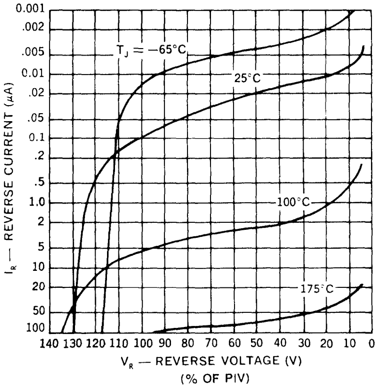
Characteristics	Forward Voltage	Forward Voltage	Forward Voltage	Forward Voltage	Forward Voltage	Reverse Breakdown Voltage
Conditions	V_{F1} $I_F = 1$ mAdc	V_{F2} $I_F = 10$ mAdc	V_{F3} $I_F = 50$ mAdc (pulse)	V_{F4} $I_F = 100$ mAdc (pulse)	V_{F5} $I_F = 200$ mAdc (pulse)	BV $I_R = 5.0\ \mu$Adc
Minimum Maximum	0.540 Vdc 0.620 Vdc	0.660 Vdc 0.740 Vdc	0.760 Vdc 0.860 Vdc	0.820 Vdc 0.920 Vdc	0.870 Vdc 1.00 Vdc	75 Vdc —

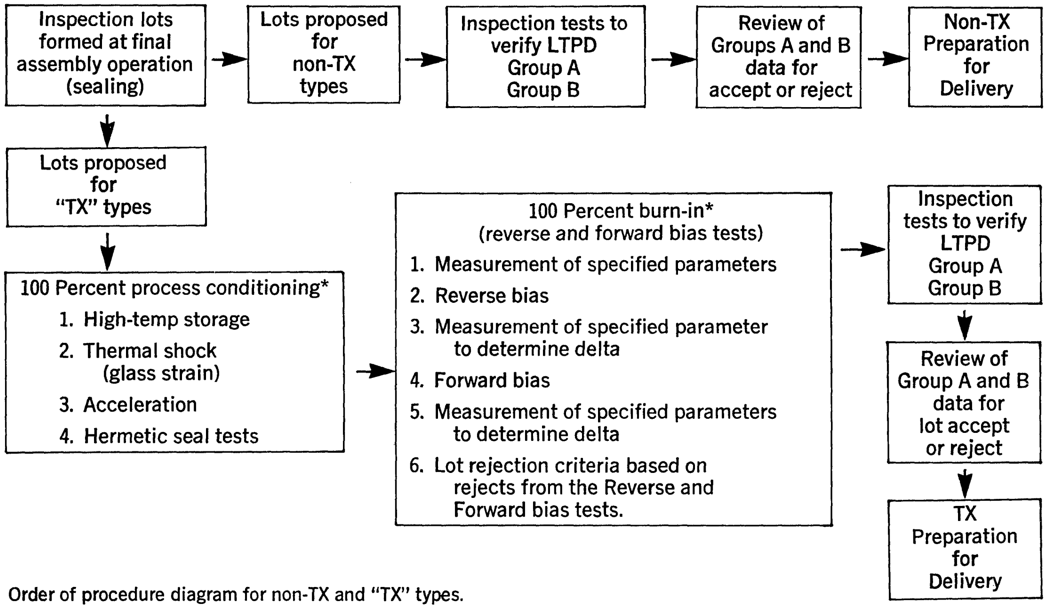
Characteristics	Reverse Current	Reverse Current	Junction Capacitance	Reverse Recovery Time	Reverse Recovery Time	Forward Recovery Time
Conditions	I_R $V_R = 50$ Vdc	I_R $V_R = 50$ Vdc $T_A = 150°C$	C $V_R = 0$ $F = 1$ MHz $V_{sig} = 50$ mv (p-p)	t_{rr1} $I_F = I_R =$ 10 to 200 mAdc; $R_L = 100$ ohms	t_{rr2} $I_F = I_R =$ 200 to 400 mAdc; $R_L = 100$ ohms	t_{fr} $I_F = 200$ mAdc; $t_p = 100$ nsec; $t_r = 0.4$ nsec
Maximum	0.1 μAdc	100 μAdc	2.5 pf	4 nsec	6 nsec	10 nsec

Typical Forward Current vs Voltage



Reverse Voltage vs. Reverse Current





Order of procedure diagram for non-TX and "TX" types.

COMPUTER DIODE
Switching

1N4149, 1N4151, 1N4154
1N4446, 1N4447, 1N4448
1N4449

FEATURES
- Metallurgical Bond
- Planar Passivated
- DO-35

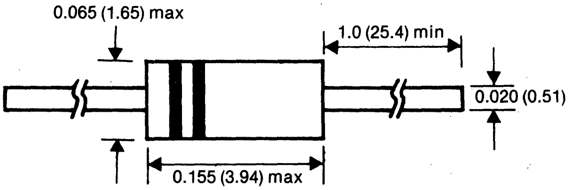
DESCRIPTION
This series offers Metallurgical Bonding and is very popular for general purpose switching applications.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

	1N4149	1N4151	1N4154	1N4446	1N4447	1N4448	1N4449
Peak Reverse Voltage	75V	75V	35V	75V	75V	75V	75V
Average Rectified Current	200mAdc						
Surge Current, 8.3 mS	500mA						
Operating Temperature Range	−65°C to +150°C						
Storage Temperature Range	−65°C to +200°C						

MECHANICAL SPECIFICATIONS

1N4149, 1N4151, 1N4154, 1N4446, 1N4447, 1N4448 1N4449



Dimensions in inches and (millimeters)

DO-35

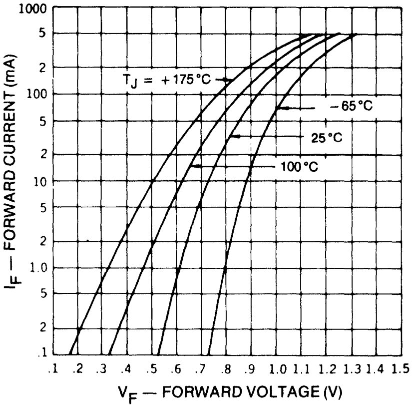
12/79

UNITRODE

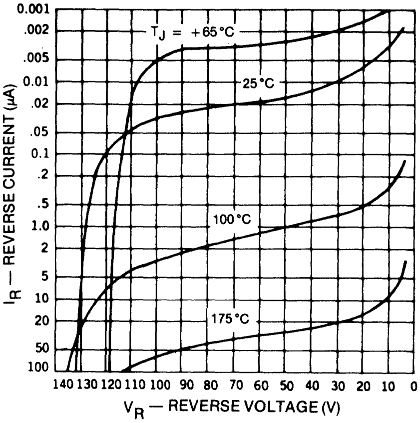
ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	Peak Inverse Voltage	Forward Voltage					Reverse Current V_R nA	Reverse Current @ 150°C V_R µA	Junction Capacitance @ 0V	Reverse Recovery Time t_{RR}
		@ 10mA	@ 20mA	@ 30mA	@ 50mA	@ 100mA				
1N4149	75	1.0	—	—	—	—	20 25	20 50	4pF	4nS
1N4151	75	—	—	—	1.0	—	50 50	50 50	4pF	2nS
1N4154	35	—	—	1.0	—	—	25 100	25 100	4pF	2nS
1N4446	75	—	1.0	—	—	—	20 25	20 50	4pF	4nS
1N4447	75	—	1.0	—	—	—	20 25	20 50	4pF	4nS
1N4448	75	—	—	—	—	1.0	20 25	20 50	4pF	4nS
1N4449	75	—	—	1.0	—	—	20 25	20 50	2pF	4nS

Typical Forward Voltage vs Forward Current



Typical Reverse Voltage vs. Reverse Current



COMPUTER DIODE

Switching

1N4152, 1N4305, 1N4444

FEATURES
- Metallurgical Bond
- Planar Passivated
- DO-35 Package

DESCRIPTION

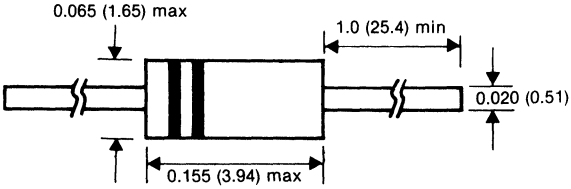
This series offers Metallurgical Bonding and is very popular for general purpose switching applications.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

	1N4152	1N4305	1N4444
Peak Reverse Voltage	40V	75V	70V
Reverse Working Voltage	30V	50V	50V
Average Rectified Current	200mAdc		
Surge Current, 8.3 mS	500mA		
Operating Temperature Range	−65°C to +150°C		
Storage Temperature Range	−65°C to +200°C		

MECHANICAL SPECIFICATIONS

1N4152, 1N4305, 1N4444



Dimensions in inches and (millimeters)

DO-35

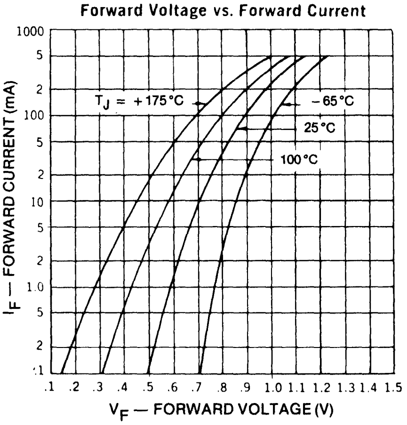
12/79

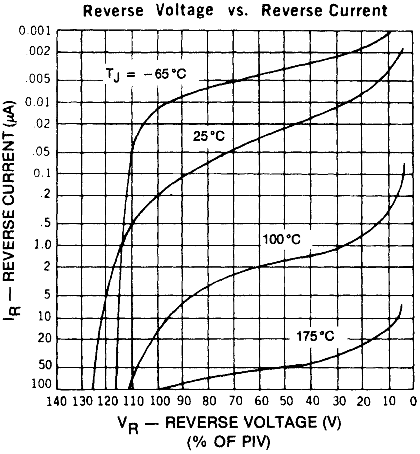
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

Type	Peak Inverse Voltage (V)	Forward Voltage @ 0.1mA		Forward Voltage @ 0.25mA		Forward Voltage @ 1.0mA		Forward Voltage @ 2.0mA		Forward Voltage @ 10mA		Forward Voltage @ 20mA		Forward Voltage @ 100mA	
		min	max	min	max	min	max	min	max	min	max	min	max	min	max
1N4152	40	0.49	0.55	0.53	0.59	0.59	0.67	0.62	0.70	0.70	0.81	0.74	0.88	—	—
1N4305	75	—	—	0.505	0.575	0.55	0.65	0.61	0.71	0.70	0.85	—	—	—	—
1N4444	70	0.44	0.55	—	—	0.56	0.68	—	—	0.69	0.82	—	—	0.85	1.0

Type	Reverse Current		Reverse Current @ 150°C		Junction Capacitance @ 0V	Reverse Recovery Time t_{rr}
	V_R	(nA)	V_R	µA		
1N4152	30	50	30	500	2pF	2nS
1N4305	50	100	50	1000	2pF	2nS
1N4444	50	50	50	500	2pF	—


Forward Voltage vs. Forward Current


Reverse Voltage vs. Reverse Current

COMPUTER DIODE

150mA
Switching Diode

JAN, JANTX & JANTXV 1N4153

FEATURES
- Metallurgical Bond
- Qualified to MIL-S-19500/337
- Planar Passivated Chip
- DO-35 Package
- Non-JAN Available

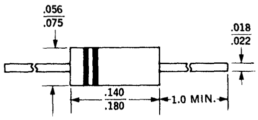
DESCRIPTION
This device is particularly suited to applications where tightly controlled forward characteristics and fast recovery time are important.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

Reverse Breakdown Voltage	75V
Peak Working Voltage	50V
Average Output Current	150mA
Surge Current, 1μsec	2.0A
Operating Temperature Range	–65°C to +200°C
Storage Temperature Range	–65°C to +200°C

MECHANICAL SPECIFICATIONS

J, JTX & JTXV 1N4153



12/79

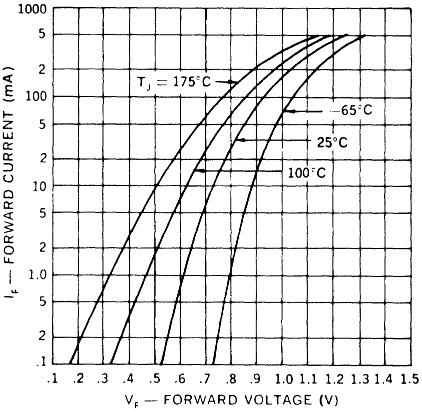
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

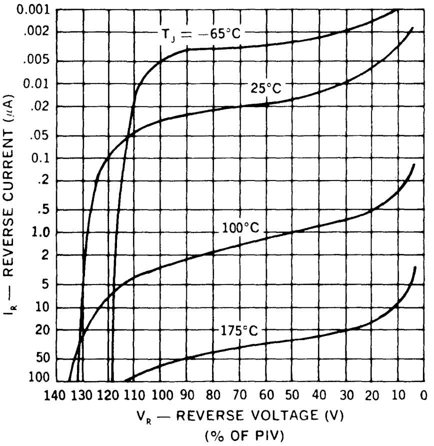
Limit	V_{F1} $I_F = 100$ μAdc	V_{F2} $I_F = 250$ μAdc	V_{F3} $I_F = 1$ mAdc	V_{F4} $I_F = 2$ mAdc	V_{F5} $I_F = 10$ mAdc	V_{F6} $I_F = 20$ mAdc
Min	0.490 Vdc	0.530 Vdc	0.590 Vdc	0.620 Vdc	0.700 Vdc	0.740 Vdc
Max	0.550 Vdc	0.590 Vdc	0.670 Vdc	0.700 Vdc	0.810 Vdc	0.880 Vdc

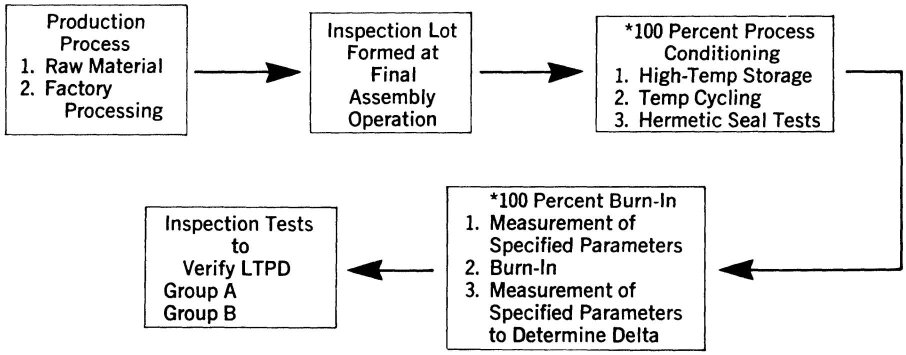
Limit	I_R $V_R = 50$ V	I_{R2} $V_R = 50$ V $T_A = 150$ C	C $V_R = 0$ f = 1 MHz	t_{rr} $I_F = I_R = 10$ mAdc $R_L = 100$ ohms	Reverse Breakdown Voltage $I_R = 5.0$ μAdc
Min	—	—	—	—	75V
Max	0.05 μAdc	50 μAdc	2.0 pF	4 ns	—

Forward Voltage vs. Forward Current



Reverse Voltage vs. Reverse Current





*Order of the tests in the blocks shall be performed as shown.

Order of procedure diagrams for TX types only.

COMPUTER DIODE
Switching

1N4450, 1N4451, 1N4453

FEATURES
- Metallurgical Bond
- Planar Passivated
- DO-35 Package

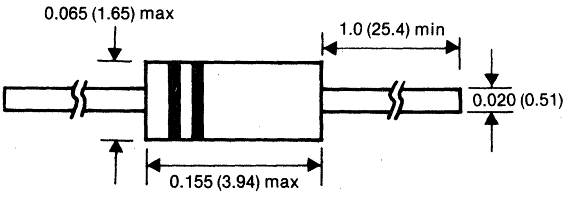
DESCRIPTION
This series offers Metallurgical Bonding and is very popular for general purpose switching applications.

ABSOLUTE MAXIMUM RATINGS, AT 25 °C

	1N4450	1N4451	1N4453
Peak Reverse Voltage	40V	40V	30V
Reverse Working Voltage	30V	30V	20V
Average Rectified Current	200mAdc		
Surge Current, 8.3 mS	500mA		
Operating Temperature Range	−65 °C to +150 °C		
Storage Temperature Range	−65 °C to +200 °C		

MECHANICAL SPECIFICATIONS

1N4450, 1N4451, 1N4453



Dimensions in inches and (millimeters)

DO-35

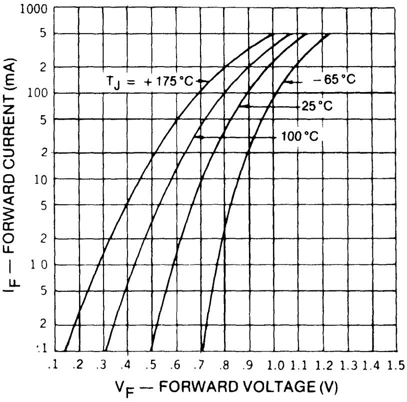
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

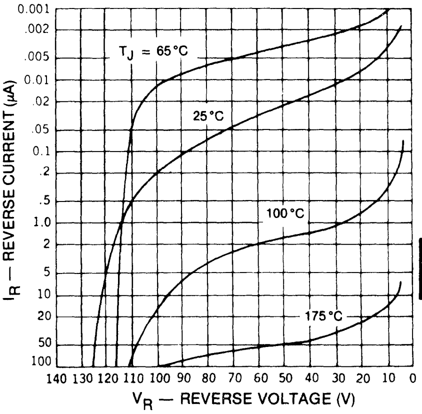
Type	Peak Inverse Voltage (V)	Forward Voltage @ 0.01mA		Forward Voltage @ 0.1mA		Forward Voltage @ 1.0mA		Forward Voltage @ 10mA		Forward Voltage @ 100mA		Forward Voltage @ 200mA		Forward Voltage @ 300mA	
		min	max	min	max	min	max	min	max	min	max	min	max	min	max
1N4450	40	—	—	0.42	0.54	0.52	0.64	0.64	0.76	0.80	0.96	—	1.0	—	—
1N4451	40	—	—	0.40	0.50	0.51	0.61	0.62	0.72	0.75	0.875	—	—	—	1.0
1N4453	30	0.43	0.55	0.51	0.63	0.60	0.71	0.69	0.80	0.80	0.92	—	—	—	—

Type	Reverse Current		Reverse Current @ 150°C		Junction Capacitance @ 0V	Reverse Recovery Time t_{rr}
	V_R	(nA)	V_R	μA		
1N4450	30	50	30	500	4pF	4nS
1N4451	30	50	30	500	6pF	—
1N4453	20	50	20	500	30pF	—

Forward Voltage vs. Forward Current



Reverse Voltage vs. Reverse Current



XI

COMPUTER DIODE

High Conductance

1N4452, 1N4607

FEATURES

- Metallurgical Bond
- Planar Passivated
- High Conductance
- DO-35 Package

DESCRIPTION

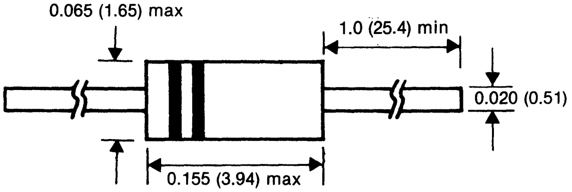
This series offers Metallurgical Bonding and is specifically designed for high conductance switching applications such as core memories.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

	1N4452	1N4607
Peak Reverse Voltage	40V	85V
Reverse Working Voltage	30V	50V
Average Rectified Current	400mAdc	
Surge Current, 8.3 mS	1A	
Operating Temperature Range	−65°C to +150°C	
Storage Temperature Range	−65°C to +200°C	

MECHANICAL SPECIFICATIONS

1N4452, 1N4607



Dimensions in inches and (millimeters)

DO-35

12/79

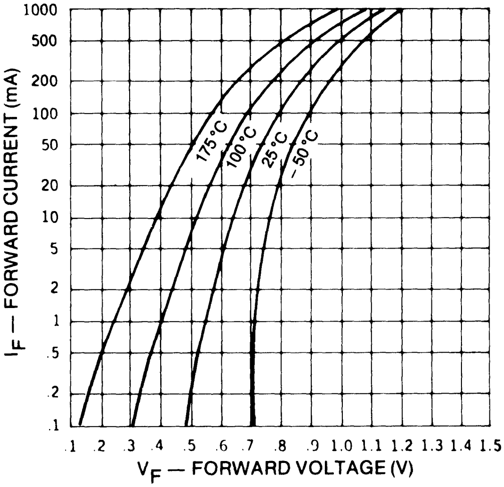
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

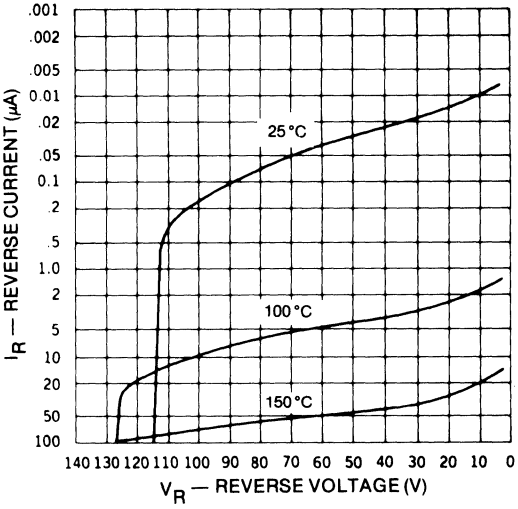
Type	Peak Inverse Voltage	Forward Voltage @ 0.1mA		Forward Voltage @ 1.0mA		Forward Voltage @ 10mA		Forward Voltage @ 100mA		Forward Voltage @ 250mA		Forward Voltage @ 350mA		Forward Voltage @ 400mA		Forward Voltage @ 600mA		Forward Voltage @ 1000mA	
		min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
1N4452	40V	0.42	0.54	0.51	0.62	0.60	0.71	0.71	0.83	—	—	—	—	—	—	—	1.0	0.90	1.2
1N4607	85V	0.39	0.50	0.50	0.60	0.61	0.72	0.74	0.87	0.81	0.95	—	1.0	—	1.1	—	—	—	—

Type	Reverse Current		Reverse Current @ 100°C		Reverse Current @ 150°C		Junction Capacitance @	Reverse Recovery Time
	V_R	nA	V_R	µA	V_R	µA	0V	t_{rr}
1N4452	30	50	—	—	30	500	—	50nS
1N4607	50	100	50	25	—	—	4pF	10nS

Typical Forward Voltage vs Forward Current



Typical Reverse Voltage vs Reverse Current



COMPUTER DIODE

500mA
Switching Diode

JAN & JANTX 1N4500

FEATURES

- Metallurgical Bond
- Qualified to MIL-S-19500/403
- Planar Passivated Chip
- DO-35 Package
- Non-JAN Available

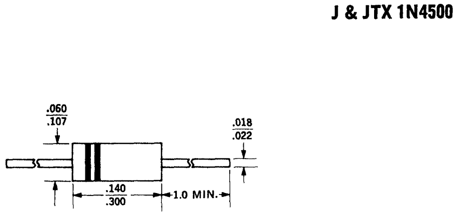
DESCRIPTION

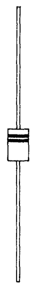
This device is a fast switching, high conductance diode for military, space, high rel and other systems.

ABSOLUTE MAXIMUM RATINGS, AT 25°C

Reverse Breakdown Voltage	80Vdc
Peak Working Voltage	75Vpk
Average Output Current	300mAdc
Surge Current, 1sec	0.5A
1μsec	4.0A
Operating Temperature Range	−65°C to +175°C
Storage Temperature Range	−65°C to +200°C

MECHANICAL SPECIFICATIONS





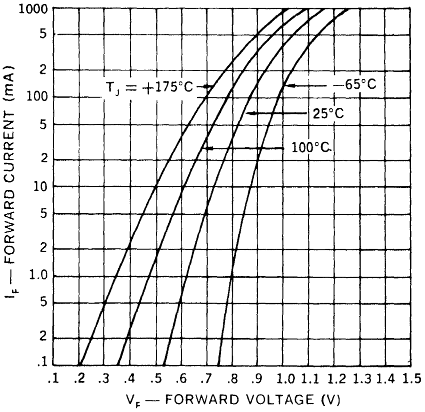
UNITRODE

ELECTRICAL SPECIFICATIONS (at 25°C unless noted)

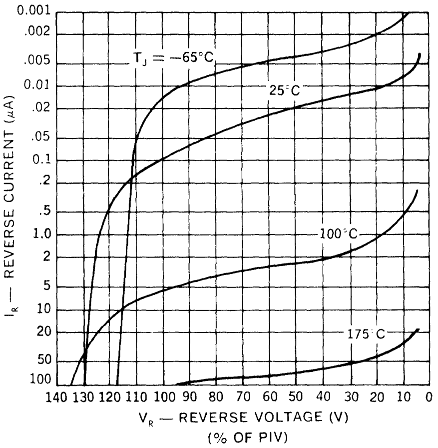
Limits	V_{F1} $I_F = 250\mu$Adc	V_{F2} $I_F = 1.0$mAdc	V_{F3} $_F = 10$mAdc	V_{F4} $I_F = 20$mAdc	V_{F5} 1/ $I_F = 300$mAdc	C $V_R = 0$ 100 kHz $\leqslant f \leqslant$ 1 MHz $v_{sig} = 50$ mv (p-p)
	mVdc	mVdc	mVdc	mVdc	Vdc	pF
Minimum	470	520	640	670	—	—
Maximum	560	600	720	770	1.10	4.0

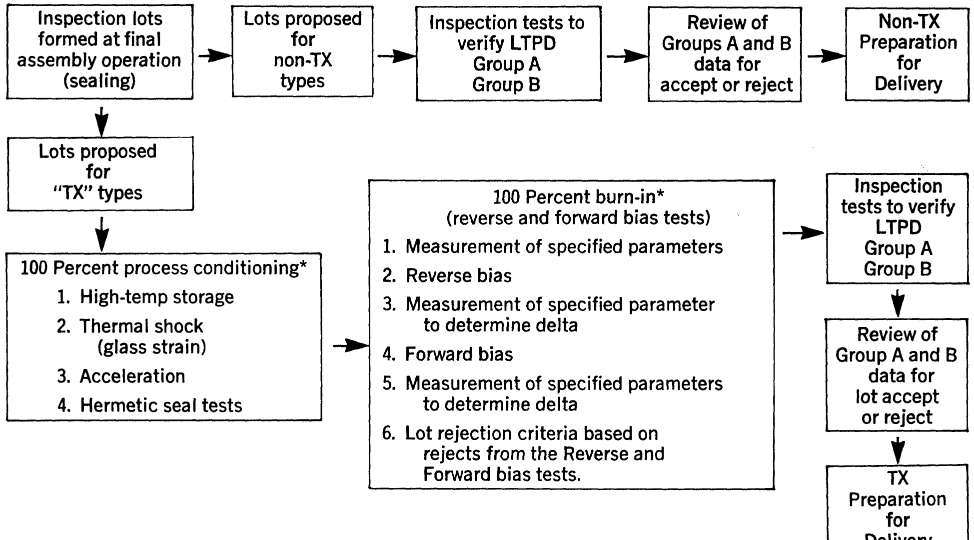
	I_R $V_R = 75$Vdc	B_V $I_R = 5\mu$Adc	I_R $V_R = 75$Vdc $T_A = 150$°C	t_{rr} $I_F = I_R =$ 10 mAdc: $R_L = 100$ ohms
	nAdc	Vdc	μAdc	nsec
Minimum	—	80	—	—
Maximum	100		100	6.0

Forward Voltage vs. Forward Current



Reverse Voltage vs. Reverse Current





Order of procedure diagram for non-TX and "TX" types.

SWITCHING & GENERAL PURPOSE DIODES

PART NUMBER INDEX

PAGE	PART NUMBER	DESCRIPTION
		DIODE
620	1N456	90mA; 25V
*	1N456A	75mA; 60V
620	1N457, J	55mA; 125V; DO-7
*	1N457A	40mA; 175V
620	1N458, J	55mA; 150V; DO-7
*	1N458A	100mA; 150V
620	1N459, J	40mA; 200V; DO-7
*	1N459A	100mA; 200V
*	1N483	100mA; 70V
*	1N483A	100mA; 70V
622	1N483B, J, JTX	200mA; 80V; DO-7
*	1N483C	100mA; 70V
*	1N485	100mA; 180V
622	1N485B, J, JTX	200mA; 200V; DO-7
		RECTIFIER
624	1N645J, JTX	400mA; 270V
624	1N645-1J, JTX, JTXV	400mA; 270V
		DIODE
626	1N914, J, JTX	75mA; 100V
*	1N914-1, A, B	75mA; 100V
*	1N916, B	75mA; 100V
628	1N3064J, JTX	75mA; 75V; DO-7
630	1N3070	200mA; 200V; DO-35
632	1N3595, J, JTX, JTXV	150mA; 150V; DO-7
634	1N3600J, JTX, JTXV	200mA; 75V; DO-7
626	1N4148, J, JTX, JTXV	200mA; 100V; DO-35
626	1N4148-1J, JTX, JTXV	150mA; 100V; DO-35
636	1N4149	200mA; 75V; DO-35
634	1N4150, J, JTX, JTXV	200mA; 75V; DO-35
634	1N4150-1J, JTX, JTXV	200mA; 75V; DO-35
636	1N4151	200mA; 75V; DO-35
638	1N4152	200mA; 40V; DO-35
640	1N4153, J, JTX, JTXV	150mA; 75V; DO-35
*	1N4153-1, J, JTX, JTXV	150mA; 75V; DO-35
636	1N4154	200mA; 35V; DO-35
638	1N4305	200mA; 75V; DO-35
638	1N4444	200mA; 70V; DO-35
636	1N4446	200mA; 75V; DO-35
636	1N4447	200mA; 75V; DO-35
636	1N4448	200mA; 75V; DO-35
636	1N4449	200mA; 75V; DO-35
642	1N4450	200mA; 40V; DO-35
642	1N4451	200mA; 40V; DO-35
644	1N4452	400mA; 40V; DO-35
642	1N4453	200mA; 30V; DO-35
628	1N4454, J, JTX, JTXV	200mA; 75V; DO-35
628	1N4454-1J, JTX, JTXV	200mA; 75V; DO-35
646	1N4500, J, JTX	300mA; 80V; DO-35
644	1N4607	400mA; 85V; DO-35

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

PIN DIODES

PRODUCT SELECTION GUIDE

SWITCHING PIN DIODES

Type	Voltage Rating Range	Capacitance (0V, 1 GHz) C_T max.	Forward Resistance (100mA, 1 GHz) R_S max.	Parallel Resistance (100V, 1 GHz) R_p min.	Average Thermal Resistance Θ_A max.	Average Power Dissipation P_A max.	Peak Power Dissipation P_p max.	Carrier Lifetime I_F = 10mA τ min.
	(V)	(pF)	(Ω)	(KΩ)	(°C/W)	(W)	(KW)	(μS)
UM4000	100-1000	3.0	0.5	2	6	25	100	5.0
UM4900	100-600	3.0	0.5	2	4	37	100	5.0
UM6000	100-1000	0.5	1.7	15	25	6	25	1.0
UM6200	100-400	1.1	0.4	10	25	6	10	0.6
UM6600	100-1000	0.4	2.5	10	35	4	13	1.0
UM7000	100-1000	0.9	1.0	10	15	10	60	2.5
UM7100	100-800	1.2	0.6	8	15	10	35	2.0
UM7200	100-400	2.2	0.25	7	15	10	20	1.5

HIGH POWER ATTENUATOR & MODULATOR PIN DIODES

Type	Voltage Ratings Range	Total Capacitance (0V, 1 GHz) C_T max.	RF Resistance (100mA, 1 GHz) R_S max.	RF Resistance (10μA, 1 GHz) R_S min.	Average Thermal Resistance Θ_A max.	Average Power Dissipation P_A max.	Carrier Lifetime I_F = 10mA τ min.
	(V)	(pF)	(Ω)	(Ω)	(°C/W)	(W)	(μS)
UM4300	100-1000	2.2	1.5	1000	8	18	5.0
UM7300	100-1000	0.7	3.0	3000	20	7.5	2.5

GENERAL PURPOSE PIN DIODE

Type	Voltage Rating (I_R=10μA)	Total Capacitance (50V, 1MHz) C_T max.	RF Resistance (10μA, 100 MHz) R_S min.	RF Resistance (20mA, 100 MHz) R_S max.	RF Resistance (100mA, 100MHz) R_S max.	Carrier Lifetime (I_R = 10mA) τ min.
	(V)	(pF)	(Ω)	(Ω)	(Ω)	(μS)
1N5767	100	0.4	1000 3000 typ.	8 4 typ.	2.5 1.5 typ.	1

LOW DISTORTION ATTENUATOR PIN DIODES

Type	Voltage Rating I_R=10μA	Total Capacitance (0V, 100MHz) C_T max.	RF Resistance (100mA, 100MHz) R_S max.	RF Resistance (10μA, 100 MHz) R_S max.	Forward Current (R_S = 75Ω F = 100MHz) Typ.	Carrier Lifetime (I_F=10mA) Typ.
	(V)	(pF)	(Ω)	(Ω)	I_F (mA)	τ (μS)
1N5957	100	0.4	3.5	1500	1.0	2
UM9301	75	0.8	3.0	3000	1.1	4

PIN DIODES

PRODUCT SELECTION GUIDE

TWO WAY RADIO ANTENNA SWITCHES

Type	Voltage Rating (I_R=10μA)	Total Capacitance (0V, 100MHz) C_T max.	RF Resistance (50mA, 100MHz) R_F max.	Transmit Harmonic Distortion F = 50MHz I = 20mA	Receive Third Order Distortion (Pin-10mW, 0 Bias) FA=50MHz FB=51MHz Max.	Average Power Dissipation P_A Max.
	(V)	(pF)	(Ω)	(dB)	(dB)	(W)
UM9401 and UM9402	50	1.5	1.0	−80	−60	5.5
UM9415	50	4.0	1.0	−80	60	10

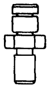
RADIATION DETECTORS

Type	Photocurrent $\frac{10^6 \text{ Rad (Si), 50V}}{\text{Sec}}$ mA min.	Photocurrent Rise Time nS Typ.	Reverse Current 50V μA max.	Capacitance F = 1 MHz, V = 50V pF max.
UM9441	4.0	10	1.0	15

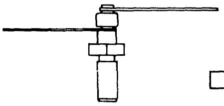
PACKAGE STYLES (For UM4000, 6000 & 7000 Series)

A Style
Basic Diode

B Style
Round Axial Leads



***C Style**
Stud



***D Style**
Insulated Stud

E Style
Ribbon Axial Leads

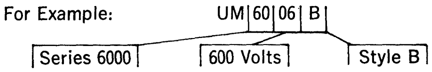
*Not available for UM6000, UM6600, UM6200.

VOLTAGE RATINGS

Series	100V	200V	400V	600V	800V	1000V
UM4000	√	√		√		√
UM4300	√	√		√		√
UM4900	√	√		√		
UM6000	√	√		√		√
UM6200	√	√	√			
UM6600	√	√		√		√
UM7000	√	√		√		√
UM7100	√	√	√		√	
UM7200	√	√	√			
UM7300	√	√		√		√

ORDERING INFORMATION

Part numbers of Microwave PIN diodes consist of the letters UM followed by four digits and one or two letters. The first two digits indicate the diode series, the next two digits specify the voltage rating in hundreds of volts. The remaining letters denote the package style. Reverse polarity is available for C, and D, style and denoted by adding second letter R.



PIN DIODE

1N5767 (5082 - 3080)SERIES
1N5957 SERIES

Features

- Useful attenuation from 1 μA to 100 mA bias.
- Capacitance below 0.4 pF.
- Low distortion in switches and attenuators.
- Rugged Unitrode construction.

Description

The 1N5767 and 1N5957 PIN diodes are based upon low capacitance PIN chips designed with long minority carrier lifetime, and thick intrinsic width. Thus operation as low as 1 MHz is possible with low distortion. Additionally, the low diode capacitance allows useful operation well into the microwave frequency range.

The 1N5767 (5082-3080) is a general purpose low power PIN diode designed for both switch and attenuator applications.

The 1N5957 is primarily used as an attenuator PIN diode and is particularly suitable wherever current controlled, wide dynamic range resistance elements are required. The 1N5957 has also been characterized for the 75Ω attenuator, commonly employed in CATV systems.

MAXIMUM RATINGS

Reverse Voltage **(V_R) — Volts** **(I_R = 10 μA)**	100V

Average Power Dissipation: (25℃) Free Air (P_A)	400 mW (Derate linearly to 175℃)

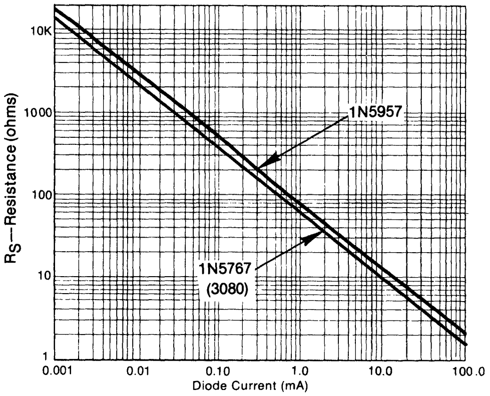
Operating and Storage Temperature Range	−65°C to +175°C

UNITRODE

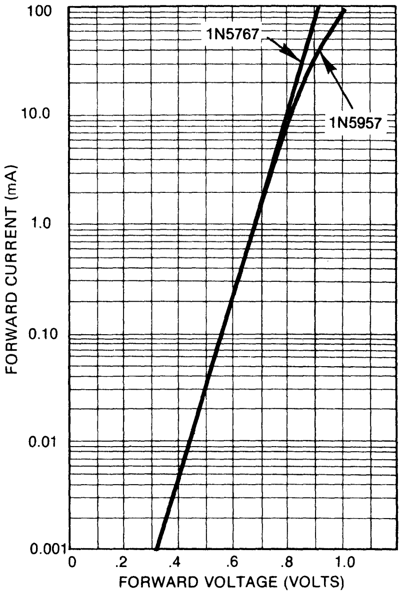
Electrical Specifications (25°C)

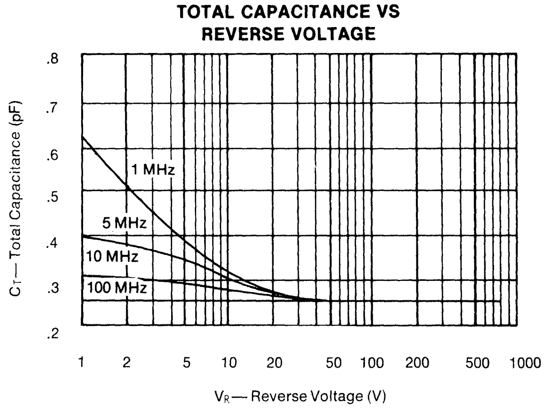
Test	Symbol	1N5767 (5082-3080)	1N5957	Conditions
Total Capacitance (Max)	C_T	0.4 pF	0.4 pF	50V, 1 MHz
Series Resistance	R_S	1000Ω(min) 2000Ω(typ)	1500Ω(min) 3000Ω(typ)	10 μA, 100 MHz
Series Resistance	R_S	8Ω(max) 4Ω(typ)	8Ω(max) 6Ω(typ)	20 mA, 100 MHz
Series Resistance	R_S	2.5Ω(max) 1.5Ω(typ)	3.5Ω(max) 2.0Ω(typ)	100 mA, 100 MHz
Carrier Lifetime (Min)	τ	1.0 μS	1.5(min) 2(typ)	I_F = 10 mA
Reverse Current (Max)	I_R	10 μA	10 μA	V_R = Rating
Current for R_S = 75Ω (typ)	I_{75}	0.7 mA	0.8 mA- 1.2 mA	R_S = 75Ω
Return Loss (typ)	—	30 dB	30 dB	Diode terminates 75Ω line
Second Order Distortion (typ)	—	−40 dB	−50 dB	Bridged tee attenuator atten. = 10 dB
Third Order Distortion (typ)	—	−60 dB	−65 dB	P_{in} = 50 dBmV F_1 = 10 MHz, F_2 = 13 MHz

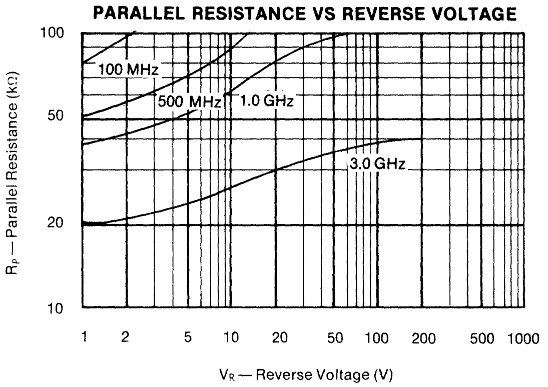
RESISTANCE VS FORWARD CURRENT (TYPICAL)



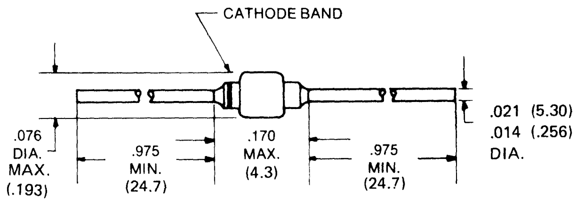
FORWARD VOLTAGE VS FORWARD CURRENT (TYPICAL)







MECHANICAL SPECIFICATIONS



Dimensions — English/Metric

PIN DIODE

UM4000 SERIES
UM4900 SERIES

Features

- Power dissipation to 37.5W
- Voltage ratings to 1000V
- Series resistance rated at 0.5Ω
- Carrier lifetime greater than 5μs

Description

The UM4000 and UM4900 series feature high power PIN diodes with long carrier lifetimes and thick I-regions. They are especially suitable for use in low distortion switches and attenuators, in the HF through S band frequencies. While both series are electrically equivalent, the UM4900 series have higher power ratings due to a shorter thermal path between chip and package. High charge storage and long carrier lifetime enable high RF levels to be controlled with relatively low bias current. Similarly, peak RF voltages can be handled well in excess of applied reverse bias voltage.

Both series have been fully qualified in high power UHF phase shifters and megawatt peak-power duplexers, accumulating thousands of hours of proven performance. Both types have been used in the design of antenna selectors and couplers, where inductive and capacitive elements are switched in and out of filter or cavity networks.

MAXIMUM RATINGS

Average Power Dissipation and Thermal Resistance Ratings

Package	Condition	UM4000		UM4900	
		P_D	θ	P_D	θ
A	25°C Pin Temperature	25W	6°C/W	37.5W	4°C/W
B&E (Axial Leads)	½ in. (12.7mm) Overall Length to 25°C Contact	12W	12.5°C/W	12W	12.5°C/W
B&E (Axial Leads)	Free Air	2.5W	—	2.5W	—
C (Studded)	25°C Stud Temperature	25W	6°C/W	37.5W	4°C/W
D (Insulated Stud)	25°C Stud Temperature	18.75W	8°C/W	25W	6°C/W

Peak Power Dissipation Rating

All Packages	1 μs Pulse (Single) at 25 °C Ambient	100 KW

Operating and Storage Temperature Range: −65°C to +175°C

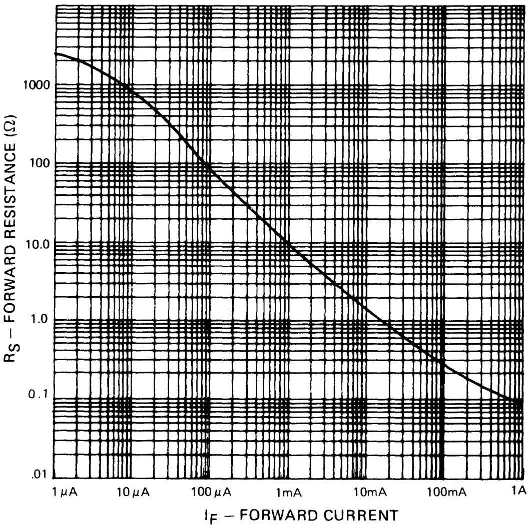
Voltage Ratings (25 °C)

Reverse Voltage (V_R) — Volts (I_R = 10 μ Amps)	Types	
100	UM4001	UM4901
200	UM4002	UM4902
400	—	UM4904
600	UM4006	UM4906
1000	UM4010	—

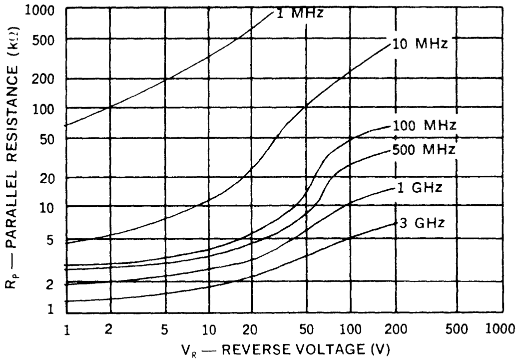
Electrical Specifications (25 °C)

Test	Symbol	UM4000 UM4900	Conditions
Total Capacitance (Max)	C_T	3 pF	0V, 1 GHz
Series Resistance (Max)	R_S	0.5Ω	100 mA, 1 GHz
Parallel Resistance (Min)	R_P	2 KΩ	100V, 1 GHz
Carrier Lifetime (Min)	τ	5μs	I_F = 10 mA
Reverse Current (Max)	I_R	10μA	V_R = Rating
I-Region Width (Min)	W	150μm	—

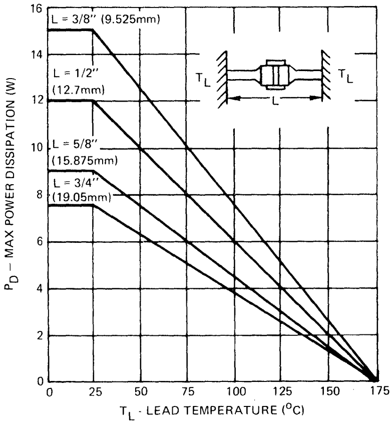
TYPICAL FORWARD RESISTANCE
VS
FORWARD CURRENT
(F = 100 MHz)



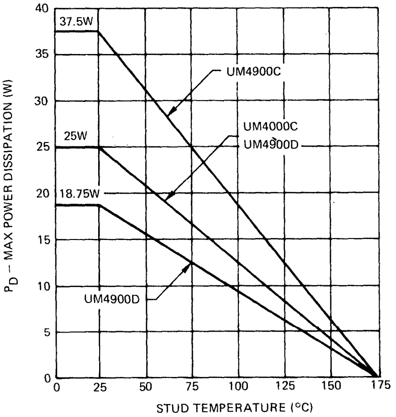
TYPICAL PARALLEL RESISTANCE CHARACTERISTIC



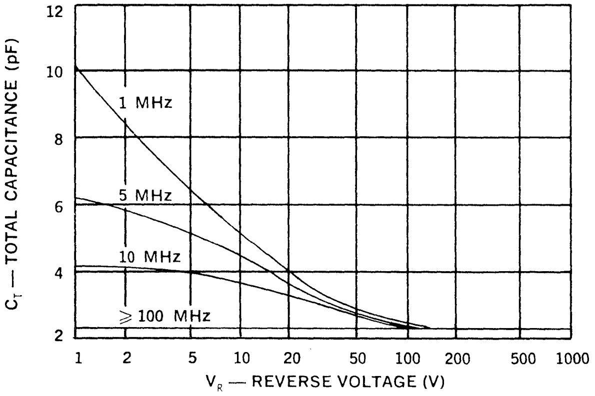
POWER RATING AXIAL LEADED DIODE



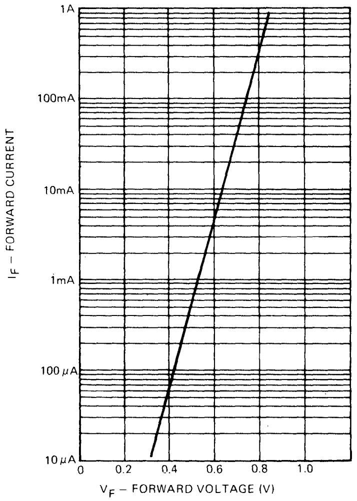
POWER RATING STUD MOUNTED DIODES



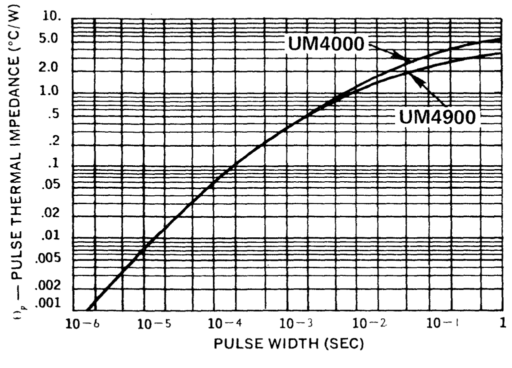
TYPICAL CAPACITANCE CHARACTERISTIC



DC CHARACTERISTICS FORWARD VOLTAGE VS FORWARD CURRENT (TYPICAL)



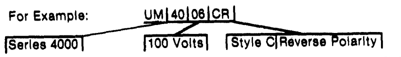
THERMAL IMPEDANCE



ORDERING INSTRUCTIONS

Part numbers of Unitrode PIN Diodes consist of the letters UM followed by four digits and one or two letters. The first two digits indicate the diode series, the next two digits specify the minimum breakdown voltage in hundreds of volts. The remaining letters denote the package style. Reverse polarity (anode large end cap) is available for the C style and denoted by adding second letter R.

For Example:

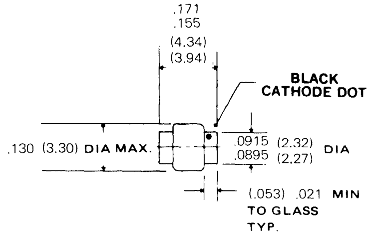


MECHANICAL SPECIFICATIONS

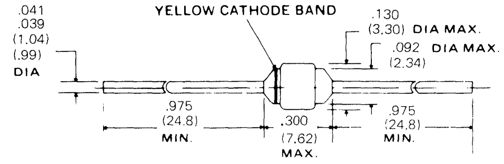
UM4000 Series

Dimensions — English/Metric

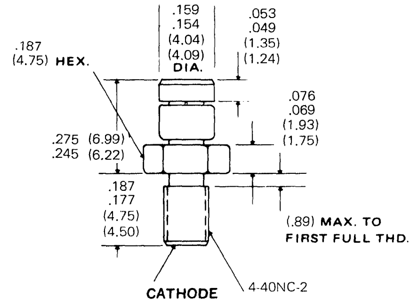
STYLE A



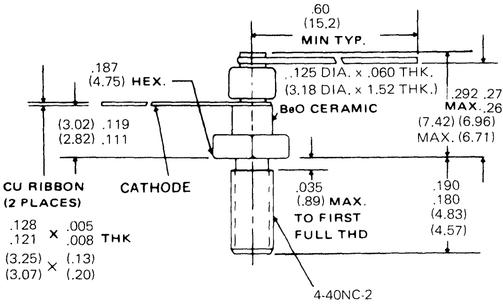
STYLE B



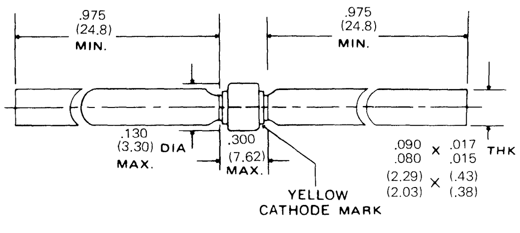
STYLE C
STUD



STYLE D
INSULATED STUD



STYLE E
RIBBON LEADS

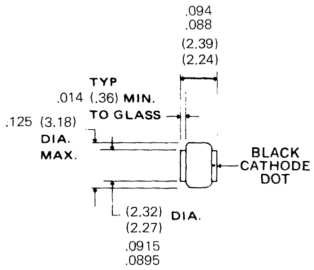


MECHANICAL SPECIFICATIONS (continued)

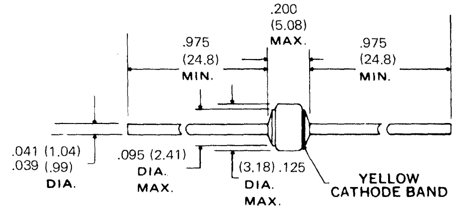
UM 4900 Series

Dimensions — English/Metric

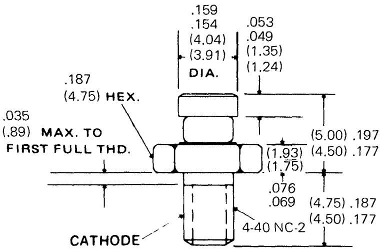
STYLE A



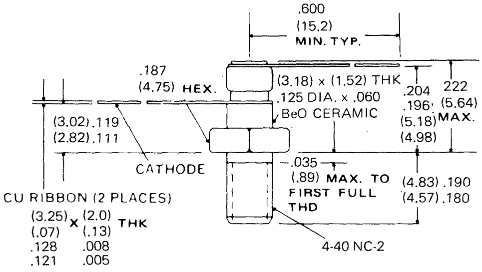
STYLE B



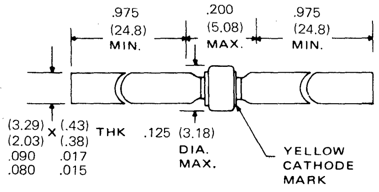
STYLE C
STUD



STYLE D
INSULATED STUD



STYLE E
RIBBON LEADS



PIN DIODE

UM4300 SERIES
UM7300 SERIES

For Attenuator Applications

Features

- Extremely low distortion performance
- Useful frequency range extends below 500 KHz
- Power dissipation to 20W (UM4300)
- Capacitance as low as 0.7 pF (UM7300)
- Voltage ratings to 1000V

Description

The UM4300 and UM7300 series combine a diode chip of extremely thick intrinsic region with a low thermal resistance construction. This results in diodes uniquely applicable to very low distortion linear attenuators and specialized switching functions. The UM4300 series, with large cross-sectional chip area offers the highest power capability, of the two series. The UM7300 series offers lower capacitance.

Both diode series are intended for use in linear attenuators operating from HF to beyond 1 GHz. Low distortion at low frequencies is a result of transit time frequencies below 5 MHz.

Operated as RF switches, either diode series can be operated at low dc reverse bias voltages, to hold off much higher RF voltage levels.

MAXIMUM RATINGS

Average Power Dissipation and Thermal Resistance Ratings

Package	Condition	UM4300		UM7300	
		P_D	θ	P_D	θ
A	25°C Pin Temperature	20W	7.5°C/W	7.5W	20°C/W
B&E (Axial Leads)	½ in. Total Length to 25°C Contact	10W	15°C/W	4W	37.5°C/W
B&E (Axial Leads)	Free Air	2.5W	—	1.5W	—
C (Studded)	25°C Stud	20W	7.5°C/W	7.5W	20°C/W
D (Insulated Stud)	25°C Stud	15W	10°C/W	6W	25°C/W

Peak Power Dissipation Rating

All packages	1μs Pulse (Single) at 25°C Ambient	500 KW	100 KW

Operating and Storage Temperature Range: −65°C to +175°C

UNITRODE

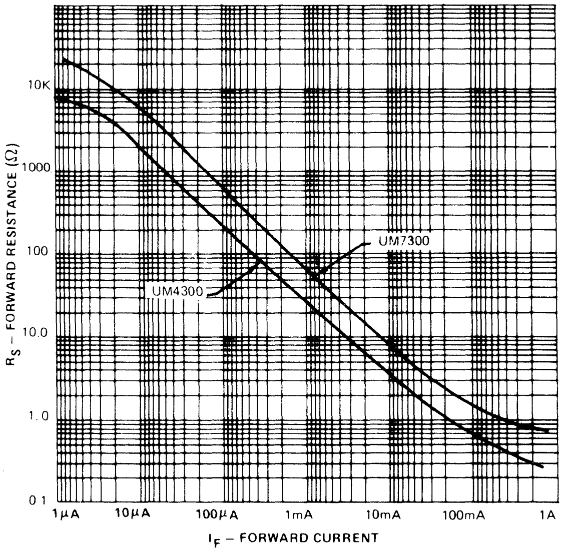
Voltage Ratings (25 °C)

Reverse Voltage (V_R) — Volts (I_R = 10 μA)	Types	
100V	UM4301	UM7301
200V	UM4302	UM7302
600V	UM4306	UM7306
1000V	UM4310	UM7310

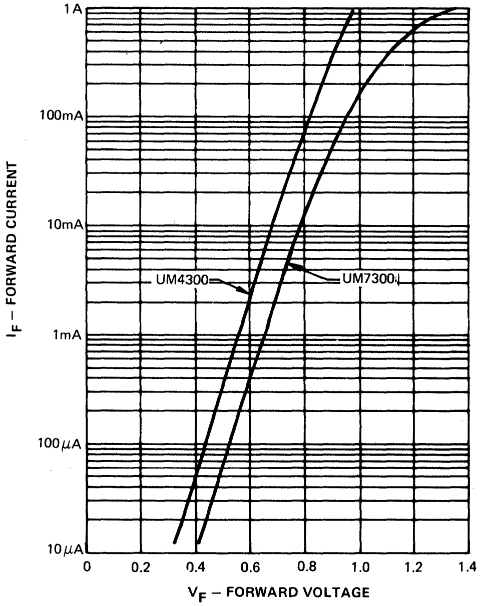
Electrical Specifications (25 °C)

Test	Symbol	UM4300	UM7300	Conditions
Total Capacitance (Max)	C_T	2.2 pF	0.7 pF	0V, 1 GHz
Series Resistance (Max)	R_S	1.5Ω	3.0Ω	100 mA, 1 GHz
Series Resistance (Min)	R_S	1000Ω	3000Ω	10 μA, 100 MHz
Carrier Lifetime (Min)	τ	6μs	4.0μS	I_F = 10 mA
Leakage Current (Max)	I_R	10μA	10μA	V_R = Rating
I-Region Width (Min)	W	250μm	250μm	—

TYPICAL FORWARD RESISTANCE
VS FORWARD CURRENT (F = 100 MHz)

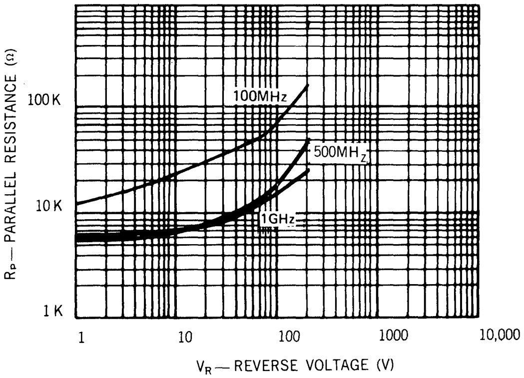


TYPICAL DC CHARACTERISTIC
FORWARD VOLTAGE
VS FORWARD CURRENT

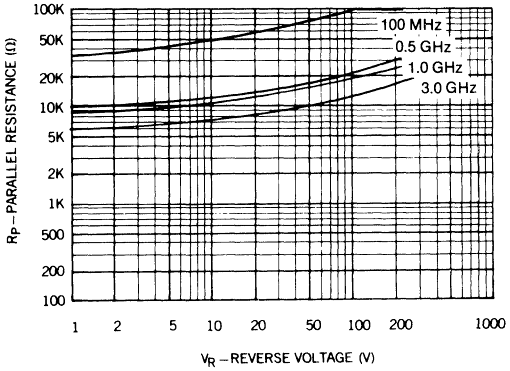


PARALLEL RESISTANCE VS REVERSE VOLTAGE

UM4300

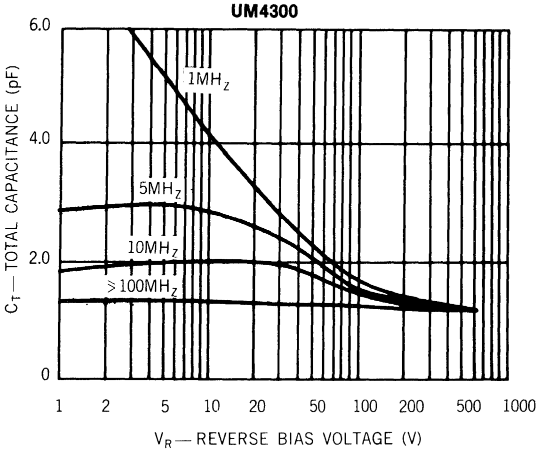


UM7300

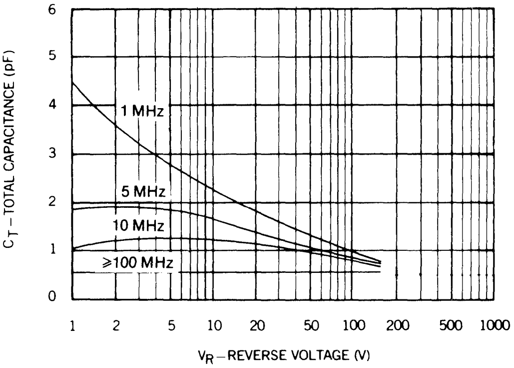


TOTAL CAPACITANCE VS REVERSE VOLTAGE

UM4300

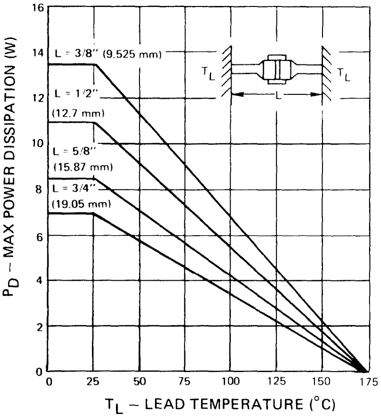


UM7300



POWER RATING AXIAL LEADED DIODE

UM4300



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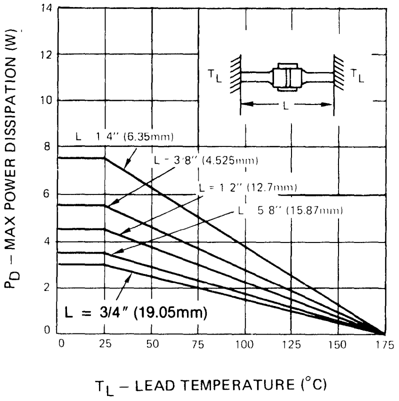
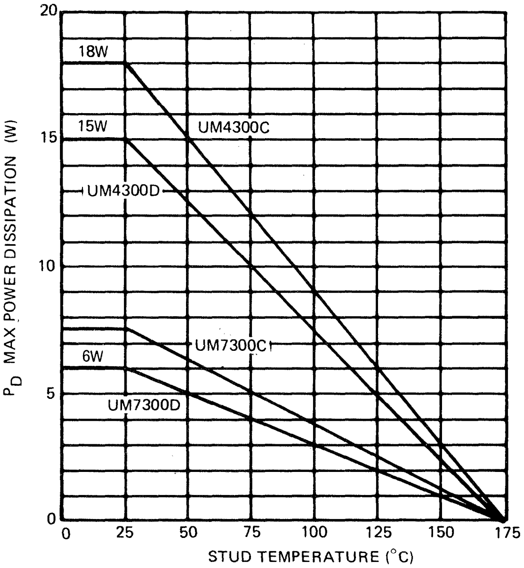
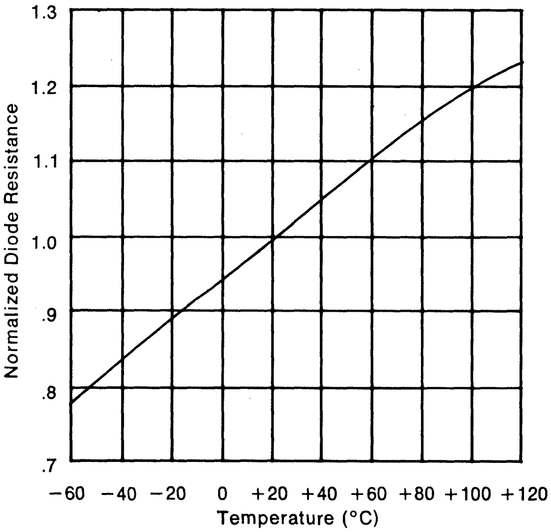


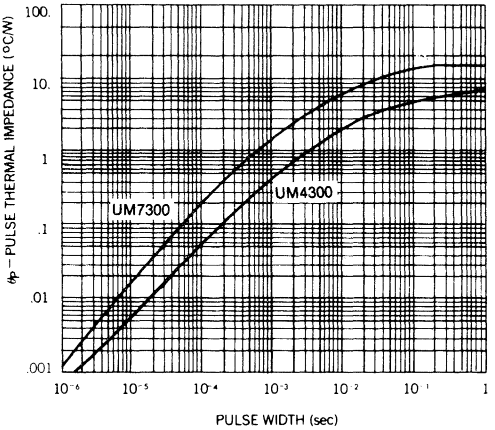
UM4300/UM7300
POWER RATING
STUD MOUNTED DIODES



NORMALIZED R_S VS TEMPERATURE



PULSE THERMAL IMPEDANCE VS PULSE WIDTH



ORDERING INSTRUCTIONS

Part numbers of Unitrode PIN Diodes consist of the letters UM followed by four digits and one or two letters. The first two digits indicate the diode series, the next two digits specify the minimum breakdown voltage in hundreds of volts. The remaining letters denote the package style. Reverse polarity (anode on stud end) is available in C or D Styles and denoted by adding second letter R.

For Example: UM|73|01|C|

Series 7300 | 100 volts | Style C

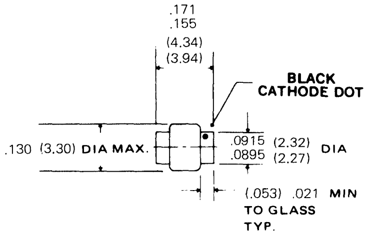
Reverse polarity available in C style. Part number designated by adding R.

MECHANICAL SPECIFICATIONS

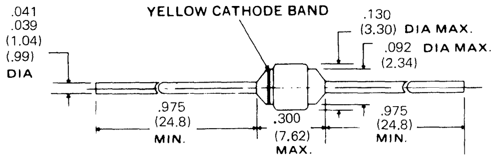
UM4300 SERIES

Dimensions — English/Metric

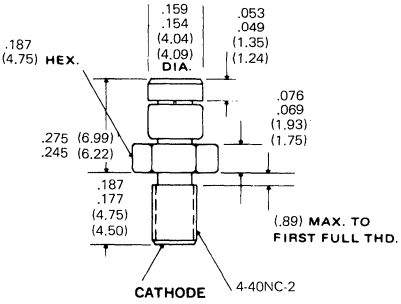
STYLE A



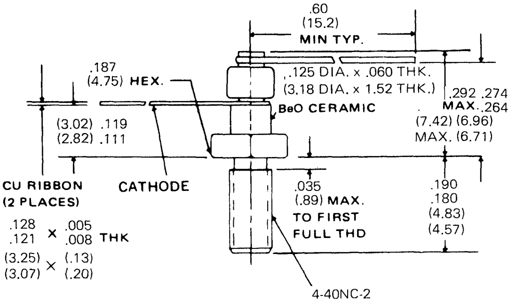
STYLE B



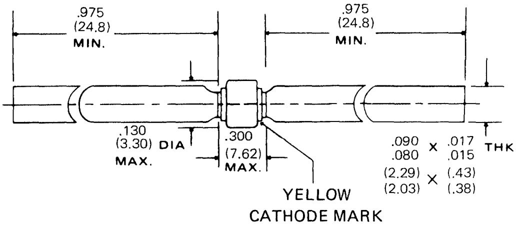
STYLE C
STUD



STYLE D
INSULATED STUD



STYLE E
RIBBON LEADS

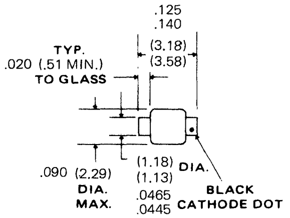


MECHANICAL SPECIFICATIONS (continued)

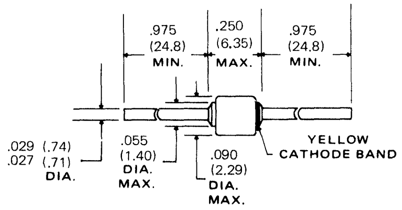
UM7300 Series

Dimensions — English/Metric

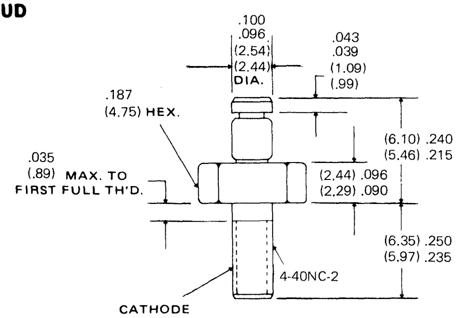
STYLE A



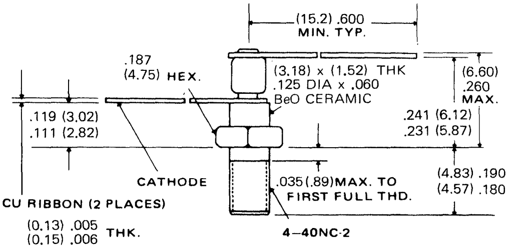
STYLE B



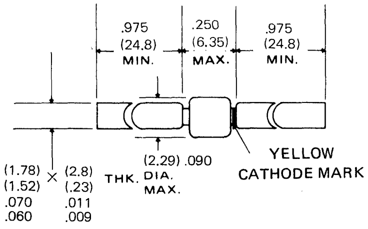
STYLE C
STUD



STYLE D
INSULATED STUD



STYLE E
RIBBON LEADS



PIN DIODE

UM6000 SERIES
UM6200 SERIES
UM6600 SERIES

Features

- Capacitance specified as low as 0.4 pF (UM6600)
- Resistance specified as low as 0.4Ω (UM6200)
- Voltage ratings to 1000V
- Power dissipation to 6W

Description

These series of PIN diodes are designed for applications requiring small package size and moderate average power handling capability. The low capacitance of the UM6000 and UM6600 allows them to be used as series switching elements to 1 GHz. The low resistance of the UM6200 is useful in applications where forward bias current must be minimized.

Because of its thick I-region width and long lifetime the UM6000 and UM6600 have been used in distortion sensitive and high peak power applications, including receiver protectors, TACAN, and IFF equipment. Their low capacitance allows them to be useful as attenuator diodes at frequencies greater than 1 GHz. The UM6200 has been used successfully in switches in which low insertion loss at low bias current is required.

The "A" style package for this series is the smallest Unitrode PIN diode package. It has been used successfully in many microwave applications using coaxial, microstrip, and stripline techniques at frequencies beyond X-Band. The "B" and "E" style, leaded packages offer the highest available power dissipation for a package this small. They have been used extensively as series switch elements in microstrip circuits. The "C" style package duplicates the physical outline available in conventional ceramic-metal packages but incorporates the many reliability advantages of the Unitrode construction.

MAXIMUM RATINGS

Average Power Dissipation and Thermal Resistance Ratings

Package	Condition	UM6000 UM6200		UM6600	
		P_D	θ	P_D	θ
A&C	25°C Pin Temperature	6W	25°C/W	4W	37.5°C/W
B&E (Axial Leads)	½ in. Total Lead Length to (12.7mm) to 25°C Contact	2.5W	60°C/W	2.0W	75°C/W
B&E (Axial Leads)	Free Air	0.5W	—	0.5W	—

Peak Power Dissipation Rating

All Packages	1 µs Pulse (Single) at 25°C Ambient	UM6000 - 25 KW UM6200 - 10 KW	UM6600 - 13 KW

Operating and Storage Temperature Range: −65°C to +175°C

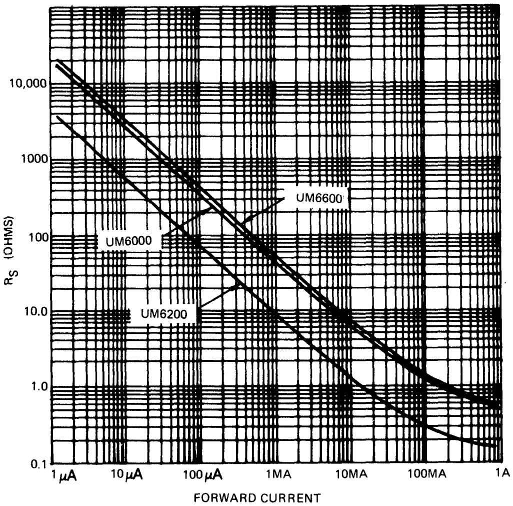
Voltage Ratings (25 °C)

Reverse Voltage (V_R) — Volts (I_R = 10 μA)	Types		
100V	UM6001	UM6201	UM6601
200V	UM6002	UM6202	UM6602
400V	—	UM6204	—
600V	UM6006	—	UM6606
1000V	UM6010	—	UM6610

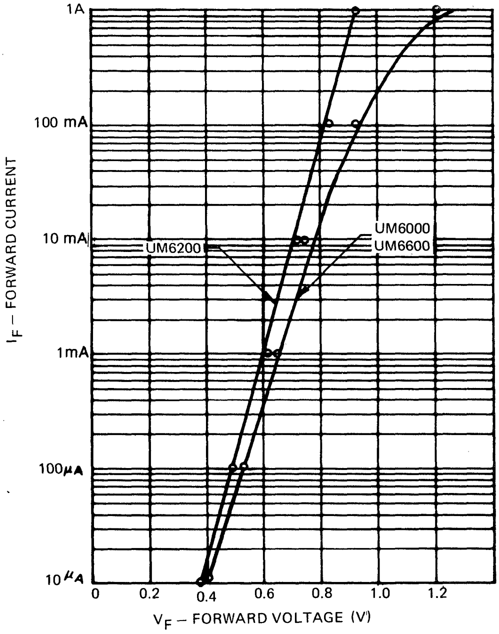
Electrical Specifications (25 °C)

Test	Symbol	UM6600	UM6000	UM6200	Conditions
Total Capacitance (Max)	C_T	0.4 pF	0.5 pF	1.1 pF	0V, 1 GHz
Series Resistance (Max)	R_S	2.5Ω	1.7Ω	0.4Ω	100 mA, 1 GHz
Parallel Resistance (Min)	R_P	10 KΩ	15 KΩ	10 KΩ	100V, 1 GHz
Carrier Lifetime (Min)	τ	1.0 μs	1.0 μs	0.6 μs	I_F = 10 mA
Reverse Current (Max)	I_R	10 μA	10 μA	10 μA	V_R = Rating
I-Region Width (Min)	W	150 μm	150 μm	40 μm	—

TYPICAL SERIES RESISTANCE
VS
FORWARD CURRENT
(F = 100MHz)

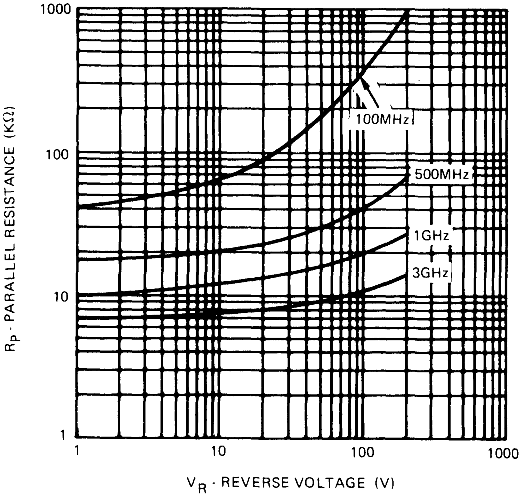


DC CHARACTERISTICS
FORWARD VOLTAGE VS CURRENT

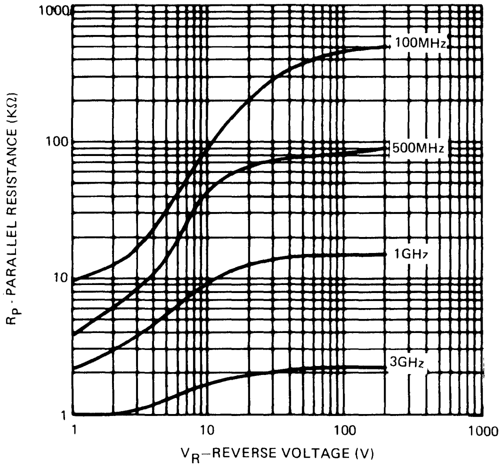


TYPICAL R_p VS VOLTAGE & FREQUENCY

UM6000/UM6600

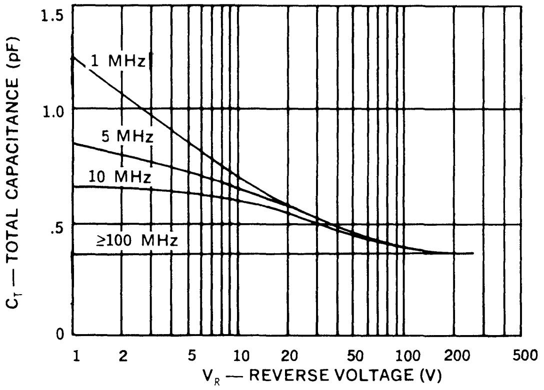


UM6200



TYPICAL CAPACITANCE VS VOLTAGE AND FREQUENCY

UM6000 SERIES



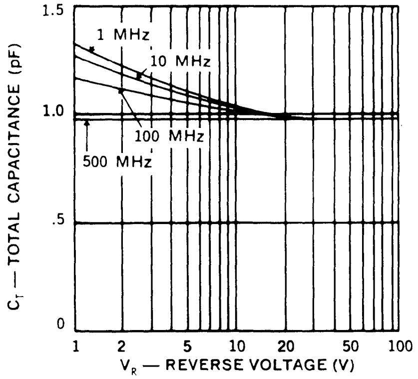
ORDERING INSTRUCTIONS

Part numbers of Unitrode PIN diodes consist of the letters UM followed by four digits and one or two letters. The first two digits indicate the diode series, the next two digits specify the minimum breakdown voltage in hundreds of volts. The remaining letters denote the package style. Reverse polarity (anode large end cap) is available for the C style and denoted by adding second letter R.

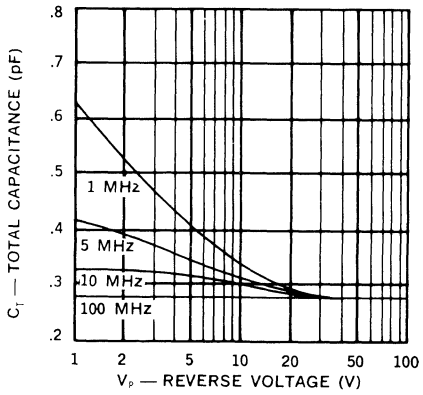
For Example: UM |60|06 |CR|

|Series 6000| |600 Volts| |Style C|Reverse Polarity|

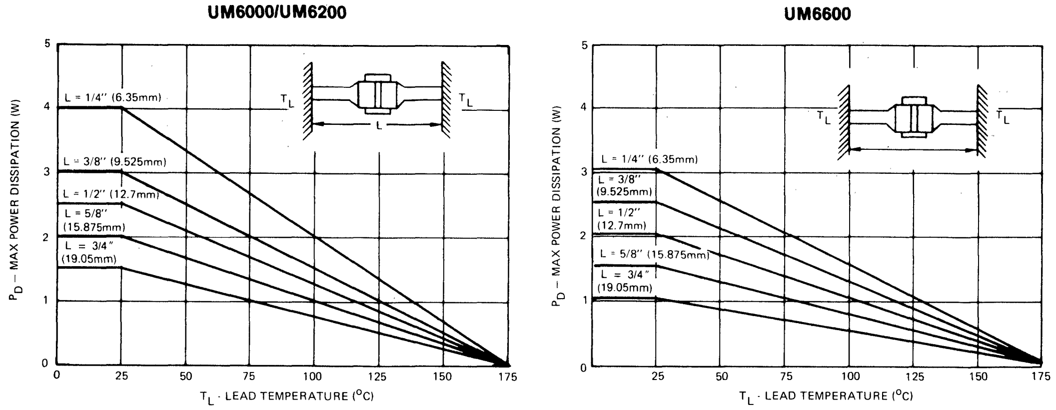
UM6200 SERIES



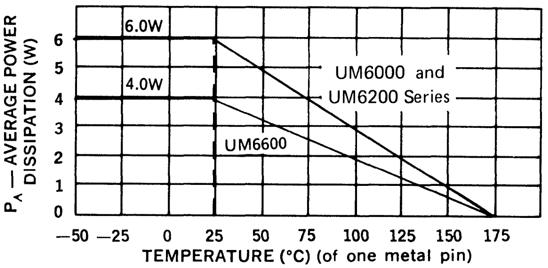
UM6600 SERIES



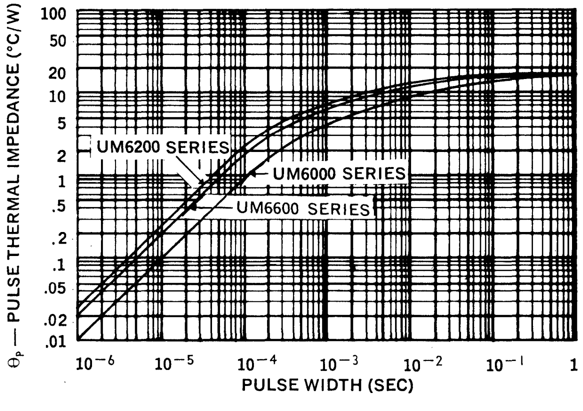
POWER RATING — AXIAL LEADED DIODE



POWER RATING

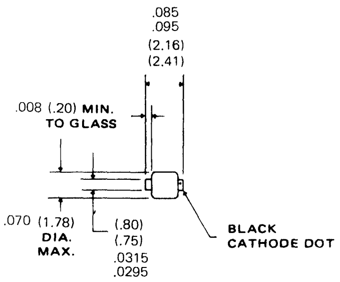


PULSE THERMAL IMPEDANCE VS PULSE WIDTH

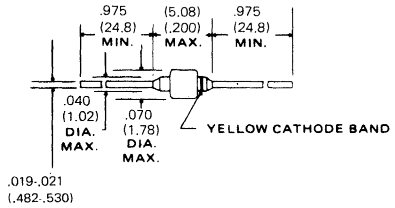


MECHANICAL SPECIFICATIONS

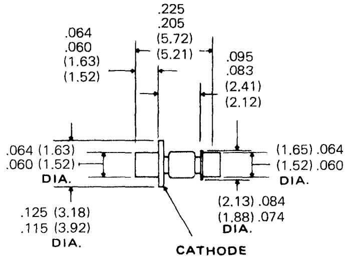
STYLE A



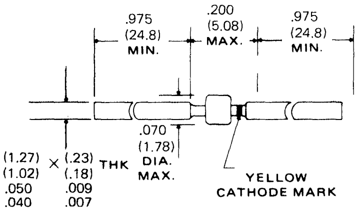
STYLE B



STYLE C
CARTRIDGE



STYLE E
RIBBON LEADS



PIN DIODE

UM7000 SERIES
UM7100 SERIES
UM7200 SERIES

Features

- Voltage ratings to 1000V (UM7000)
- Wide variety of package styles
- Rated average power dissipation to 10W
- Cost effective in volume applications

Description

The UM7000 and UM7100 series offer moderately high power handling in combination with reasonably low levels of both series resistance and capacitance. The UM7200 series offers the lowest series resistance, but the highest capacitance of the group. The differences in specified performance, for each of the series, results from different I-region thicknesses. The three series have broad applicability in many RF and microwave switch and attenuator circuits. Additionally, the UM7100 in leaded versions, is usually the most cost-effective diode choice in high volume usage.

MAXIMUM RATINGS

Average Power Dissipation and Thermal Resistance Ratings

Package	Condition	P_D	θ
A	25 °C Pin Temperature	10W	15 °C/W
B&E (Axial Leads)	½ in.(12.7 mm) Lead Length to 25 °C Contact	5.5W	27.5 °C/W
B&E (Axial Leads)	Free Air	1.5W	—
C (Studded)	25 °C Stud Temperature	10W	15 °C/W
D (Insulated Stud)	25 °C Stud Temperature	7.5W	20 °C/W

Peak Power Dissipation Rating

All Packages	1 μs Pulse (Single) at 25 °C Ambient	UM7000 - 60 KW UM7100 - 35 KW UM7200 - 20 KW

Operating and Storage Temperature Range: − 65 °C to + 175 °C

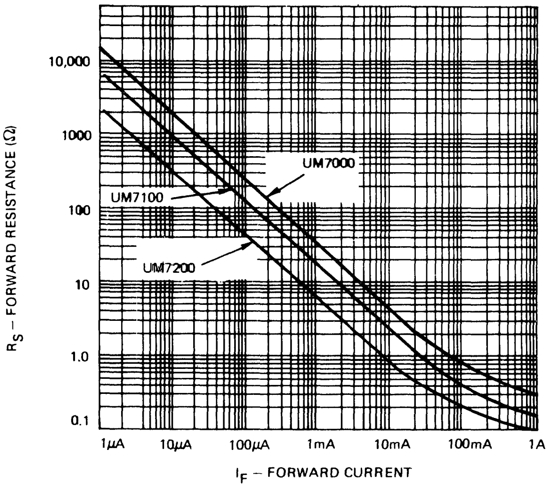
Voltage Ratings (25 °C)

Reverse Voltage (V_R) — Volts (I_R = 10 µA)	Types		
100V	UM7001	UM7101	UM7201
200V	UM7002	UM7102	UM7202
400V	—	UM7104	UM7204
600V	UM7006	—	—
800V	—	UM7108	—
1000V	UM7010	—	—

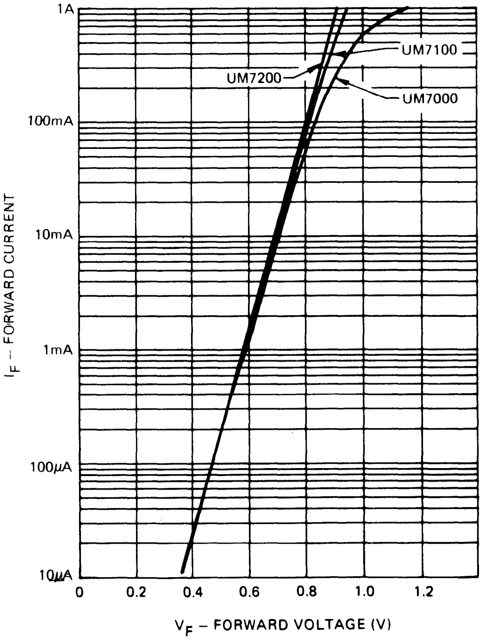
Electrical Specifications (25 °C)

Test	Symbol	UM7000	UM7100	UM7200	Conditions
Total Capacitance (Max)	C_T	0.9 pF	1.2 pF	2.2 pF	0V, 1 GHz
Series Resistance (Max)	R_S	1.0Ω	0.6Ω	0.25Ω	100 mA, 1 GHz
Parallel Resistance (Min)	R_P	10 KΩ	8 KΩ	7 KΩ	100V, 1 GHz
Carrier Lifetime (Min)	τ	2.5 µs	2.0 µs	1.5 µs	I_F = 10 mA
Reverse Current (Max)	I_R	10 µA	10 µA	10 µA	V_R = Rating
I-Region Width (Min)	W	150 µm	80 µm	40 µm	—

TYPICAL FORWARD RESISTANCE
VS FORWARD CURRENT
(F = 100 MHz)

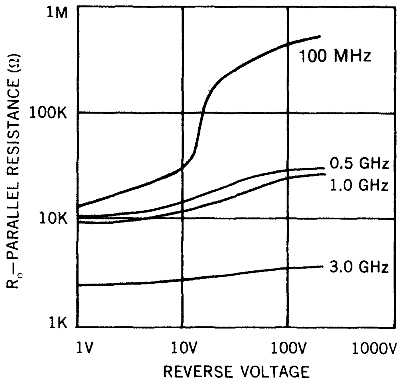


TYPICAL DC CHARACTERISTIC
FORWARD VOLTAGE
VS FORWARD CURRENT
UM7000/UM7100/UM7200

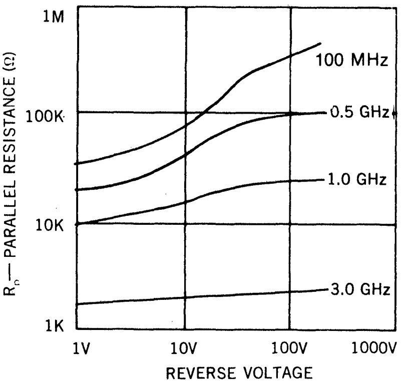


TYPICAL Rp CHARACTERISTIC

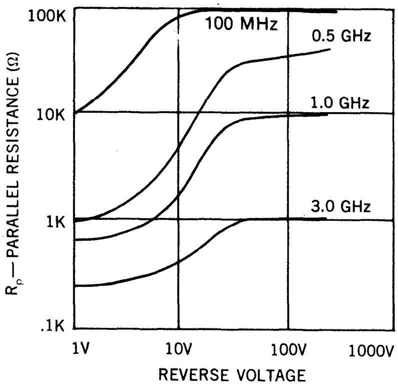
UM 7000 SERIES



UM7100 SERIES

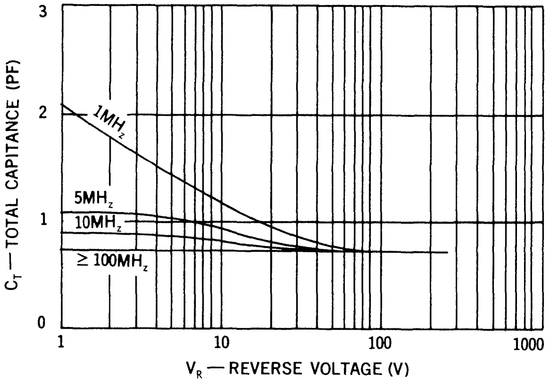


UM 7200 SERIES

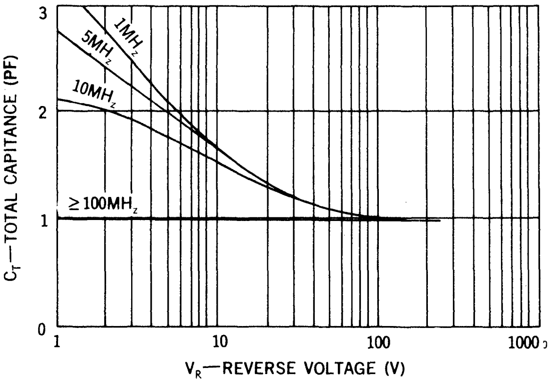


TYPICAL C_T CHARACTERISTIC

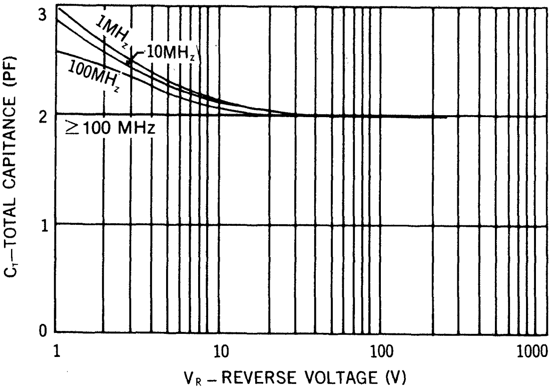
UM 7000 SERIES



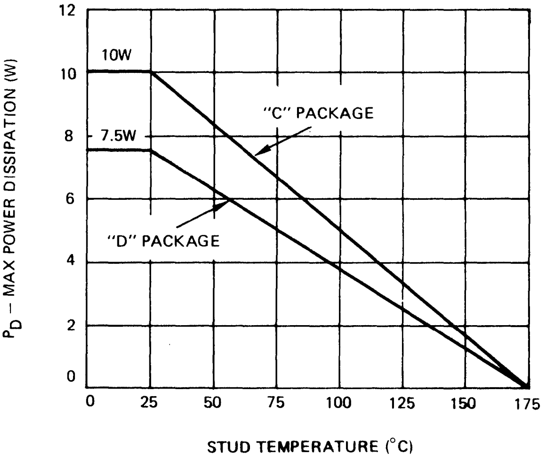
UM 7100 SERIES



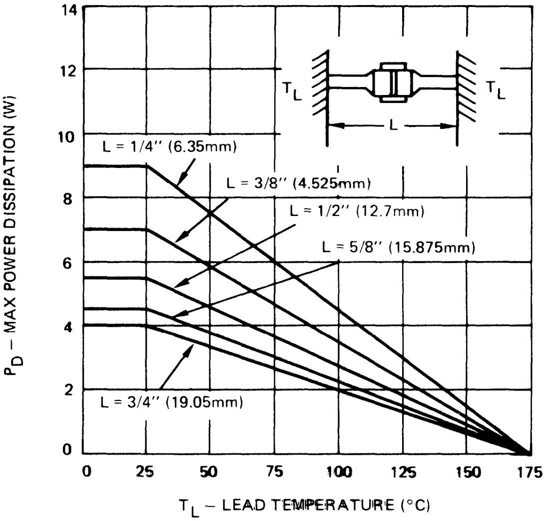
UM 7200 SERIES



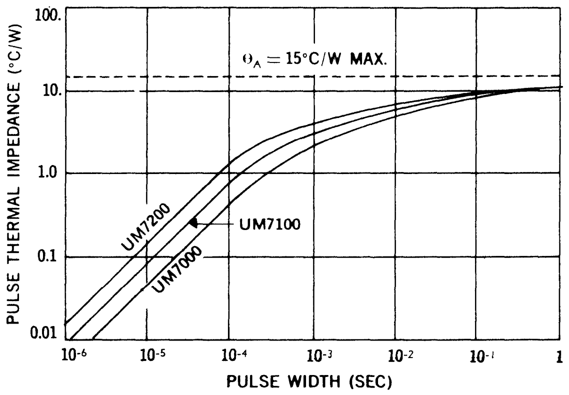
POWER RATING STUD MOUNTED DIODES



POWER RATING — AXIAL LEADED DIODES



PULSE THERMAL IMPEDANCE VS PULSE WIDTH



ORDERING INSTRUCTIONS

Part numbers of Unitrode PIN Diodes consist of the letters UM followed by four digits and one or two letters. The first two digits indicate the diode series, the next two digits specify the minimum breakdown voltage in hundreds of volts. The remaining letters denote the package style. Reverse polarity (anode on stud end) is available in C or D Styles and denoted by adding second letter R.

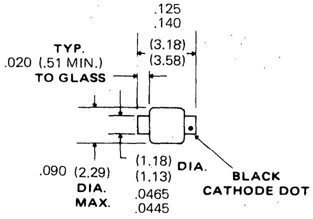
For Example: UM 70 01 C

Series 7000 | 100 volts | Style C

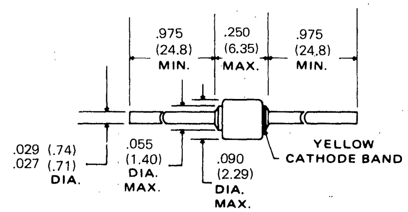
MECHANICAL SPECIFICATIONS

Dimensions — English/Metric

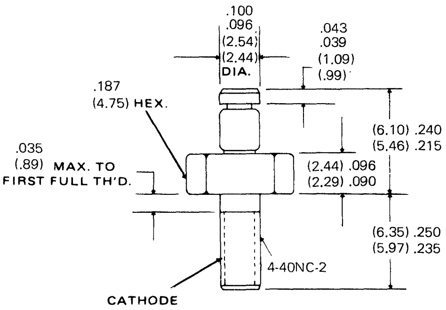
STYLE A



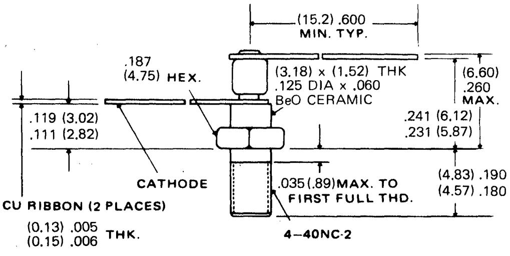
STYLE B



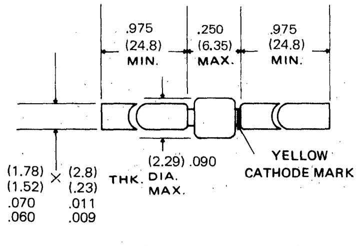
STYLE C
STUD



STYLE D
INSULATED STUD



STYLE E
RIBBON LEADS



PIN DIODE

UM9301 SERIES

COMMERCIAL ATTENUATOR DIODE

Features

- Specified low distortion
- Low rectification properties at low reverse bias
- Resistance specified at 3 current points
- High reliability fused-in-glass construction

Description

The UM9301 PIN Diode utilizes a special overall chip geometry with an extremely thick intrinsic "I" region, to offer unique capabilities in both RF switch and attenuator applications. Volume production also makes the diode an economical choice suitable for many commercial low power equipments.

The UM9301 has been designed for use in bridged TEE attenuator circuits commonly utilized for gain and slope control in CATV amplifiers. Low distortion and high dynamic range are characteristic of the diodes' outstanding performance.

The UM9301 is also appropriate for switch applications, when little or no bias voltage is available. Frequent applications occur in portable 12 volt-powered communications equipments, operating at frequencies as low as 2 MHz.

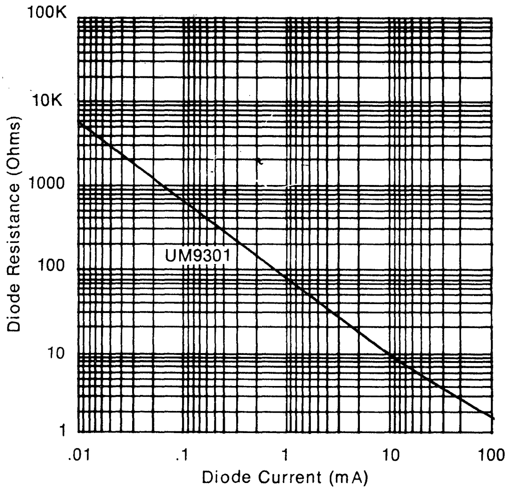
MAXIMUM RATINGS

Reverse Voltage **(V_R) — Volts** **(I_R = 10 μA)**	75V
Average Power Dissipation @ (P_A) Leads ½ in. overall to 25°C Contact	1.0W (Derate linearly to 175°C)
Operating and Storage Temperature Range	−65°C to +175°C

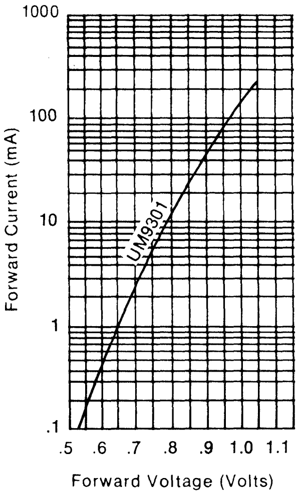
Electrical Specifications (25 °C)

Test	Min	Typ	Max	Units	Conditions
Diode Resistance R_S		1.7	3.0	Ω	I = 100 mA, f = 100 MHz
		80	150	Ω	I = 1 mA, f = 100 MHz
	3000	5000		Ω	I = 0.01 mA, f = 100 MHz
Current for $R_S = 75\Omega$	0.5	1.1	2.0	mA	f = 100 MHz
Capacitance			0.8	pF	V = 0V, f = 100 MHz
Return Loss	25			dB	Frequency Range: 10 - 300MHz $R_S = 75\Omega$ @ 100 MHz Diode Terminates 75Ω line
Second Order Distortion		55	50	−dB	f_1 = 10 MHz, f_2 = 13 MHz P = 50 dBmV, See Test Circuit
		70		−dB	F_1 = 67 MHz, F_2 = 77 MHz P = 50 dBmV, See Test Circuit
Third Order Distortion		75	65	−dB	F_1 = 10 MHz, F_2 = 13 MHz P = 50 dBmV, See Test Circuit
		95		−dB	Triple Beat; 205 + 67 − 77 MHz P = 50 dBmV, See Test Circuit
Cross Modulation Distortion		75		−dB	12 Channel Test P = 50 dBmV, See Test Circuit Dix Hills Test Set
Reverse Current			10	μA	V = 75V
Carrier Lifetime	4.0			μs	I = 10 mA

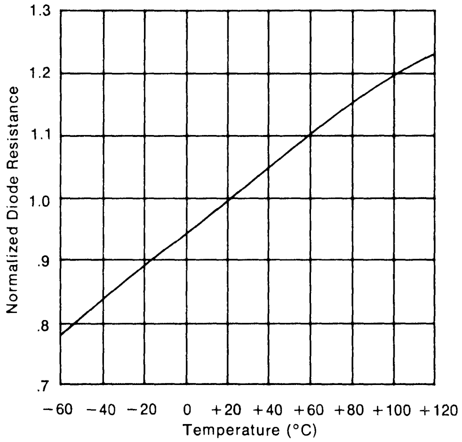
DIODE RESISTANCE VS DIODE CURRENT (TYPICAL)



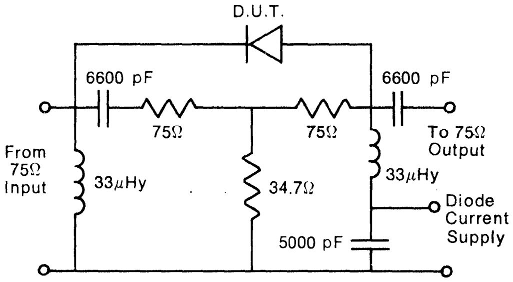
FORWARD CURRENT VS FORWARD VOLTAGE (TYPICAL)



NORMALIZED R_S VS TEMPERATURE



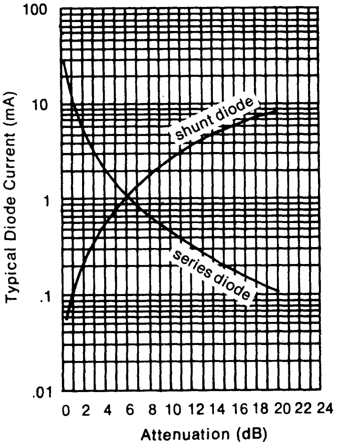
TEST CIRCUIT FOR DISTORTION MEASUREMENTS



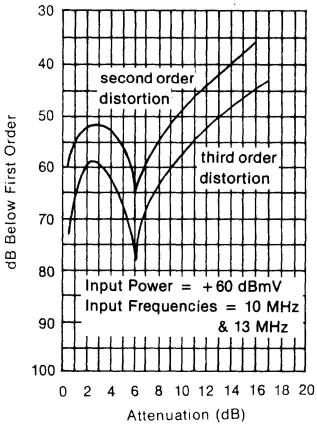
Note: Diode Current adjusted for 10dB Attenuation

TYPICAL BRIDGED TEE ATTENUATOR PERFORMANCE

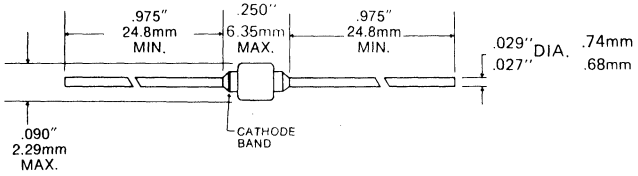
DIODE CURRENT VS ATTENUATION UM9301



DISTORTION ATTENUATION



MECHANICAL SPECIFICATIONS



PIN DIODE

UM9401 SERIES
UM9402 SERIES
UM9415 SERIES

COMMERCIAL TWO-WAY RADIO ANTENNA SWITCH DIODES

Features

- Specified low distortion
- Unitrode ruggedness and reliability
- Low bias current requirements
- Priced for high quantity applications

Description:

Unitrode offers a series of PIN diodes specifically designed and characterized for solid state antenna switches in commercial two-way radios. Antenna switches using the UM9401 and UM9415 series PIN diodes provide high isolation, low loss and low distortion characteristics formerly possible only with electromechanical relay type switches.

The UM9401 and UM9402 diodes can handle above 100W of transmitter power, while the UM9415 will handle over 1000W. The extensive characterization of these PIN diodes in antenna switch applications has resulted in guaranteed low distortion specifications under transmit and receive conditions. These diodes also feature low forward bias resistance and high zero bias impedance which are required for low loss, high isolation and wide bandwidth antenna switch performance.

MAXIMUM RATINGS

	UM9401	UM9402	UM9415
Reverse Voltage (V_R) — Volts ($I_R = 10\ \mu A$)	50V	50V	50V

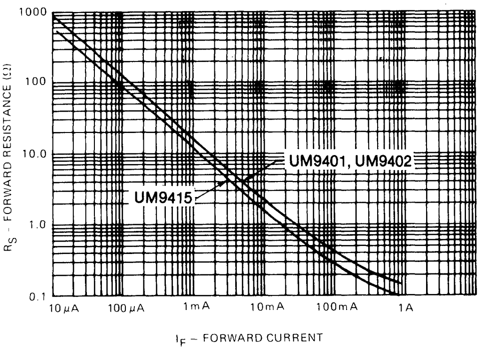
Average Power Dissipation (P_A)			
Leads - ½in. Overall to 25°C	5.5W	—	10W
Heat Sink 25°C (Package Flange) Temperature	—	10W	—
Free Air	1.5W		2.5W

Operating and Storage Temperature Range	−65°C to +175°C

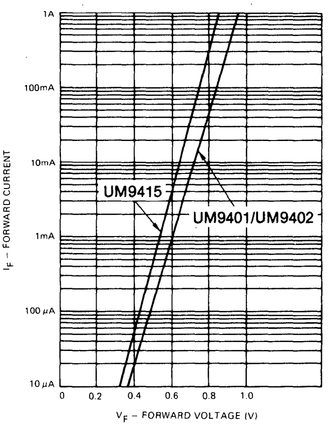
Electrical Specifications (at 25 °C)

Test	Symbol	UM9401/UM9402			UM9415			Units	Conditions
		Min	Typ	Max	Min	Typ	Max		
Diode Resistance	R_S		0.75	1.0		0.75	1.0	Ω	f = 100MHz typical I = 50 mA
Diode Capacitance	C_T		1.1	1.5			4	pF	f = 100 MHz V = 0V
Parallel Resistance	R_P	5K	10K		1K	2K		Ω	f = 100 MHz V = 0V
Carrier Lifetime	τ	1.0	2.0		5			μS	I = 10 mA
Transmit Harmonic Distortion	$\frac{R_{2A}}{A}, \frac{R_{3A}}{A}$			80			80	– dB	P_{IN} = 50W f = 50 MHz, I = 50 mA
Receive Third Order Distortion	$\frac{R_{2AB}}{A}$			60			60	– dB	P_{IN} = 10 mW, 0V Bias f_A = 50 MHz, f_B = 51 MHz
Reverse Leakage Current	I_R			10			10	μA	V = 50V
Forward Voltage	V_F			1.0			1.0	V	I_F = 50 mA

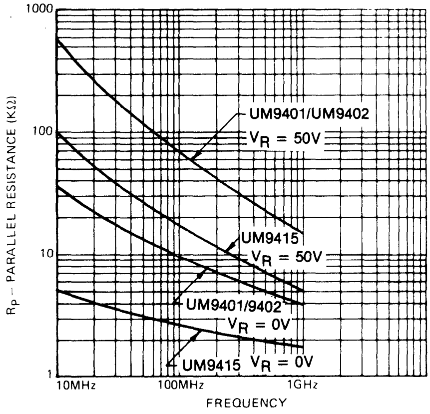
TYPICAL FORWARD RESISTANCE VS FORWARD CURRENT (F = 100 MHz)



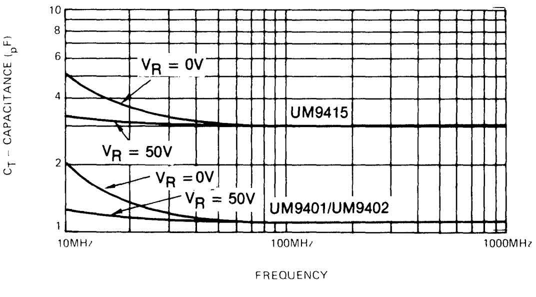
TYPICAL DC CHARACTERISTIC



TYPICAL R_p CHARACTERISTICS

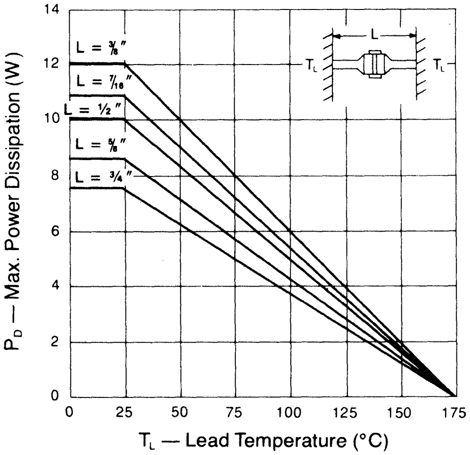


TYPICAL CAPACITANCE CHARACTERISTIC

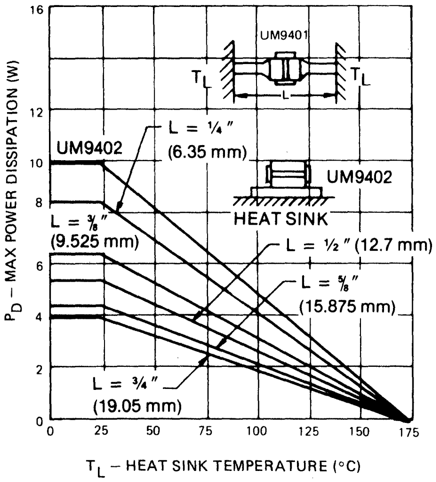


MAXIMUM TRANSMITTER POWER

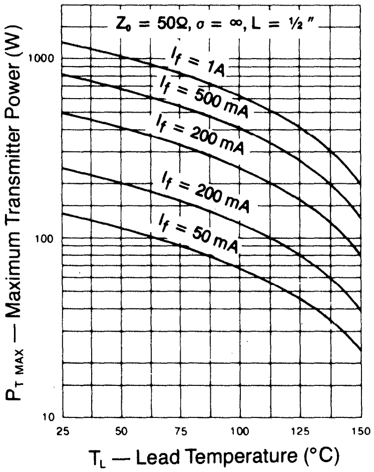
POWER RATING
UM9415



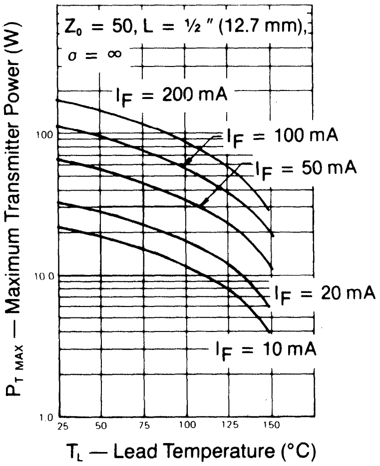
POWER RATING
UM9401/9402



UM9415



UM9401/UM9402



Maximum Transmitter Power

The maximum CW transmitter power, $P_{T(max)}$, a PIN diode antenna switch can handle depends on the diode resistance, R_S, power dissipation, P_D, antenna SWR, σ, and nominal impedance, Z_0. The expression relating these parameters is as follows:

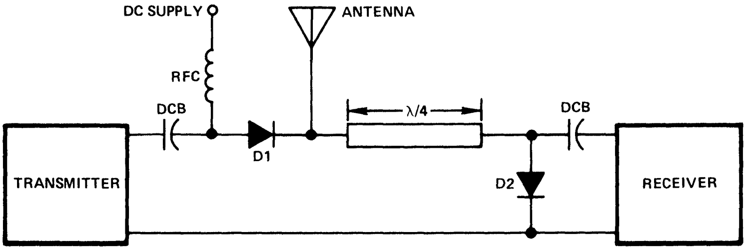
$$P_{T(max)} = \frac{P_D \times Z_0}{R_D} \left(\frac{\sigma + 1}{2\sigma}\right)^2 \text{ [Watts]}$$

Characteristic curves are shown in the data section which give both the maximum and typical diode resistance, R_S as a function of forward current. The maximum power dissipation rating of the PIN diode depends both on the length of the diode leads and the temperature of the contacts to which the leads are connected. A graph defining the maximum power dissipation at various combinations of overall lead length (L) and lead temperature (T_L) is given in the data section. From these curves and the above equation, the power handling capability of the PIN diode may be computed for a specific application.

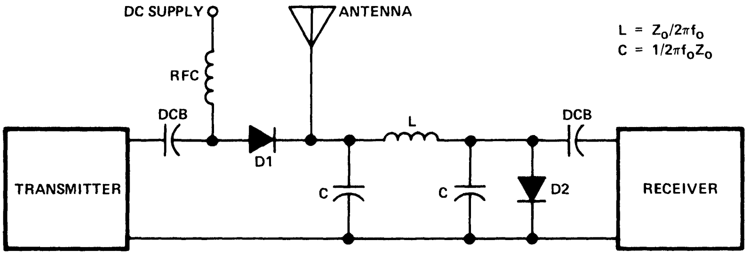
Curves are also presented which show the maximum transmitter power that an antenna switch using UM9401s and UM9415s can safely handle for various forward currents and lead temperatures. These curves are based on a typical design condition of a ½ in. total overall lead length, 50Ω line impedance and a totally mismatched antenna ($\sigma = \infty$). For the case of a perfectly matched antenna, the maximum transmitter power can be increased by a factor of 4.

Design Information

A circuit configuration for a two-way radio antenna switch using PIN diodes consists of a diode placed in series with the transmitter and a shunt diode placed a quarter wavelength from the antenna in the direction of the receiver as shown. For low frequency operation, the quarter wave line may be simulated by lumped elements. Typical performance of antenna switches using PIN diodes forward biased at 100 mA is less than 0.2 dB insertion loss and 30 dB isolation during transmit; at zero bias the receive insertion loss is less than 0.3 dB. This performance is achievable across a ±20% bandwidth at center frequencies ranging from 10 to 500 MHz.

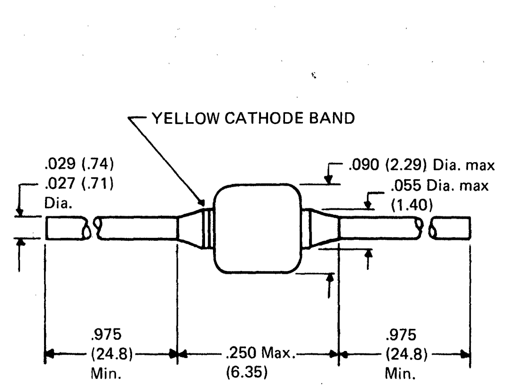


ⓐ

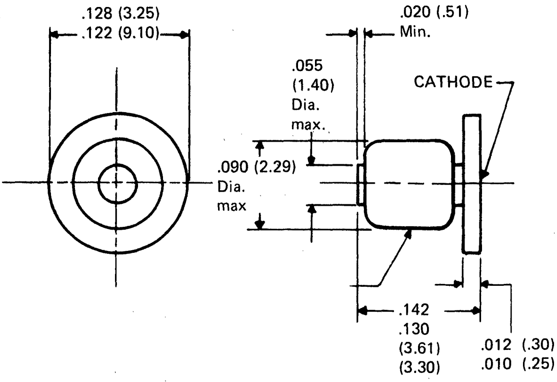


ⓑ

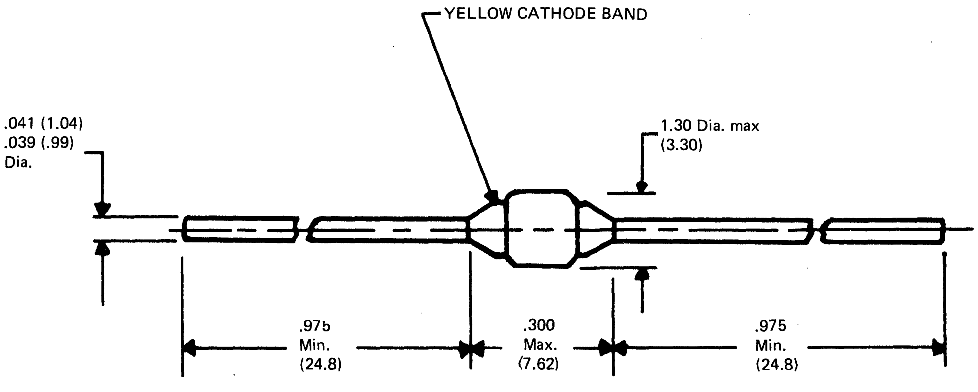
UM9401



UM9402



UM9415



Dimensions: inches (millimeters)

PIN RADIATION DETECTORS

UM9441

Features

- High Photocurrent Sensitivity
- High Reliability Construction
- Fast Rise Time
- Wide Dynamic Range
- Hardness to Neutron Bombardment
- Low Operating Voltage

Description

Silicon PIN devices are effective detectors of nuclear and electromagnetic radiation. This includes gamma radiation, electrons, and X-rays. The detectors can be used across the temperature range of −55 °C to +175 °C instead of being restricted to use at low temperatures.

The absorbed radiation produces electron-hole pairs in the space charge region. These charges are swept out by the applied field and result in a current flow proportional to the rate of absorbed radiation.

The Unitrode UM9441 series utilizes high resistivity material and is designed to have a uniform area mesa structure to define the active volume. The current sensitivity of these devices is proportional only to the I-region volume and is independent of temperature so long as applied voltage exceeds the saturation voltage. This structure also minimizes the effects of permanent damage caused by neutrons and other high energy radiation. Experiments on devices of the UM9441 design show no degradation in gamma sensitivity resulting from a total dose of 10^{14} neutrons/cm^2 of 1 MeV equivalent.

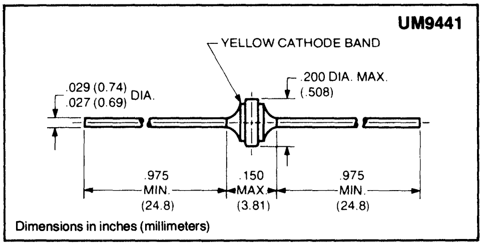
Package

The UM9441 is an axially leaded device constructed by metallurgically bonding the PIN chip in between two molybdenum refractory pins that are typically 0.125 inches in diameter and 0.050 inches long. Hyper-pure glass is then fused over this bond to form a voidless seal. Leads are then brazed to ends of molybdenum pins. This results in a high-reliability package using materials so well thermally matched that the UM9441 can withstand temperature shock or cycling from −196 °C to +300 °C.

ABSOLUTE MAXIMUM RATINGS

Reverse Voltage 100V
Photocurrent 1A
Storage Temperature . . . −55 °C to +200 °C
Operating Temperature . −55 °C to +175 °C

MECHANICAL SPECIFICATIONS



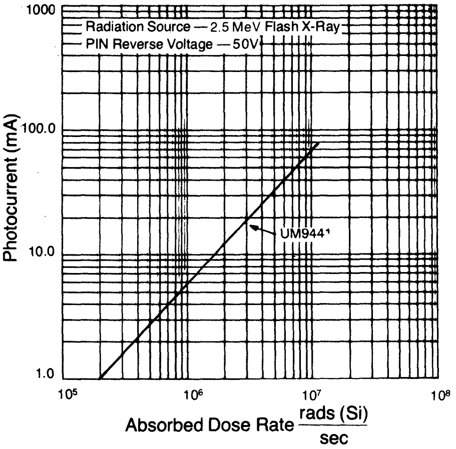
Dimensions in inches (millimeters)

UNITRODE

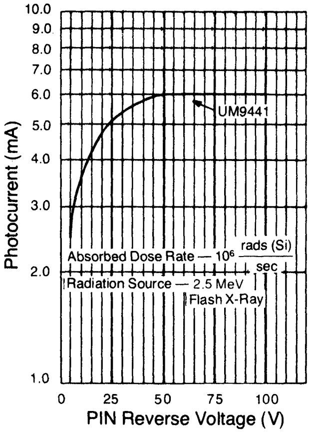
Electrical Specifications (at 25°C)

Test	Min	Typ	Max.	Units	Test Conditions
Photocurrent	4.0	6.0		mA	$V_R = 50V$ $10^6 \frac{\text{rads (Si)}}{\text{sec.}}$ 2.5 MeV Flash X-Ray Ion Physics Corp. FX-25
Photocurrent Rise Time (10%-90%)		10		ns	
Capacitance		10	15	pF	F = 1 MHz, V = 50V
Reverse Current			1.0	μA	$V_R = 50V$
Minority Carrier Lifetime	2.0			μS	$I_f = 10mA$

TYPICAL PHOTOCURRENT SENSITIVITY



TYPICAL VOLTAGE SENSITIVITY



RELIABILITY

The UM9441 is consistent with Unitrode's reputation as a manufacturer of high reliability semiconductors. Unitrode is equipped to perform JAN type testing, base-lining and documental conformance to a wide range of reliability testing. This commitment to reliability has enabled Unitrode to be a qualified supplier of semiconductor devices to many high-reliability programs such as:

APOLLO
DRAGON
HAWK
MARINER
MINUTEMAN
SPRINT
TRIDENT
VIKING

PIN DIODES

PAGE	PART NUMBER	DESCRIPTION
653	1N5767	General Purpose, PIN
653	1N5957	Low Distortion, AGC Diode
656	UM4000 series	0.5Ω, 3.0pF. 25W, 100-1200V
661	UM4300 series	1.5Ω, 2.2pF, 18W, 100-1000V
656	UM4900 series	0.5Ω, 3.0pF, 37W, 100-600V
667	UM6000 series	1.7Ω, 0.5pF, 6W, 100-1000V
667	UM6200 series	0.4Ω, 1.1pF, 6W, 100-400V
667	UM6600 series	2.5Ω, 0.4pF, 4W, 100-1000V
672	UM7000 series	1.0Ω, 0.9pF, 10W, 100-1600V
672	UM7100 series	0.6Ω, 1.2pF, 10W, 100-800V
672	UM7200 series	0.25Ω, 2.2pF, 10W, 100-400V
661	UM7300 series	3.5Ω, 0.7pF, 7.5W, 100-1000V
677	UM9301 series	CATV Attenuator Diodes
680	UM9401 series	2-Way Radio Switch Diodes
680	UM9415	2-Way Radio Switch Diodes
685	UM9441	Radiation Detector

*Contact Unitrode for specifications and ratings.

Legend: J — JAN JTX — JANTX JTXV — JANTXV

CAPACITOR DESIGNERS' GUIDE

Glass-Sealed Axial Leaded Ceramic Capacitors

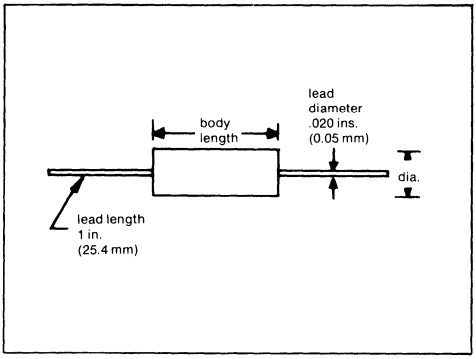
Since 1973 Unitrode Computer Products Corporation has manufactured and shipped millions of glass-sealed axial lead ceramic capacitors to computer, general industrial, and commercial customers. Designed for automatic insertion, and packaged in taped reels, they are ideal for high volume applications.

Unitrode capacitors provide optimum performance and dependability at the lowest possible cost. Capacitor chips are manufactured in our modern facility in San Diego, California, where advanced research programs are continually developing ways to improve ceramic formulations. Chips are encapsulated and sealed in our Methuen, Massachusetts facility, utilizing techniques that have made Unitrode a leading supplier of glass silicon switching diodes.

Rigid quality control is the cornerstone of all manufacturing operations. Unitrode tests for capacitance and dissipation factor on a 100% basis and supplies to an incoming AQL of 0.65% for electrical parameters. Mechanical parameters are supplied to 1.0% AQL. All Unitrode capacitors meet or exceed MIL-C-55681, MIL-C-11015 and MIL-C-39014.

Unitrode axial lead ceramic capacitors: a top quality, low cost capacitor for high volume applications.

MECHANICAL SPECIFICATIONS



HOW TO ORDER

CG	PACKAGE	EIA CAPACITANCE CODE	TOLERANCE	VOLTAGE	TEMPERATURE CHARACTERISTIC
	A .170 X .075		G + 2%	C 25	N NPO
	B .170 X .100		J +5%	D 50	X X7R
	C .200 X .100		K + 10%	E 100	Z Z5U
	D .260 X .100		M + 20%	F 200	
	E .300 X .100		Z +80%, -20%		
	F .400 X .150		V GMV		

CAPACITOR VALUE VS PACKAGE

MAXIMUM CAPACITANCE/
VOLTAGE/PACKAGE

	NPO (COG)			X7R (BX)			Z5U (General Purpose)		
PKG	**50V**	**100V**	**200V**	**25V**	**50V**	**100V**	**25V**	**50V**	**100V**
A	330pF	150pF	68pF	.012mF	1200pF	1000pF	.039mF	.027mF	.01mF
B	560pF	680pF	220pF	.033mF	.022mF	.01mF	.082mF	.068mF	.022mF
C	1200pF	820pF	330pF	.047mF	.027mF	.012mF	.15mF	.12mF	.056mF
D	2700pF	1500pF	680pF	.082mF	.047mF	.022mF	.22mF	.18mF	1mF
E	4700pF	2200pF	1200pF	.15mF	.12mF	.039mF	.39mF	.27mF	.15mF
F	.01mF	5600pF	3300pF	.27mF	.22mF	.056mF	1.5mF	1.0mF	.27mF

CAPACITOR DESIGNERS' GUIDE

Glass-Sealed Axial Leaded Ceramic Capacitors (continued)

PHYSICAL CHARACTERISTICS

NPO

(COG)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-11015 and MIL-C-39014.

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rated voltage applied, @ 25°C (see curve for other temperatures)

Dielectric Strength:
2.5 X WVDC

Life Test:
2 X WVDC @ 125°C, 1000 hours

Lead Material:
Tinned Copper Clad Steel

Temperature Range:
-55°C to +125°C

Temperature Coefficient:
0 ± 30 PPM/°C

Dissipation Factor:
0.1% max at 1 MHz @ 1 VRMS (100 PF)
1 KHz @ 1 VRMS (100 PF)

Capacitance Tolerance:
F (±1%)
G (±2%), J (±5%)
K (±10%), M (±20%)

X7R

(BX)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-11015 and MIL-C-39014.

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rated voltage applied, @ 25°C (see curve for other temperatures)

Dielectric Strength:
2.5 X WVDC

Life Test:
2 X WVDC @ 125°C, 1000 hours

Lead Material:
Tinned Copper Clad Steel

Temperature Range:
-55°C to +125°C

Temperature Coefficient:
± 15%

Dissipation Factor:
2.5% @ 1 KHz @ 1 VRMS

Capacitance Tolerance:
J (± 5%), K (± 10%), M (± 20%).

Z5U

(General Purpose)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-11015 and MIL-C-39014.

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rated voltage applied, @ 25°C (see curve for other temperatures)

Dielectric Strength:
2.5 X WVDC below .5 mfd; 2.0 X WVDC .5 mfd and above

Life Test:
2 X WVDC @ 85°C, 1000 hours

Lead Material:
Tinned Copper Clad Steel

Temperature Range:
+10°C to +85°C

Temperature Coefficient:
+22, -56%

Dissipation Factor:
3.0% max. at 1 KHz., 25°C, @ .3 VRMS

Capacitance Tolerance:
M (± 20%), Z (+80%, -20%)
GMV (+100%, -0%)

TYPICAL CHARACTERISTICS

Please refer to curves at end of Designers Guide.

QUALITY ASSURANCE

Unitrode Computer Products Corporation is committed to marketing high quality products at the lowest possible cost. We work continually, through advanced research and development programs, to improve product performance and increase manufacturing efficiency. This effort results in occasional specification changes, which we may make without previous notice.

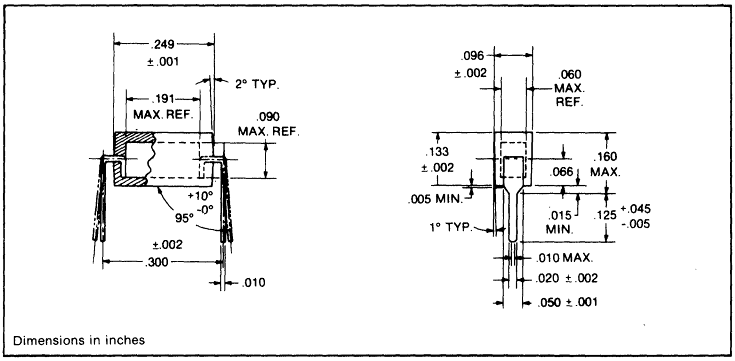
Dual-In-Line Package Ceramic Capacitors

Monolithic ceramic capacitors in this form factor are ideally suited for automatic insertion on printed circuit boards using the same insertion equipment that is employed in the insertion of the dual-in-line package integrated circuit.

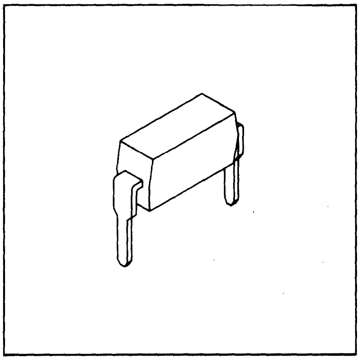
HOW TO ORDER

CD	PACKAGE	EIA CAPACITANCE CODE	TOLERANCE	VOLTAGE	TEMPERATURE CHARACTERISTIC
	P		F ±1%	D 50	N NPO
			G ±2%	E 100	X X7R
			J ±5%	F 200	Z Z5U
			K ±10%		
			M ±20%		
			Z +80%, -20%		
			V GMV		

MECHANICAL SPECIFICATIONS



Dimensions in inches



CAPACITANCE RANGES

	NPO (COG)			X7R (BX)			Z5U (General Purpose)		
	50V	100V	200V	50V	100V	200V	50V	100V	200V
Unitrode Reference CDP	10pF to 4700pF	10pF to 2700pF	10pF to 1200pF	1000pF to 120,000pF	1000pF to 39,000pF	1000pF to 10,000pF	10,000pF to 560,000pF	10,000pF to 224,000pF	10,000pF to 56,000pF

CAPACITOR DESIGNERS' GUIDE

Dual-In-Line Package Ceramic Capacitors (continued)

PHYSICAL CHARACTERISTICS

NPO

(COG)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-39014.

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rates voltage applied, @ 25° C (see curve for other temperatures)

Dielectric Strength:
2.5 X WVDC

Life Test:
2 X WVDC @ 125° C, 1000 hours

Lead Material:
Copper (olin 194)

Temperature Range:
-55° C to +125° C

Temperature Coefficient:
0 ± 30 PPM/° C

Dissipation Factor:
0.1% max at 1 MHz @ 1 VRMS (100 PF)
1 KHz @ 1 VRMS (100 PF)

Capacitance Tolerance:
G (± 2%), J (± 5%),
K (± 10%), M (± 20%)

X7R

(BX)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-39014.

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rated voltage applied, @ 25° C (see curve for other temperatures)

Dielectric Strength:
2.5 X WVDC

Life Test:
2 X WVDC @ 125° C, 1000 hours

Lead Material:
Copper (olin 194)

Temperature Range:
-55° C to +125° C

Temperature Coefficient:
± 15%

Dissipation Factor:
2.5% @ 1 KHz @ 1 VRMS

Capacitance Tolerance:
J (± 5%), K (± 10%), M (± 20%).

Z5U

(General Purpose)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-39014.

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rated voltage applied, @ 25° C (see curve for other temperatures)

Dielectric Strength:
2.5 X WVDC below .5 mfd; 2.0 X WVDC .5 mfd and above

Life Test:
2 X WVDC @ 85° C, 1000 hours

Lead Material:
Copper (olin 194)

Temperature Range:
+10° C to +85° C

Temperature Coefficient:
+22, -56%

Dissipation Factor:
3.0% max. at 1 KHz, 25° C, @ 3 VRMS

Capacitance Tolerance:
M (± 20%), Z (+80%, -20%)
GMV (+100%, -0%).

TYPICAL CHARACTERISTICS

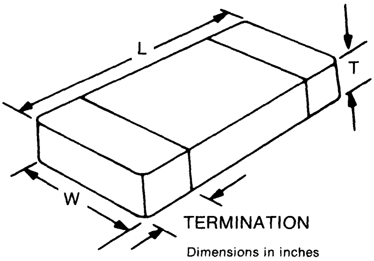
Please refer to curves at end of Designers' Guide.

Monolithic Ceramic Chip Capacitors

Unitrode Computer Products Corporation has applied to monolithic ceramic capacitors the same dedication to product excellence achieved in semiconductors. In our goal in bringing you something better, design and production innovations derived from a mature technology are utilized in achieving uniformity of a high volume, high yield output and without quality compromise.

	D	103	K	P	N
SIZE CODE	**VOLTAGE**	**VALUE**	**TOLERANCE**	**TERMINATION MATERIAL**	**TEMPERATURE CHARACTERISTIC**
1- .050 x .040	C = 25VDC	Capacitance	C = ±.25PF (1PF-10PF)	A = Ag	N = NPO
2- .080 x .050	D = 50VDC	Value in PF	D = ±.5PF (1PF-10PF)	B = PdAg	X = X7R
3- .100 x .050	E = 100VDC	(EIA Code)	F = ±1%	C = Solder Coat	Z = Z5U
4- .150 x .050	F = 200VDC		G = ±2%	(604 Ag STANDARD)	
5- .125 x .095			J = ±5%		
6- .180 x .050			K = ±10%		
7- .180 x .080			M = ±20%		
8- .175 x .125					
9- .250 x .225					

MECHANICAL SPECIFICATIONS



Dimensions in inches

HOW TO ORDER

SIZE	1	2	3	4	5	6	7	8	9
L.	.050	.080	.100	.150	.125	.180	.180	.175	.250
W.	.040	.050	.050	.050	.095	.050	.080	.125	.225
T. MAX.	.040	.050	.050	.050	.060	.060	.050	.060	.060
Termination	.010	.020	.020	.030	.020	.030	.030	.030	.030

CAPACITOR DESIGNERS' GUIDE

Monolithic Ceramic Chip Capacitors (continued)

CAPACITANCE RANGES
CAPACITOR VALUE VS CHIP SIZE
MAXIMUM CAPACITANCE/VOLTAGE/CHIP

	NPO (COG)			X7R (BX)			Z5U (General Purpose)		
SIZE	**50V**	**100V**	**200V**	**25V**	**50V**	**100V**	**25V**	**50V**	**100V**
1	390pF	220pF	150pF	.01mF	6800pF	3300pF	.039mF	.027mF	.012mF
2	100pF	680pF	220pF	.033mF	.022mF	.01mF	.12mF	.082mF	.033mF
3	1500pF	820pF	560pF	.047mF	.027mF	.012mF	.15mF	.1mF	.039mF
4	2700pF	1800pF	1000pF	.082pF	.056mF	.027mF	.33mF	.22mF	.082mF
5	4700pF	3300pF	1800pF	.12mF	.082mF	.039mF	.56mF	.39mF	.15mF
6	3900pF	3700pF	1200pF	.12mF	.082mF	.039mF	.39mF	.27mF	.1mF
7	8200pF	5600pF	3900pF	.33mF	.22mF	.1mF	.82mF	.56mF	.22mF
8	.015mF	.01mF	5600pF	.47mF	.33mF	.18mF	1.0mF	.68mF	.27mF
9	.033mF	.018mF	.012mF	1.0mF	.68mF	.33mF	1.8mF	1.2mF	.47mF

PHYSICAL CHARACTERISTICS

NPO
(COG)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-55681

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rated voltage applied, @ 25°C (see curve for other temperatures).

Flash Test:
2.5 x WVDC

Life Test:
2 x WVDC @ +125°C, 1000 hours.

Temperature Range:
-55°C to +125°C

Temperature Coefficient:
0 ± 30 PPM/°C

Dissipation Factor:
.1% max. @ 1 KHZ

Capacitance Tolerance:
C (±.25PF, 1 PF-10PF), D (±.5PF, 1PF-10PF), F (±1%), G (±2%), J (±5%), K (±10%), M (±20%)

*All L&W values ±.010
**All termination measurements ±.010 except .010 value which is ±.005

X7R
(BX)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-55681

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rated voltage applied, @ 25°C (see curve for other temperatures).

Flash Test:
2.5 x WVDC

Life Test:
2 x WVDC @ 125°C, 1000 hours

Temperature Range:
-55°C to +125°C

Temperature Coefficient:
± 15%

Dissipation Factor:
2.5% max. @ 1 KHz, 25°C, 1 VRMS

Capacitance Tolerances and Codes:
J (+5%), K (±10%), M (±20%), Z (+80%, -20%), V (GMV)

*All L&W values ±.010
**All termination measurements ±.010 except .010 value which is ±.005

Z5U
(General Purpose)

MIL Specifications:
Meets or exceeds applicable portions of MIL-C-55681

Insulation Resistance:
Minimum 100,000 megohms or 1,000 megohm microfarads, whichever is less, with rated voltage applied, @ 25°C (see curve for other temperatures).

Flash Test:
2.5 x WVDC

Life Test:
2 x WVDC @ 85°C.

Temperature Range:
+10°C to +85°C

Temperature Coefficient:
+22
-56%

Dissipation Factor:
3.0% max. @ 1 KHz, 25°C, .5 VRMS

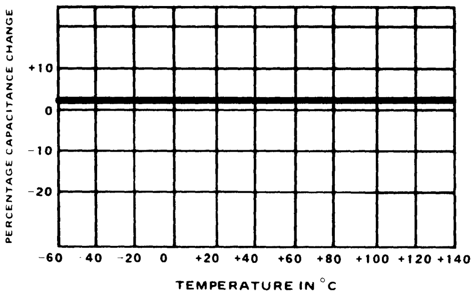
Capacitance Tolerances and Codes:
M (±20%), Z (+80%, -20%), V (GMV)

*All L&W values ±.010
**All termination measurements ±.010 except .010 value which is ±.005

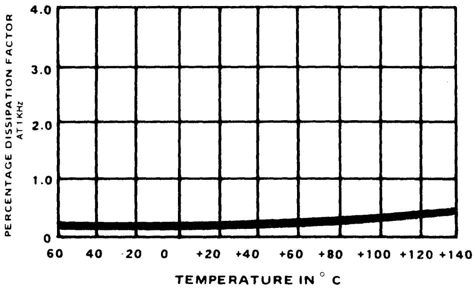
TYPICAL CHARACTERISTICS
Please refer to curves at end of Designers' Guide.

NPO (COG) Typical Characteristics

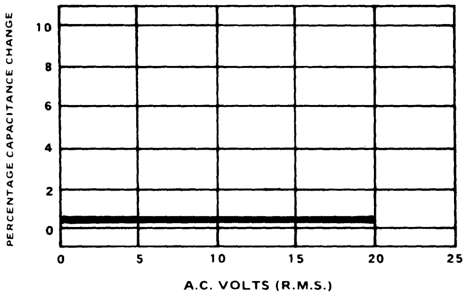
Δ C vs TEMP



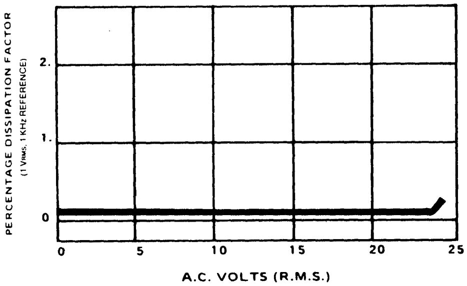
Df vs TEMP



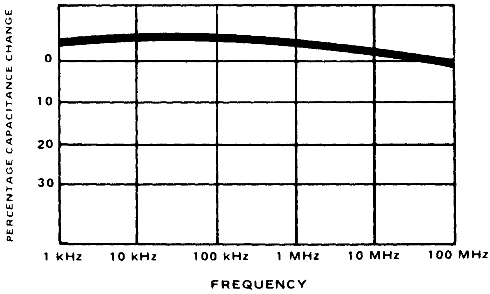
Δ C vs VAC



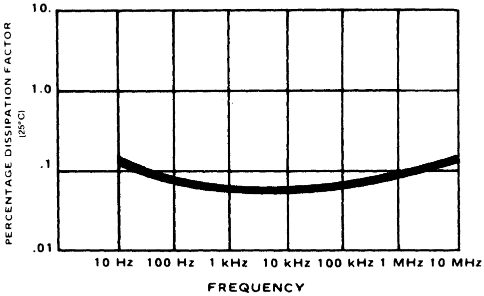
Df vs VAC



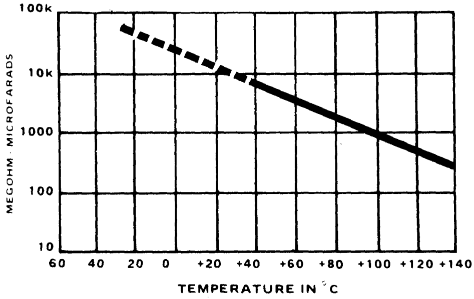
Δ C vs FREQ



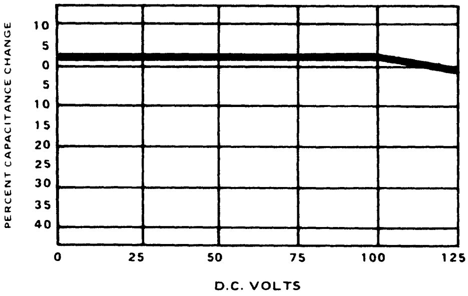
Df vs FREQ



IR vs TEMP



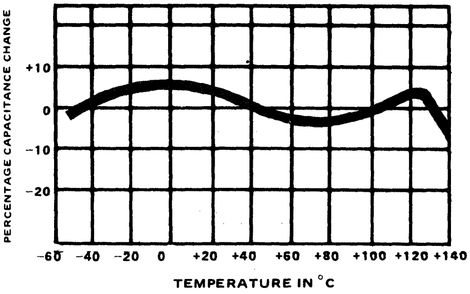
Δ C vs DCV



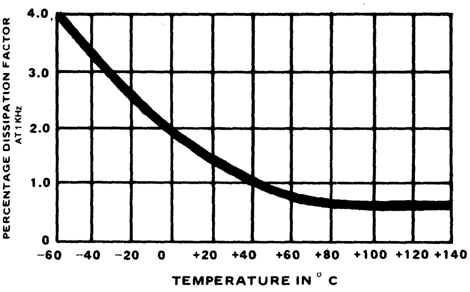
CAPACITOR DESIGNERS' GUIDE

X7R (BX) Typical Characteristics

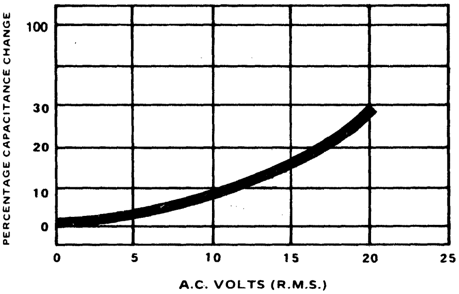
Δ C vs TEMP



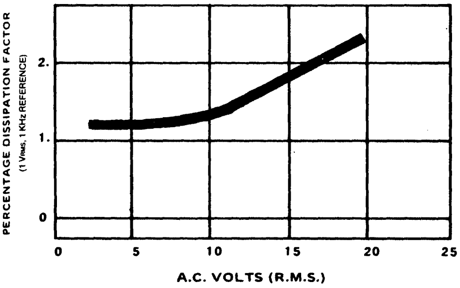
Df vs TEMP



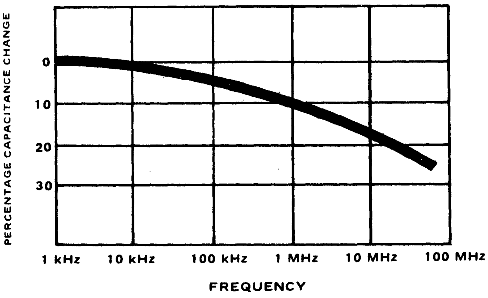
Δ C vs VAC



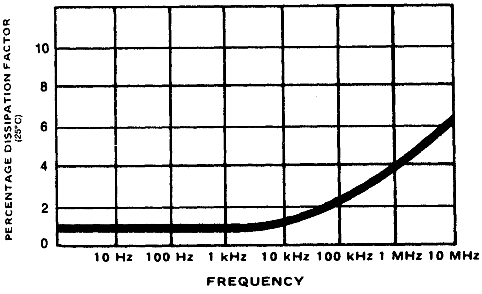
Df vs VAC



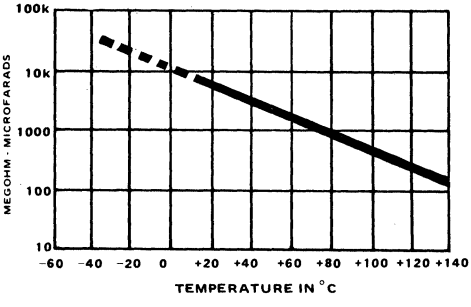
Δ C vs FREQ



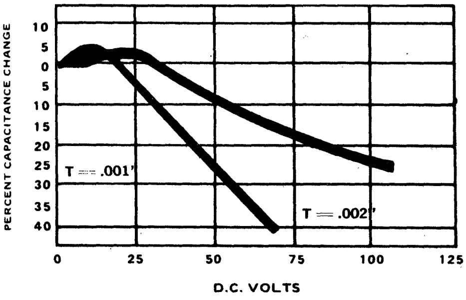
Df vs FREQ



IR vs TEMP

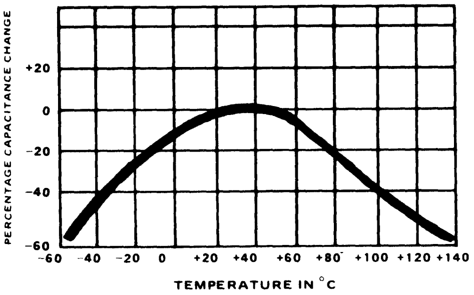


Δ C vs DCV

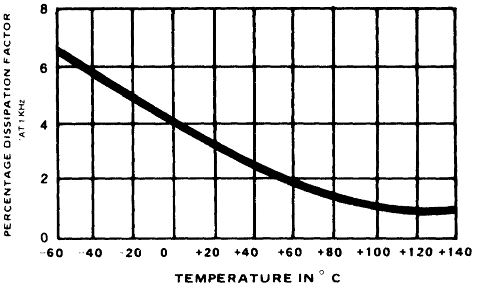


Z5U (General Purpose) Typical Characteristics

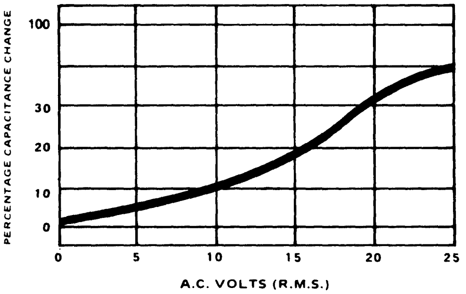
Δ C vs TEMP



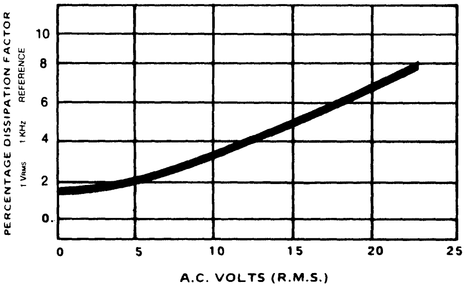
Df vs TEMP



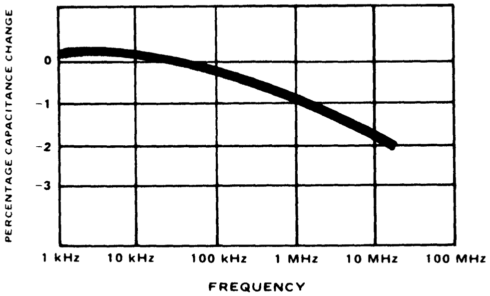
Δ C vs VAC



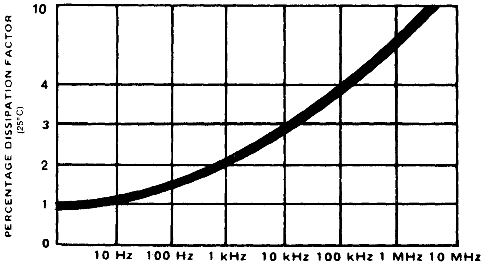
Df vs VAC



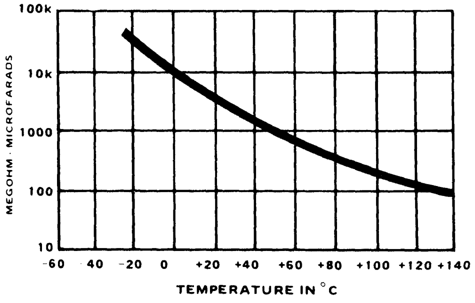
Δ C vs FREQ



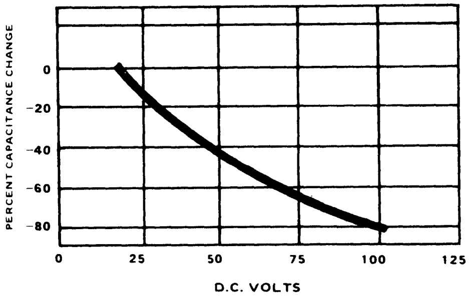
Df vs FREQ



IR vs TEMP



Δ C vs DCV



APPLICATION AND DESIGN NOTES

*Does not appear in databook

NOTE: All Application and Design Notes may be obtained as single printed pieces.

PROGRAMMABLE UNIJUNCTION TRANSISTORS

INTRODUCTION

The Programmable Unijunction Transistor is today's preferred device for low cost timing circuits, oscillators, sensing circuits, and a wide range of other applications where a variable voltage level threshold is desired. This note describes the principle of operation of the PUT, its electrical characteristics, and its various applications.

PRINCIPLE OF OPERATION

The PUT is a three-terminal device as shown in the schematic representation, Fig. 1a. The anode voltage V_A and the gate voltage V_G are measured with respect to the cathode (k). The corresponding anode, gate and cathode currents are given respectively by I_A, I_G, and I_K. The most general usage of a PUT involves an external gate resistor R_G as shown in Fig. 1a. Hence, the voltage generally referred to in characterizing PUT's is the applied voltage V_S rather than the gate voltage V_G which is less than V_S by the voltage drop across R_G.

The theory of operation of the PUT can perhaps be best understood by considering that it is a four-layer (PNPN) device, as is a silicon-controlled rectifier (SCR). The basic PUT structure is shown in Fig. 1b, in which it is noted that the gate is adjacent the anode, in contrast to an SCR in which the gate lead is adjacent the cathode. As shown in Fig. 1c, the PUT, has a two-transistor analogy, which is similar to that used to explain the operation of an SCR, except that the gate connection is common to the PNP base and the NPN collector. Regenerative switching occurs when the sum of the alpha's dynamically approach unity. The net result is that when the anode voltage exceeds the gate voltage by an amount equal to the emitter to base drop of the PNP transistor, the positive feedback drops the anode-cathode voltage and presents a negative resistance.

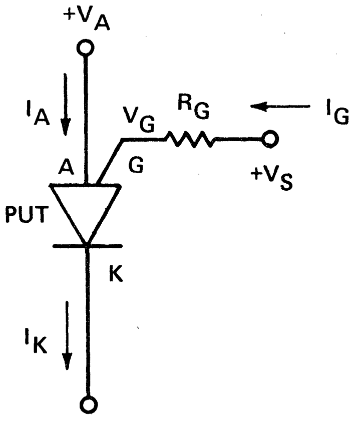


Figure 1a. PUT Parameters

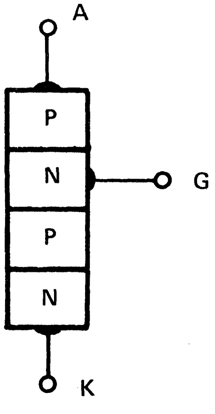


Figure 1b. PUT Structure

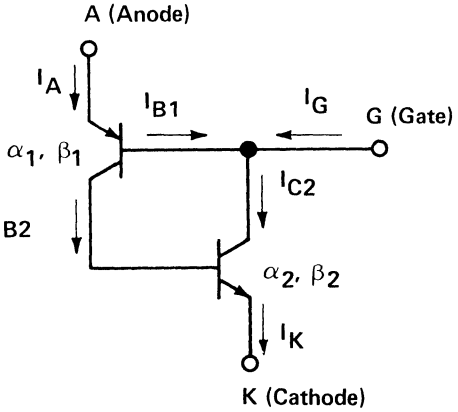


Figure 1c. Two Transistor Analogy

ANODE CHARACTERISTIC

The PUT, together with R_G as shown in Fig. 1a, exhibits a negative resistance characteristic illustrated in Fig. 2 for a fixed value of V_S and R_G. For anode voltages less than the peak voltage V_P at which a current I_{GA} flows. (Region I), a positive incremental resistance results. For anode currents above the valley current I_V, which occurs at the valley voltage V_V (Region III) a positive incremental resistance also occurs. However, for anode currents between the peak point current I_P and the valley current I_V (Region II) the incremental resistance is negative. This region is unstable and forms the basis for use in oscillator circuits. With V_A less than V_S forward anode current flows. At the peak current point, I_P where V_A exceeds V_P the PUT will regeneratively switch to its low impedance state: anode current increases rapidly to a level limited by external load resistance. The PUT will remain on this "ON STATE" until the anode current is reduced to a level below the valley current, I_V. At this point the PUT returns to its blocking or "OFF STATE", because operation in the negative region is unstable. Operation in the region between 'o and I_V will be covered in detail.

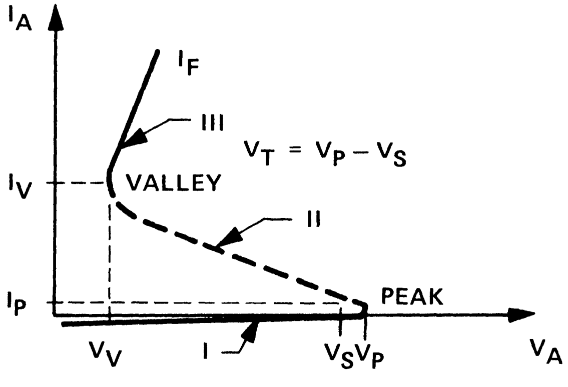


Figure 2. PUT Characteristics

ADVANTAGES

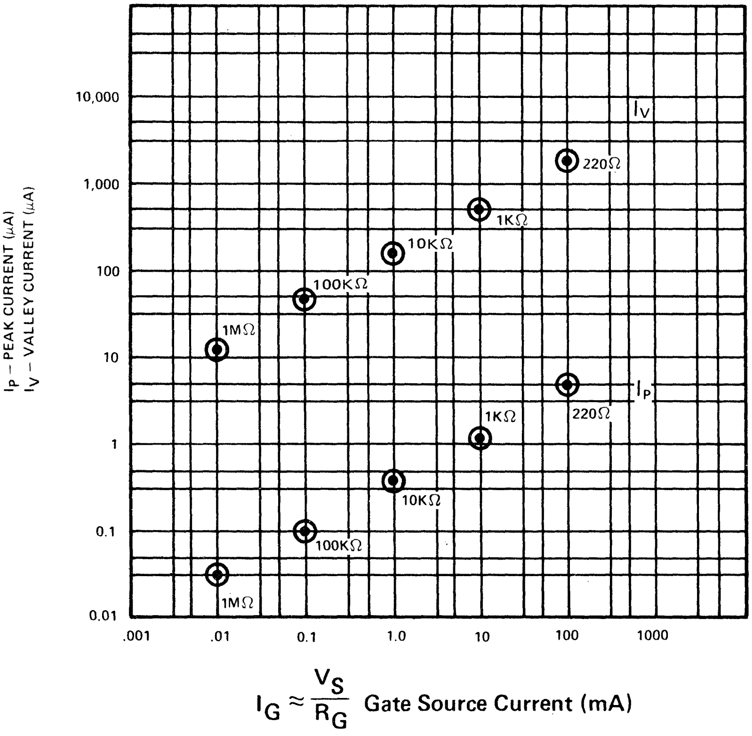
The primary advantage of the PUT over the UJT is the programmability of operating parameters such as peak point current (I_p), valley current (I_V), and offset voltage (V_T), which is defined as

$$V_T = V_P - V_S \qquad (1)$$

These are easily programmed over a range by the choice of circuit components. Shown in Fig. 3 are the relationships between I_P and I_V vs stand off voltage (V_S) and gate source impedance (R_g). As observed from Fig. 3, operation at higher voltages allow a greater spread between I_P and I_V. The significance of this becomes apparent in applications where the negative resistance (Region II, Fig. 2) must be large and must remain relatively broad over a temperature range.

Other advantages of the PUT over the UJT are:

1. Lower current drain through R_1 and R_2; the UJT required several milliamperes of current, The PUT micro amperes of current.
2. Lower peak point current of the PUT allows use of larger R_t (timing resistor) therefore, the C_t may be smaller for the same time delay hence, lower in cost. Lower capacitance values also result in lower leakage current and lower temperature coefficient.
3. Higher efficiency is available due to greater energy transfer from the capacitor to the load. The on state voltage (V_F) is considerably lower for a PUT than for a UJT.
4. High or low operating voltages may be used; V_S as low as 2V or greater than 40V will operate the PUT.
5. The PUT has an overall extended operating range due to programmability of I_P and I_V.
6. Greater uniformity of triggering point. Stand off ratio η is not determined by manufacturing tolerance.



$I_G \approx \frac{V_S}{R_G}$ Gate Source Current (mA)

Figure 3.

BASIC PUT OSCILLATOR

An analysis of the basic PUT oscillator demonstrates the inter-relationship of parameters. From Fig. 4b, the voltage Va changes at a rate determined by the R_tC_t charging path. When the PUT is operating in Region I, the anode voltage is given by

$$V_a = V_{BB}\,(1-e^{-t/R_tC_t}) \tag{2}$$

The standoff voltage is related to the supply voltage V_{BB}

$$V_S = \eta V_{BB} \tag{3}$$

where

$$\eta = \frac{R_1}{R_1 + R_2} \tag{4}$$

Triggering is accomplished when the voltage on the capacitor reaches the standoff voltage V_S; plus the offset voltage V_T, i.e.

$$V_{BB}\,(1-e^{-t/R_tC_t})-V_T = \eta V_{BB} \tag{5}$$

The switching time occurs at

$$t = R_tC_t\ \ell n\left(\frac{1}{1-\eta-\frac{V_T}{V_{BB}}}\right) \tag{6}$$

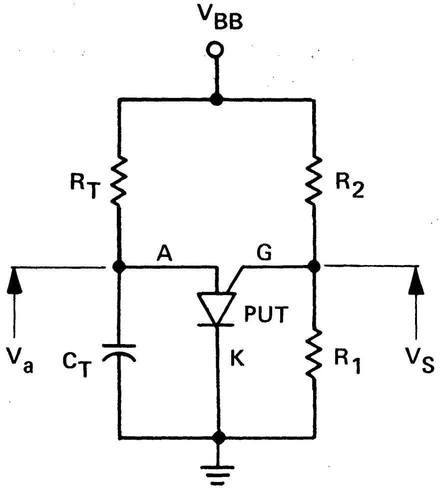
V_T varies only slightly with temperature having a temperature coefficient of about 2.5 mv/^{O}C.

Advantages of the PUT over the UJT are readily observed by comparing their operation in a simple relaxation oscillator circuit. Figure 4a shows a typical UJT oscillator with the simplified UJT model. In the off state the resistance ratio at the intersection of r_1 and r_2 is a fixed value represented by η (intrinsic stand off ratio). This ratio which determines the device triggering voltage is established in the manufacturing process by the resistance of the silicon material and the diode contact. Manufacturing tolerance result in values of η which typically range in value from about 0.4 to 0.9. Replacing the UJT with a PUT results in stable operation in any given circuit (Fig. 4b). The parameter stand-off ratio η is now established exclusively by setting the value of R_2 and R_1 and remains relatively temperature stable. I_P and I_V are controlled by gate source resistance R_g and stand off voltage V_S (Fig. 3). A detailed discussion of the PUT oscillator will be given.

Typical UJT Oscillator

UJT Model

Figure 4a.



$$\eta = \frac{R_1}{R_1 + R_2}$$ Standoff Ratio

$$V_S = \eta V_{BB}$$ Standoff Voltage

$$V_T = V_P - V_S$$ Offset Voltage

$$R_G = \frac{R_1 R_2}{R_1 + R_2}$$ Gate Source Resistance (7)

Fig. 4b

CONDITIONS FOR OSCILLATION

Switching on takes place at the peak point (I_P) switching off requires that current through the PUT be less than the valley current (I_V). Therefore, the load line must intersect the characteristic curve in the negative resistance region Fig. 5 and must be above the I_P point.

CONDITION FOR SUSTAINED OSCILLATION

$$\frac{V_{BB} - V_P}{R_T} \text{(max)} > I_P \text{(max)}$$ This condition insures current levels greater than the I_P (8)

$$\frac{V_{BB} - V_V}{R_T} < I_V$$ This condition insures current levels lower than the I_V (9)

$$1 - \eta >> \frac{V_T}{V_{BB}}$$ This condition insures more stable operation. (10)

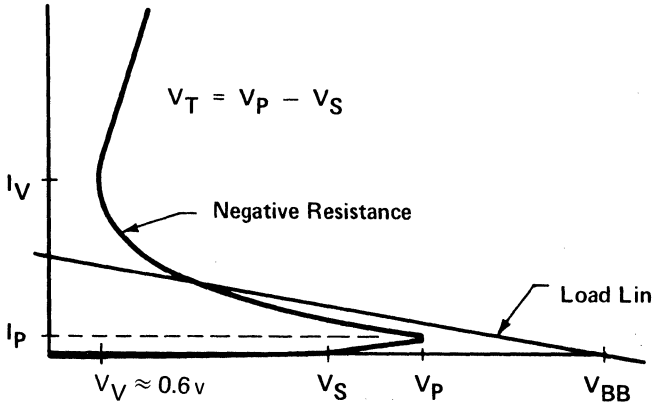


Figure 5. Offset Voltage

CONDITIONS FOR ONE SHOT OPERATION

$$\frac{V_{BB} - V_P}{R_T} > I_P \text{ (max)} \qquad \frac{V_{BB} - V_V}{R_T} > I_V$$

must be satisfied. Since the load current is in the positive resistance region, the PUT will LATCH on and remain on.

PUT OFFSET COMPENSATION

In order to compensate for offset voltage (V_T) temperature shift, a diode D_1 forward biased through R_D may be used Fig. 6. The value of R_D is selected by:

$$R_D = \frac{V_{BB}}{I_P \text{ (max)}}$$

A diode having a forward voltage temperature characteristic similar to the offset voltage temperature coefficient (TC) would provide optimum compensation.

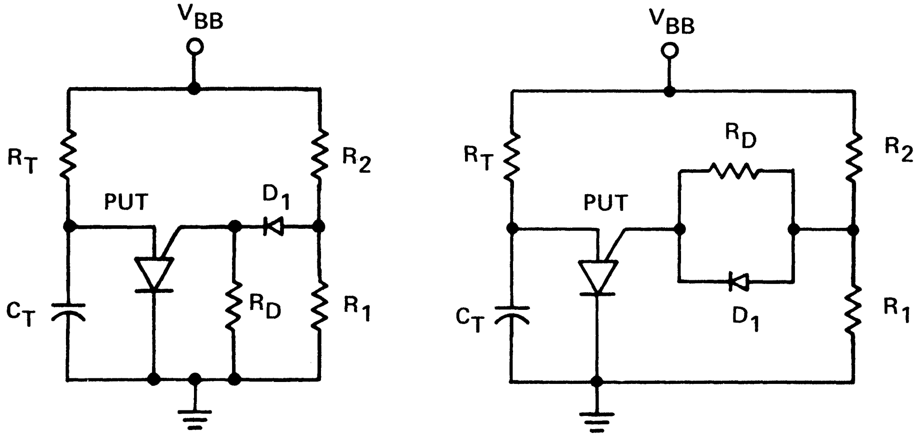


Figure 6. Offset Compensation Methods

TUNABLE FREQUENCY OSCILLATORS

Variable oscillator circuits which include active elements for discharging the timing capacitor C_T are shown in Fig. 7. A second method is given as in Fig. 8.

FREQUENCY RANGE
40 Hz to 65 kHz

OUTPUT PULSE

Rise time ~ 200 nsec.
Pulse width ~ 10 μsec.
Recovery time < 200 nsec.

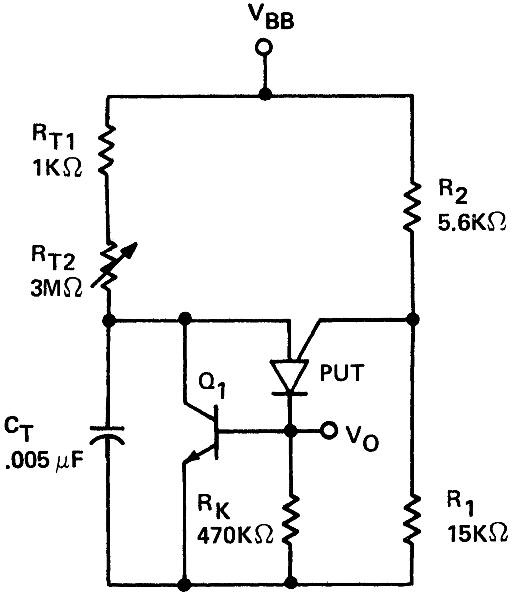


Fig. 7

FREQUENCY RANGE
40 Hz to 40 kHz

OUTPUT PULSE

Width ~ 5 μsec.

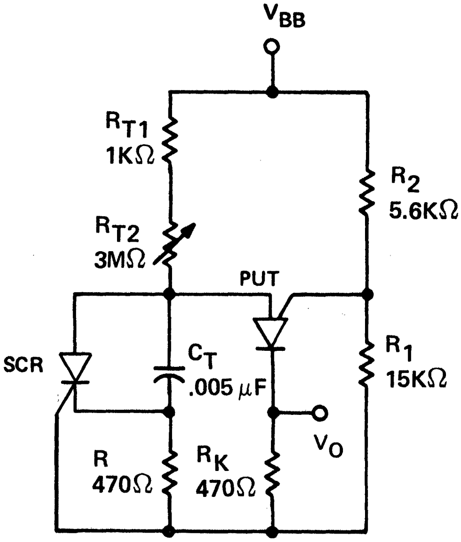


Fig. 8

DESIGN EXAMPLE

A relaxation oscillator. A trigger generator is needed to provide a pulse of energy.

The required repetition rate is 1000 pulses per second. A power source of 20 Vdc is available.

Step 1 Select the value of R_1 and R_2 based on Ip, I_V requirements. For $R_G = 10K\Omega$, (Fig. 3) $R_1 \sim 27K\Omega$, $R_2 \sim 16K\Omega$ this will give an η of ~ 0.63. (Equations 7 and 4).

Step 2 From Fig. 9 with T given as 0.001 sec and η of 0.63. $R_tC_t = 0.001$, $T/R_TC_T = 1$ @ $\eta = 0.63$.

Step 3 The condition for sustained oscillation must be satisfied (equations 8 and 9) hence, $275K < R_t < 1.4$ meg (using spec values for a 2N6027).

Step 4 The value of capacitance is chosen by considering the rise time and energy required. Since $R_TC_T = 0.001$ the C_T range is $0.0007 < C_T < 0.0036\mu fd$. Choose a standard value of capacitance and resistance. For example, $C_T = 0.002\mu fd$ and $R_T = 470K\Omega$ (Standard Value).

For this example $R_t = 470K\Omega$, $C_t = 0.002\mu fd$. A cathode resistance of 20Ω will provide a pulse of current of 130 ma with a pulse width of 300 nsec.

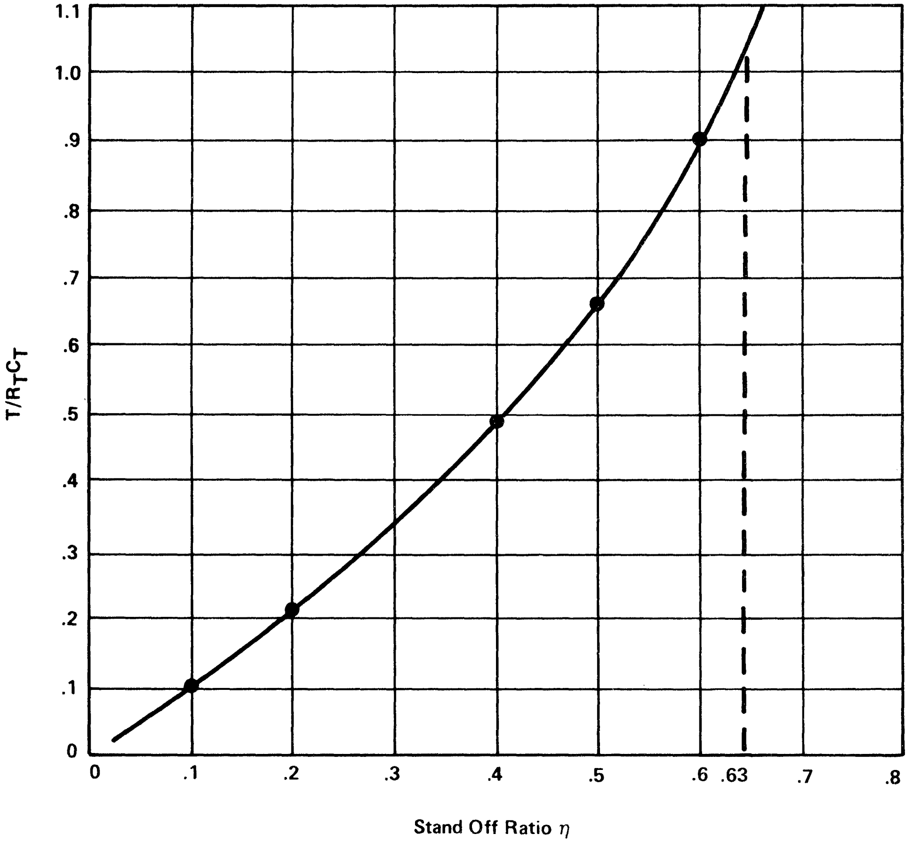


Fig. 9

APPLICATION NOTE

U-68A

SWITCHING REGULATOR DESIGN GUIDE

I. The Advantages of the Switching Regulator

Unlike conventional "dissipative" series or shunt regulators, in which the power-regulating transistor operates in a continuous-conduction mode, dissipating large amounts of power at high load currents – especially when the input-output voltage difference is large – the switching regulator has high efficiency under all input and output conditions. Furthermore, since the power-transistor "switch" is always either cut off or saturated (except for a very brief transition between those two states), the switching regulator can achieve good regulation despite large changes in input voltage, and maintains high efficiency over wide ranges in load current.

Because the switching regulator regulates by varying the ON-OFF duty cycle of the power-transistor switch, and the switching frequency can be made very much higher than the line frequency, the filtering elements used in the power supply can be made small, lightweight, low in cost, and very efficient – i.e., with almost negligible power losses. It is possible to drive the switching regulator with very poorly filtered DC (in fact, in high-power applications, three-phase rectification *without* filtering of any kind is often used to develop the input DC from the power line), thereby eliminating large and expensive line-frequency filtering elements.

Finally, it is possible to design switching regulators with excellent load-transient properties, so that step increases of load current cause relatively small instantaneous changes in output voltage, recovery from which is essentially completed in a few hundred microseconds.

The switching regulator has become increasingly popular in new-equipment designs, not only in aerospace and defense applications, but in computers, industrial process control systems, instrumentation, and communication.

Compared to the dissipative regulator, the switching regulator does have some disadvantages which preclude its use in some applications. The primary power source delivers current to the switching regulator in pulses which, for efficiency reasons, have short rise and fall times. In those applications where a significant series impedance appears between the supply and the regulator, the rapid changes in current can generate considerable noise. This problem can be reduced by reducing the series impedance, increasing the switching time, or by filtering the input to the regulator.

A second problem of the switching regulator, compared to the dissipative regulator, is its response time to rapid changes in load current. The switching regulator will reach a new equilibrium only when the average inductor current reaches its new steady-state value. In order to make this time short, it is advantageous to use low inductor values, or else to use a large difference between the input and output voltage.

Improved circuits for controlling switching regulators have been developed at Unitrode, thereby eliminating some earlier design constraints and optimizing the performance attainable with available hardware. These new circuits permit taking full advantage of the economy and efficiency of the Unitrode PIC600 Series Hybrid Power Switch.

The design approach used herein is believed to be original, and to be clearly superior to earlier methods of calculating the key parameters and designing the power inductor . . . yielding explicit, accurate results in significantly less time than the approximate equations in common use.

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II. The Switching Regulator Described and Characterized

The basic configuration of a switching regulator is shown in Figure 1. It accepts a DC voltage input, Ein, and regulates a DC ouput voltage, Eo, despite variations in Ein and load current. Although the static regulation, dynamic regulation, and ripple rejection of this type of regulator cannot be as easily optimized as they can in a continuous (so-called "dissipative") series regulator, its efficiency, power density (Watts output per cubic inch) and economy are all markedly superior to the series regulator . . . particularly for low-voltage, high-current supplies. Unlike a series regulator, it maintains high efficiency with high input voltages. Switching regulators can thus be employed with high efficiency to derive low voltage outputs from a high voltage unregulated supply.

All of these advantages derive from the method of regulating the output voltage: *by varying the duty cycle of a power-transistor switch,* rather than varying the voltage drop across a power transistor operating in the linear mode. Because the switch (Q1 in Figure 1) is always in the saturated state when it is conducting, and is otherwise completely non-conducting (except for a brief commutation time between the ON and OFF states), the power dissipated in the regulator is much lower than it would be in a series regulator for the same input and output conditions.

The basic switching regulator circuit functions as follows:

The control circuit causes transistor switch, Q1, to switch on and off at a predetermined frequency, f. During the time that Q1 is on, t_{on}, the input voltage, Ein, is applied to the input of the LC filter, causing current i_1 to increase. When Q1 is off, the energy stored in the inductor, L, maintains current flow to the load, circulating through "catch" diode D1. The input of the LC filter is now at zero Volts, i_1 decreases to its original value and the cycle repeats.

The output voltage, Eo, will equal the time average of the voltage at the input of the LC filter:

$$Eo = Ein\, t_{on}/\tau$$

where: $\tau = 1/f$

The control circuit senses and regulates Eo by controlling the duty cycle, $\alpha = t_{on}/\tau$. If Ein increases, the control circuit will cause a corresponding reduction in the duty cycle, α, so as to maintain a constant Eo.

$$Eo = \alpha\ Ein$$

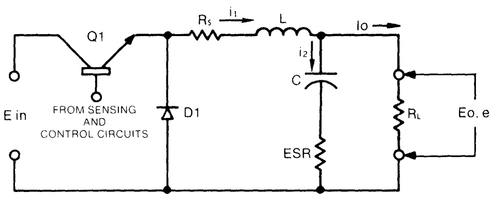
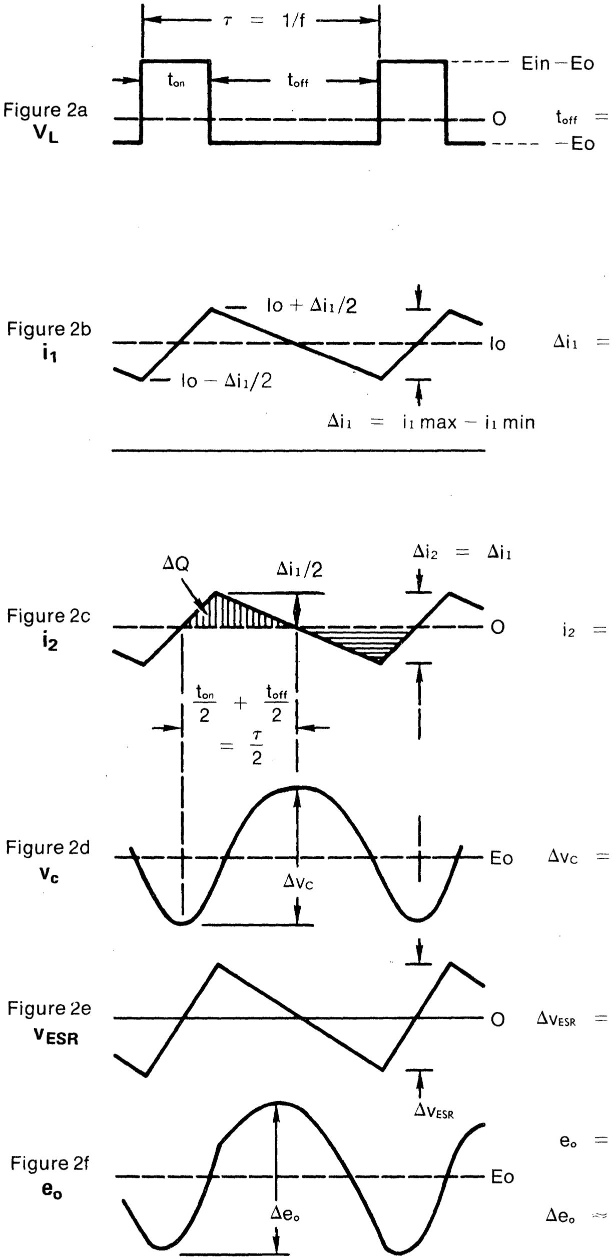


Figure 1. Switching Regulator Basic Configuration



$$t_{on} = \tau \frac{Eo}{Ein}$$

$$t_{off} = \tau - t_{on} = \tau\left(1 - \frac{Eo}{Ein}\right) = \frac{1}{f}\left(1 - \frac{Eo}{Ein}\right)$$

$$\Delta i_1 = \frac{Ein - Eo}{L} t_{on} = \frac{Eo}{L} t_{off}$$

$$i_2 = i_1 - Io \;;\; \Delta i_2 = \Delta i_1$$

$$\Delta v_C = \frac{\Delta Q}{C} = \frac{\frac{1}{2} \cdot \frac{\Delta i_1}{2} \cdot \frac{\tau}{2}}{C} = \frac{\Delta i_1}{8fC}$$

$$\Delta v_{ESR} = \Delta i_1 \cdot ESR$$

$$e_o = v_C + v_{ESR}$$

$\Delta e_o \approx \Delta v_C$ OR Δv_{ESR}, whichever is greater.

NOTE: See Appendix A for rigorous analysis and justification

Figure 2. Switching Regulator Waveforms

Figure 2 shows some of the important waveforms and equations which define the operation of the switching regulator power circuit. The following discussion is based on several simplifying assumptions which are explained and justified or corrected in Appendix A. The most significant assumptions are to neglect the saturation voltage of Q1, the forward drop of D1, and the series loss resistance, R_S, of the inductor, L.

Figure 2a shows the voltage across inductor, L, which equals (Ein − Eo) during t_{on} and (−Eo) during t_{off}. Under equilibrium conditions, when output load current, Io, is constant, the average voltage across L must, by definition, equal zero.

Figure 2b shows the current i_1 through the inductor. Under equilibrium output current conditions, the increase in current during t_{on}, Δi_1, must equal the decrease in current during t_{off}. The average value of i_1 equals the output current, Io.

Figure 2c shows current i_2 through the capacitor, which is equal to (i_1 − Io). The average value of $i_2 = 0$, and $\Delta i_2 = \Delta i_1$. Current i_2 causes a ripple voltage to appear at the output. The output ripple voltage, e_o, has two components, a capacitive component, v_C, and a resistive component, v_{ESR}, caused by the equivalent series resistance of the capacitor.

Figure 2d shows the capacitive component, v_C, of the ripple voltage, which is the time integral of the capacitor current, i_2. Note that v_C is the integral of a triangular wave, and is not sinusoidal. Also note that v_C is in "quadrature" with i_2, in the sense that v_C min and v_C max occur at times A and B, midway in the t_{on} and t_{off} intervals, when i_2 is zero. The total charge, ΔQ flowing into C is computed graphically by finding the area of the triangular current waveform between time A and time B (Area = ½ bh; $\Delta Q = ½ \times \tau/2 \times \Delta i_2/2$). The peak to peak capacitive ripple component $\Delta v_C = \Delta Q/C = \Delta i_1/8fC$. (The factor 8f for a triangular current waveform is comparable to $2\pi f$ for a sinusoidal input current.)

Figure 2e shows the resistive component, v_{ESR}, of the ripple voltage which simply equals $i_2 \times$ ESR, and is in phase with i_2.

Figure 2f, the total output ripple voltage, e_o, is the sum of the waveforms in Figures 2d and 2e. Note that since v_C and v_{ESR} are in quadrature, the greater of these two components dominates, and for all practical purposes the peak to peak output ripple voltage, Δe_o, is equal to either Δv_C or Δv_{ESR} whichever is greater.

The magnitude of v_{ESR} in comparison with v_C shown in these waveforms is not exaggerated. Indeed, when designing a switching regulator to operate at frequencies greater than 20 kHz in order to achieve small size and low cost in the L and C filter elements, the ESR of the capacitor usually dominates completely. Even when high quality capacitors (low ESR) are employed, it is usually necessary to use a larger capacitance value than would otherwise be required in order to realize the ESR required to achieve the ripple objective of the design.

With conventional free running switching regulator control circuits, capacitor ESR also causes very significant departure from the design frequency, which can result in large ripple magnitude, inductor saturation, and switching transistor failure. In the circuits developed at Unitrode and presented in the next section, the frequency-variation effect caused by ESR is effectively eliminated, leaving only the ripple consideration.

Detailed design considerations for switching regulator power circuits are contained in Section IV.

III. Applications Circuits for Switching Regulators

The design and performance of conventional switching regulators are usually dominated by the ESR of the output capacitor. However, in the group of circuits described in this section, the following parametric relationships and circuit characteristics are easily and economically attained:

- The switching frequency may be selected and established at the optimum value for the switching components, and *will be independent of the value of the ESR of the output capacitor.*
- The value of t_{off} is held relatively constant, over wide ranges of load current and input voltage, and independent of the ESR of the output capacitor. Constant t_{off} results in constant ripple current and output ripple voltage.
- Settable overcurrent limiting is provided, thereby protecting both the load and the switching transistors under all conditions, and preventing saturation of the power inductor during the startup transient period, thereby minimizing startup overshoot.
- The overcurrent limiting circuit is significantly lower in dissipation than conventional current-limit-feedback arrangements.
- The drive current to the power output (switch) stage is regulated to a pre-determined value, for best efficiency and optimum switching speed. Drive current is automatically increased at low temperatures and decreased at high temperatures, thereby maintaining optimum drive conditions for the power switch.

Note that, although the use of this circuit approach permits essentially constant "t_{off}" operation even with capacitors having relatively high ESR, the output ripple voltage is increased by high ESR. (If the ripple developed across ESR is significantly larger than that developed across C, then the ripple is essentially proportional to ESR.)

Not all of the circuits that follow have all of the virtues listed above, but the exceptions will be noted. Figure 3 typifies this family of regulators. It is shown implemented by the popular LM305 regulator IC, and a Unitrode Series PIC600 Hybrid Power Switch, comprising a quasi-Darlington switching transistor, a fast recovery catch diode, and transistor bias resistors, all matched for optimum efficiency and switching speed (up to 100 kHz without derating). The configuration of Figure 3 is a *positive* output regulator, with performance characteristics as follows:

Ein = 20 to 40V

Eo = 5V ± 1%

Δe_o = 100 mV p-p (2% p-p ripple)

Io = 2 to 10A

Isc = 12A

Regulation versus Ein (20 to 40V) <25 mV

Transient Recovery Time for step change in load current from 2A to 10A, or 10A to 2A <150 μsec.

f = 50 kHz nominal

Efficiency >70%

The circuit of Figure 3 operates in the fixed-off-time mode; hence, output ripple is independent of input voltage over wide ranges. In this circuit, two feedback signal paths are provided:

- *DC Feedback.* A fraction of the DC output voltage, Eo, is fed back to the inverting input of the LM305 through voltage divider R1, R2. The DC voltage at the inverting input is compared to a reference voltage (approximately 1.8V) within the LM305, and the LM305 regulates Eo so that the voltage fed back to the inverting input is essentially equal to the built in reference voltage. The R1, R2 divider ratio therefore establishes the level of the DC output voltage, Eo. Resistor R5 improves output voltage regulation versus input voltage changes by feeding a small compensating voltage proportional to the input voltage into the inverting input of the LM305.

- *AC Feedback.* Capacitor C1 feeds back an AC voltage waveform to the inverting input of the LM305. This voltage is proportional to the output ripple voltage plus the AC voltage developed across R_l, $\Delta e_o + \Delta v_{Rl}$.

  Capacitor C2 feeds back an AC voltage to the non-inverting input of the LM305. This voltage is proportional to the output ripple voltage plus the AC voltage across R3, $\Delta e_o + v_{R3}$.

When the circuit values are properly established, the same fraction of Δe_o is fed back to both inverting and non-inverting inputs, thereby effectively cancelling. The operation of the switching regulator is thus rendered independent of the output ripple voltage developed across the C or ESR of the output capacitor.

Since the Δe_o components cancel each other, the LM305 essentially compares Δv_{Rl} at the inverting input to Δv_{R3} at the non-inverting input. Voltage Δv_{R3} is a rectangular waveform with a peak-to-peak amplitude equal to I drive × R3, where I drive is the base drive to the hybrid switching transistor provided by the LM305, and Δv_{Rl} is a triangular waveform with a peak-to-peak amplitude equal to $\Delta i_1 \times R_l$, where Δi_1 is the ripple current through inductor L. When the drive current is on, Δv_{R3} is at its peak positive amplitude. As i_1 increases, v_{Rl} increases proportionately. When the positive amplitude of Δv_{Rl} reaches Δv_{R3}, this causes the LM305 to switch off the drive current, Δv_{R3} immediately drops to its peak negative amplitude, and i_1 starts to fall. When Δv_{Rl} reaches a negative amplitude equal to Δv_{R3}, the LM305 switches the drive current back on, and the process repeats. In this manner, the LM305 controls the power switch so that Δi_1 is fixed. Since $t_{off} = \Delta i_1 \times L/Eo$, with fixed values of L and Eo, t_{off} is fixed and independent of changes in Ein or capacitor C or ESR values.

R4, connected between pins 1 and 8 of the LM305, establishes the desired level of base drive for the PIC600 Series Hybrid Power Switch, and determines the hysteresis voltage across R3.

Current-limiting action is provided by transistor Q1, the collector of which is connected to the "gate" or "inhibit" terminal of the LM305 (pin 7). When the load current is normal, Q1 is cut off and pin 7 floats; but when the voltage drop across R_l increases to a value greater than the sum of V_{BE} (Q1) and v_{R3}, Q1 turns on, cutting off the drive current from the LM305 and, ultimately, the power switch. This cutoff action is made to "latch" by the fact that, with the drive cut off, v_{R3} disappears. This keeps Q1 on, until the current through R_l drops significantly – enough to make the voltage drop across R_l fall below the V_{BE} of Q1.

The current through R_l, following such an overload cutoff action, falls linearly at the rate of Eo/L. When Q1 is cut off, drive current is restored. The circuit will then continue to switch on and off at a frequency comparable to normal operation, with the average current limited at the design limit, and power dissipation held to safe values.

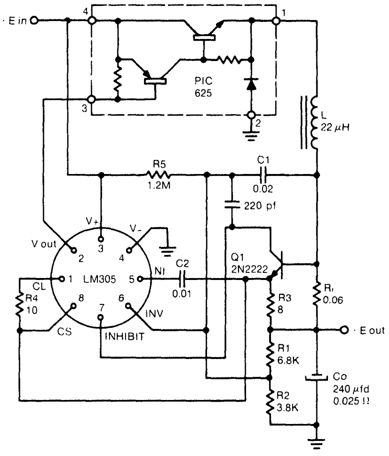


Figure 3. Positive Voltage Switching Regulator

Transient response of the switching regulator of Figure 3 is shown in Figures 4, 5, and 6.

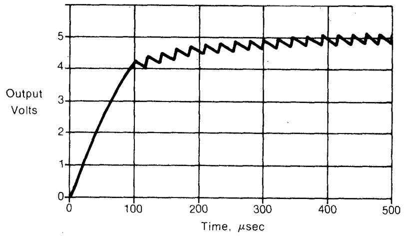


Figure 4. Ein from 0 to 25V

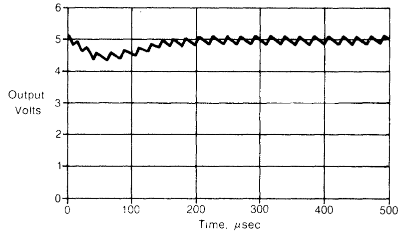


Figure 5. Io from 4A to 10A

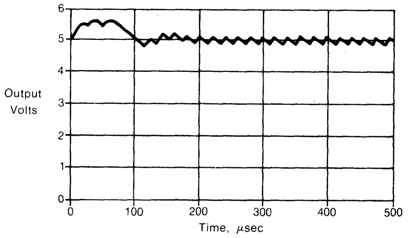


Figure 6. Io from 10A to 4A

It is usually necessary to employ a noise filtering capacitor across the input of any switching regulator. This functions to prevent the steep waveform of the rectangular current pulse associated with the power switch turning on and off from propagating into the Ein supply line. The capacitance value required is a function of the impedance characteristics of the Ein supply and intervening wiring. Watch out for underdamped resonance with the inductance of the input wiring, or transient induced ringing may occur. The input capacitor must have short leads, and the ground side should preferably be connected directly to the ground side of the output filter capacitor.

A 10A negative voltage switching regulator, utilizing an LM304 and PIC600 series, is shown in Figure 7.

A reference voltage is determined by resistor R1 and R2. The error amplifier controls the output voltage at twice the voltage across R2. Diode D1 is used to ensure a potential difference of less than 2V at the unregulated input (pin 5) with respect to the reference supply (pin 3). (If the unregulated supply terminal gets more than 2V positive with respect to reference supply, the collector isolation junction of transistor Q6 of LM304 becomes forward biased and disrupts the reference.)

Current limiting is achieved, in Figure 7, by means of reducing the reference voltage to ground with the help of transistor Q1 and resistor R8, instead of turning off the base drive to the power output switch as in Figure 3.

The functions of the rest of the components and the operation of the switching regulator are the same as described for Figure 3.

A positive switching regulator using a μA723 is shown in Figure 8.

The basic performance and circuit operation is the same as Figure 3.

The circuit shown in Figure 9 is a high voltage positive switching regulator. Because the LM305 (like almost all IC regulators) cannot be operated at supply voltage in excess of 40V, this circuit uses a fraction of Ein as a power supply for the IC circuit by means of zener diode and current limiting resistor R9. The voltage isolation between LM305 and power switch, and the regulated base drive to the power switch are provided by transistor Q2.

The basic operation of the circuit and design approach is the same as that of a low voltage positive switching regulator.

The circuit shown in Figure 10 is a negative high voltage switching regulator.

This circuit is similar to the low voltage negative switching regulator with a minor modification. Transistor Q2, resistor R10 and R11 are all used to provide regulated base drive to the power output stage and also to provide the voltage isolation between power output stage and LM305. The resistor R9 is used to limit current through zener diode under steady state and startup conditions.

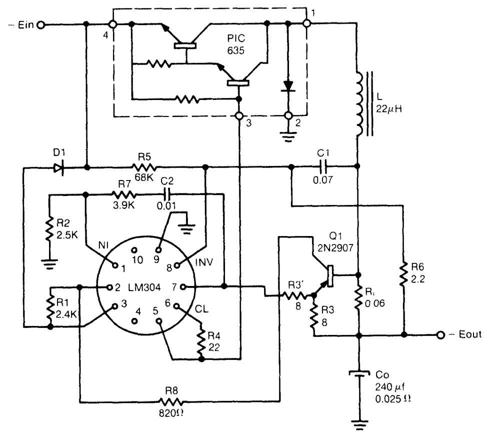


Figure 7. Negative Voltage Switching Regulator

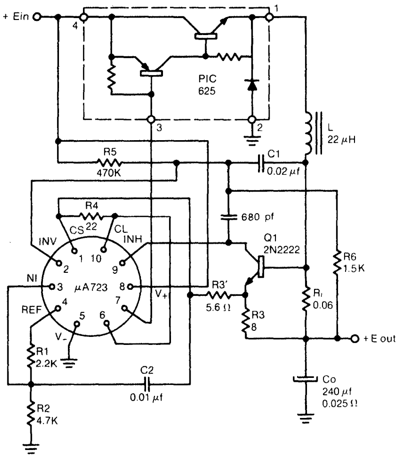


Figure 8. Positive Voltage Switching Regulator

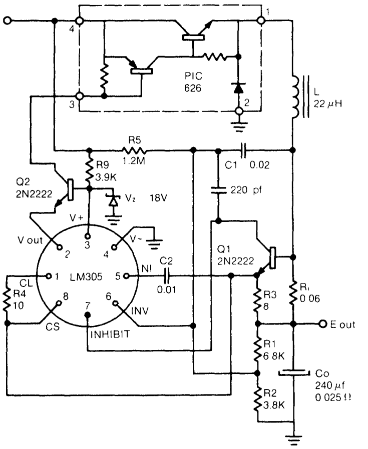


Figure 9. High Voltage Positive Switching Regulator

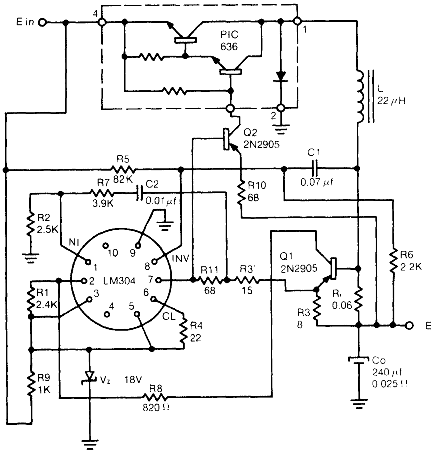


Figure 10. High Voltage Negative Switching Regulator

IV. Designing the Power Circuit

In designing a switching regulator power supply, the following parameters will normally be predefined. Specific values shown for each parameter will be used as the basis for a design example:

Eo = 5V Output Voltage
Δe_o = 100 mV Output Ripple Voltage, Peak to Peak
Io max = 10A Output Current, Full Load
Io min = 2A Output Current, Minimum Load
Ein max = 40V Input Voltage, Maximum
Ein min = 20V Input Voltage, Minimum

The first step in the design is to decide on the operating frequency of the switching regulator. No concrete rules can be given for this decision.

High frequency operation is distinctly advantageous in that the cost, weight and volume of both L and C filter elements are reduced. However, above the frequency where the capacitor ESR exceeds its capacitive reactance, no further reduction in capacitor size or cost will occur. This frequency, in the range of 1-50 kHz, depends upon the "quality" of the capacitor in terms of ESR. Above this frequency, the inductor will continue to diminish in size and cost, although when the inductor reaches a very small size, cost will level off.

Operation above 20 kHz is desirable to eliminate the possibility of audio noise.

The main factor limiting high frequency operation is the drop in efficiency caused by switching losses in the power switching transistor and "catch" diode. The higher cost of these fast switching semiconductors required to operate efficiently at high frequencies must be weighed against the reduced cost, size and weight of the L and C components to arrive at the optimum frequency for any specific application. It may be desirable to work the design through at several frequencies in order to make a decision.

In the specific application defined at the beginning of this section, the power output (Eo × Io max) is 50W. Referring to the specification for the Unitrode PIC 625/635 Hybrid Power Switch, the DC losses (Transistor V_{CEsat}, Diode V_F) under the conditions of this application amount to 10W. The following tabulation shows the switching losses and overall efficiency at several frequencies.

Frequency	**1 kHz**	**20 kHz**	**50 kHz**	**100 kHz**
Power output	50	50	50	50
DC losses	10	10	10	10
Switching losses	0.05	1	2.5	5
Total power input	60.05	61	62.5	65
Realizable efficiency	83.3%	82%	80%	77%

For our example, we will choose a frequency of 50 kHz, even though the efficiency is not significantly reduced at 100 kHz. At 100 kHz most currently available tantalum and aluminum electrolytic capacitors begin to exhibit series inductance.

Transistors and diodes which do not have the fast switching capabilities of the PIC 625/635 will become efficiency limited at much lower frequencies. Note that in this specific application, a dissipative regulator design will incur power losses in the series transistor of 350W, resulting in an efficiency of 12.5 percent!

The control circuits shown in the previous section control the on-off switching periods by sensing and controlling the ripple current, Δi_1, through the inductor L. This mode of operation results in a constant ripple current and (assuming Eo and L are fixed) constant off time, t_{off}, independent of input voltage. The relationship between t_{off}, f, Eo, and Ein is as follows (from Figure 2a):

$$t_{off} = (1 - Eo/Ein) / f$$

With t_{off} and Eo fixed by the control circuit, f will change when Ein changes, and f will be maximum when Ein is maximum. In our specific example,

f max = 50 kHz
Ein max = 40 V
Eo = 5V

so that:

$$t_{off} = (1 - 5/40) / 50{,}000 = 17.5 \mu sec$$

Now, with t_{off} fixed at 17.5 μsec, if Ein changes to Ein min = 20V,

$$f_{min} = \frac{(1 - Eo/Ein)}{t_{off}} = \frac{(1 - 5/20)}{17.5 \times 10^{-6}} = 43 \text{ kHz}$$

The fact that the frequency changes slightly with Ein is really not important, as stated earlier, because constant t_{off} operation results in more constant output ripple than constant frequency operation.

Having determined (or assumed) the maximum operating frequency and calculated t_{off}, we next proceed to find specific values for L and C. L and C together form a low pass filter which reduces the rectangular waveform at the filter input to a DC output voltage, Eo, with a small amount of ripple, Δe_o, superimposed. To achieve a specified Δe_o requires a specific LC product, independent of load current. Theoretically, this LC product can be achieved with any L/C ratio – small L and large C, or large L and small C (or very large L and no C at all, using instead the load resistance R_L as one element of an L/R filter). There are, however, several practical economic and performance considerations that apply to selecting specific L and C values.

It is favorable to push in the direction of small L and large C for the following reasons:

1. Under the power and frequency ranges commonly encountered in switching regulator circuits, it costs more to store energy in an inductor than in a capacitor. Also, an inductor will have considerably greater weight and volume than a capacitor with equal energy storage capacity. Small L and large C, within the limits defined below, will usually result in the lowest cost, weight and size design.
2. Small L and large C results in low "surge impedance" of the filter, hence better transient behavior with step changes in load current.
3. Losses in a practical inductor are higher than in a capacitor with equal energy storage capacity (assuming low ESR). This again argues for small L, large C.

One major objection to a low L/C ratio is that it causes large and sometimes intolerable overshoot in input current and output voltage on startup, when the circuit is first energized. Input current overshoot can saturate the inductor and destroy the switching transistor. The current limiting feature of the applications circuits shown in Section III effectively controls the startup transient, thereby protecting all components and minimizing voltage overshoot. With current limiting, this problem is eliminated and no longer pertains to the selection of L and C values.

Referring to Figure 2b and its associated equations, the peak-to-peak ripple current through the inductor, Δi_1, is inversely proportional to the inductance, L. As L is made smaller, Δi_1 increases. Maximum limits on Δi_1 determine how small L is permitted to be, as follows:

1. The instantaneous current through L ranges between a maximum of $Io + \Delta i_1/2$ and a minimum of $Io - \Delta i_1/2$. If $\Delta i_1/2$ is permitted to become larger than Io, the minimum inductor current becomes a negative value. This is impossible, since neither the switching transistor nor the "catch" diode will conduct. Therefore, the switching regulator goes into a discontinuous mode of operation which is perfectly safe, but the frequency changes considerably and regulation with output current changes becomes relatively poor. The worst case consideration to insure that discontinuous operation does not occur is to make $\Delta i_1/2$ equal to the *minimum* load output current, Io min, or $\Delta i_1 = 2$ Io min.

   It is not practical to apply this criterion if Io min is very small (<0.05 Io max) because Δi_1 would then be very small, forcing an impractically large L value. In applications where Io min is very small, there are two alternatives: (a) raise Io min by preloading the supply, or (b) make $\Delta i_1 = 2(0.05$ Io max$) = 0.1$ Io max realizing that when Io becomes less than 0.05 Io max, the discontinuous mode will occur.

2. The maximum peak current is equal to the full load current, Io max $+ \Delta i_1/2$. As L is decreased, the corresponding increase in Δi_1 will begin to cause a significant increase in the maximum peak current. Since the inductor must be designed not to saturate at the maximum peak current, this begins to negate the cost, size and weight advantages of making the L value smaller. Higher peak currents will have an adverse effect on efficiency and transistor drive requirements, and may require transistor and "catch" diodes with higher current ratings (and higher cost). It is, therefore, recommended that $\Delta i_1/2$ be no greater than 0.25 Io max, which will limit the maximum peak current to 1.25 Io max, or Δi_1 max = 0.5 Io max.

In summary:

Δi_1 = 2 Io min, within the following somewhat arbitrary limits:

Δi_1 min = 0.1 Io max

Δi_1 max = 0.5 Io max

In our example, Io min = 2A, Io max = 10A. Calculating $\Delta i_1 = 2$ Io min $= 4A$, which is acceptable since Δi_1 max $= 0.5 \times 10A = 5A$, and Δi_1 min $= 0.1 \times 10A = 1A$.

Now that t_{off} and Δi_1 have been determined, L can be calculated as follows:

$$L = \frac{Eo \times t_{off}}{\Delta i_1} = \frac{5 \times 17.5 \times 10^{-6}}{4} = 21.9\,\mu H$$

The final step is to determine the requirements for the capacitor C and ESR values which will result in the desired output ripple voltage, Δe_o. Since the two components of Δe_o : Δv_C and Δv_{ESR}, are in "quadrature", we can consider each component separately, with a worst case error of less than 20 percent when both components are equal. This much error is highly unlikely, since the ESR component usually dominates completely when operating at high frequencies.

From Figure 2d:

$$C = \frac{\Delta i_1}{8f\,\Delta v_C}$$

note that C varies inversely with f. In order to achieve Δv_C less than the desired maximum Δe_o, the minimum value for C must be determined at the lowest frequency, f_{min}, calculated previously.

$$\begin{aligned} C\text{ min} &= \frac{\Delta i_1}{8f_{min}\,\Delta e_o \text{ max}} \\ &= \frac{4}{8 \times 43 \times 10^3 \times 100 \times 10^{-3}} \\ &= 114\,\mu F \end{aligned}$$

From Figure 2e:

$$\begin{aligned} \text{ESR max} &= \frac{\Delta v_{ESR}}{\Delta i_1} = \frac{\Delta e_o \text{ max}}{\Delta i_1} \\ &= \frac{100 \times 10^{-3}}{4} \\ &= 0.025\Omega \end{aligned}$$

With high frequency operation, capacitor ESR usually dominates, forcing the use of a C value much greater than C min in order not to exceed ESR max.

Subsequent sections deal with designing the inductor and selecting the capacitor and other components of the switching regulator.

V. Design of the Power Inductor

This simplified nomographic method facilitates selecting the smallest core that will achieve the desired characteristics of the power inductor. This procedure is useful in selecting the proper core and determining wire size, number of turns, copper losses, and temperature rise. It also permits investigating the effects of change in assumed initial conditions and in "trimming" the design.

A detailed analysis of this inductor design procedure is contained in Appendix B.

Tables 1 and 2 give core parameters for a variety of commonly used ferrite pot cores and Mo-Permalloy toroids. (Note: There is no significance to the selection of manufacturers, nor is any intended. Many manufacturers make roughly equivalent cores in these sizes, with similar magnetic properties.)

Ferrite and Mo-Permalloy powder are excellent core materials for the switching regulator inductor. Since the rms AC current through the inductor is small compared to the DC current, AC losses in the winding and core losses will be negligible compared with DC winding losses.

Selection of the proper core for a specific application is a process concerned with two factors: (1) The core must provide the desired inductance without saturating magnetically at the maximum peak overload current, i_1 max. In this respect each core has a specific $(LI^2)_{sat}$ energy storage capability. (2) The core must have a window area for the winding which admits the number of turns necessary to obtain the required inductance with a wire size which will result in acceptable DC losses in the winding at the full load output current, Io. Each core has a specific $(LI^2)_{diss}$ capability that will result in a specific power loss or temperature rise.

The significant core parameters are primarily core size and the magnetic gap in series with the flux path. Consider a very small (for the application) ferrite pot core with no air gap. The effective permeability, μ_e, will be very large because there is no gap. Relatively few turns will be required to achieve the desired inductance, and the power loss at Io will be small, but the core cannot store the required energy $L(i_1 \text{ max})^2$ without saturating. If we introduce a gap into this core, the energy storage capability increases (the extra energy is actually stored in the gap, not in the ferrite material). However, the gap causes the effective permeability to drop, which requires more turns of finer wire to achieve the desired inductance. If the core is too small, as the gap is increased to the point required to achieve the necessary energy storage capability without saturating, the DC resistance of the increased number of turns of finer wire has increased to the point where the power dissipation and temperature rise is too great. This conflict is resolved by going to a larger core with appropriate gap.

To facilitate core selection, Tables 1 and 2 contain tabulated values of $(LI^2)_{sat}$ energy storage capability (saturation limited) and $(LI^2)_{25C}$ capability (based on power dissipation resulting in 25°C temperature rise). These values have been calculated for various size cores with different gaps, by methods described in Appendix B. Also given in the tables are the power dissipation corresponding to a 25°C rise for each core size, and the effective window area for the winding, A_W'. Tabulated A_L values relate to different gaps. (A_L is the inductance index at a particular gap setting – defined as the inductance in mH for 1000 turns.)

The optimum cores for switching regulator inductor applications generally have quite large gaps, and consequent relatively low A_L values. This is fortuitous, since the core properties are then dependent mostly on the gap itself, and variations in the magnetic materials of the core are swamped out, resulting in excellent stability and linearity. Note, however, that in the ferrite pot core table, many of the lower A_L values are not supplied as stock items by the manufacturer, and the desired gap must be ground to size on a special order basis.

Mo-Permalloy powder cores are effectively "gapped" by the manufacturer by means of varying the amount of non-magnetic binder that holds the Mo-Permalloy particles together within the core, and by the size and shape of the Mo-Permalloy particles. Thus, the "gap" is actually distributed throughout the core material. These cores are supplied with many different A_L values in each size.

One of the main advantages of ferrite pot cores and ferrite E-I cores (not tabulated, but worth considering) is that the winding is easily formed on a bobbin which is subsequently assembled within the two-piece core assembly. Ferrite toroids are not recommended because of the practical difficulty of introducing a gap. Mo-Permalloy toroids are not as convenient to wind, but this is not a serious problem as most switching regulator inductor designs require few turns of relatively heavy wire.

Example of Inductor Design

The example shown below will illustrate the method of solution, as drawn on the nomograph of Figure 11.

Given:

$$\begin{aligned} L &= 21.9\,\mu H \\ Io &= 10A \\ i_1\,max &= 14A \text{ (current limited)} \\ Eo \times Io &= 50W \text{ (output of regulator)} \end{aligned}$$

Copper losses not to exceed 1% of output power, and temperature rise of inductor not to exceed 25°C.

Step 1: Draw line ① from Io = 10A on the "I" scale, to 0.0219 mH (21.9 μH) on the "L" scale through the "LI²" scale. Note that $LI_o^2 = 2.19$ millijoules.

Step 2: Draw line ② from i_1 max = 14A on the "I" scale to the 0.0219 mH on the "L" scale through the "LI²" scale. Note that $L(i_1\,max)^2 = 4.3$ millijoules.

Step 3: Find the smallest core in Tables 1 or 2 that has $(LI^2)_{25C}$ capability greater than LI_o^2 defined in step 1, and $(LI^2)_{sat}$ capability greater than $L(i_1max)^2$ defined in step 2. This appears to be a 2616-3B7 pot core with $A_L = 160$ from Table 1, or an A-291061-2 toroid from Table 2.

Step 4: Actual temperature rise of the core and power loss can be calculated as follows:

Temperature rise of pot core;

$$\begin{aligned} \text{Actual } \Delta T &= 25°C \frac{LI_o^2 \text{ (step 1)}}{(LI^2)_{25C} \text{ from core table}} \\ &= 25°C \times \frac{2.19}{2.288} \\ &= 24°C \end{aligned}$$

Power loss in inductor;

$$\begin{aligned} \text{Actual } P_W &= P_{25C} \times \frac{LI_o^2}{(LI^2)_{25C}} \\ &= 0.547 \times \frac{2.19}{2.288}\ W \\ &= 0.524W \end{aligned}$$

Actual power loss in the inductor as a percentage of the power output of the switching regulator is:

$$\frac{P_W \times 100\%}{Eo \times Io} = \frac{0.524 \times 100\%}{50} = 1.05\%$$

If power losses are not acceptable, then select a core with higher $(LI^2)_{25C}$ capability.

Step 5: In the nomogram, draw line ③ from 0.0219 mH on the "L" scale through $A_L = 160$ on "A_L" scale to the "N" scale. Note that 12 turns are required to obtain the desired inductance.

Step 6: Enter the $A_W' = 0.193$ from the table for the core selected on the "A_W'" scale. Draw ④ from "N" scale where N = 12 through $A_W' = 0.193$ to the "wire size" scale. From this scale, note that wire size is AWG 15.2. Select the next highest integer, AWG 16, in order to fit within the available window area. This will result in a slight increase in power loss and temperature rise.

The same procedure applies if a toroid is selected instead of a pot core.

If both the LI_o^2 and $L(i_1max)^2$ values calculated in steps 1 and 2 are less than the appropriate limiting (LI^2) values for the core selected, it is suggested that the L value of the application be increased until one or the other of the core limits is reached. This will permit reduction of Δi_1, and reduce the requirements of the output capacitor.

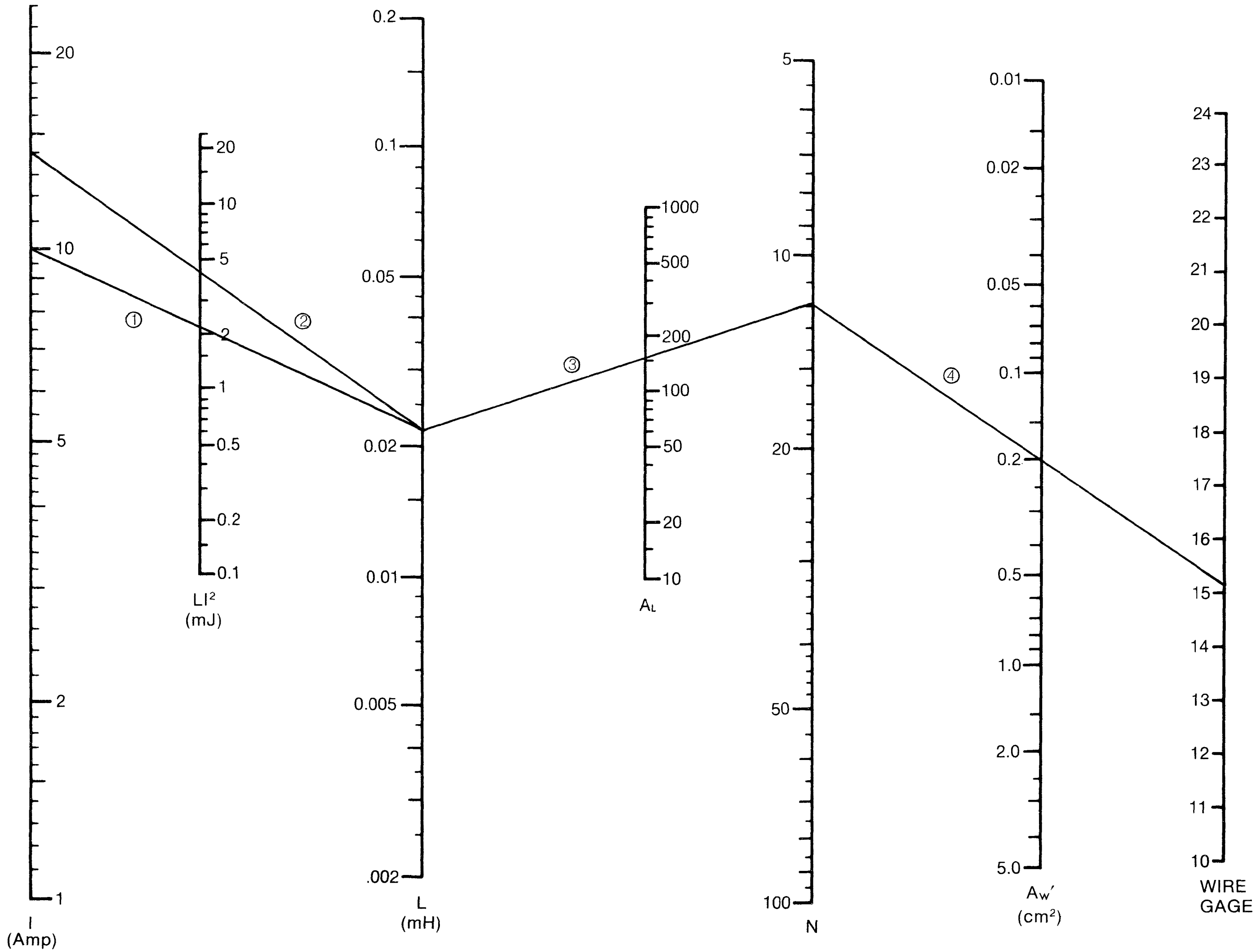


Figure 11. Inductor Design Nomograph

Table 1. Ferrite Pot Cores

Ferroxcube Part No.	Dimensions (inches)		Power Dissipation 25°C rise (watts)	Window Area 0.65 A_W (cm^2)	Inductor Index	Saturation Limit (mJ)	Dissipation Limit 25°C rise (mJ)
	(OD)	(HT)	(P_{25C})	(A_W')	(A_L)	($(LI^2)_{sat}$)	($(LI^2)_{25C}$)
1107-A100-3B7	0.445	0.264	0.100	0.034	100	0.200	0.077
1107-A160-3B7	0.445	0.264	0.100	0.034	160	0.144	0.124
1408-A100-3B7	0.559	0.334	0.158	0.063	100	0.490	0.180
1408-A160-3B7	0.559	0.334	0.158	0.063	160	0.324	0.288
1811-A160-3B7	0.716	0.428	0.259	0.122	160	1.02	0.719
2213-A160-3B7	0.858	0.538	0.358	0.193	160	2.12	1.32
2616- * -3B7	1.024	0.640	0.547	0.263	160*	5.06	2.29
2616-A250-3B7	1.024	0.640	0.547	0.263	250	3.24	3.58
3019- * -3B7	1.201	0.754	0.754	0.382	200*	8.57	4.90
3622- * -3B7	1.418	0.880	1.04	0.486	200*	18.4	7.21
4229- * -3B7	1.697	1.16	1.60	0.910	200*	31.8	17.9

*Indicates not stock item. Gap must be ground to obtain desired A_L.

Table 2. Mo-Permalloy Toroids

Arnold Part No.	Dimensions (inches)		Power Dissipation 25°C rise (watts)	Window Area 0.5 A_W (cm^2)	Inductor Index	Saturation Limit (mJ)	Dissipation Limit 25°C rise (mJ)
	(OD)	(HT)	(P_{25C})	(A_W')	(A_L)	($(LI^2)_{sat}$)	($(LI^2)_{25C}$)
A-307032-2	0.425	0.180	0.072	0.082	32	0.180	0.065
A-051027-2	0.530	0.217	0.125	0.192	27	0.296	0.199
A-189043-2	0.710	0.280	0.209	0.319	43	0.782	0.659
A-059043-2	0.930	0.330	0.346	0.703	43	1.55	2.06
A-894075-2	1.09	0.472	0.520	0.781	75	3.40	4.32
A-291061-2	1.33	0.457	0.708	1.47	61	4.54	8.97
A-298028-2	1.33	0.457	0.708	1.47	28	9.90	4.12
A-085035-2	1.60	0.605	1.04	2.14	35	20.1	8.65
A-087059-2	1.875	0.745	1.48	2.14	59	40.2	16.0

VI. Component Selection

1. *Power Switching Components*

Voltage ratings of the power switching transistor and catch diode must be greater than the maximum input voltage, Ein, including any transient voltages that may appear at the input of the switching regulator. Low transistor $V_{CE\,sat}$ and diode V_F at full load output current are important considerations to maintain high efficiency (Ref efficiency calculations – Appendix A).

Fast switching diodes and transistors are required to maintain good efficiency in high frequency switching regulators. Transistor switching losses become significant when combined rise time plus fall time exceeds approximately $0.025 \times \tau$. Thus, for 50 kHz operation, $t_r + t_f$ should be approximately 0.5 μsec or less. Transistor delay and storage times do not affect efficiency, but cause delays in turn on and turn off resulting in lowering the frequency of operation and increasing ripple. Combined $t_d + t_s$ should be less than $0.05 \times \tau$.

Unitrode manufactures a broad variety of fast switching power transistors and Darlingtons, which are listed in the Power Transistor & Darlington Product Selection Guide. Their combinational high voltage, high current, low saturation voltage and medium to fast switching characteristics make them ideal for this application.

The diode reverse recovery time must be no more than about half the current rise time through the transistor. If this requirement is not met, large amplitude reverse recovery current spikes will be drawn from the input power supply causing severe EMI problems. Large transient currents through the transistor may cause degradation or second breakdown. Referring to Figure 1, Section II, during the time that the transistor is off, the catch diode is conducting the output current, Io, and the transistor V_{CE} equals Ein. When base drive is applied to the transistor to turn it on, current through the transistor rises from 0 to Io. During this current rise time interval, t_{ri}, the diode remains in forward conduction, but the diode current declines from Io to 0, since the inductor maintains the total current at a constant value equal to Io. If the diode has recovered at the end of the t_{ri} interval, the voltage across the transistor will start to decrease and the diode will go into the reverse direction. This period of time is the transistor voltage rise time interval, t_{rv}, which is terminated when the transistor V_{CE} reaches $V_{CE\,sat}$ and the diode V_R reaches Ein. If the diode has *not* recovered at the end of the t_{ri} interval, it will remain a low impedance instead of proceeding smoothly into the reverse direction. Transistor current will increase well above Io until the diode recovers, pulling the additional current through the diode in the reverse direction.

This problem has probably caused more grief in switching regulator applications than any other, and almost completely dominates diode selection. Diode switching losses will be completely negligible if the diode is fast enough to minimize the recovery problem, i.e., two to three times faster than the transistor turn-on rate.

Unitrode UES rectifiers, listed in the Rectifier Product Selection Guide, are uniquely suited to this type of application. With low forward drop and typical recovery time of 20 nsec from forward currents as high as 50A, they cause no discernible recovery spike when used in conjunction with Unitrode's medium frequency switching transistors.

Unitrode PIC600 Hybrid Power Switches summarized in the Switching Regulator Power Circuits Product Selection Guide combine in a single package the UES rectifier and power switching transistor with its associated drive transistor and bias resistors. Power transistor, drive transistor and rectifier are matched to optimize switching speeds and $V_{CE\,sat}$. Available in NPN and PNP versions, the PIC600 series can operate at 50 kHz with only 2.5 percent loss of efficiency compared with operation at lower frequencies. Significant reduction of EMI can be achieved because of the reduction of circuit wiring.

2. *Output Filter Capacitor.*

The most difficult component selection problem for high frequency switching regulator applications is to find and specify an output capacitor with suitably low ESR. Most tantalum and aluminum electrolytic capacitor types do not have ESR specifications (probably because ESR is not very good). In some cases, the dissipation factor, DF, is given in the specification. However, DF is usually specified at 60 Hz, which is more indicative of effective *parallel* resistance, and is virtually useless in determining ESR. When DF is specified at 1 kHz or higher, it may be used to determine ESR:

$$ESR = DF\,(\%) \times 0.01 \times X_C = \frac{DF\,(\%) \times 0.01}{2\pi fC}$$

The power circuit design example given in Section IV requires an output capacitor with C_{min} of 114 μfd and ESR_{max} of 0.025Ω. The capacitor which comes closest to meeting this requirement (after a limited search) is solid tantalum, Mallory THF, 120 μfd @ 10V. This capacitor has a max DF of 8% at 1 kHz, which defines $ESR_{max} = 0.106\Omega$. ESR is typically 0.05Ω. Two of these capacitors in parallel are required, based on typical ESR, to achieve an ESR of 0.025Ω; four in parallel are required, based on ESR_{max} of the capacitor. The aluminum electrolytic which comes closest (again based on a limited search) is the Sprague 672D series, 1000 μfd @ 12V, which has an ESR_{max} of 0.065Ω @ 50 kHz. Typical ESR is 0.025Ω. In either case, a much larger C value is required in order to achieve the desired ESR. This does have the advantage of reducing transient voltage changes with sudden changes in load current.

It is worth noting again that with the control circuits shown in Section III (unlike conventional switching regulator control circuits), the operating frequency will remain relatively constant, regardless of ESR, although the output ripple voltage will vary directly with ESR. In some cases, it may be economically advantageous to increase the value of L (and the size and cost of the inductor) in order to reduce ripple current, $\Delta i_1 = \Delta i_2$, and thereby increase the ESR_{max} requirement.

In addition to considering the C and ESR values and appropriate voltage derating for the application, most capacitors have maximum RMS ripple current or max RMS ripple voltage ratings which should not be exceeded. Actual RMS ripple current and voltage in the application can be calculated as follows:

$$\Delta e_{o\,RMS} = \Delta e_o\,\text{p-p}/3.0$$
$$\Delta i_{RMS} = \Delta i_1\,\text{p-p}/3.5$$

In the design example of Section IV, $\Delta e_{o\,RMS} = 0.033V$, which is less than the 0.05V max ripple rating of the 10V Mallory THF capacitor, and $\Delta i_{RMS} = 1.14A$, which is less than the 2.47A max ripple current rating of the 1000 μfd, 12V Sprague 672D capacitor.

Series inductance of the capacitor is usually not significant compared to ESR at frequencies below 100 kHz. However, inductance can become dominant if good wiring practices are not followed. Specifically, the ground side of the catch diode should be returned directly and as close as possible to the ground side of the capacitor, and capacitor lead length including circuit wiring on both sides of the capacitor should be minimized.

3. *Control Amplifier and Reference.*

Control circuits for switching regulators can be designed around IC operational amplifiers and separate voltage references, or around low power voltage regulator IC's which have built-in references. Voltage regulator IC's such as the LM304, LM305, and μA723 have the added advantage that the output current they provide to drive the power switching transistor can be caused to diminish at higher temperatures, which conforms to the transistor drive requirements vs. temperature and helps to maintain optimum switching speeds over a range of temperatures. Amplifiers used in the control circuit should be uncompensated in order to obtain fast switching speeds, otherwise the delay times introduced will result in lower frequency operation and larger ripple amplitudes, and may cause circuit instability.

Appendix A
Analysis of Power Circuit

The design equations for the switching regulator power circuit used throughout this design guide were based on several simplifying assumptions, which will now be dealt with.

The simplified equations neglected the effect of "catch" diode forward drop, V_F, transistor saturation voltage, V_{sat}, and the IR drops in the inductor and current sensing resistor, $Io\ R_X$. If a design is implemented using the values of L, C, ESR, and Δi derived from the simplified equations, then t_{on}, t_{off}, f, and Δe_o will differ from the design values because of the effect of the simplifying assumptions as follows, from Figure 2b:

Simplified :

$$\Delta i_1 = \frac{(Ein - Eo)t_{on}}{L} \quad (1)$$

Exact :

$$\Delta i_1 = \frac{(Ein - Eo - V_{sat} - Io\ R_X)t_{on}'}{L} \quad (2)$$

Simplified :

$$\Delta i_1 = \frac{Eo\ t_{off}}{L} \quad (3)$$

Exact :

$$\Delta i_1 = \frac{(Eo + V_D + Io\ R_X)t_{off}'}{L} \quad (4)$$

Note that Δi_1 is fixed, because the control circuit controls this value directly. Instead of the original design values of t_{on} and t_{off}, actual values t_{on}' and t_{off}' will be observed. Since Δi_1 is fixed, we can equate Equations (1) to (2) and (3) to (4):

$$\frac{t_{on}'}{t_{on}} = \frac{(Ein - Eo)}{(Ein - Eo - V_{sat} - IoR_X)} \quad \text{and}$$

$$\frac{t_{off}'}{t_{off}} = \frac{Eo}{Eo + V_D + IoR_X}$$

Although the actual t_{off}' is less than the assumed t_{off}, t_{on}' is greater than the assumed t_{on}, so that their net effect on the operating frequency is reduced. In the worst case, when Eo is small (5V) and Ein is high (50V), the actual frequency will be 25 percent higher than the original assumed frequency, resulting in a very slight drop in efficiency. Output ripple component Δv_C will be smaller because of the higher frequency, and Δv_{ESR} will not change because Δi_1 is fixed. Component tolerances will result in larger deviations than those caused by the use of the simplified equations.

The only other assumption that could have possible significance is that the transistor switching times are negligible at the highest frequency of operation. The validity of this assumption is normally assured by selecting appropriate devices (see Section VI). This also applies to the speed of the control circuit. If delay time through the control circuit in addition to transistor turn-on and turn-off times is significant with respect to the total period, τ, the consequent delay in turning the power circuit on and off will cause a proportional increase in Δi_1 and Δe_o, and a proportional decrease in frequency.

XIV

Efficiency Calculations: The efficiency of a switching regulator depends upon the factors given in the following equation:

$$\text{Efficiency} = \frac{\text{Pout}}{\text{Pin}} \times 100\%$$

$$= \frac{\text{Eo} \times \text{Io}}{\text{Eo} \times \text{Io} + P_T + P_D + p_T + p_D + P_L + P_l + p_C + P_C}$$

Note that the worst case for each factor does not necessarily occur under the same conditions.

1. *DC Losses – Transistor.* (Worst case when Ein is lowest because t_{on} is largest.)

$$P_T = V_{CE\,sat} \times \text{Io} \times \frac{t_{on}}{\tau}$$

where: $\frac{t_{on}}{\tau} = \frac{\text{Eo}}{\text{Ein}}$

2. *DC Losses – Diode.* (Worst case when Ein is highest.)

$$P_D = V_F \times \text{Io} \times \frac{t_{off}}{\tau}$$

where: $\frac{t_{off}}{\tau} = 1 - \frac{\text{Eo}}{\text{Ein}}$

3. *Switching Losses – Transistor.* (Worst case when Ein is high. $t_d + t_s$ do not contribute to power losses.)

$$p_T = \text{Ein} \times \text{Io}\,\frac{t_r + t_f}{2\tau}$$

where: $t_r = t_{rv} + t_{ri}$, $t_f = t_{fv} + t_{fi}$

4. *Switching Losses – Diode.*

This is a very complex calculation if diode recovery time is not much smaller than the transistor rise time, because the diode will short-circuit the power supply prior to turn-off, affecting the transistor dissipation, possibly causing second breakdown, and generating intolerable EMI. By using a diode whose recovery time is not more than half the transistor rise time, all these problems become negligible.

5. *DC Losses – Inductor.* (AC losses are negligible when Δi_1 is small compared to Io.)

$$P_L = \text{Io}^2 \times R_S$$

where: R_S is equal to effective series resistance of inductor.

6. *DC Losses – Current Sense Resistor.* (AC losses negligible when Δi_1 is small compared to Io.)

$$p_l = \text{Io}^2 \times R_l$$

7. *AC Losses – Capacitor.* (Usually negligible.)

$$p_C = \frac{\Delta i_1{}^2}{12} \times \text{ESR}$$

8. *Control Circuit Losses.* (Base drive to switching transistor is dominant, but usually negligible.)

$$P_C = \text{Ein} \times I_b \times \frac{t_{on}}{\tau} = \text{Eo} \times I_b$$

where: $\frac{t_{on}}{\tau} = \frac{\text{Eo}}{\text{Ein}}$

Appendix B
Analysis of Power Inductor Design

This appendix describes the methods used to develop the core tables given in Section V and the nomographic method for design of the power inductor. Core parameters for any cores not listed in the tables can be derived from the equations given.

The following equations provide the basis for this design approach. Equation (1a) defines the value of inductance, L, in terms of basic core parameters and the total number of turns, N, wound on the core:

$$L = N^2 \times 0.4\pi\mu\frac{A_e}{\ell_e} \times 10^{-5} \quad \text{mH} \qquad (1a)$$

where: μ = effective permeability of core

ℓ_e = effective magnetic path length – cm

A_e = effective magnetic cross section – cm²

For most standard cores, the above calculation has been simplified by listing the compound parameter A_L, called the "inductor index", as follows:

$$L = N^2 A_L \times 10^{-6} \quad \text{mH} \qquad (1b)$$

where: $A_L = 0.4\pi\mu\frac{A_e}{\ell_e} \times 10$ mH for 1000 turns

Multiplying both sides of Equation (1b) by I^2,

$$LI^2 = (NI)^2 A_L \times 10^{-6} \quad \text{millijoules} \qquad (2)$$

Core Saturation Limits.

Any specific core has a maximum ampere-turn, NI, capability limited by magnetic saturation of the core material. $(NI)_{sat}$ is listed in some core catalogs, in which case the maximum $(LI^2)_{sat}$ capability of the core can be calculated from Equation (2). $(NI)_{sat}$ is related to the saturation flux density, B_{sat}, as follows:

$$(NI)_{sat} = 10\frac{B_{sat}A_e}{A_L} \quad \text{ampere-turns} \qquad (3)$$

Substituting Equation (3) into (2),

$$(LI^2)_{sat} = \frac{B_{sat}^2 A_e^2 \times 10^{-4}}{A_L} \quad \text{millijoules} \qquad (4)$$

Values of $(LI^2)_{sat}$ are given for each core represented in Tables 1 and 2 of Section III. Equation (2) *or* (4) was employed, using values for either B_{sat} or NI which would result in a reduction of A_L (and L) of 20 percent under maximum overload conditions, according to the core manufacturer's data. The core selected for an application must have an $(LI^2)_{sat}$ value greater than $L(i_1 \max)^2$ to insure that the core will not saturate under maximum peak overload current conditions.

Power Dissipation and Temperature Rise Limits.

In switching regulator applications, the AC current component is small compared to the DC current through the power inductor. Power dissipation in the inductor is almost entirely DC losses in the winding. DC resistance of the winding, R_s, is calculated from the following:

$$R_s = \rho \frac{\ell_w}{A_x} N \qquad \text{ohms} \qquad (5)$$

where: ℓ_w = mean length of turn – cm
A_x = effective area of wire – cm²
ρ = resistivity of wire – Ω-cm

Core geometry provides a certain window area, A_W, for the winding, but only a fraction of this area can be occupied by the actual conductor. The *effective* window area, A_W' is taken as 0.5 A_W for toroids, and 0.65 A_W for pot cores. This allows for wasted area of uniformly wound round wire with HF insulation, allows for the fact that the central fourth of the window area of a toroid cannot practically be filled, and allows for a single section bobbin in the case of the pot core. The number of turns, area of wire, and effective window area of a fully wound core are related by:

$$A_x = \frac{A_W'}{N} \text{cm}^2 \qquad (6)$$

Substituting Equation (6) into (5):

$$R_s = \rho \frac{\ell_W}{A_W'} N^2 \qquad \text{ohms} \qquad (7)$$

Multiplying both sides of Equation (7) by I^2, the power dissipation in the winding, P_L, is:

$$P_L = I^2 R_s = I^2 \rho \frac{\ell_W}{A_W'} N^2 \qquad \text{Watts} \qquad (8)$$

Substituting for N from Equation (1b), and rearranging:

$$LI^2 = P_L \frac{A_L A_W'}{\rho \ell_W} \times 10^{-6} \qquad \text{millijoules} \qquad (9)$$

Equation (9) shows that the LI^2 capability is directly related to, and is limited by the maximum permissible power dissipation. Using a value for P_L that will result in a 25°C rise in the temperature of the inductor, values of $(LI^2)_{25C}$ are calculated for each core in Tables 1 and 2 of Section III. For these calculations, resistivity, ρ, is assumed to be 1.9×10^{-6} Ω-cm, the resistivity of copper wire at 65°C. The power dissipation that will result in a 25°C rise is calculated and tabulated for each core as follows:

$$\Delta T = 850 \frac{P_L}{A_s} \qquad {}^\circ\text{C} \qquad (10)$$

where: ΔT = temperature rise
A_s = surface area of inductor – cm²

The factor 850 in the above equation represents a temperature rise of 850°C for 1W power dissipation from 1 cm² surface area, empirically determined for natural convection cooling. The surface area, A_s, used in the calculation is taken as the top and sides of the inductor, ignoring the mounted bottom surface. Substituting a temperature rise of 25°C:

$$P_{25C} = \frac{25 \times A_s}{850} \qquad \text{Watts} \qquad (11)$$

Appendix C
Analysis of Application Circuits

The design equations for the critical components and operating parameters of Figure 3, Section III, are given below, for the following design objectives:

$$
\begin{aligned}
\text{Eo} &= +5\text{V} \\
\Delta e_o &= 100\text{ mV p-p} \\
\text{Ein} &= 20\text{V min, } 40\text{V max} \\
\text{Io} &= 2\text{A min, } 10\text{A max} \\
\text{Current Limit} &= 14\text{A max peak}
\end{aligned}
$$

Using the procedure described in Section IV, the following parameters were established:

$$
\begin{aligned}
f &= 50\text{ kHz (nominal)} \\
t_{off} &= 17.5\ \mu\text{sec} \\
L &= 22\ \mu\text{H} \\
C &= 120\ \mu\text{F min} \\
\text{ESR of capacitor} &= 0.025\ \Omega\text{max} \\
\Delta i_1 &= 4\text{A}
\end{aligned}
$$

From the manufacturer's design data for the LM305, we know that: the internal reference voltage, V_{ref}, is 1.8V, nominal; the impedance of the inverting input is very high; the threshold level of the drive-current-limiting circuit is 0.30V; and the impedance of the non-inverting input (Rin) is 2.4K, nominal.

From the Unitrode data for the PIC625 Hybrid Power Switch, the drive current (I drive) required for Io = 10A is 30 mA. The V_{BE} of Q1 is taken as 0.6V.

First, we may calculate the values R1 and R2 of the output divider. We will make the effective parallel resistance of R1 and R2 equal to 2.4K, so that the impedance at the inverting input will be approximately the same as the noninverting input of the LM305:

$$\frac{R2}{R1 + R2} = \frac{Vref}{Eo} = \frac{1.8}{5}$$

$$\frac{R1\ R2}{R1 + R2} = Rin = 2.4K$$

The resulting values are R1 = 6.8K, R2 = 3.8K. R2 may be trimmed for precise setting of Eo.

C1 and C2 function to provide negative and positive AC feedback, and should be large enough to result in small losses to the AC signals. Assuming that Rin = (R1 × R2)/(R1 + R2), the value of C1 should be twice the value of C2, so that the negative feedback will be dominant over positive feedback at all frequencies, thereby ensuring circuit stability. The following relationships satisfy these conditions:

$$C2 \geqq \frac{1}{Rin \times f} \quad ; \quad C1 = 2 \times C2$$

where: f = the nominal switching frequency.

These equations are satisfied by C2 ≈ 0.01 μF and C1 = 0.02 μF. Making C1 and C2 too large will have an adverse effect on transient recovery time of the switching regulator.

R4 is calculated from the threshold voltage of the LM305 drive current limiting circuit and the required base drive current.

$$R4 = \frac{V\text{ threshold}}{I\text{ drive}} = \frac{0.3V}{0.03A} = 10\Omega$$

Current sampling resistor R_I is determined by the desired short circuit current limit and the V_{BE} of Q1. As described in Section III, under *current overload conditions,* current i_1 ranges between two values. The maximum instantaneous overload current is defined by: $i_1 \times R_I = V_{BE} + V_{R3}$. The minimum instantaneous overload current is defined by: $i_1 \times R_I = V_{BE}$.

Since Δi_1 has been previously defined as 4A p-p, if we assume a minimum value of 10A for i_1 under overload conditions, then the maximum peak overload value for i_1 will be 14A, and the average value of i_1 = Io under overload conditions is 12A.

$$R_I = \frac{V_{BE}}{i_1\text{ (min overload)}} = \frac{0.6V}{10A} = 0.06\Omega$$

Power dissipation in R_I will be 6W under full load conditions, and 8.64W under overload conditions.

R3 determines Δi_1 under overload conditions as well as for normal operation of the switching regulator:

$$R3 \times I_{drive} = R_I \times \Delta i_1$$

$$R3 = \frac{R_I \times \Delta i_1}{I_{drive}} = \frac{0.06 \times 4}{0.030} = 8\Omega$$

The value of R5 is determined empirically to optimize regulation versus changes in Ein. With R5 omitted, Eo changes approximately 70 mV when Ein is changed from 20V to 40V. With R5 = 1.2 MΩ, the change in Eo is reduced to less than 25 mV.

APPLICATION NOTE **U-73A**

THE IMPORTANCE OF RECTIFIER CHARACTERISTICS IN SWITCHING POWER SUPPLY DESIGN

With the increasing interest in switching regulated power supplies designers have directed much of their effort to selecting transistors with low switching losses and adequate power handling capability. While recognizing that they must use fast recovery rectifiers, less attention has been given to "how fast" or "what type of recovery characteristic" is desired. More detailed knowledge of rectifier behavior allows determination of the magnitude of increased losses and stress on the transistor by the non-ideal diode. By choosing the best available rectifier, transistor stress can be minimal, thereby resulting in higher reliability. Other benefits are:

A. Improved power supply efficiency
B. Lower noise
C. Lower cost and/or
D. Smaller size and weight

The performance of fast recitifiers in the most popular switching circuits is discussed below.

"Switcher" inputs use available DC voltages, or rectifiers directly off the AC line. This DC "input" is converted by semiconductor switches operating at high frequency in circuits such as buck, flyback or boost regulators and in pulse-width-modulated or square wave inverters.

Inverter output rectifiers and regulator "catch" diodes are subject to unusual stresses due to the fast switching rates and very low impedance seen by the diode during the reverse transient (diode turn-off) and a momentary high impedance during diode turn-on.

These new square wave switching supplies are limited in efficiency and frequency by transistor stress and switching losses, some of which is due to diode switching characteristics. Faster transistors and diodes are helping to increase efficiency and/or frequency. At low output voltages, and lower frequency the DC characteristics ($V_{CE(sat)}$ and V_F) have the major influence on efficiency. However, as frequency and/or input voltage increase the switching characteristics become increasingly important.

BUCK REGULATOR ANALYSIS

Ideal Diode — For better understanding consider the buck regulator and resulting waveforms, using an *ideal* diode and assuming linear current rise and fall in the power transistor during switching. Similar considerations apply to other types of switching regulator circuits.

The transistor "on" time, t controls the conversion such that,

$$(1)\ V_o = \frac{t}{\tau} V_i$$

where τ is the period. t is determined by the control circuit which senses output voltage and controls transistor base drive.

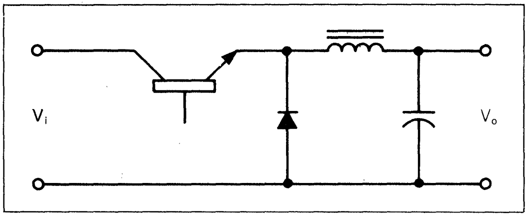


Figure 1a

In this regulator the inductor current is essentially constant as it flows alternately through the transistor or "catch" diode. The sum of the transistor current and diode current must always equal the current in the inductor, which cannot change instantaneously.

At t_0 the diode is conducting inductor current while the transistor is blocking the input voltage.

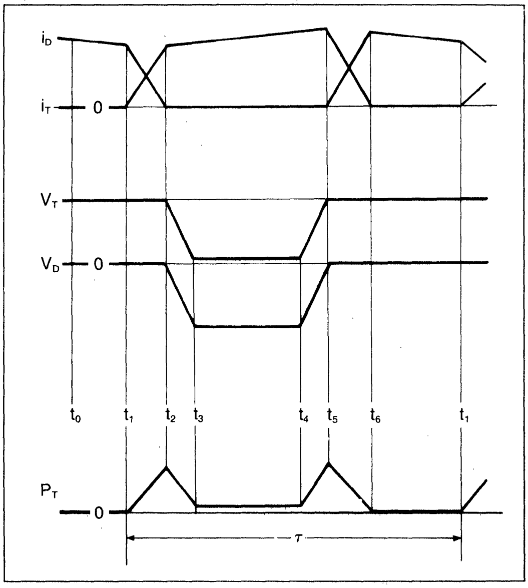


Figure 1b

t_1 to t_2 is the current rise time t_{ri} of the transistor. Since inductor current is not changing, the diode current must decrease. The forward biased diode maintains full input voltage across the transistor.

At t_2 the transistor is conducting all the inductor current so the diode turns off and voltage across the transistor starts to decrease toward $V_{CE\ (sat)}$.

t_2 to t_3 is the voltage rise time, t_{rv} of the transistor.

From t_3 to t_4 the transistor is saturated and conducting the inductor current i_L.

At t_4 the transistor starts to turn off and V_{CE} increases.

t_4 to t_5 is the voltage fall time t_{fv} of the transistor. During this time the transistor must conduct the entire inductor current because the diode is still reverse biased. At t_5 the diode is forward biased and the transistor is blocking the full input voltage. Diode current starts to increase and the transistor current decreases, the sum equalling i_L.

t_5 to t_6 is the current fall time t_{fi} of the transistor. Diode current increases in a complementary manner. From t_6 to t_1 the transistor is off and the diode is conducting all the inductor current.

To simplify the illustration assume the inductor current constant and equal to I_o. Transistor dissipation P_T is the sum of transient switching and DC losses. Neglecting losses due to DC leakages, which are generally negligible:

$$(2)\quad P_T = \frac{V_i\, I_o}{2}\,\frac{(t_{ri} + t_{rv} + t_{fv} + t_{fi})}{\tau} + \frac{V_{CE\ (sat)}\, I_o\,(t_4 - t_3)}{\tau}$$

$$(3)\quad P_T = \frac{I_o}{\tau}\left\{\frac{V_i}{2}(t_{ri} + t_{rv} + t_{fv} + t_{fi}) + V_{CE(sat)}\,(t_4 - t_3)\right\}$$

Practical diode — Now consider how the non-ideal diode with reverse recovery, junction capacitance, forward recovery and DC loss affects the circuit of Figure 1a.

In Figure 1c the solid lines are the waveforms using a practical diode in a buck regulator circuit. Comparing them with the dotted lines of the ideal diode previously considered we see three significant differences during transient switching and one during DC conduction:

1. The peak collector current increases (above I_o) during a period of high dissipation t_2 to t_2'.
2. Rise times t_{ri} and t_{rv} are increased. $(t_2' - t_1) > (t_2 - t_1)$ and $(t_3' - t_2') > (t_3 - t_2)$.
3. Maximum collector voltage peaks up above V_i briefly at t_5.
4. The diode has DC loss (from t_6 to t_1) and switching loss (principally from t_2' to t_3').

From the P_T curve of Figure 1c it is obvious that transistor power dissipation increases above that of (3) due to the "real" diode, — see the hatched regions.

The magnitude of these detrimental factors depends on the choice of rectifier. Before considering losses more fully let us examine the switching periods in greater detail.

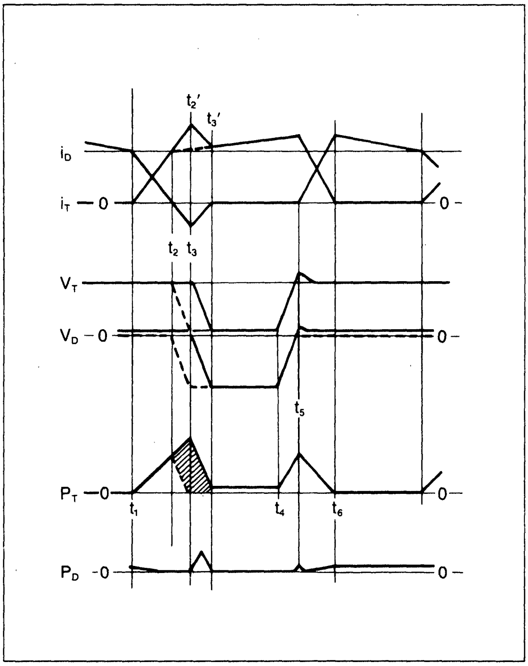


Figure 1c

TRANSISTOR TURN-ON BEHAVIOR

The transistor "turn-on transient", when the diode is switching from forward conduction to reverse blocking, results in the following transistor and diode waveforms:

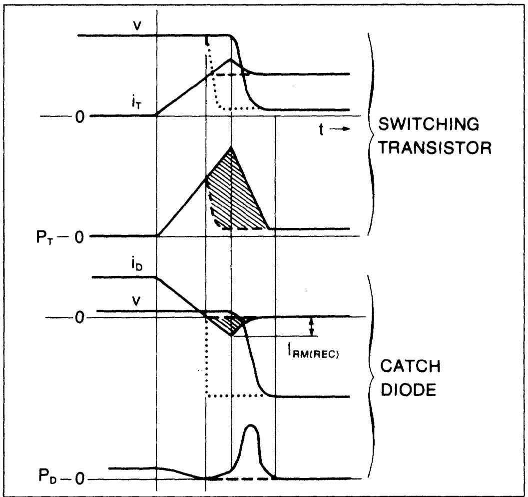


Figure 2

Dashed lines show what the current and power would be if the *diode* were ideal to the extent of having no reverse recovery time or junction capacitance. (Dotted lines show the voltage for the ideal diode case.) The reverse diode current caused by diode capacitance and recovered charge is shown by the cross hatched area of the i_D curve. The transistor must conduct this reverse diode current as well as the inductor current. The grey area represents additional transistor dissipation due solely to the diode recovered charge and capacitance.

Faster switching transistors will not necessarily result in reduced switching losses. Unless a diode with recovery time 2 or 3 times faster than the transistor current rise time is used, a faster transistor will increase the peak recovery current in the diode and thus increase overall switching losses. Furthermore, a diode with a "soft" recovery characteristic will cause more dissipation than an "abrupt" type with the same peak recovery current. The relationship of recovery characteristic to switching rate is discussed in Appendix B. With many switching transistors now available a 200 nS fast-recovery rectifier will have a peak recovery current $I_{RM(REC)}$ greater than shown in the i_D waveform of Figure 2, where it is about ⅓ of the forward current. This rather modest additional collector current (of 33% above that limited by an ideal diode) can cause increased transistor power dissipation of 100 to 150% during the turn-on period. Other serious problems can occur from high peak currents, such as noise transients in the line, the transistor coming-out of saturation and forward-biased second breakdown.

Rectifiers are now available with recovery characteristics to keep these problems minimal. Their use is required for a switching supply of maximum reliability and efficiency.

TRANSISTOR TURN-OFF BEHAVIOR:

When the transistor turns off, the diode turn-on characteristic usually has little effect on power dissipation but may cause voltage spiking, with resulting noise and the possibility of exceeding the transistor voltage ratings. Diode characteristics and conditions under which these transients occur are discussed in Appendix C. The voltage spike is due to the forward recovery characteristic and, when present, will occur as shown (dotted) in Figure 3. To correct it a snubber (series RC across the diode) may be needed. However, the choice of an optimum diode will minimize or eliminate this need.

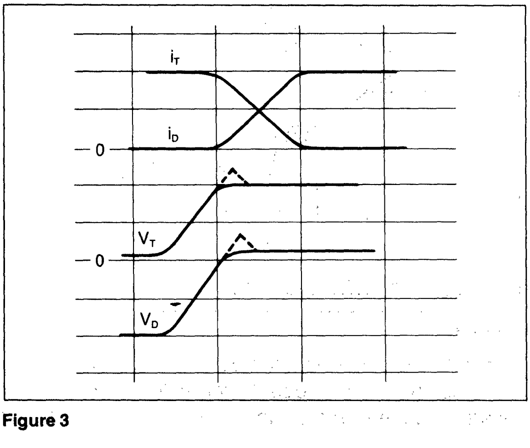


Figure 3

POWER LOSSES IN THE SEMICONDUCTOR DEVICES

DC Losses in the buck regulator occur alternately when the diode is forward conducting and when the transistor is turned on. Referring to Figure 1 these intervals are t_6 to t_1 and t_3 to t_4 respectively. During *either* interval the dissipation is independent of input voltage, V_i, or output voltage, V_o, depending only on load current and device voltage drop. *Total circuit DC losses* are a function of V_o/V_i because a) this ratio relates to "on" time and b) transistor $V_{CE(sat)}$ will probably not equal diode V_F. Neglecting switching intervals the dissipation due to DC losses is:

$$(4)\quad P_{DC} = V_F I_O \frac{V_i - V_o}{V_i} + V_{CE\,(sat)} I_o \frac{V_o}{V_i}\ .$$

Loss of efficiency due to DC losses is greatest when V_o is low, with diode loss being more significant when V_i is relatively high and transistor loss dominating when V_i is close to V_o.

Transient (switching) losses in the regulator vary considerably with voltage, being highest at "high line" V_i (see Eq. 3). Furthermore, high voltage transistors and rectifiers generally have longer switching times than low voltage types. Speed and "recovery characteristic" (see Appendix B), and consequently losses, can vary greatly between different device types and manufacturing processes. A relationship for calculating approximate transient dissipation of practical devices during the transistor turn-on interval is given in Appendix B. The other component (turn-off interval) can be similarly developed but it is not significantly affected by diode selection. However, when transistors and/or drive techniques are chosen for shorter fall times overall losses are reduced *and* the benefits of optimum diode selection become more significant. Proper diode (and transistor) selection is important in all switching supplies, but the higher the voltage (and frequency) the more significant will be the effect of selection on switching losses.

OTHER SWITCHING CIRCUITS

The pulse-width-modulated inverter (PWM) supply (Figure 4a) has much in common with the buck regulator. Output rectifiers also perform the catch diode function. Current waveforms are shown in Figure 4b, with overshoot due to diode reverse recovery and capacitance. Here again slow diodes cause additional transistor stress, usually not reduced significantly by transformer impedance. Leakage reactance will often require the use of a snubber, to protect the transistor.

Transistor "on" time t and the turns-ratio control the conversion such that

$$(5)\ V_o = \frac{2t\ N_s}{\tau N_p} V_i$$

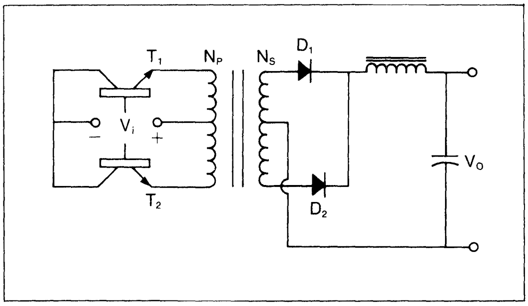


Figure 4a

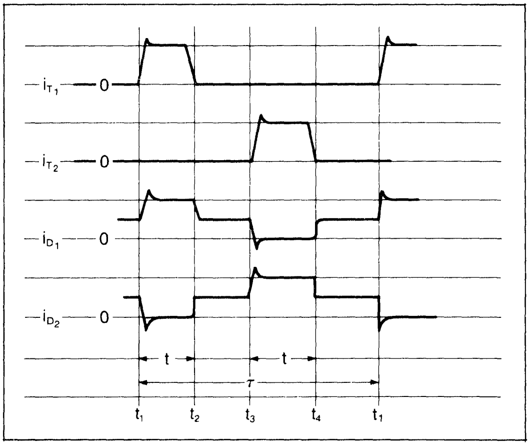


Figure 4b

From t_1 to t_2 transistor T_1 and diode D_1 conduct, with diode current equal to inductor current i_L.

At t_2 the transistor turns off and the inductor "pulls" i_L equally through D_1 and D_2.

At t_3 transistor T_2 turns on, driving full i_L through D_2 and causing D_1 to be reversed biased. D_2 current is increased by the recovery current of D_1, and T_2 current also increases proportionally.

From t_4 to t_1 both transistors are again off and at t_1 the events of t_3 occur on the opposite device pair.

One difference between the inverter and the regulator is that here the DC diode losses are more significant because they (D_1 and/or D_2) are conducting the full cycle regardless of V_i to V_o ratio. Another difference is that here the diode recovery is from half, rather than full, load current.

The square wave inverter can be considered, in terms of device operation, a special case of the PWM where 2t approaches τ. Regulation is achieved by varying V_i.

EMI, RFI, NOISE —

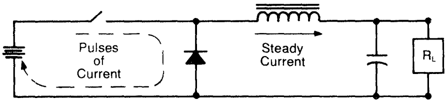
Given any inductance in a circuit "loop" of wiring, a rapid current change will generate a voltage transient, $V = L\ di/dt$, and the energy in such a transient will vary with the square of the current, $E = ½LI^2$. The interference and voltage spiking will be easier to filter if the energy is low and has predominantly high frequency components.

We can establish a priority of factors for reducing EMI:

1. $I_{RM(REC)}$ should be as low as possible, — accomplish by diode selection (see Appendix B and Fig. 7).
2. L (circuit loop) should be minimum, — accomplish by layout and interconnect geometry. (See Fig. 5).
3. Use a "soft recovery" diode (See Appendix B). However, this is an item of possible trade-off since such a device may have longer t_{rr}, higher $I_{RM(REC)}$ and, thus, create much higher switching loss.

An ultra-fast device with moderate recovery (vs. abrupt or soft) will often be the best choice.

REDUCE EMI BY LOWERING CIRCUIT WIRING INDUCTANCE:



Low L needed in loop shown in grey. Avoid ground loop noise by returning input capacitor directly to diode.

Figure 5a

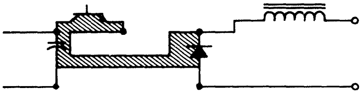


Figure 5b

SELECTING THE BEST SWITCHING RECTIFIER

Ratings and characteristics have different priorities and significance when they are to be applied to these power switching circuits. Selection should be based on the following:

1. Peak inverse voltage, PIV of "catch" diodes must at least equal the highest input voltage, while PIV of center-tap output rectifiers must be at least twice the maximum output voltage in a square wave inverter and much greater in the pulse width modulated inverter. More significant perhaps are the transient voltages in practical fast switching circuits partly due to wiring inductance and rectifier's own recovery. Unless these are intentionally clipped, damped, or "designed out" it is advisable to use a safety factor of 2 or 3. PIV selected should apply over a range from lowest ambient to the highest expected junction temperature.

2. Reverse recovery time t_{rr} must be much lower than the rise time of the transistor with which it will be used, — preferably by at least 3 times when measured at conditions similar to circuit operation. Selection is complicated because rectifiers are normally specified at conditions less severe than in power switching circuits. Furthermore, correlation between test conditions is not always the same (see Table I of Appendix B).

Following preliminary selection from available data the devices should be compared in a circuit developing the highest current, junction temperature and rate of current switching (– di/dt) expected.

The desired goal is to minimize peak recovery current $I_{RM(REC)}$ and switching loss. Note that these are the same order of magnitude with Schottky rectifiers (due to high capacitance, principally) as with the fastest PN rectifiers. The figures below illustrate these points. Figure 6 shows the variation of peak current with switching rate, using the Unitrode UES 801 in a special test circuit. Figure 7 shows the difference in $I_{RM(REC)}$ and t_{rr} when representative fast recovery DO-5 devices are measured in a JEDEC test circuit at different temperatures. In Figure 8 the incremental collector current (the peak value in excess of 30 A) for a 30 A buck regulator using 50, 100, and 200 nS catch diodes is plotted as a function of transistor rise time (and resulting di/dt). Figures 9a, b, and c show the loss of efficiency due to transistor turn-on dissipation as a function of operating frequency, with 3 transistor rise times and 3 diode recovery times, in a regulator operated with 40 V in and 10 V out. Similar figures can be developed for other conditons using the model and assumptions in Appendix B.

3. Forward voltage should be as low as possible to optimize efficiency, especially for inverter output rectifiers and regulators with high V_i/V_o ratios. Loss of efficiency due to V_F is most significant at low output voltages. Figure 10, which relates this loss to device choice over the range of available forward voltages, applies to output rectifiers of inverter supplies with popular output voltages.

Schottky rectifiers have the lowest V_F and are therefore widely used as output rectifiers for 5 V supplies. Their limitations in PIV, transient voltage capability and temperature must be considered when applying them in other applications.

Selection should be based on conditions where losses are most significant, — at rated supply output current and anticipated junction temperature. The approximate range of V_F, at rated current and 25°C, as well as at more typical operating conditions, is shown in Figure 11 for representative fast rectifier types. Note that the Unitrode UES series is closest to the Schottky, especially at expected operating conditions.

4. Maximum average rectified output current at maximum expected case or ambient temperature must always be considered. Note however, that standard current rating is based on a half sine waveform. These square wave applications at average current equal to this rating will usually dissipate somewhat lower power, and, thus, be used conservatively. However, regulators with $V_i \lesssim 1.5\ V_o$ should use a catch diode with a higher rating than the average current it conducts at full load.

5. Peak voltage $V_{F(DYN)}$ during forward recovery will be of significance when using transistors with fast fall times at close to the V_{CE} rating. This is further discussed in Appendix C. See Table II for typical performance of representative devices. At lower values of di/dt the peak voltages will be lower.

6. Surge current (8.3 mS) is not of great significance because transistor saturation limits fault current. If the power supply is designed to provide rapid charging of a large output capacitor the "overload" requirement for the charge time (perhaps 0.1 to 2 seconds or so) must be considered.

$I_{RM(REC)}$ & t_{rr} vs $\frac{di}{dt}$

CONDITIONS I_{FM} = 10A, LINEAR SLOPE. UNITRODE UES 801 RECTIFIER.

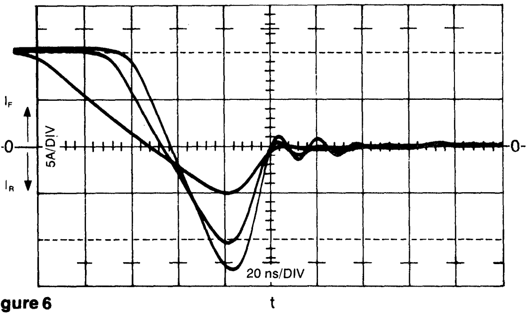


Figure 6

$I_{RM(REC)}$ & t_{rr} of DO5 FAST RECTIFIERS

CONDITIONS: I_{FM} = 30A $-\frac{dI}{dt}$ = 30A/μS (30V JEDEC)

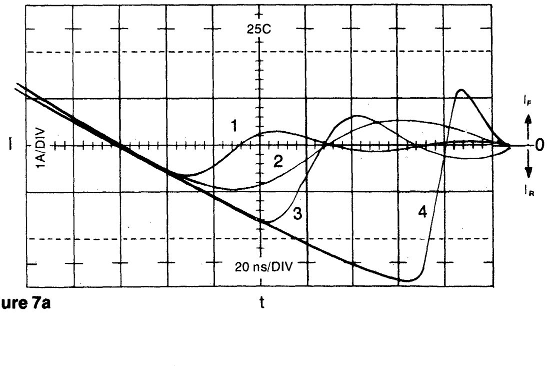


Figure 7a

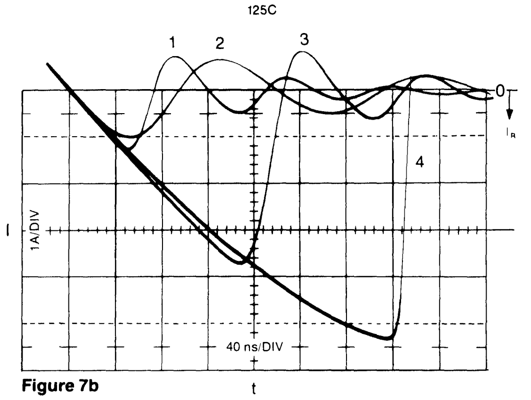


Figure 7b

DEVICE TYPE	$I_{RM(REC)}$ 25°C (A)	$I_{RM(REC)}$ 125°C (A)	t_{rr} 25°C (nS)	t_{rr} 125°C (nS)	t_{rr} MAX. At Low Current Cond'ns.
1	0.6	1.3	50	72	50
2	1.0	1.0	86	95	—
3	1.7	3.7	86	185	100
4	2.9	5.4	142	296	200

1 Unitrode UES 803
2 Schottky rectifier.
3 100nS rectifier.
4 200nS rectifier.

Figure 7c

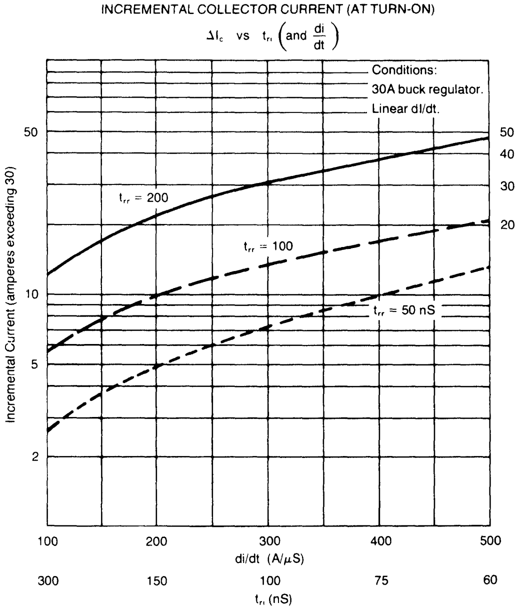
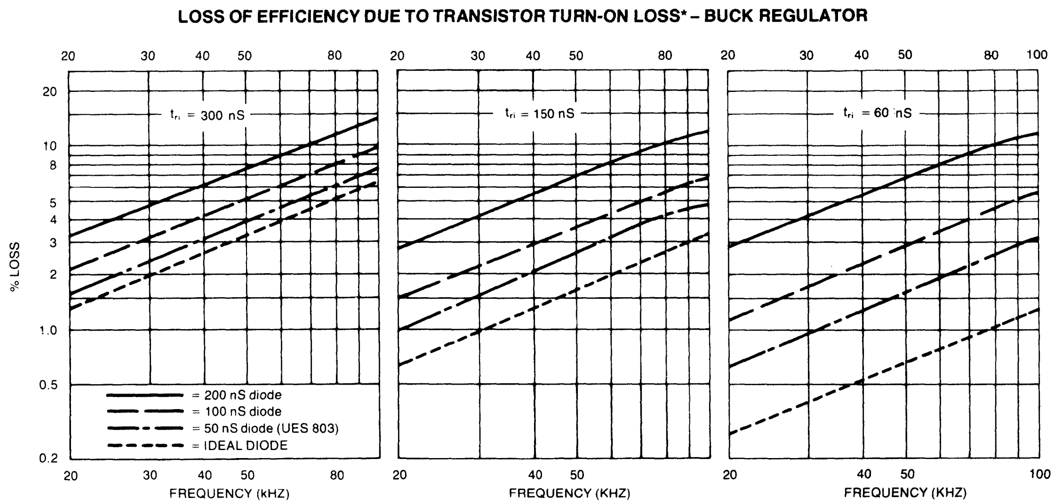
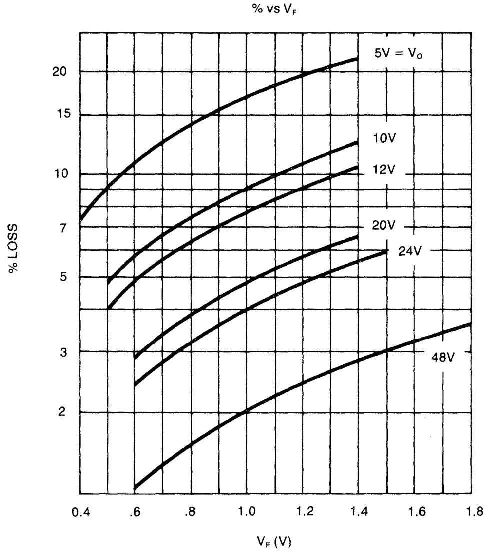


Figure 8



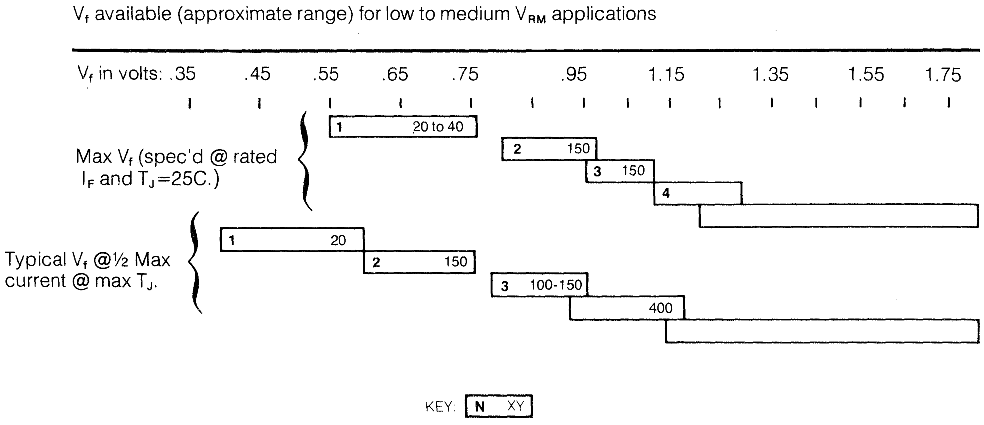
* Calculations of total switching losses (diode and transistor) per model in Appendix B for a 30A buck regulator with V_{in} = 40V and V_{OUT} = 10V.

Figure 9



LOSS OF EFFICIENCY DUE TO FORWARD VOLTAGE OF INVERTER OUTPUT RECTIFIERS.

Figure 10



1 = Schottky.

2 = Unitrode UES 150 V series.

3 = Other devices for low forward voltage.

4 = Typical fast recovery (200 nS) devices.

5 = Fast devices to 800 V.

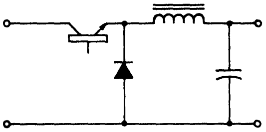
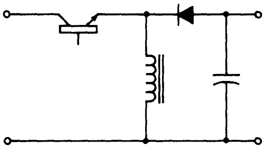
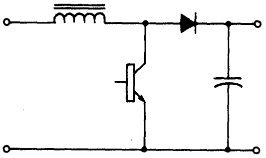
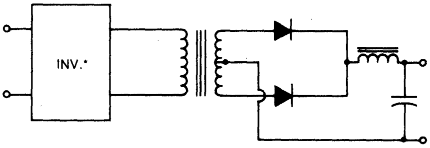
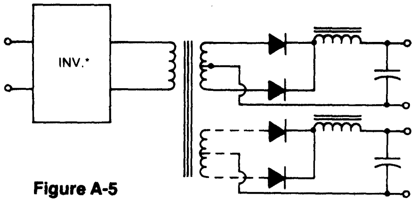
N = Device Class

XY=V_{RW}
(Max at T_J noted above).

Figure 11

Appendix A
"Off-Line" Supplies

FROM RECTIFIED, OFF-LINE (OR OTHER DC) SOURCE

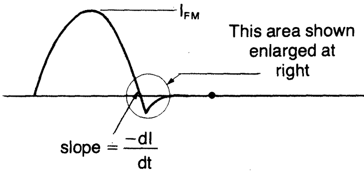
BASIC CIRCUIT	TYPE	FEATURES
Figure A-1 	a) Buck Regulator	$V_o < V_{in}$. Output non-isolated. Easy to filter output. Noisy input.
Figure A-2 	b) Flyback Regulator	V_o opposite polarity from V_{in}. (Unless isolated). Output can be isolated. Output can be stepped up to HV. Noisy input and output.
Figure A-3 	c) Boost Regulator	$V_o > V_{in}$. Output non-isolated. Hard to filter output. Quiet input.
Figure A-4 	d) PWM (Variable Duty Cycle) Inverter.	Used with single V_o, - also common for lab supplies. Provides isolation. Does not need separate catch diode, - rectifiers serve this function, possibly with small HV diodes in primary for magnetizing current.
INPUT FROM a, b, or c. **Figure A-5** 	e) Square Wave Inverter (50% Duty)	Regulation provided by previous input. Regulates one of (possible) multiple outputs. Uses high transistor count. Provides isolation. Does not need separate catch diode, - rectifiers serve this function, possibly with small HV diodes in primary for magnetizing current.

(*) INV. = Bridge, center-tap, or half-bridge inverter.

XIV

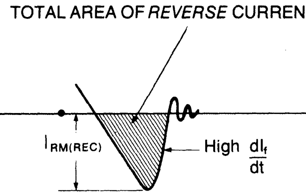
Appendix B
Reverse Recovery Behavior and Dissipation

1. Waveforms and definition of terms:



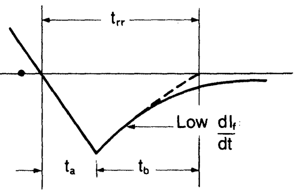
JEDEC test - standard slope = 25A/μS

Figure B-1



"ABRUPT"

Figure B-2



"SOFT"

Figure B-3

2. Discussion of Variables:

Any PN junction diode operating in the forward direction contains stored charge in the form of excess minority carriers. The amount of stored charge is proportional to the forward current level.

The diode or rectifier in a switching regulator is switched from forward conduction to reverse at a specific ramp rate (−dI/dt) determined by the external circuit, usually by the turn-on time of the associated switching transistor. During the first portion of the reverse recovery period, t_a, charge stored in the diode is able to provide more current than the circuit demands, so that the device appears to be a short circuit. Transition from t_a to t_b occurs when stored charge has been depleted to the point where it can no longer supply the increasing current demanded by the circuit. The device becomes a high impedance and during t_b the reverse voltage is permitted to increase. Reverse current, no longer circuit determined, dwindles as excess stored charge depletes to zero. Stored charge is depleted by the reverse current flow and also by recombination within the device.

At (−dI/dt) rates which are slow relative to the rate of recombination of the specific device relatively little stored charge is swept out. Recovery time, t_{rr} is determined mainly by the recombination rate, independent of (−dI/dt). Peak reverse recovery current $I_{RM(REC)}$, and total charge associated with reverse current, $Q_{R(REC)}$ are almost directly proportional to (−dI/dt) (Region I, Figure B-4). The recovery characteristic with slow (−dI/dt) rates tends to be soft.

When the (−dI/dt) rate is fast compared to recombination rate (transistor turn-on faster than diode recovery time), t_{rr} decreases as −dI/dt increases, because more of the available stored charge is swept out sooner, leaving little to be depleted by recombination. As (−dI/dt) increases, peak recovery current increases and can become much greater than the original forward current level. However, $Q_{R(REC)}$ levels off as (−dI/dt) increases because it can only approach but not exceed the total stored charge which is a function of the original forward current level (Region II, Figure B-4).

Higher voltage devices have poorer recovery characteristics because they require thicker regions of higher resistivity, resulting in greater volume of stored charge and longer recombination rates.

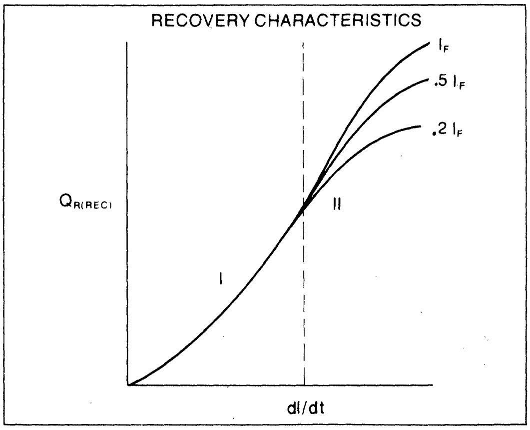


Figure B-4

With a given I_F and dI/dt the $Q_{R(REC)}$, $I_{RM(REC)}$, and t_{rr} all increase with temperature. Recovery characteristic changes as well (generally becoming more abrupt if reverse current is not circuit limited, and softer if limited). Furthermore, $Q_{R(REC)}$ increases and recovery generally softens if higher circuit voltage is applied to a given diode.

3. Comparison of devices at popular test conditions:
Table I, below, shows measured t_{rr} values (in nanoseconds) using ultra-fast and fast recovery DO-5 rectifiers.

I_F (A)	I_R (A)	$-di/dt$ (A/μS)	T (°C)	$I_{R(REC)}$ (t_{rr} Measured to (A))	UNITRODE UES803	MANUFACTURER			
						B	C	D	E
0.5	1.0	step	25	0.25	38	50	42	—	—
1.0	1.0	step	25	0.10	45	75	50	63	120
1.0	1.0	step	125	0.10	60	90	122	135	300
	(85V JEDEC circuit)								
30	—	30	25	0	75	120	85	105	150
30	—	30	125	0	100	150	140	210	300
30	—	100	25	0	45	72	66	92	—
30	—	100	125	0	65	114	106	160	—
MAX t_{rr} per manufacturer's stated condition					50	50 to 100			200

Table I

4. Turn-on switching losses, assuming linear V and I transitions:

With an ideal diode, switching losses are entirely in the transistor as follows (from Eq. 2).

$$\text{(B1)}\ P_{(tri)} = V_{in} \cdot \frac{I_C}{2} \cdot \frac{t_{ri}}{T}$$

$$\text{(B2)}\ P_{(trv)} = \frac{V_{in}}{2} \cdot I_C \cdot \frac{t_{rv}}{T}$$

A practical diode with finite t_{rr} and $I_{RM(REC)}$ will cause *additional* switching losses as follows:

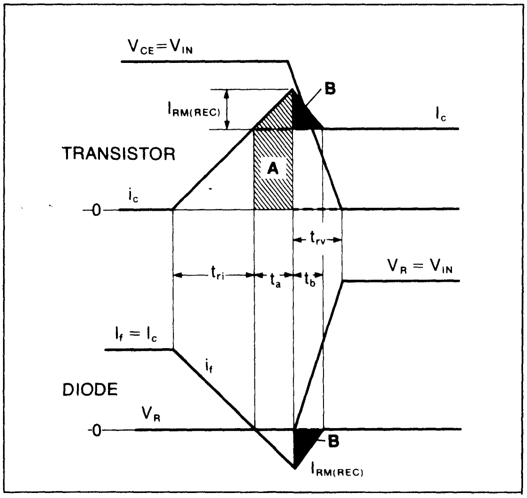


Figure B-5

Diode recovery time component t_a effectively increases transistor rise time, and delays the voltage transition, t_{rv}. During time t_a, the diode conducts reverse current but remains a low impedance. Transistor V_{CE} remains equal to V_{in} while collector current continues to rise above I_C to $I_C + I_{RM(REC)}$. The entire amount of charge shown in shaded area A results in increased switching loss in the *transistor only* (increase in diode loss is negligible):

$$\text{(B3)}\ P_{(t_a)} = V_{in}\left(I_C + \frac{I_{RM(REC)}}{2}\right)\frac{t_a}{T}$$

$$\text{(B4)}\ t_a = t_{ri}\left(\frac{I_{RM(REC)}}{I_C}\right)$$

$$\text{(B5)}\ P_{(t_a)} = V_{in}\left(I_C + \frac{I_{RM(REC)}}{2}\right)\left(\frac{t_{ri}}{T}\ \frac{I_{RM(REC)}}{I_C}\right)$$

$$\text{(B6)}\ P_{(t_a)} = V_{in} \cdot I_{RM(REC)}\left(I + \frac{I_{RM(REC)}}{2I_C}\right)\frac{t_{ri}}{T}$$

If diode $I_{RM(REC)}$ is half of I_C (1.5:1 current overshoot in transistor) total transistor switching losses during current turn-on ($t_{ri} + t_a$) will be 2.25 times greater than with an ideal diode (Eq. B1).

During diode recovery time component t_b, the diode continues to conduct reverse current, but becomes a high impedance, permitting the transistor voltage transition, t_{rv}, to take place. Diode reverse current during t_b causes increased switching losses in the transistor and/or the diode. It is difficult to quantify these losses in the diode and transistor separately, since transistor V_{CE} is decreasing and diode V_R is increasing during all or part of period t_b. However, the total increase in losses in both diode and transistor during t_b is:

$$\text{(B7)}\ P_{(t_b)} = V_{in} \cdot \frac{I_{RM(REC)}}{2} \cdot \frac{t_b}{T}$$

$$\left(\text{area B} = \frac{I_{RM(REC)}}{2} \cdot t_b\right)$$

Note: $P_{(t_b)}$ loss is in *addition* to the ideal diode case transistor losses, $P_{(t_{rv})}$ (Eq. B2). With a very fast diode, t_b will be much shorter than t_{rv}, and most of the $P_{(t_b)}$ loss will occur in the transistor, although it will be negligible. With a slow diode, where t_b is much longer than t_{rv}, $P_{(t_b)}$ loss will be significant and will occur mostly in the diode.

$P_{(t_a)}$ is usually much greater than $P_{(t_b)}$. Since all of $P_{(t_a)}$ is dissipated in the transistor, it can be seen that most of the increased switching losses caused by diode reverse recovery are borne by the switching transistor, not by the rectifier.

Appendix C
Forward Recovery Behavior and Characterization

When used in some circuits, any diode may exhibit the phenomenon known as forward recovery. Under these conditions, the device has an impedance which, for a short time after initial application of forward current, is higher than its normal "on" value. The magnitude and duration of this transient impedance will depend on circuit conditions and device design, varying from no effect in many circuits to a few microseconds in the worst case. When present, the effect is generally less with fast-recovery rectifiers, and much less with "computer-type" switching diodes.

Circuits with very fast current rise time, in the direction of forward conduction, will allow this phenomenon to appear. Generally, these will be low-inductance circuits which allow the current to rise from zero to rated forward current in less than the reverse recovery time for fast stud-mounted rectifiers, and in less than 0.1 x t_{rr} for lead mounted fast devices.

When such a source has a high voltage, of at least 10 times V_F, the forward recovery phenomenon exhibits an initial higher-than-steady-state forward voltage. The rise time of current is not limited by the diode and the peak voltage decays to the specified measurement level in the "forward recovery time" t_{fr}. The peak voltage $V_{F(DYN)}$ will be strongly influenced by the current rise time di/dt, and current I_F.

When a fast-rise source has an open circuit (compliance) voltage of less than several times the diode V_F, the forward recovery phenomenon may exhibit a delay in the rise of forward current. In this case the peak diode voltage is limited by the source, and the "turn-on" time is the rise time to 90% of I_F.

A comparison of the Unitrode UES 803 with a typical 200 nS rectifier is shown in Table II below.

	Unitrode UES 803		**DO5 200 nS**	
Test Condition	**$V_{F(DYN)}$ (v)**	**t_{fr} (nS)**	**$V_{F(DYN)}$ (v)**	**t_{fr} (nS)**
I_F to 1A in 8 nS	1.2	20	12	300
I_F to 1A in 125nS and continuing to 50A with $t_r = 10\mu S$	0.9	—	2.8	350

Table II

APPLICATION NOTE U-75

HIGH VOLTAGE, HIGH PERFORMANCE POWER SWITCHING TRANSISTORS

Abstract

During turn-off of a conventional high voltage power switching transistor, conduction shifts from the emitter periphery toward the center of the emitter structure, resulting in degraded turn-off time and $E_{s/b}$ performance.

The Unitrode Barrier™ Transistor represents an innovative approach to device designs which prevents this shift in conduction during turn-off provides substantial improvement in turn-off times and $E_{s/b}$, and makes it possible to achieve switching times satisfactory for 25 KHz off-line switching with simplified base drive circuitry. A base drive circuit utilizing a small ferrite bead for turn-off energy storage is discussed.

1. Introduction

Any power transistor designed for fast switching performance employs narrow base width to obtain high fT. However, high voltage transistors do not achieve the switching speed performance that would be expected from their fT. Complex and expensive base drive circuitry is required in order to reduce switching losses to an acceptable level in 25 KHz off-line switching regulated power supply applications. High fT devices with fast switching performance have poor reverse biased second breakdown capability, forcing a design trade-off in performance vs ruggedness.

2. Switching Dynamics

2.1 Performance Limitations

There are two primary reasons why high voltage power transistors do not achieve switching performance consistent with fT:

(1) High voltage transistors have quasi-sat characteristics that extend to relatively high collector voltages. Rise and fall times are considerably lengthened in transiting the region of quasi-sat.

(2) During turn-off, conduction in the transistor shifts from the emitter periphery (where it conducts while the transistor is on) toward the center of the emitter, thereby increasing series base resistance. This makes it impossible to maintain the initial value of I_{B2}, resulting in longer fall times.

2.2 Quasi-Saturation

Figure 1 shows the output characteristic of a "typical" transistor with 8 Ampere and 400 volt V_{CEO} ratings, such as the 2N6545, 2N6308, or 2N6513. The device shown exhibits a current gain of 50 at 5 Amperes — above 50 volts V_{CE} — but below 50 volts the gain drops off considerably and in a distinctly non-linear manner. Below 50 volts, the device is operating in the quasi-saturation region. At 200mA I_B (100mA base overdrive) V_{CE} at 5 Amperes is down to 11 volts, but to achieve 1 volt V_{CE}, 600mA I_B (500mA base overdrive) is required.

Clamped inductive load switching performance of the same device at 5 Amperes is shown in Figure 2. Current transitions occur while V_{CE} is at high voltage, well above quasi-saturation. Current rise and fall times approach values limited by fT. Switching times in the high voltage portions of the voltage transitions are limited by C_{OB}, but in the quasi-sat region (Q to S) below 50 volts, the device slows down considerably. It may take as much as several microseconds for V_{CE} to reach equilibrium saturation conditions, and since full collector current is flowing throughout this time, switching losses are significant. The slowest portions — the "tails" of the voltage transitions are not included in the arbitrary 10% to 90% definition of rise and fall times.

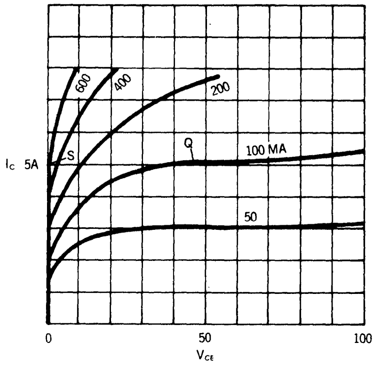


Figure 1.

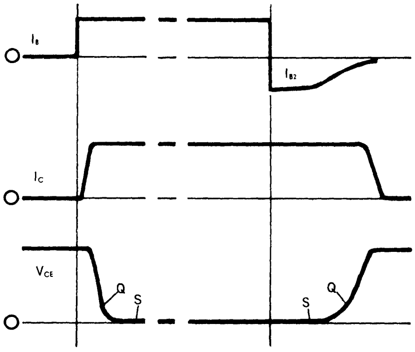


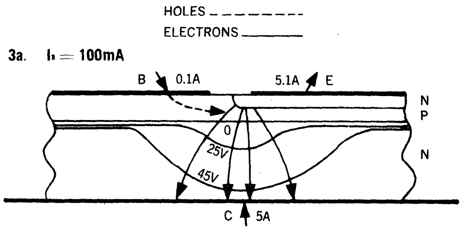
Figure 2.

Let us briefly examine the physical process within the device while operating the quasi-sat region. Figures 3A, 3B, and 3C depict the device cross-section at the emitter edge. In Figure 3A, the device is operating at the beginning of quasi-sat, with $I_C = 5A$, $V_{CE} = 50$ volts, and $I_B = 100$ mA.

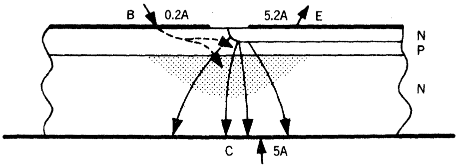
Minority carriers (electrons) are injected by the emitter and collected in a narrow region at the periphery of the emitter. Collector current flows through the 3-4 mil thick high resitivity (40 ohm-cm) collector material, resulting in voltage drop of 50 volts in the collector bulk. Thus, the collector-base junction immediately under the emitter periphery starts to be forward biased, while those areas of the collector-base junction away from the emitter edge remain reverse biased at 50 volts.

In Figure 3B, I_B is increased from 100 mA to 200 mA. The excess I_B of 100 mA is injected across the forward biased collector-base junction under the emitter periphery, mostly as holes injected from the lower resistivity base into the higher resistivity collector. These minority carriers

3a. I_B = 100mA



3b. I_B = 200mA



3c. I_B = 600mA

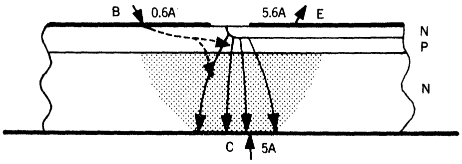


Figure 3. Turn On

injected into the collector find themselves in an electric field which repels them back toward the collector-base junction. They pile up at the collector-base junction, but with the continuing supply of minority carriers injected from the base a minority carrier gradient is established, which forces the carriers to move out into the collector against the opposing electric field.

The equilibrium boundary of this minority carrier penetration into the collector region is established at the point where the carriers recombine at the same rate at which they are injected, in this case 100 mA. Within the minority carrier boundary, collector resistivity is radically reduced because of the large number of carriers present. Although the equilibrium boundary extends approximately half way across the collector, the resistance of the remaining high resistivity collector is much less than halved, because collector current flows through a larger area.

The net result is that the V_{CE} drops 50 volts at 100 mA I_B, at the beginning of quasi-sat, to 11 volts at 200 mA I_B. In Figure 3C, with 600 MA I_B, an excess of 500 mA, the minority carrier boundary extends across the entire collector thickness, and the device is fully saturated.

The total number of minority carriers contained within the boundary is approximately proportional to the third power of the distance that the boundary penetrates into the collector region. This is because the carriers spread laterally as well as vertically, and as the thickness traversed increases, an increasing carrier concentration is required at the collector-base junction in order to maintain the necessary concentration gradient. It follows that the excess base current necessary to maintain these minority carriers must also increase with the third power of the distance traversed into the collector. This explains the non-linearity of the static collector characteristic in the quasi-sat region.

2.2.1 Switching Through the Quasi-Saturation Region

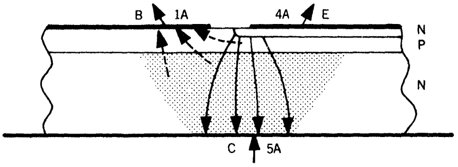
Referring back to Figure 2, when a high voltage transistor is turned on, the time required to switch through the quasi-sat region from Q to S is almost entirely determined by the amount of charge required to establish the minority carrier boundary across the entire thickness of the collector.

Likewise, the time required to switch from S to Q during turn-off is largely determined by the time required to remove the charge. The time is a function of the I_{B2} applied to the base during the Q to S transition, not the initial I_{B2}.

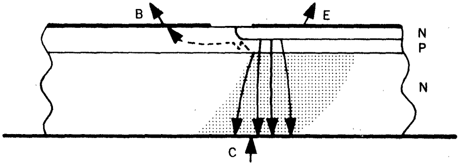
2.3 Turn-Off — Series Base Resistance

Referring to Figure 4A, immediately prior to turn-off, minority carriers extend across the entire collector region directly under the emitter edge, and also extend a considerable distance laterally in both directions — under the inner region of the emitter as well as under the external base region outside the emitter. When turn-off is initiated, the excess I_{B1} which had been maintaining the minority carriers in the collector is terminated, and the electric field in the collector tries to sweep the minority carriers back across the collector-base junction. The rate at which these carriers can be swept out is limited by I_{B2}. Charge sweepout is aided by minority carrier recombination particularly during the earlier portion of the storage time period. As the minority carrier concentration is reduced, the rate of recombination also reduces, so that during the fall time, the rate of minority carrier removal is almost entirely dependent on I_{B2}.

4a — Initial



4b — Mid-Storage Time



4c — Fall Time

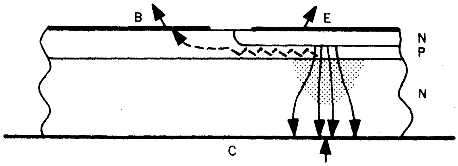


Figure 4 — Turn Off

During the first half of the storage time period, minority carriers swept out through the base terminal by I_{B2} are removed selectively from the outer region below the external base as shown in Figure 4B. The remaining carrier gradient continues to conduct emitter and collector current.

It is important to note that during the entire turnoff process — until I_C falls to a value less than I_{P2} — emitter current must flow. The only way this can be accomplished is for the emitter-base junction to remain forward biased at the site of conduction, since the emitter current consists entirely of electrons injected from the emitter into the base.

However, once the outer minority carriers have been swept out as in Figure 4B, I_{B2} commences to sweep out carriers under the emitter edge. The forward bias voltage of the outermost edge of the emitter is reduced, and injection of electrons at the edge ceases. Since the charges stored under the inner area of the emitter have not yet been removed, and because emitter current must be maintained, the emitter starts to inject more heavily toward the center of the emitter, making up for the injection lost at the emitter edge.

This process continues, with I_{B2} sweeping out the outermost stored charges until device conduction has shifted to approximately the inner boundary of the minority carriers originally stored in the collector, as in Figure 4C. When the remaining stored charges are insufficient to supply both the base drive and I_{B2} requirements, collector current can no longer be maintained, fall time commences, and the device finally turns off.

The shift in device conduction from the periphery of the emitter toward the center, during the latter portion of the turn-off interval, is largely responsible for the relatively poor times exhibited by high voltage power transistors. This is because as conduction shifts toward the center, an increasing resistance — that of the transverse base region under the emitter — is interposed between the base terminal and the forward biased conduction site.

The negative base drive source must pull I_{B2} out through the increasing series base resistance, causing the base terminal voltage to become negative and resulting in a decrease in I_{B2} to a small fraction of its initial value during the fall time period. This reduction of I_{B2} results in a reduced rate of minority carrier sweep-out, substantially increasing the fall time.

Figure 2 shows the manner in which I_{B2} decreases because of the increase in RB' from an initial value of 0.25 ohms while conduction remains at the emitter periphery to 50 ohms during the fall time period due to the shift in conduction toward center of the emitter.

There is one other serious effect of the shift in conduction during turn-off. Any unclamped inductive portion of the collector load circuit will force a continuation of collector current flow after the normal turn-off time, by forcing an increase in V_{CE} to the sustaining voltage level. If the unclamped inductance is large enough, the conduction shift will continue to propagate to the very center of the emitter.

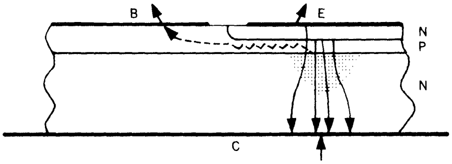
The resulting extremely high current and power densities cause reverse biased second breakdown failure, $E_{s/b}$. Fast switching devices have inherently poor $E_{s/b}$ capability because their narrow base width and high transverse base resistance cause conduction to shift more rapidly to the center and to a higher current and power density.

3. A New Design Approach — The Unitrode Barrier™ Transistor

The problems caused by the shift in conduction during turn-off — high series base resistance and degraded fall time and $E_{s/b}$ performance — have been minimized through a new approach to device design applied by Unitrode in the recently announced UMT1009 Barrier™ Transistor family. This proprietary process has no effect on the static characteristics or turn-on performance but provides substantial improvement in the turn-off performance by providing an effective barrier which blocks the shift in conduction toward the center of the emitter during the turn-off.

Figures 5A and 5B contrast the conduction patterns within the device near the end of the turn-off period, with and without the added barrier. In Figure 5B the conduction shift has stopped at the barrier, resulting in considerably lower series base resistance during fall time. With an unclamped inductive load, conduction cannot shift to the center of the emitter. Device current and power dissipation remain distributed around the emitter periphery, resulting in higher $E_{s/b}$ capability.

5a — Conventional Design



5b — Unitrode Barrier™ Transistor Design

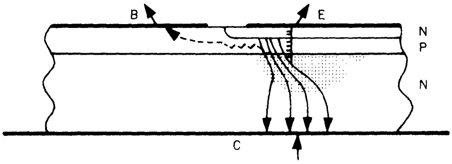


Figure 5 — Turn Off Comparison

The waveforms of Figure 6 show the effect of the barrier design on the clamped inductive load switching characteristics. Initial I_{B2} of 1 ampere is developed through an external 5 ohm resistor to −4 volts. The solid lines indicate the barrier design, and the dash lines the conventional design.

The two designs appear identical in performance until the latter half of the turn-off interval.

Although the Barrier Transistor design does exhibit an increase in RB' as conduction shifts away from the emitter edge, this increase is limited to 3 or 4 ohms when the barrier is reached, whereas the conventional device shows a continuing increase in RB' to as much as 50 ohms during the fall time. The negative trend of V_{BE} and the reduction of I_{B2} are also arrested when the barrier is reached. Fall times are considerably reduced because I_{B2} is maintained at a level much closer to the initial value of 1 ampere.

The differences between the Barrier Transistor design and the conventional design are even more apparent at elevated temperature, because the series base resistance increases with temperature.

3.1 Performance Comparisons

It is impossible to make direct comparisons of switching speed performance from the spec sheets of various transistor types because the test conditions differ radically. However, the UMT1009 Barrier Transistor test conditions are identical to the 2N6545 clamped inductive test at 100°C. Note that the definition of fall time in the 2N6545 spec does not include the voltage transition, whereas the UMT1009 spec defines fall time as including both the voltage and current transitions. Table I shows the UMT1009 performance and spec limits for both types.

TABLE I — 2N6545 TEST CIRCUIT

Clamped Inductive Load Test:
$I_C = 5A$, $V_{CLAMP} = 450V$, $I_{B1} = 1A$, $V_{BE'off)} = 5V$, $T_C = 100°C$

	t_s	t_f	E_s/I_b
2N6544 Spec. Limit	4.0μS	0.9μS	0.5mJ
Mfr('s) Published Typical	1.9	0.45	—
UMT1009 Barrier Transistor Median	1.8	0.11	3.0mJ
	t_s	t_f*	E_s/I_b
UMT1009 Barrier Transistor Spec. Limit	4.0μS	.4μS	1.5mJ

t_f is current fall time only
t_s is storage time only
t_f* includes voltage and current fall time

4. Base Drive Simplification

The statement that the UMT1009 Barrier Transistor demonstrates a fall time of 110 nanoseconds in the 2N6545 switching speed test circuit may well evoke the response: "Who needs it?" Indeed, 110 nanosecond fall time is probably not needed or even desirable in a 25 KHz off-line switching power supply.

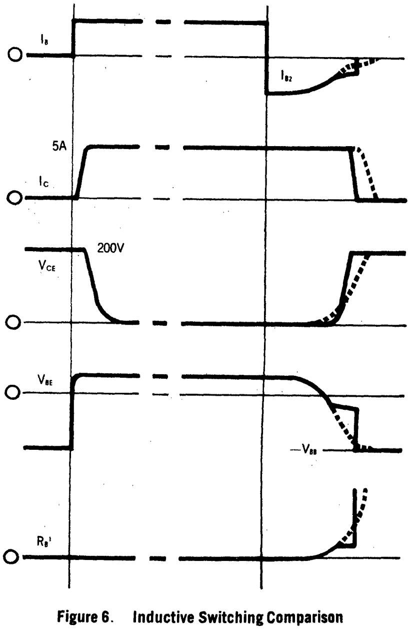


Figure 6. Inductive Switching Comparison

The problem with conventional high voltage switching transistors is that it is difficult and expensive to achieve even 500 nanosecond fall time. Because of the high series base resistance, a negative voltage is required for the I_{B2} drive source in order to sustain the I_{B2} level needed for a reasonable fall time. This is particularly difficult to achieve with the upper devices in a bridge or half-bridge inverter, where transformer coupled base drive is usually employed because the emitter and base voltage are switching across the full rectified line input. Many clever solutions to this problem have been developed, but they invariably add significantly to the component count and cost.

The main advantage offered by the low series base resistance of the Barrier Transistor design is that fall times acceptable for 25KHz operation can be achieved with relatively simple and inexpensive turn-off base drive circuits.

4.1 Shorting Base to Emitter

In the circuit of Figure 7, turn-off is accomplished by turning on a low voltage switching transistor which shorts the base to emitter of the power switching device. This technique is commonly employed to turn off inherently fast low voltage power switching transistors, but does not provide adequate fall times when used with conventional high voltage switching transistors because of their RB' limitation.

In this circuit, the UMT1009 Barrier Transistor switches 3 amperes and 250 volts with a fall time of 500 nanoseconds. The storage time of the high voltage switching transistor in this circuit is minimized by selecting a low voltage drive transistor with $V_{CE(SAT)}$ less than 0.15 volts at 1 ampere, and fast turn-on between 1 volt and 0.15 volts (a low V_{CEO} design will have the least quasi-sat problem).

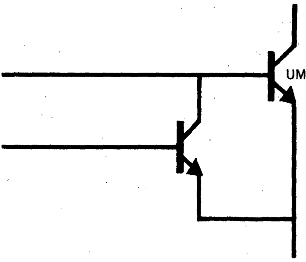


Figure 7. Shorted Base-Emitter Turnoff

4.2 Transductor Turn-Off

A small amount of energy stored in an inductor in the base circuit can provide a great assist in turning off a high voltage switching transistor. The circuit of Figure 8 employs a tapped inductor consisting of 4 turns of wire through an inexpensive ferrite bead. In this circuit, the UMT1009 Barrier Transistor switches 5 amperes and 250 volts with a storage time of 1.5 microseconds and fall time of 500 nanoseconds at 100°C. With a 4 volt input pulse and a $V_{BE(SAT)}$ of 1 volt, steady state current values are: $I_1 = 1.5A$, $I_2 = 0.5A$, and $I_{B1} = 1.0A$. Energy stored in the inductor is proportional to the total number of ampere-turns. In this case, $I_1 \times 2$ turns $+ I_2 \times 2$ turns is a total of 4 ampere-turns. When the drive transistor turns off, the input drive transformer becomes a high impedance, and I_1

ceases. Since the energy stored in the inductor requires the maintainance of 4 ampere-turns, I_2 jumps 2 amperes (ideally), providing 2 amperes I_{B2} to initiate turn-off of the UMT1009. Losses in the ferrite bead actually result in an initial I_{B2} of 1.5 amperes.

Winding N_2, which supplies I_{B2}, has an effective inductance of 4 microhenries. This is sufficient to sustain I_{B2} and obtain 500 nanoseconds fall time with the UMT1009. This circuit does not work effectively with conventional devices because their large values of RB' reduce the circuit time constant, and the energy stored in the inductor is dissipated in RB'.

After the UMT1009 turns off, its base becomes a high impedance. The reverse voltage swing of the inductor due to remaining energy is clamped through the input drive transformer and the 10 volt zener diode on the primary side, to that the negative base-emitter voltage applied to the UMT1009 does not exceed 2 volts.

4.2.1 Tailoring I_{B1}

It might be expected (the author expected) that the presence of the inductor in the base circuit would delay initiation of I_{B1} and degrade turnon performance. Such is not the case. When the resistor ratio, R_1/R_2 is equal to the square of the turns ratio, $(N1/N2)^2$, the initial value of I_{B1} is identical to the steady-state value. In other words, the I_{B1} waveform is a rectangular pulse, even though I_1 and I_2 are both changing during the initial portion of the turn-on pulse.

If R_1/R_2 is made larger than $(N1/N2)^2$ and the input pulse voltage is adjusted to maintain the desired steady-state drive conditions, the initial value of I_{B1} will be greater than the steady-state value, resulting in a faster turn-on time, if desired. Conversely, if R_1/R_2 is smaller than $(N1/N2)^2$, the initial value of I_{B1} will indeed be smaller than steady-state value, slowing up the turn-on time.

In the circuit of Figure 8, values were chosen to obtain a rectangular I_{B1} pulse. This is easily proven by assuming the result — that the initital value of I_{B1} is the same as the final value of 1 ampere. The initial value of current in the inductor must be zero, since there was no current in the inductor prior to the turn-on pulse, and the inductor current cannot change instantaneously. In order to satisfy the initial I_{B1} of 1 ampere requires equal and opposite currents of 0.5 amperes through winding N1 and N2, which cancel each other and cause no net change of energy in the inductor.

Since I_2 is 0.5 amperes, a 1 volt drop occurs across R_2, this puts the bottom of winding N2 at −1 volt. Since the center tap of the inductor is at +1 volt (V_{BE} with an I_{B1} of 1 ampere), the top of winding N1 must be at +3 volts, because of the mutual coupling between N1 and N2. The I_1 value of 0.5 amperes causes a 1 volt drop across R_1. Therefore, the input pulse voltage should be 4V. That's exactly what it is!

Resistor R_1 may be located on the input side of the input drive transformer, adjusted in value according to the drive transformer turns ratio squared. This reduces the power handling requirement of the drive transformer.

The ferrite bead is Stackpole #57-1552, and is .300" O.D. and .210" length.

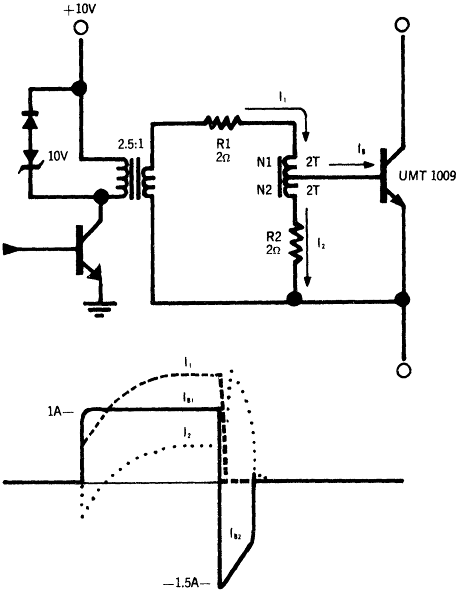


Figure 8 — Transducor Base Drive

APPLICATION NOTE **U-76**

FLYBACK AND BOOST SWITCHING REGULATOR DESIGN GUIDE

Section One — Flyback Regulator

I. Definition

The flyback switching regulator described in this application note accepts a DC voltage input and provides a regulated output voltage of opposite polarity. This method of conversion, compared to a conventional DC to DC converter, provides advantages of high efficiency, low cost, circuit simplicity, and a rather wide, easily selectable choice of the regulated output voltage. The switching transistor is not stressed to second breakdown in either the forward or reverse bias modes. Thus, it provides a reliable method of converting the input voltage. The disadvantage of the flyback switching regulator described here is that it provides no isolation and requires a large output filter capacitor. Primary usage of this type of regulator is in low current and/or high voltage applications.

II. Design Approaches to Flyback Regulator

The principal difference between a flyback regulator and a buck regulator (Ref. Unitrode Design Guide U-68) is the manner in which energy is transferred to the output capacitor. In a buck regulator, energy is provided continuously, while in a flyback regulator, energy is pumped in a discontinuous fashion. The flyback regulator can be operated in two modes.

A. Continuous Mode (see Figure 1a)

In this mode of operation, a large inductor is required to insure that the inductor current never goes to zero. Although the current through the inductor flows continuously, the charging current to the filter capacitor is in the form of discontinuous current pulses. This large peak-to-peak current waveform requires a much larger filter capacitor than the buck regulator. Component cost is higher than with the discontinuous mode of operation because of the large inductance required, and transient response is worse.

B. Discontinuous Mode (see Figure 1b, 1c)

In this mode, the regulator is designed such that at maximum output load current and minimum input voltage, the transistor starts conducting as soon as the catch diode stops conducting. At a lower output current or higher input voltage there is a dead time when neither device conducts.

The output voltage can be regulated by varying the duty cycle of the transistor switch.

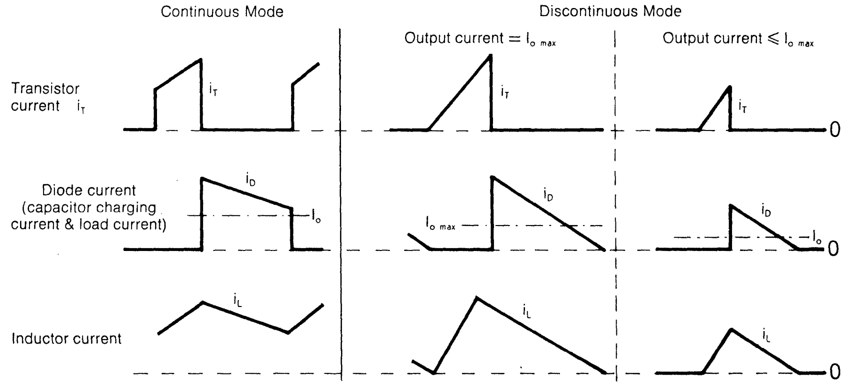


Figure 1a Figure 1b Figure 1c

Figure 1. Current Waveforms

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III. The Flyback Switching Regulator Described and Characterized

The basic circuit configuration and generalized current waveforms are shown in Figure 2. When transistor Q_1 is turned on, the supply voltage, E_{IN}, is applied across power inductor L. The current through the inductor rises linearly to a peak current level I_P:

$$I_p = \frac{E_{IN} \times t_T}{L} \quad \text{.......................... A.}$$

This results in an energy transfer from the input supply to the power inductor:

$$W = \frac{1}{2} L I_p^2 \quad \text{.......................... B.}$$

When the transistor turns off, a voltage is induced across inductor L which forces the current to flow through diode D_1. All of the energy stored in the inductor is transferred to the output capacitor and load R_L, and the inductor current diminishes linearly from I_p to zero according to the relationship:

$$I_p = \frac{E_o \times t_D}{L} \quad \text{.......................... C.}$$

The power delivered to the load is equal to the peak energy stored in the inductor times the number of pump cycles per second:

$$P_{out} = E_o \times I_o = \frac{1}{2} L I_p^2 \times f \quad \text{............ D.}$$

The voltage induced in the inductor is such that E_o is opposite in polarity from E_{IN}. The relationship between E_o and E_{IN} is established by combining equations A and C, eliminating I_p and L:

$$\frac{E_O}{E_{IN}} = \frac{t_T}{t_D} \quad \text{............................. E.}$$

DC output current I_o is equal to the average current through the diode:

$$I_o = \frac{I_P}{2} \times \frac{t_D}{\tau} = \frac{I_P}{2} \times t_D \times f$$

The output voltage can be regulated by operating at a fixed frequency and varying the transistor on time, t_T. However, because of the inherent "pumping" action of the flyback regulator, the output voltage diminishes while the switching transistor is on, and increases when the transistor is off. This characteristic makes it difficult to control on a fixed frequency basis.

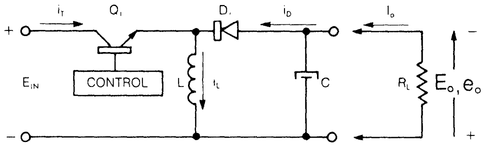


Figure 2a. Flyback Switching Regulator

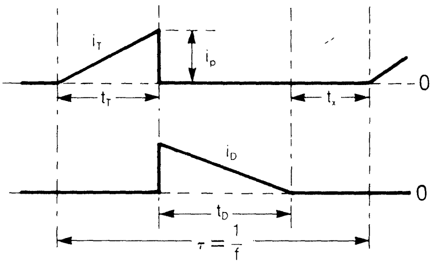
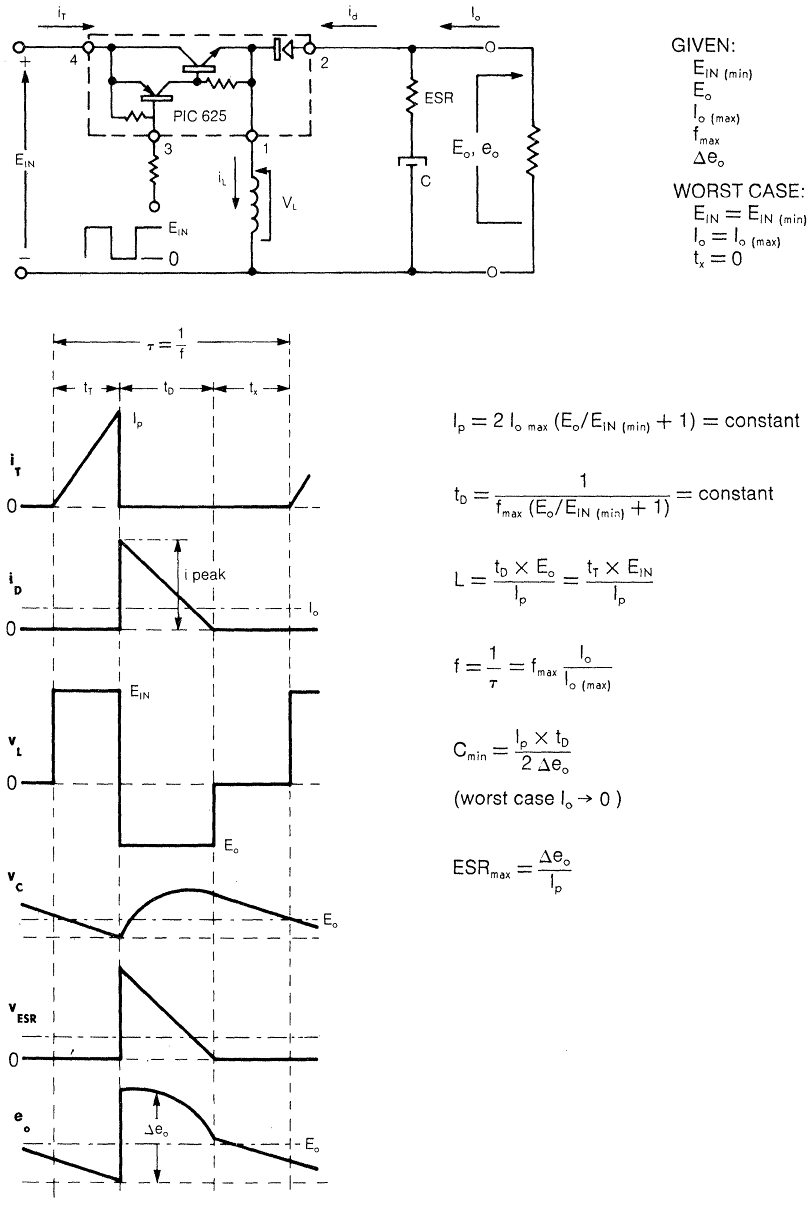


Figure 2b. Generalized Current Waveforms of a Flyback Switching Regulator

The simplest approach to controlling the flyback regulator in the discontinuous mode is to establish a fixed peak current through the inductor, which determines a fixed diode conduction time, t_D. Frequency then varies directly with output current, and transistor on-time varies inversely with input voltage. This is the approach used in this application note, resulting in a simple and economical control circuit.

IV. Worst Case Design Conditions

Design equations based on the fixed peak current mode of operation are shown in Figure 3. The worst case condition exists when input voltage is low while output current is at maximum. Under these worst case conditions, frequency is maximum and t_x is zero because the pass transistor turns on as soon as diode stops conducting.



GIVEN:
$E_{IN\ (min)}$
E_o
$I_{o\ (max)}$
f_{max}
Δe_o

WORST CASE:
$E_{IN} = E_{IN\ (min)}$
$I_o = I_{o\ (max)}$
$t_x = 0$

$$I_p = 2\, I_{o\ max}\, (E_o/E_{IN\ (min)} + 1) = \text{constant}$$

$$t_D = \frac{1}{f_{max}\, (E_o/E_{IN\ (min)} + 1)} = \text{constant}$$

$$L = \frac{t_D \times E_o}{I_p} = \frac{t_T \times E_{IN}}{I_p}$$

$$f = \frac{1}{\tau} = f_{max} \frac{I_o}{I_{o\ (max)}}$$

$$C_{min} = \frac{I_p \times t_D}{2\, \Delta e_o}$$

(worst case $I_o \rightarrow 0$)

$$ESR_{max} = \frac{\Delta e_o}{I_p}$$

Figure 3. Flyback Regulator

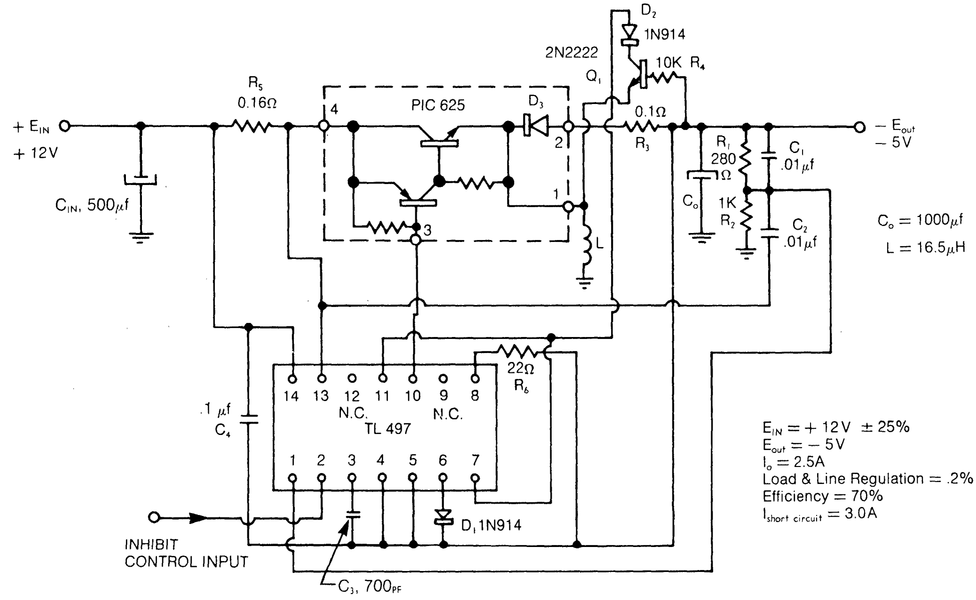
V. Circuit Design and Description

In designing a flyback switching regulator power supply, the following parameters will normally be predefined. Numerical values are given and computed for the example shown in Figure 4.

E_o = 5V output
Δe_o = 100 mV output ripple voltage peak to peak
$I_o max$ = 2.5A
$E_{IN} min$ = 9V (minimum)
$E_{IN} max$ = 15V (maximum)

Since the output voltage is derived from pulses of current, it is desirable to keep the operating frequency as high as possible in order to obtain small size and lower cost of the filter inductor and capacitor. However, above 5-10 kHz, capacitor impedance is usually dominated by its equivalent series resistance, ESR, rather than C value. Since the ESR remains essentially constant regardless of operating frequency, operation at higher frequencies does not enable the size and cost of the capacitor to be further reduced.

Also, at higher frequencies, transistor switching losses become significant. Thus, a maximum operating frequency of 25 kHz is chosen for this design.



$C_o = 1000\mu f$
$L = 16.5\mu H$

$E_{IN} = +12V \pm 25\%$
$E_{out} = -5V$
$I_o = 2.5A$
Load & Line Regulation = .2%
Efficiency = 70%
$I_{short\ circuit} = 3.0A$

Figure 4. Flyback Regulator, +12V Input, –5V Output

Referring to Figure 3, the design calculations are:

$$I_p = 2\, I_o max\, (E_o/E_{IN}min + 1) = 2 \times 2.5\, (5/9 + 1)$$

$$= 7.8A \text{ (constant)}$$

$$t_D = \frac{1}{f_{max}\, (E_o/E_{IN}min + 1)} = \frac{1}{25 \times 10^3\, (5/9 + 1)}$$

$$= 25.7\, \mu s \text{ (constant)}$$

$$L = \frac{t_D \times E_o}{I_p} = \frac{25.7 \times 10^{-6} \times 5}{7.8}$$

$$= 16.47\, \mu H$$

$$C_{min} = \frac{I_p \times t_D}{2\, \Delta e_o} = \frac{7.8 \times 25.7 \times 10^{-6}}{2 \times 0.1}$$

$$= 1002\, \mu F$$

$$ESR_{max} = \frac{\Delta e_o}{I_p} = \frac{0.1}{7.8} = 0.0128\, \Omega$$

The operating frequency will change in proportion to load current, I_o:

$$f = f_{max} \times \frac{I_o}{I_{o\ max}}$$

The PIC625 hybrid power output stage incorporates a fast PNP quasi-darlington switching transistor and UES catch diode. The quasi-darlington switch requires 30 mA of drive current. This drive current is provided with diode D_1 and Resistor R_6 in conjunction with the Integrated circuit TL497. (Refer to Figure 4)

$$I_{DRIVE} = \frac{V_{be}}{R_6} = \frac{0.65}{R_6}$$

$$\therefore\ R_6 = 22\, \Omega$$

The output voltage is preset by divider network R_1 and R_2, according to the relationship:

$$E_o = \left[1 + \frac{R_2}{R_1}\right] V_{REF}$$

where $V_{REF} = 1.22V$. Assuming a nominal value for $R_2 = 1K$, then:

$$R_1 = 320\, \Omega$$

R_1 may be trimmed to obtain the precise output voltage.

The TL497 control circuit operates in the current limiting mode under normal operating condition. Thus, the peak current value, I_p, is determined by the current limiting resistor R_5. Capacitor C_3 is required to prevent the TL497 from terminating the transistor on-time prematurely. This causes an 8 μs delay, once over-current is detected at the short circuit sense input (pin 13 of TL497) before the transistor switch turns off. The delay time is the time required to charge capacitor C_3 to the predetermined voltage level before drive current to the pass transistor is removed. The current limit threshold voltage is about 1.2 volts.

$$R_5 = \frac{1.2V}{I_p}$$

$$= \frac{1.2}{7.8A}$$

$$= 0.153\, \Omega$$

The function of transistor Q_1, diode D_3 and resistor R_3 and R_4 is to provide short circuit protection. The transistor Q_1 prevents turn-on of the pass transistor as long as the catch diode continues to conduct. Thus, it limits the maximum current and operating frequency under short circuit conditions. D_2 and R_4 providing voltage isolation to transistor Q_1.

C_2 is required for circuit stabilization; capacitor C_1 provides AC coupling of ripple voltage to the control circuit. C_{IN} and C_o are filter capacitors.

Unitrode Switching Regulator Design Guide U-68 covers the design of a buck regulator, and contains a section on power inductor design which is applicable to the flyback and boost regulators.

Section Two — Boost Switching Regulator

The boost switching regulator is described briefly in this application note. It accepts a DC voltage input and provides a regulated output voltage which must be greater than input voltage.

The basic circuit configuration of a boost regulator is shown in Figure 5. When the transistor switch is turned on, the supply voltage E_{IN} is applied across power inductor L. The diode is reverse biased by voltage E_o. Energy is transferred from the input supply to the power inductor. When the transistor is turned off, the energy stored in the inductor L induces a voltage such that the diode conducts and transfers the energy to the load and the output capacitor. In addition to the energy stored in the inductor, additional energy is transferred from the input directly to the output during the diode conduction time.

This pumping action, similar to the flyback regulator, also makes it desirable to operate the boost regulator in the discontinuous mode with a fixed peak current through the inductor. However, unlike the flyback regulator, in the boost regulator the diode conduction time is not fixed, but varies according to the input voltage:

$$t_D = \frac{L\, I_p}{E_o - E_{IN}}$$

Output voltage is regulated by controlling the duty cycle:

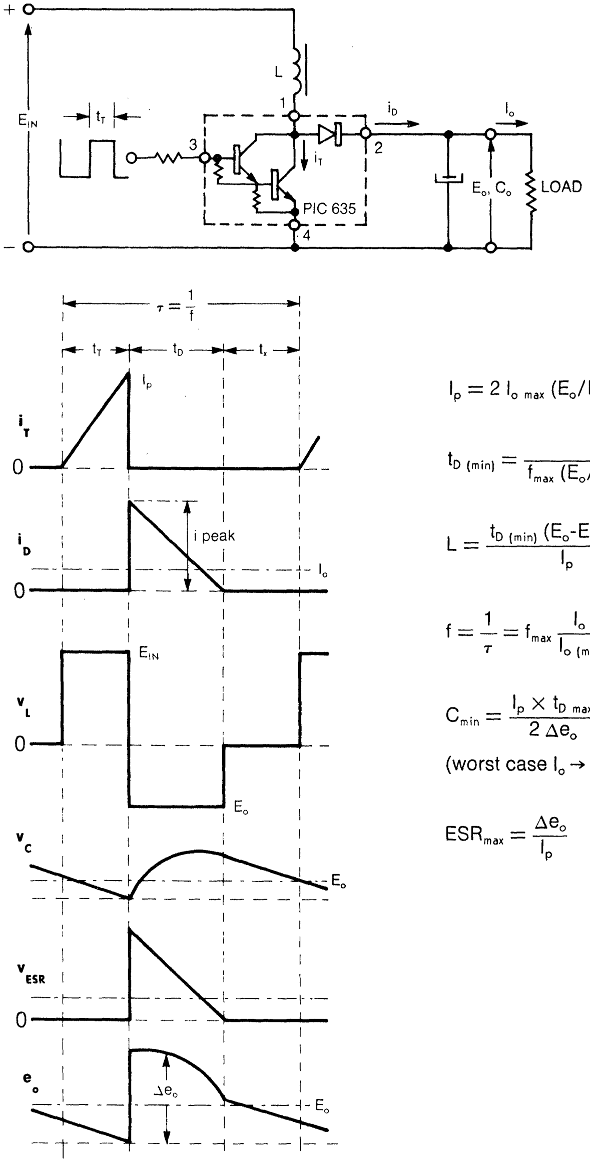
$$\frac{E_o}{E_{IN}} = \frac{t_T}{t_D} + 1$$

Since the ripple voltage across the output capacitor is directly proportional to diode conduction time, t_D, capacitor requirements are determined by the maximum t_D:

$$t_D \max = \frac{L\, I_p}{E_o - E_{IN}\,(\max)}$$

The Figure 6 is a complete schematic diagram of a boost switching regulator. It accepts +12V of DC input voltage and provides regulated +24V of output voltage.

The design procedure and circuit description is similar to the flyback switching regulator.



GIVEN:
$E_{IN\ (max)}$
$E_{IN\ (min)}$
E_o
$I_{o\ (max)}$
$f_{(max)}$
Δe_o

WORST CASE:
$E_{IN} = E_{IN\ (min)}$
$I_o = I_{o\ (max)}$
$t_x = 0$

$$I_p = 2\, I_{o\ max}\, (E_o / E_{IN\ (min)}) = \text{constant}$$

$$t_{D\ (min)} = \frac{1}{f_{max}\, (E_o / E_{IN\ (min)})}$$

$$L = \frac{t_{D\ (min)}\, (E_o\text{-}E_{IN\ min})}{I_p}$$

$$f = \frac{1}{\tau} = f_{max}\, \frac{I_o}{I_{o\ (max)}} \times \frac{E_o\text{-}E_{IN}}{E_o\text{-}E_{IN\ (min)}}$$

$$C_{min} = \frac{I_p \times t_{D\ max}}{2\, \Delta e_o}$$

(worst case $I_o \rightarrow 0$)

$$ESR_{max} = \frac{\Delta e_o}{I_p}$$

Figure 5. Boost Regulator

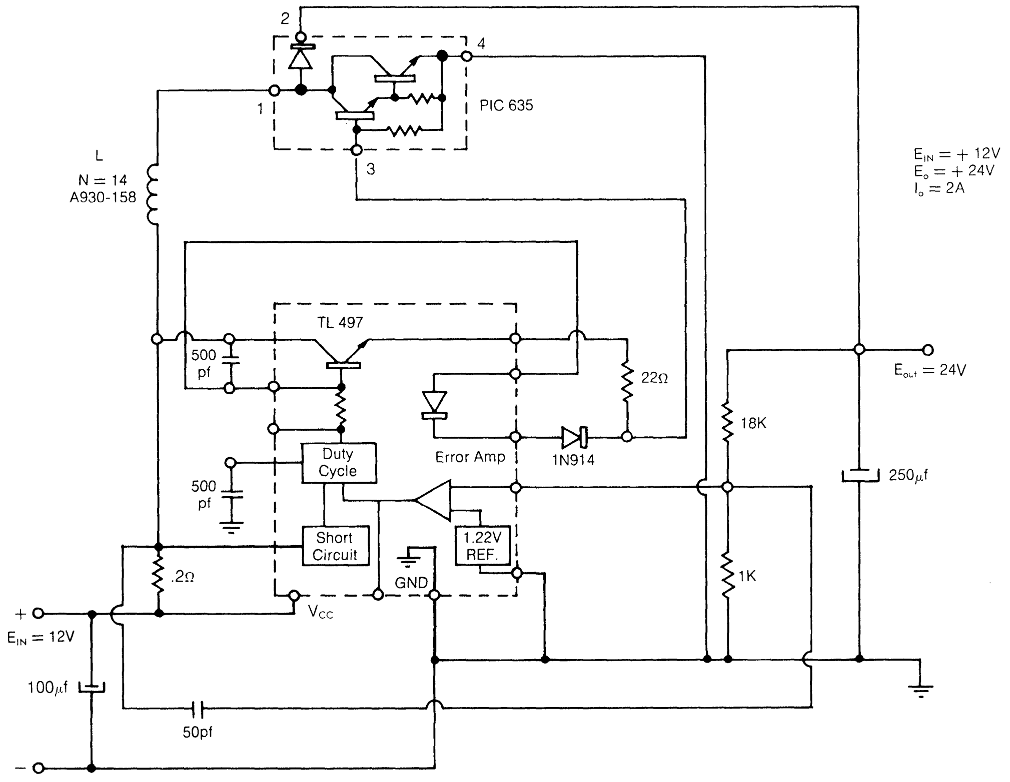


Figure 6. Boost Switching Regulator

Appendix A — Derivation of Design Equations

The basic circuit configuration of the flyback switching regulator is shown in Figure 3. Assuming a fixed value of peak current, I_p, and output volts, E_o, the following equations are evident:

$$E_{IN}\, t_T = E_o\, t_D = I_p \times L \tag{1.}$$

$$t_T = t_D \times E_o/E_{IN} \tag{1a.}$$

$$\tau = t_T + t_D + t_X = 1/f \tag{2.}$$

Worst case $\tau = \tau_{min}$, $f = f_{max}$, $t_X = 0$, $E_{IN} = E_{IN}$ min. Substituting Equation 1a:

$$\tau_{min} = \frac{1}{f_{max}} = t_D\,(E_o/E_{IN}\ \text{min} + 1) \tag{2a.}$$

$$\therefore\ t_D = \frac{1}{f_{max}\,(E_o/E_{IN}\ \text{min} + 1)} \tag{2b.}$$

Since in Equation 1, E_o, I_p and L are all constant values for a given application, t_D is also a constant value.

By inspection of Figure 3 output current waveforms:

$$I_o = \frac{I_p}{2} \times \frac{t_D}{\tau} = \frac{I_p}{2} \times t_D \times f \tag{3.}$$

Taking worst case conditions and substituting Equation 2b:

$$I_o\ \text{max} = \frac{I_p}{2} \times f_{max} \times \frac{1}{f_{max}\,(E_o/E_{IN}\ \text{max} + 1)} \tag{3a.}$$

$$\therefore\ I_p = 2\, I_o\ \text{max}\,(E_o/E_{IN}\ \text{max} + 1) \tag{3b.}$$

Rearranging Equation 1:

$$L = \frac{t_D \times E_o}{I_p} \tag{1b.}$$

The ripple voltage, Δv_c, across the output filter capacitor:

$$\Delta v_c = \frac{\Delta Q}{C} \tag{4.}$$

The worst case net charge into the capacitor is equal to the area under the diode current waveform

$$\Delta Q_{max} = \frac{I_p \times t_D}{2} \tag{4a.}$$

Substituting into Equation 4 and rearranging:

$$\therefore\ C_{min} = \frac{I_p \times t_D}{2\,\Delta e_o} \tag{4b.}$$

The ripple voltage, v_{ESR} across the capacitor series resistance, ESR.

$$v_{ESR} = I_p \times ESR \tag{5.}$$

$$\therefore\ ESR_{max} = \frac{\Delta e_o}{I_p} \tag{5a.}$$

The frequency, f, will vary as a function of load current. Rearranging Equation 3:

$$\frac{I_o}{f} = \frac{I_p}{2} \times t_D = I_o\ \text{max}/f_{max} \tag{6.}$$

$$\therefore\ f = f_{max} \times \frac{I_o}{I_{o\ max}} \tag{6a.}$$

and

$$f_{min} = f_{max} \times \frac{I_{o\ min}}{I_{o\ max}}$$

APPLICATION NOTE U-77

THERMAL DESIGN CONSIDERATIONS FOR OPERATING UNITRODE'S TO-92 TRANSISTORS AND DARLINGTONS IN PULSED-POWER APPLICATIONS

Introduction

Unitrode's power Darlingtons (U2TA506, U2TA508, U2TA510) and power transistors (UPTA510, UPTA520, UPTA530 and UPTB520, UPTB530, UPTB540, UPTB550) in economical TO-92 plastic packages are ideally suited for use in pulsed power applications, such as lamp driving or printer driving where the inrush or pulse drive current can be as high as several amperes. When compared with transistors or Darlingtons in conventional power packages, the Unitrode TO-92 devices offer cost savings of 50% or more, take up significantly less board space, and lend themselves to tape and reeling and automatic insertation. They also offer the advantage of a maximum operating junction temperature ($T_{J(max)}$) of 175°C versus 150°C or 125°C for other plastic packaged devices.

Thermal considerations are of prime concern when the TO-92 power transistors and Darlingtons are used in pulsed power applications. This Design Guide provides a method for determining the junction temperature and maximum allowable peak power dissipation for the U2TA506, U2TA510 and UPTB520 series when they are operated at frequencies of 10 kHz or less, where the switching losses are negligible and can be ignored. This method is valid for the vast majority of pulse applications.

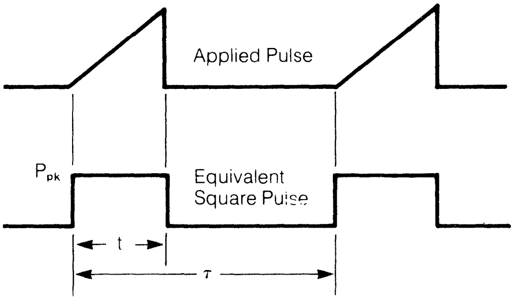
Thermal Analysis

A detailed transient thermal analysis is required to determine the peak junction temperature and maximum allowable power dissipation since the junctions of the transistor or Darlington are subjected to temperature excursions due to the applied, periodic power pulses.

A) Effective Pulsed Thermal Impedance

The effective pulsed thermal impedance (Θ_p) of a device subjected to a periodic train of power pulses can be calculated as follows:

$$\Theta_p = (\Theta_{j\text{-}A})(D) + (1-D)(r(t+\tau)) - r(\tau) + r(t) \; \ldots\ldots\ldots \; (1)$$



Where: t = pulse width
τ = period
D = t/τ (Duty Cycle)
$r(t+\tau)$ = transient thermal impedance at time $t + \tau$
r(t) = transient thermal impedance at time t
$\Theta_{j\text{-}A}$ = DC junction to ambient thermal impedance
P_{pk} = The peak power of a square power pulse with equivalent energy to that of the actual power pulse.

Figure 1. Power Pulses

The DC junction to ambient thermal impedance ($\Theta_{j\text{-}A}$) is 200°C/W maximum for the UPTA510 and UPTB520 series and is 155°C/W maximum for the U2TA506 Series.

The transient thermal impedance for the U2A506, UPTA510, and UPTB520 series can be obtained from the curves presented in Figure 2:

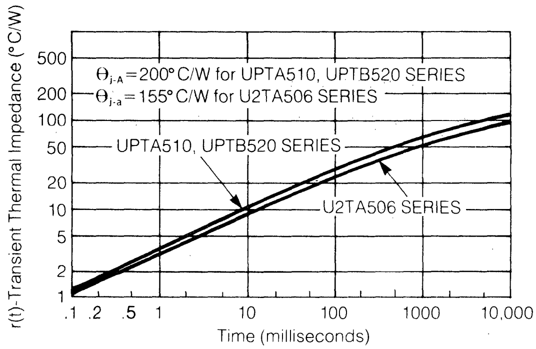


Figure 2. Junction to Ambient Transient Thermal Impedance

B) Peak Junction Temperature

The peak junction temperature of a device subjected to a periodic train of power pulses can be calculated using the previously derived effective pulsed thermal impedance as follows:

$$T_{j\,(peak)} = T_{Ambient} + (P_{pk})(\Theta_p) \quad \dots\dots\dots\dots\dots\dots (2)$$

In the case of a single shot pulse the term for Θ_p reduces to

$$\Theta_p = r\,(t)$$

and the equation used to calculate peak junction temperature becomes

$$T_{j\,(peak)} = T_{Ambient} + (P_{pk})\,(r(t)) \quad \dots\dots\dots\dots\dots\dots (3)$$

Allowable Peak Power Dissipation

The allowable peak power dissipation can be derived from the following equation:

$$P_{pk(max)} = \frac{T_{j\,(max)} - T_{Ambient}}{\Theta_p} \quad \dots\dots\dots\dots\dots\dots (4)$$

Where $T_{j\,(max)}$ is the maximum allowable junction temperature. For the U2TA506, UPTA510 and UPTB520 series the maximum junction temperature is 175°C.

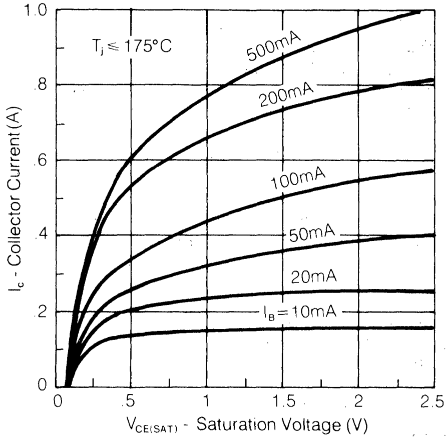


Figure 4. UPTA510 Series. Maximum Saturation Voltage vs. Collector Current

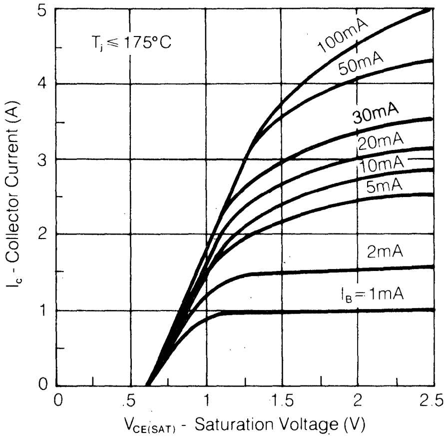


Figure 3. U2TA506 Series. Maximum Saturation Voltage vs. Collector Current

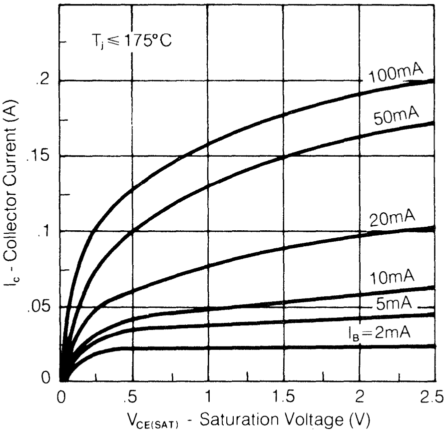


Figure 5. UPTB520 Series Maximum Saturation Voltage vs. Collector Current

Peak Power

The peak power can be expressed as follows:

$$P_{pk} = (V_{CE\,(SAT)})\,(I_{pk}) + (V_{BE\,(SAT)})\,(I_B) \ldots\ldots\ldots\ldots (5)$$

Where I_{pk} is the peak collector current of a square pulse of current equivalent to the applied current pulse, $V_{CE(SAT)}$ is the transistor or Darlington saturation voltage at I_{pk}, $V_{BE(SAT)}$ is the base-to-emitter saturation voltage and I_B is the base current. Figures 3, 4, and 5 are plots of $V_{CE(SAT)}$ for the U2TA506, UPTA510 and UPTB520 series Darlingtons and transistors. Figures 6 and 7 are plots of the $V_{BE(SAT)}$. These curves can be used in determining P_{pk}.

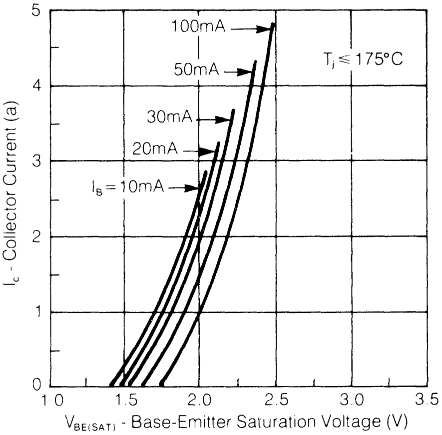


Figure 6. U2TA506 Series Maximum Base to Emitter Saturation Voltage vs. Collector Current

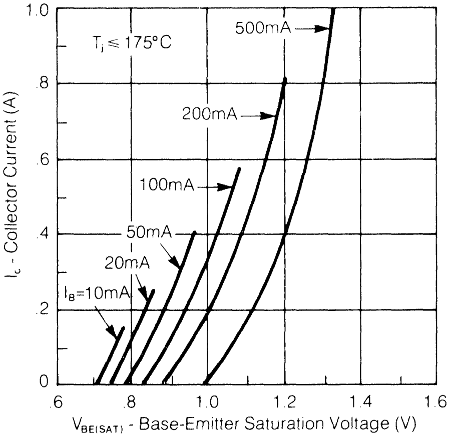


Figure 7. UPTA510, UPTB520 Series. Maximum Base to Emitter Saturation Voltage vs. Collector Current

Design Examples

1. An incandescent lamp is controlled by a U2TA506 Darlington operating from a 12V battery. When switched on the lamp draws an inrush current of 3A which decays exponentially to a steady-state value of 300mA. The time constant of the inrush current is 50 milliseconds and the worst case ambient temperature is 55°C. The Darlington's base drive is 30mA dc.

Problem:

Calculate the peak junction temperature due to the inrush pulse and the steady-state junction temperature.

Solution:

The inrush current can be approximated by a square wave of 3A peak and 50 milliseconds duration. The equivalent square pulse of current will have the same energy as the exponential pulse if the $V_{CE(SAT)}$ of the Darlington is assumed to remain constant. Since the $V_{CE(SAT)}$ will actually drop as the inrush current exponentially decays, the result obtained from using the square wave approximation will be conservative.

Using equations (3) and (5)

$$T_{j(peak)} = T_{Ambient} + (P_{pk})(r(t)) \ldots\ldots\ldots\ldots (3)$$

Where: $T_{Ambient} = 55°C$

$r(t) = r(50mSec) = 17.5°C/W$ (from Figure 2)

$P_{pk} = (V_{CE(SAT)})\,(I_{pk}) + (V_{BE(SAT)})\,(I_B) \ldots (5)$

$= (1.5V)\,(3A) + (2.15V)\,(30mA)$

(from Figures 3 and 6)

$= 4.56W$

Therefore:

$$T_{j(peak)} = 55°C + (4.56W)\,(17.5°C/W) = 135°C$$

Since 135°C is 40°C less than the maximum operating junction temperature for the U2TA506 ($T_{j(max)} = 175°C$), the Darlington is operating well within its rating.

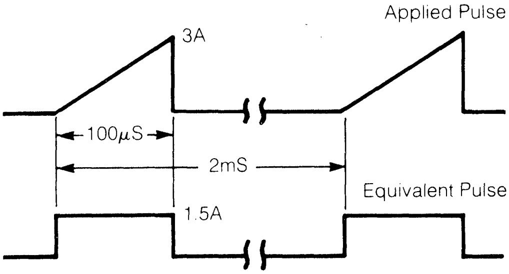
The Steady-state junction temperature can be determined as follows:

$T_{j(ss)} = (P_{(ss)})\,(\Theta_{j\text{-}A}) + T_{Ambient}$

$= ((.3A)(.73V) + (.03A)(1.60V))\,(155°C/W) + 55°C$

$= 96°C$

2. A U2TA508 is used to drive a solenoid load in an impact printer. The collector current waveform is as shown below along with the equivalent square pulse:



The Darlington is switching in a clamped mode so the energy stored in the solenoid inductance during the on-time is dissipated in the clamp and not in the Darlington. The maximum ambient temperature is 80°C and the base drive current is 20mA.

Problem:
Find the worst case junction temperature and determine if it is within the maximum rating of the U2TA508.

Solution:
Use equation (1) to determine Θ_p

$\Theta_p = (\Theta_{j\text{-}A})(D) + (1-D)(r(t+\tau)) - r(\tau) + r(t)$ ....(1)

$\Theta_{j\text{-}A} =$ 155°C/W (from Figure 2)

$D = \frac{.1\text{mSec}}{2\text{mSec}} = .05$

$r(t+\tau) = r(2.1\text{mSec}) = 4.2°\text{C/W}$ (from Figure 2)

$r(\tau) = r(2\text{mSec}) = 4.1°\text{C/W}$ (from Figure 2)

$r(t) = r(.1\text{mSec}) = 1.1°\text{C/W}$ (from Figure 2)

Therefore:

$\Theta_p = (155°\text{C/W})(.05) + (.95)(4.2°\text{C/W}) - 4.1°\text{C/W} + 1.1°\text{C/W}$

$= 8.75°\text{C/W}$

Using equation (5)

$P_{pk} = (V_{CE(SAT)})(I_{pk}) + (V_{BE(SAT)})(I_B)$ .... (5)

$I_{pk} = 1.5\text{A}$

$V_{CE(SAT)}$ + 2V (from Figure 3)

(The $V_{CE(SAT)}$ value at 3A was chosen to give a conservative answer. If T_j is found to be greater than 175°C it may be necessary to recompute using a closer approximation of the actual $V_{CE(SAT)}$ which varies as the current increases from 0 to 3A.)

$I_B = 20\text{mA}$

$V_{BE(SAT)} = 2.1\text{V}$ (from Figure 6)

(Again the $V_{BE(SAT)}$ value at 3A was chosen to give a conservative result.)

Therefore:

$P_{pk} = (2\text{V})(1.5\text{A}) + (2.1\text{V})(.02\text{A}) = 3.04\text{W}$

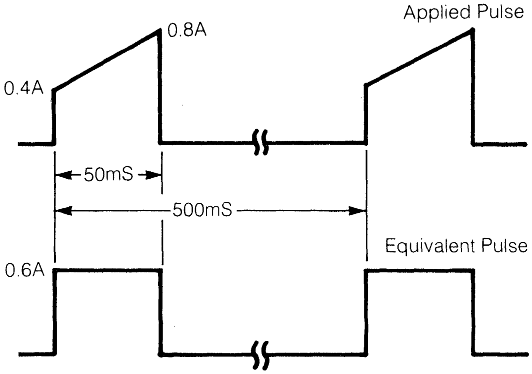
Now T_j can be determined from equation (2)

$T_j = T_{ambient} + (P_{pk})(\Theta_p)$ .... (2)

$= 80°\text{C} + (3.04\text{W})(8.75°\text{C/W}) = 107°\text{C}$

This is well within the maximum rating of 175°C for the U2TA508.

3. A UPTA530 is used to drive a high voltage DC motor in a display application the current waveform as is shown below:



The base drive is 200 mA and the worst case ambient temperature is 65°C.

Problem:
Determine the junction temperature to insure it is within the maximum rating of 175°C for the UPTA530.

Solution:
Using Equation (1)

$\Theta_p = (200°\text{C/W})(.1) + (.9)(52°\text{C/W}) - 50°\text{C/W} + 21°\text{C/W}$

$= 37.8°\text{C/W}$

From equation (5) and Figures 4 and 7.

$P_{pk} = (2.3\text{V}(.6\text{A}) + (1.2\text{V})(.2\text{A}) = 1.6\text{W}$

(Again $V_{CE(SAT)}$ and $V_{BE(SAT)}$ values at .8A rather than .6A were used to insure a conservative answer).

Therefore, from equation (2)

$T_j = 65°\text{C} + (1.6\text{W})(37.8°\text{C/W}) = 126°\text{C}$

It becomes readily apparent from these examples that Unitrode's TO-92 transistors and Darlingtons can be operated with significant safety margin in a wide variety of pulsed-power applications.

POWER SWITCHING CAPABILITIES OF IMPROVED TO-92 THYRISTORS

I) Basic Performance Considerations:

The conventional advantage of the TO-92 plastic package over other medium power packages (TO-18, TO-5, etc.) is its low cost. However, in most cases, the performance trade-off required produces low steady-state power handling capability due to relatively high junction-to-case thermal impedance. This is caused by small pellet, low conduction area designs. These conventional design TO-92 devices also have lower pulse power handling capability due to low thermal capacity in the TO-92 package materials. The resulting thermal management problem makes it difficult for conventional planar SCR device designs to exceed 0.8A RMS at 65°C case and 6.0A peak surge current in the TO-92.

As a result of new construction techniques, the Unitrode IP200/2N6681-5 series SCR can handle 1.0A RMS at 65°C case and 8.3 ms surge current pulses of 15A. See Figs. 1A and 1B.

Increased current handling capability, coupled with a high voltage design, permit this device to deliver up to 400W to a steady-state, 60 Hz, 1/2 sinewave load while dissipating less than 1.0W. Proper load configuration can realize this extremely energy efficient design potential.

II) Additional Advantages:

Perhaps the most significant advantage of the IP200/2N6681-5 series over previous TO-92 SCR devices in terms of meeting the needs of existing equipment designs is a considerable improvement in its ability to withstand overloads.

Many applications of such medium power devices are subject to fault conditions in which many times the normal load current is caused to flow in the control device. The curves in Figs. 1B and 1C illustrate the advantage of the IP200/2N6681-5 series surge capability. The thermal management advantages of the IP200/2N6681-5 series also help it to survive fault or spurious circuit conditions which cause the SCR to turn-on without gate drive such as over-voltage or dv/dt triggering. Under these circumstances, only a small pipe-like region of the device is originally brought into conduction. The increased thermal capacity on both the anode and cathode side inherent in the IP200/2N6681-5 series construction provides increased thermal damping right at the surface of the silicon. This keeps the thermal excursion, caused by such high energy density conditions, to a minimum.

The high voltage capability of the IP200/2N6681-5 series is also a tremendous advantage in equipment fault or transient input conditions.

The combined effect of both of these increased capabilities can allow the finished equipment package to more easily meet severe fault or transient line conditions without permanent damage.

An example of this type of requirement is available in ground-fault interrupter circuits. In this type of equipment, a TO-92 SCR is frequently used as a relay coil control element. A simplified circuit diagram is shown in Fig. 2. It is evident that any voltage surge applied to the line input will, to an extent, depending on circuit details, be applied to the SCR. The circuit steps necessary to survive such transients will be reduced in proportion to the degree to which the SCRs' overload capability is enhanced.

III) Switching High Power Pulses:

Perhaps one of the fastest design paths for new equipment, taking advantage of the ratings of the IP200/2N6681-5 series, is in the area of pulse power applications involving the transfer of energy from a storage element to a load. For example, since the energy stored in a capacitor is directly proportional to the square of the charging voltage, an 800V device can allow four times the energy storage of a 400V device using the same capacitance.

In some applications, the efficient use of this energy requires its rapid transfer to a load. The same construction techniques which enhance the long pulse surge capability of the IP200/2N6681-5 series by increasing the thermal capacity of the package also give the device a strong advantage at shorter pulse widths. This advantage is demonstrated in Fig. 3.

The upper trace of Fig. 3 shows a short pulse of current (Time: 10 μs/square, Current: 40A/square) which was used to stress each of two different types of TO-92 SCRs. The lower set of traces are the resulting on-state voltage as a function of time for each SCR (Voltage: 5V/square).

The highly non-linear voltage trace is the response of the conventional design TO-92 SCR. The extreme level of heating in this device is indicated by the magnitude of the excursion in on-state voltage.

The other voltage trace is the response of an IP200/2N6681-5 series device. The absence of any thermally generated on-state voltage excursion is evident.

Even though both devices showed no measurable change in electrical characteristics after this test, the small amount of irreversible damage which accumulates with each such surge pulse would be far lower for the IP200/2N6681-5 series.

In fact, in most cases, the IP200/2N6681-5 series can handle an indefinite number of surge pulses at the non-repetitive rating level of previously available TO-92 SCRs. (Refer to Fig. 1C.)

Given this combination of high voltage and high pulse current capability, Fig. 1C indicates that the IP200/2N6681-5 series of devices can deliver energy to a load at a maximum rate of 40,000W and sustain this level for 100μs.

An example of this type of application is in feedback terminated (variable exposure) flash circuits. These circuits are basically an application of Class D inverter circuits. The simplified circuits in Fig. 4 show the use of the IP200/2N6681-5 series as a commutating SCR, quench tube trigger or "Pilot" SCR. These applications, especially the "Pilot" SCR, can find uses other than in flash units.

This capability is also useful in capacitor discharge ignition systems such as the small engine breakerless ignition circuit shown in Fig. 5. In this circuit, a 1.0 μF capacitor, charged to 400V can deliver 0.08 joule of energy to a spark (not counting circuit losses). An example of such a circuit using a 12V automotive ignition coil with the secondary shorted and a 1.0 μF low loss capacitor, produced a peak current of 10A in the SCR at a 400V charging voltage. The IP200/2N6681-5 series case temperature rose to 50°C above free air ambient at 60 Hz rate (3600 RPM for single cylinder engines). Due to the 150°C/W case-to-ambient thermal impedance of this device, the device was dissipating approximately 0.33W or about 7% of the energy being stored in the capacitor.

Other possible applications of the IP200/2N6681-5 series high voltage, pulse handling capability include the direct discharge of capacitors such as small power supply crowbars, and the switching of crystalline optical shutters.

The device also has interest as a source of high voltage PNP transistor action. Even though individual gain is low, darlington configurations are possible.

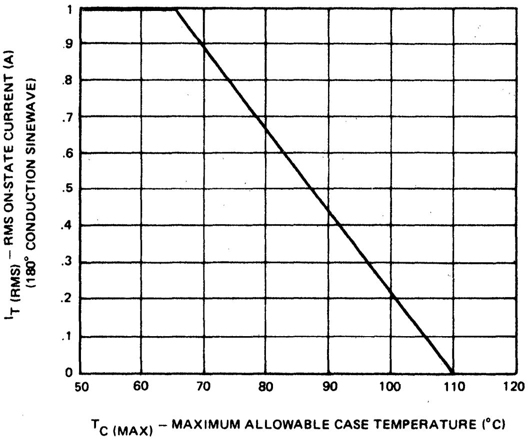


Fig. 1A. Maximum Allowable Case Temperature vs. On-State Current (60 Hz)

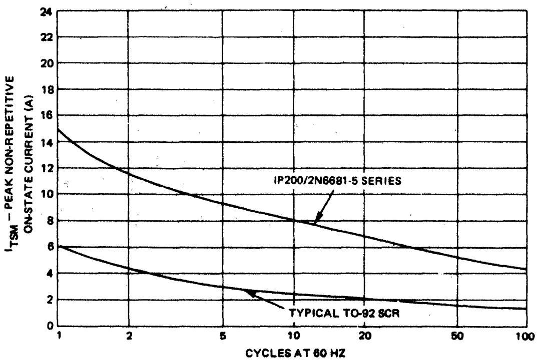


Fig. 1B. Maximum Allowable Non-Repetitive Peak On-State Current Following Rated Load Conditions

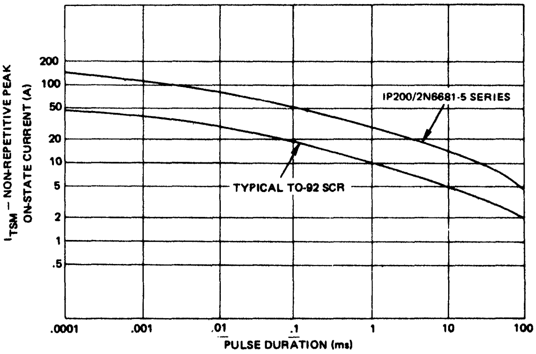


Fig. 1C. Surge Rating vs. Pulse Duration

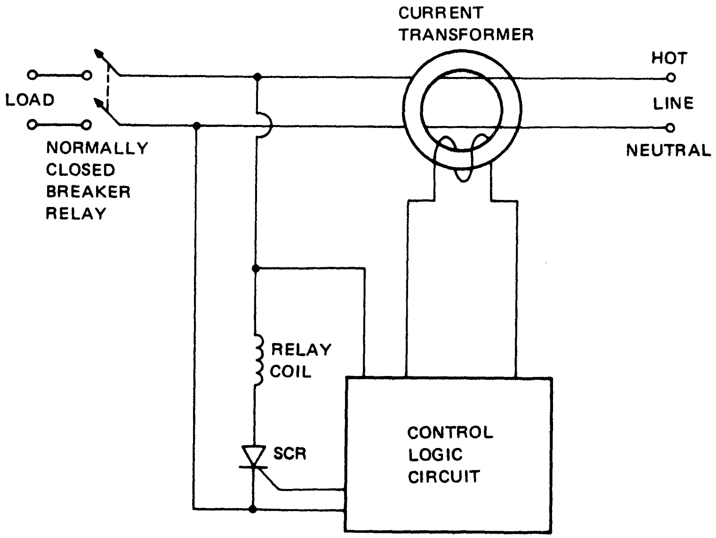
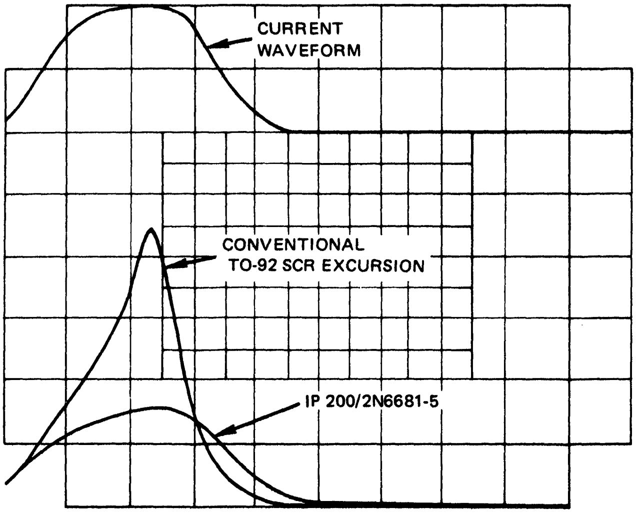


Fig. 2. Ground-Fault Interrupter Circuit



TIME: 10 µS/SQUARE
CURRENT: 40 A/SQUARE (UPPER TRACE)
VOLTAGE: 5 V/SQUARE (LOWER TRACES)

Fig. 3. Response to Short Pulse Surge Stress

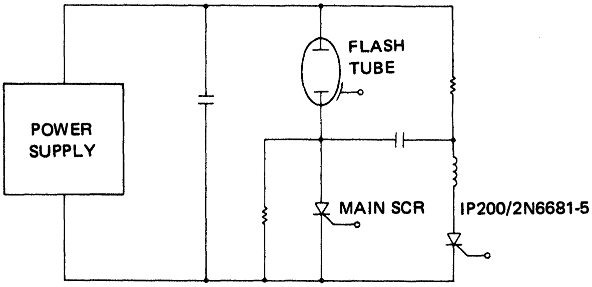


Fig. 4A. Commutating SCR

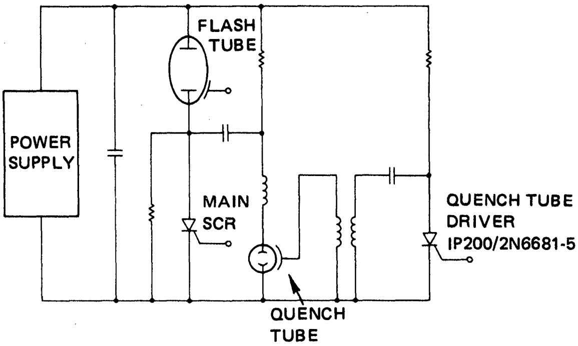


Fig. 4B. Quench Tube Driver

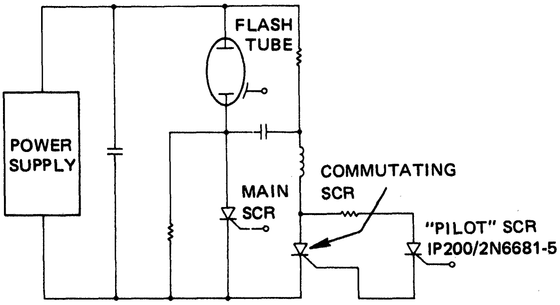


Fig. 4C. "Pilot" SCR

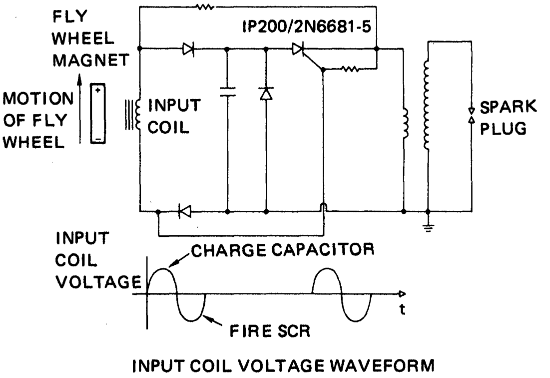


Fig. 5. Small Engine Ignition

APPLICATION NOTE **U-79**

GUIDELINES FOR USING TRANSIENT VOLTAGE SUPPRESSORS

1.0 Introduction

During transient periods, system voltages and currents are often many times greater than their steady-state values. These transients must be considered in overall electronic systems design to insure required circuit performance and reliability both during and after the transient.

Transients may result from a variety of causes. The most common of these are: normal switching operations (power supply turn-on and turn-off cycles), routine AC line fluctuations, or abrupt circuit disturbances (faults, load switching, voltage dips, magnetic coupling by electro-mechanical devices, lightning surges, etc.). Voltage transients are a major cause of component failures in semiconductors. Random high voltage transient spikes can permanently damage these voltage sensitive devices and disrupt proper system operation. Catastrophic power supply conditions should not necessarily be the designer's prime concern, since lower level transients can cause improper operation of a system even though no component failures are caused. Normal power supply on-off cycles have the potential of emitting spikes with sufficient energy to destroy an entire semiconductor device chain. Any surviving devices are also suspect. Trouble shooting, isolating, and replacing damaged devices is time consuming and costly; especially when performed in the field.

Unitrode's TVS305 and TVS505 series of transient voltage suppressors (TVS) offer the designer significant price/performance advantages over other protection methods. Their miniature size permits simple "close-in" installation in applications where circuit boards are dispersed throughout one or more electronic racks. Dispersed usage aids system trouble shooting and affords transient voltage protection where internal system disturbances such as those caused by inductive load switching could occur.

In spite of their small size, the TVS305 and TVS505 suppressor series can dissipate 500 watts and 150 watts (respectively) of peak pulse power for 1 millisecond. Response time to transients is just about instantaneous — about 1×10^{-12} seconds. These devices perform to their data sheet specifications without significant degradation throughout their operating life. Unitrode has performed full power pulse life tests for 100,000 pulses with negligible change in characteristics. These devices are suitable for almost any equipment and environment.

2.0 Choosing the Correct Transient Voltage Suppressor for the Application

Certain critical terms must be defined before any discussion of "how to" choose the correct TVS.

1. Stand-Off Voltage (V_R) is the highest reverse voltage at which the TVS will be non-conducting.
2. Min. Breakdown Voltage (BV_{min}) is the reverse voltage at which the TVS conducts 1 mA. This is the point where the TVS becomes a low impedance path for the transient.
3. Max. Clamping Voltage (V_{Cmax}) is the maximum voltage drop across the TVS while it is subjected to the peak pulse current, usually for 1mS.

Figure 1 graphically shows all three terms.

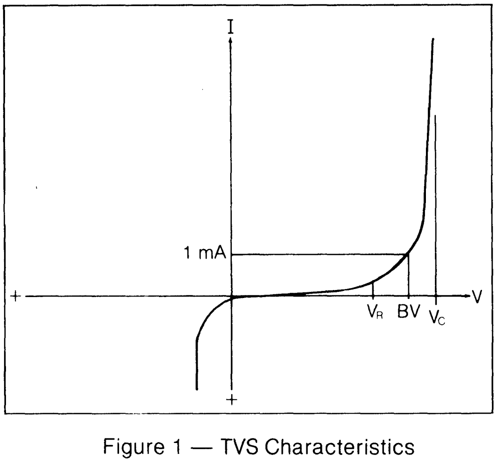


Figure 1 — TVS Characteristics

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2.1 Determining Pulse Power Levels

Since a zener TVS has an almost constant clamping voltage throughout a transient pulse, the transient pulse power (P_p) equals the peak pulse current (I_{pp}) multiplied by the clamping voltage (V_C).

$$P_p = V_C \times I_{pp}$$

2.2 Choosing the Appropriate Transient Voltage Suppressor

The three most important factors in choosing the appropriate TVS for your application, in their order of importance are:

1. Pulse power (P_p) — Choose the TVS series that will handle the Transient Pulse Power. To determine Transient Pulse Power use the simple equation in section 2.1. If I_{pp} is not known or measurable, it can be calculated — see Sections 3 and 4. The pulse duration vs. pulse power graph on the Unitrode TVS305/TVS505 data sheet can then be used to determine the TVS series that will handle the transient. This graph for the TVS505 series is shown in Figure 2.
2. Stand-off voltage (V_R) — From the TVS series selected, choose the device with the stand-off voltage equal to or greater than your normal circuit operating voltage. This insures that the TVS will draw a negligible amount of current from the circuit during normal circuit operation. The electrical specifications for the TVS505 series are shown in Figure 3.
3. Maximum Clamping Voltage (V_{Cmax}) — Determine the clamping voltage of the device chosen for the transient given and be sure it is below the voltage that might damage any components in the protected circuit. See Figure 3.

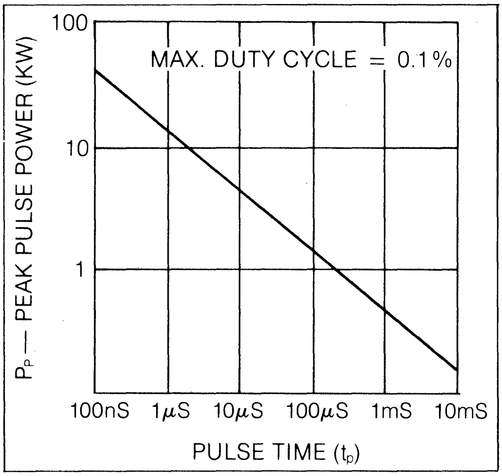


Figure 2 — Peak Pulse Power vs. Pulse Duration

TVS Part No.	Stand-off Voltage V_R	Min. Breakdown Voltage $BV_{(min)}$ @ 1mA	Max. Leakage Current I_R @ V_R	Max. Clamping Voltage V_C @ 1A	Max. Clamping Voltage V_C @ 5A	Max. Clamping Voltage V_C @ 10A	Max. Peak Pulse Current I_{PP}	Max. Clamping Voltage V_C @ I_{PP}
	V	V	µA	V	V		A	V
TVS505	5.0	6.0	300	7.4		7.9	53.7	9.3
TVS510	10.0	11.1	5	13.2		14.4	30.3	16.5
TVS512	12.0	13.8	5	16.5		18.5	23.8	21.0
TVS515	15.0	16.7	5	19.7		22.2	19.8	25.2
TVS518	18.0	20.4	5	23.8	26.0		16.3	30.5
TVS524	24.0	28.4	5	32.4	37.0		11.9	42.0
TVS528	28.0	30.7	5	35.9	41.0		10.7	46.5

Figure 3 — Electrical Specifications @ 25°C

If the actual pulse power and pulse width are different from those listed on the data sheet, the clamping voltage can be calculated. The actual calculation method is beyond the scope of this note. Instead, we offer a graphical approximation using Figure 4. The approximation is based on the ratio of the actual and rated pulse power.

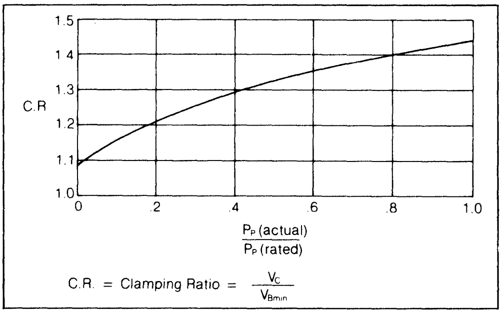


Figure 4 — Graphical Approximation for the Clamping Ratio

The procedure is as follows:

a. Calculate P_p (actual)≈1.3BV_{min} I_{pp}.

b. For P_p (rated) use value from TVS data sheet curve (See Fig. 2 for example).

c. Calculate P_p (actual)/P_p (rated).

d. Use Fig. 4 to find corresponding value of C.R.

e. Calculate V_C = C.R. × BV_{min}.

2.3 Installation Considerations

1. Locate the TVS as close to the device or circuit to be protected as possible.
2. Minimize the "common path" through the TVS to minimize voltage spikes produced by fast risetime transients in lead and wiring stray inductance. See Figure 5.

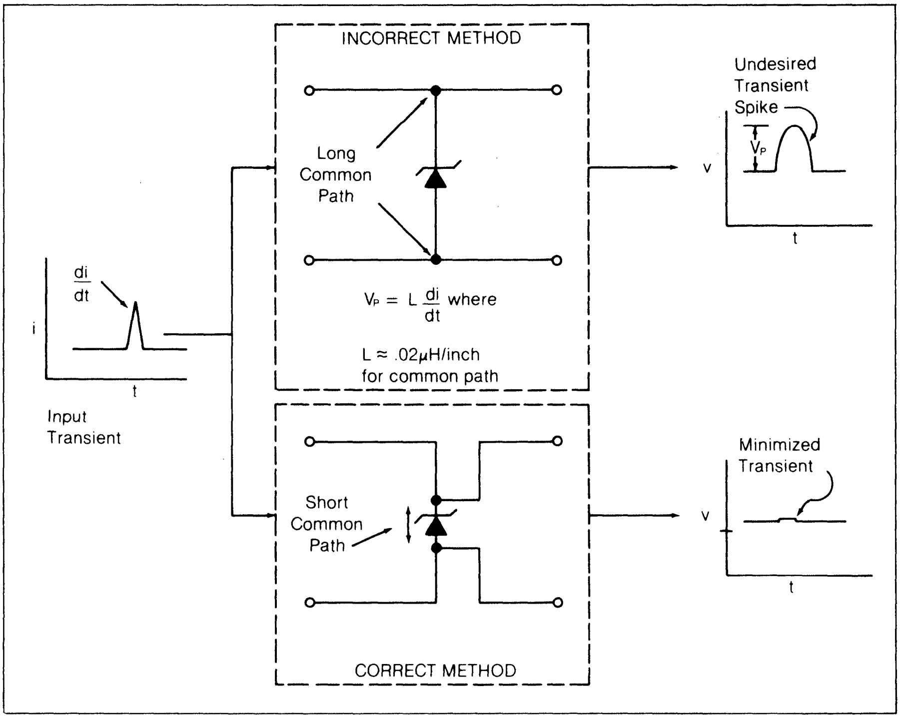


Figure 5 — Minimizing the Common Path

3.0 Transient Levels and Waveforms

3.1 Voltage, Current and Power Levels

Since TVS tests and specs may be written in terms of voltage, current or power levels, the relationships are shown in Figure 6 for (a) field conditions and (b) test conditions.

In addition to the magnitude of the voltage, current or power, the waveform or pulse width should be specified, as shown in Figure 7, for example.

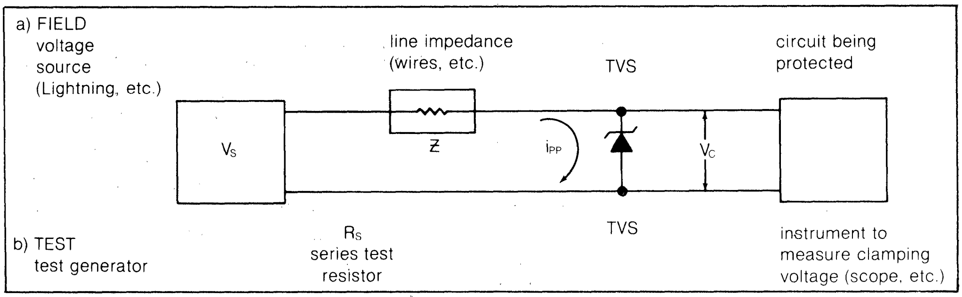


Figure 6 — Equivalent Circuit for Field and Test Conditions

3.2 Typical Transient Levels

Martzloff and Hahn in their paper on transients on 120 volt power lines* produced this table showing the surges recorded at a number of different locations over a two year period. The table indicates two primary causes of transients; load switching within the house and lightning storms.

Table 1*
Detailed Analysis of Recorded Surges

	Most Severe Surge			Most Frequent Surge				
House	Type†	Crest (volts)	Duration (μs or cycles)	1 5mHz Type†	Crest (volts)	Duration (μs or cycles)	Average Surges per Hour	Remarks
1	*A*-1 5	700	10 μs	*A*-1 5	300	10 μs	0 07	
2	*A*-2 0	750	20 μs	*A*-2 0	500	20 μs	0.14	fluorescent light
3	*B*-0 5	600	1 cycle	*B*-0 5	300	1 cycle	0.05	switching
4	*B*-0 5	400	2 cycles	*B*-0 5	300	2 cycles	0.2	
5	*C*	640	5 μs	too few to show typical			10 total	
6	*B*-0 3	400	1 cycle	*B*-0 3	250	1 cycle	0 01	
7	*B*-1	1800	1 cycle	*B*-1 0	800	1 cycle	0 03	lightning storm
8	*C*	1200	10 μs	*B*-0 5	300	4 cycles	0 1	
9	*B*-0 25	1500	1 cycle	same as most severe			0 2	oil burner
10	*B*-0 25	2500	1 cycle	*B*-0 25	2000	1 cycle	0 4	oil burner
11	*B*-0 2	1500	1 cycle	same as most severe			0 15	water pump
12	*B*-0 2	1700	1 cycle	*B*-0 2	1400	1 cycle	0 06	oil burner
13	*B*-0 1	350	1 cycle	too few to show typical			4 total	house next to 12
14	*C*	800	15 μs	—	—	—	1 total	lightning
15	*B*-0 25	800	3 cycles	*B*-0 25	600	3 cycles	0 05	rural area
16	*B*-0 15	400	15 μs	*B*-0 13	200	30 μs	0 4	surges
Street pole	*B*-0 5	5600	4 cycles	*B*-0 3	1000	1 cycle	0 1	lightning stroke nearby
Hospital	*C*	2700	9 μs	*C*	900	5 μs	0 1	lightning storm
Hospital	*B*-0 3	1100	1 cycle	too few to show typical			4 total	
Dept store	*B*-0 5	300	1 cycle	*B*-0 5	300	1 cycle	0 5	
Street pole	*B*-0 2	1400	4 cycles	*B*-0 2	600	4 cycles	0 07	lightning storm

†*A*—long oscillation. *B*—damped oscillation *C*—unidirectional Number shows frequency in megahertz

*Reprinted from *Surge Voltages in Residential and Industrial Power Circuits* by Francois D. Martzloff, Member, IEEE, and Gerald J. Hahn. Reprinted by permission from *IEEE Transactions on Power Apparatus and Systems,* Vol. PAS-89, No. 6, July/August 1970, pp. 1049-1056. Copyright 1970, by the Institute of Electrical and Electronics Engineers, Inc. Printed in U.S.A.

3.3 Commonly Used Test Waveforms

1. The 10 × 1000μS Test Waveform used by many TVS manufacturers, also by incoming inspection departments of users, represents some commonly encountered transients. (See Figure 7).
2. The IEEE Standard (ANSI C 37.90a — 1974) for surge withstand capability. (See Figure 8).

3.4 Surge Testing

Figure 9 shows a typical test set used to produce an exponentially decaying current pulse of 1mS to 50% down. (10 × 1000μS). The 1mS waveform is used by many manufacturers to test and characterize their TVS devices for pulse power and clamping voltage.

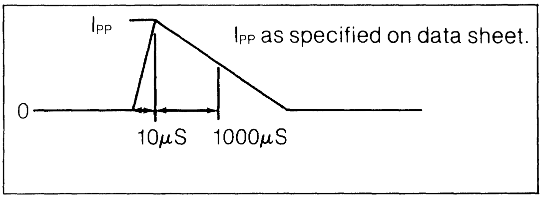


Figure 7 — Commonly Used Test Waveform

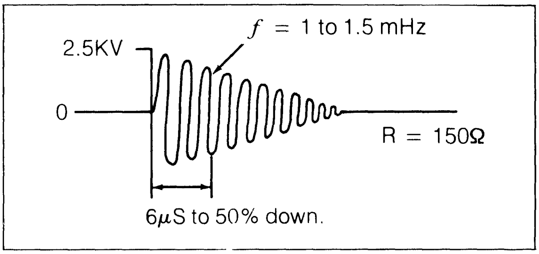


Figure 8 — More Complex Standard Waveform

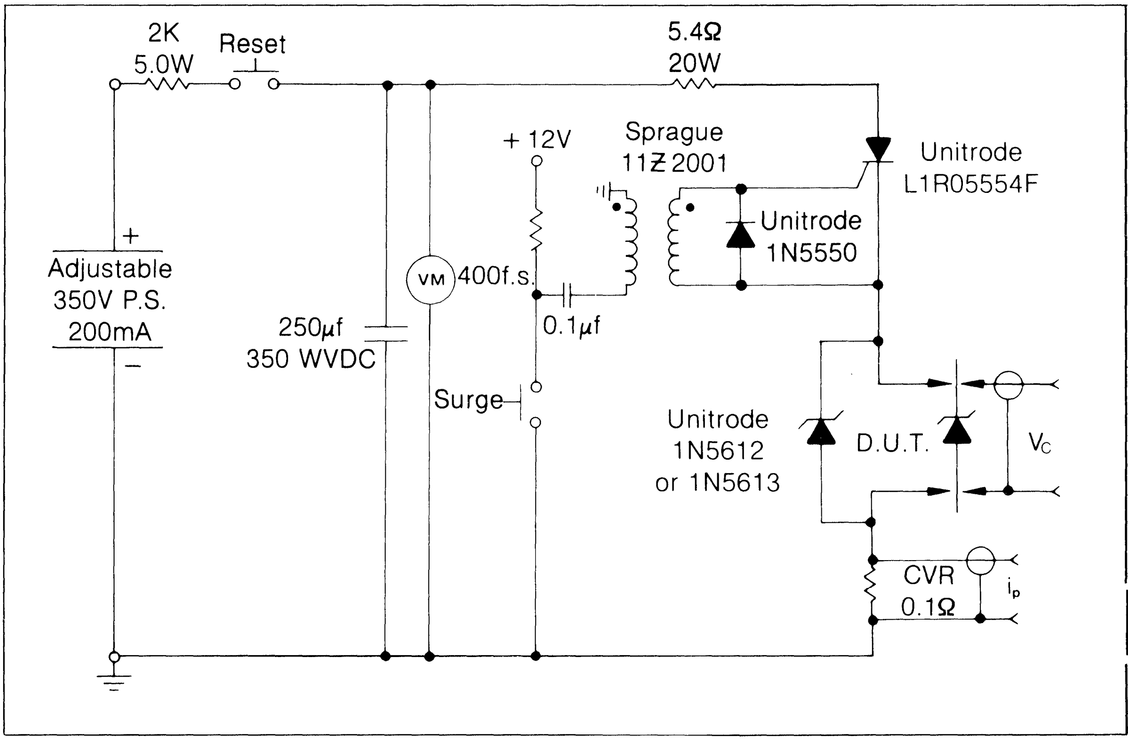


Figure 9 — Suggested Set-up for Surge Testing

4.0 Examples

4.1 Relay and Solenoid Applications

When the energy stored in the coil inductance of a relay or solenoid is released it can damage contacts or drive transistors. It can also produce EMI interference. A TVS used as shown in Figure 10 will provide reliable operation.

Just before the switch opens, the initial inductor current $I_O = \frac{V_{CC}}{R_L}$.

This is the worst case (maximum) current and assumes the switch was closed long enough for the circuit to reach steady-state.

After the contacts switch at $t = 0$, $e = -L\frac{di}{dt}$, and when using a TVS the change in coil current, $\frac{di}{dt} = \frac{V_C}{L}$. Referring to Figure 10d, $t_1 = \frac{I_O}{di/dt} = \frac{V_{CC}/R_L}{V_c/L} = \frac{V_{CC}L}{R_L V_c}$. Note that the higher the V_c of the TVS, the shorter the current decay time.

In order to select the proper TVS, determine:

1. Peak pulse power $P_p = I_p \times V_c$, where $I_p = I_o$.
2. Pulse time t_p (@ 50% down point of i_{TVS}) $= \frac{t_1}{2}$.
3. These values of P_p and t_p are used with graphs of pulse power vs. pulse duration provided on the TVS305 and TVS505 data sheet to select proper device. See example in Figure 2.

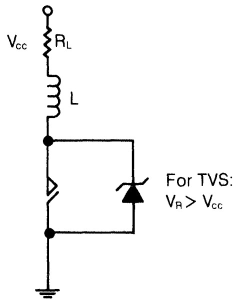


Figure 10a, DC Coil and Contacts.

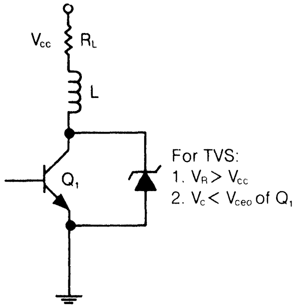


Figure 10b, DC Coil and Transistor.

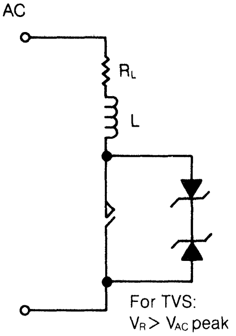


Figure 10c, AC Coil and Contacts.

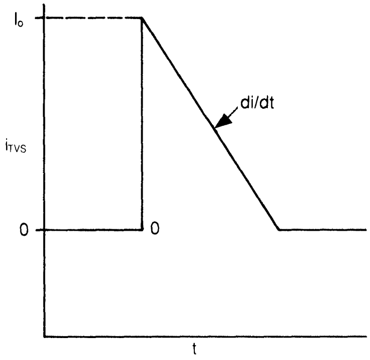


Figure 10d, Simplified Current Waveform in the TVS.

NOTE: In some cases, because of accessibility, the TVS must be located across the coil; in that case a diode should be used in series with the TVS, connected back to back as shown in Figure 11.

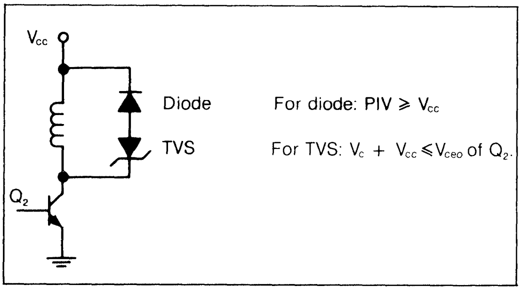


Figure 11 — Using TVS Across Coil

Sample Calculations:

For example, using the circuit of Figure 10a, and sample values of:

$V_{cc} = 14V, \quad L = 1mH, \quad \text{and} \quad R_L = 2\Omega;$

For V_{cc} = 14V, the next higher V_R is 15V. (Note that V_c = 22.2V at 10A).

STEP 1: $I_o = \frac{V_{cc}}{R_L} = \frac{14V}{2\Omega} = 7A$

$P_p = I_p \times V_c = 7.0A \times 22.2V = 155W$

STEP 2: $t_1 = \frac{V_{cc}/R_L}{V_c/L} = \frac{14/2}{22.2/10^{-3}} = 0.32mS$

so $t_p = \frac{0.32mS}{2} = 0.16mS = 160\mu S$

STEP 3: From Figure 2, P_{pmax} for $t_p = 160\mu S$ is 1200W, which is well above the circuit value of 155W.

4.2 Protecting Switching Power Supplies

The designer needs to protect against:

1. Load transients
2. Line transients
3. Internally generated transients including those produced by internal faults or failures.

Transients can produce failures because of their own high energy level; and also they can cause improper operation and component failure.

Figure 12 shows a simplified schematic of a typical switching power supply.

Referring to Figure 12, the TVS devices shown protect the following circuit components:

1. the rectifiers.
2. the HV switching transistors.
3. the output rectifiers.
4. the control circuitry.

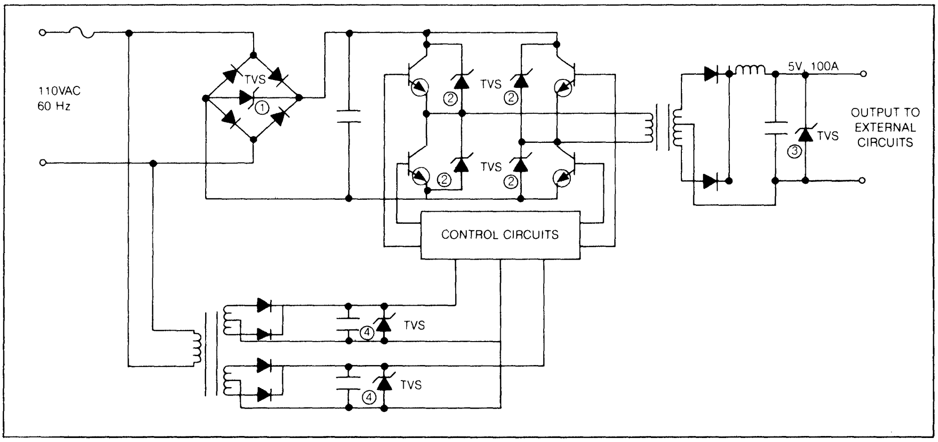


Figure 12 — Typical Switching Power Supply

4.3 Protecting Microprocessor Based Systems

While most microprocessor and IC semiconductor manufacturers design some form of diode-resistive input clamping network on the chip itself, transient voltage protection offered is very minimal — on the order of a few watts of pulse power. Manufacturers are also reluctant to make device performance and reliability claims when power supply operation extends beyond the maximum rated level of the individual device for even relatively short durations such as those that may be encountered during on-off transitions. Therefore, there is a need for some external protective device to suppress voltage transients, as shown in Figure 13.

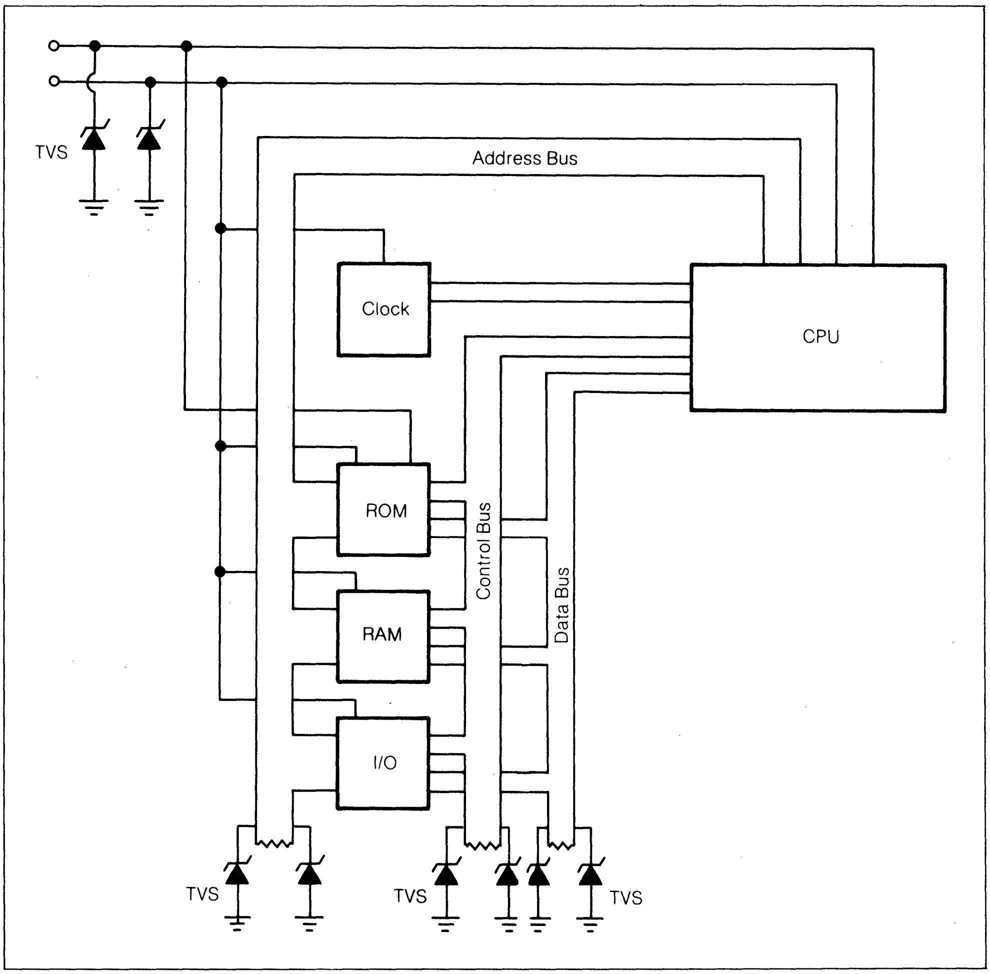


Figure 13 — Protecting Microprocessors

5.0 Alternative Protection Devices

Other protective devices such as MOVs, spark gaps, and crowbars have one common disadvantage when compared to zener TVS products; the response time is from nanoseconds to as much as tens of microseconds as compared to 1 pS for an avalanche zener diode. Even 50nS is long enough to allow a transient to destroy the small junctions used in most integrated circuits, logic, fast transistors, etc.

In circuits where transient pulses are fairly common, device degradation becomes a significant problem. TVS products do not significantly degrade even after 100,000 transients.

In many cases, the zener TVS and one of the alternative devices can complement each other. For example, when used with an SCR crowbar, the zener TVS will keep the voltage during a transient to an acceptable level until the crowbar, which may take 10μS to short the line, can protect the load circuits, and in the case of a heavy transient protect the smaller TVS as well.

OPERATING BUCK TYPE SWITCHING REGULATORS ABOVE 100 KHz

1. INTRODUCTION

Until now, most switching regulated power supplies have been designed to operate between 20 and 40KHz, generally because of various device limitations. Because of the recent availability of power MOSFETS, there has been considerable interest shown in operating switching power supplies at much higher frequencies (above 100KHz). The advantages and disadvantages of operating regulators at higher frequencies are discussed in this application note. Important characteristics of MOSFET and Bipolar devices are considered for buck type switching regulators. The circuit described presents an economical design of a buck type regulator that operates above 100KHz using bipolar devices(in this case the Unitrode PIC600 switching regulator output stage).

2. SWITCHING REGULATOR HIGH FREQUENCY CONSIDERATIONS

When "Off Line", including buck type, switching regulators are operated at higher frequencies, the following advantages are achieved:

A. Lower filter cost (L and C).
B. Reduced size and weight.
C. Improved transient response.
D. Effective, inexpensive and lightweight(aluminum) shielding of noise radiation (EMI)
E. Simpler EMI filtering.
F. Improved minimum loading requirements for multiple output voltage tracking.
G. Greater control over output ripple.

The disadvantages are:

A. Increase in transistor switching losses.
B. Increase in magnetic losses.
C. Increase in diode reverse recovery losses.

Normally the "Off Line" switching regulator operates at much higher input voltage than the popular "point-of-use" buck type switching regulator. Since switching losses are directly dependent upon the input voltage, switching characteristics become more significant in an "Off Line" switching regulator.

3. BUCK TYPE SWITCHING REGULATORS (LOW INPUT VOLTAGE)

A buck type switching regulator is normally used to (a) provide regulation of multiple outputs from the output of an "Off Line" switching regulator, (b) convert unregulated DC input voltage into regulated low voltage output, (c) drive a stepper motor drive, or (d) control the speed of a DC motor.

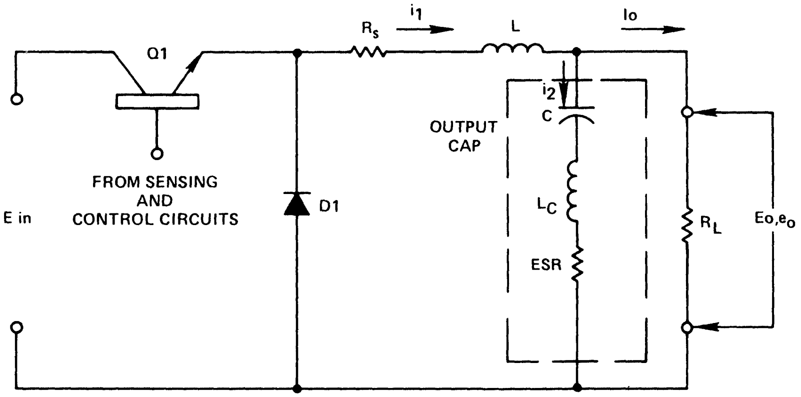


Fig. 1 Switching Regulator Basic Configuration (Buck Type)

Since this regulator operates at a lower input voltage than the "Off-Line" version, the power losses during switching are not significant up to 500KHz if the transistors and the catch diode are properly selected.

3.1 Turn-on Time

The shortest possible turn-on time of a pass transistor or MOSFET is limited by the reverse recovery time of the catch diode. Presently the fastest available recovery time of a power PN junction diode (such as the Unitrode UES1301) is about 20nSec. The Schottky diode also has about the same effective reverse recovery time due to its high junction capacitance. To minimize the over-shoot during the current rise time, one must increase the (turn-on) rise time of a MOSFET. A properly selected bipolar device (e.g. PIC600) matches perfectly without controlling current rise time.

Figure 2 shows the reverse recovery characteristics of a Schottky and a PN junction rectifier in a buck type switching regulator (Fig 1).

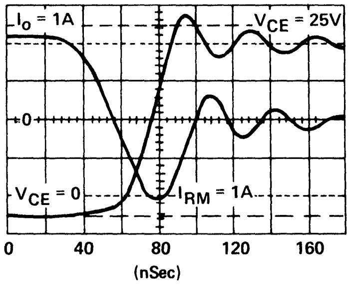


Fig. 2A Reverse Recovery of a Schottky Rectifier (SD41)

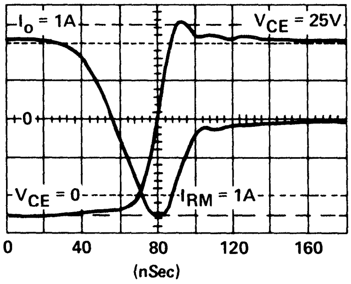
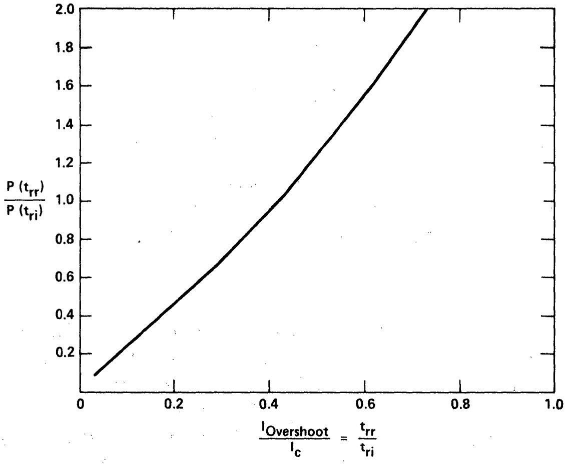


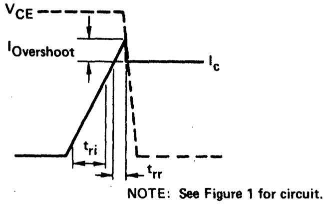
Fig. 2B Reverse Recovery of a PN junction (UES701)

NOTE: The ringing in Fig. 2A is due to the large junction capacitance and high Q of the Schottky Rectifier which is series resonating with a filter choke. This effect is negligible with a Unitrode PN junction device.

Thus, the losses during turn-on will remain the same regardless of whether the pass element is a bipolar or a MOSFET device.

The importance of the ratio of reverse recovery time to current rise time is shown in Figure 3. It is obvious that the current rise time of the MOSFET or bipolar transistor should be at least 3 times slower than reverse recovery time of the catch diode. Figure 4 shows the reverse recovery times, and current rise times of commercially available fast switching diodes and transistors.





t_{rr}:	Reverse Recovery Time, Rectifier.
t_{ri}:	Current Rise Time, Transistor.
I_c:	Collector Current.
$I_{overshoot}$:	Overshoot of Collector Current Due to Reverse Recovery.
$P(t_{rr})$:	Power Dissipation in Transistor Due to Reverse Recovery Time.
$P(t_{ri})$:	Power Dissipation in Transistor Due to Current Rise Time.

Fig. 3 Importance of Current Rise Time of a Transistor and Reverse Recovery of a Rectifier

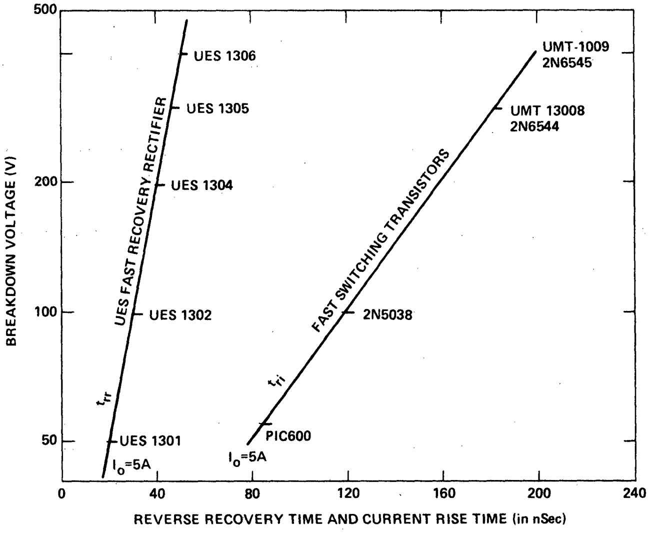


Fig. 4 Switching Times vs Breakdown Voltage (Unitrode Rectifiers and Transistors)

3.2 Storage Time

Since the bipolar transistor is a minority carrier device it has a finite storage time. This time can be significantly reduced if the device is clamped out of saturation. In a low voltage device, there is less majority carrier injection in the collector region, due to its lower collector resistivity, than in high voltage devices. By preventing the output transistor from saturating, significant improvement in the storage time can be achieved. The Unitrode PIC600 series device (see Fig.5) provides a natural clamp. The output device, Q1 which carries the loadcurrent, is kept out of saturation by driver transistor, Q2. The driver transistor operates in saturation mode. At frequencies above 100KHz however, the storage time of the driver transistor , Q2, needs to be reduced.

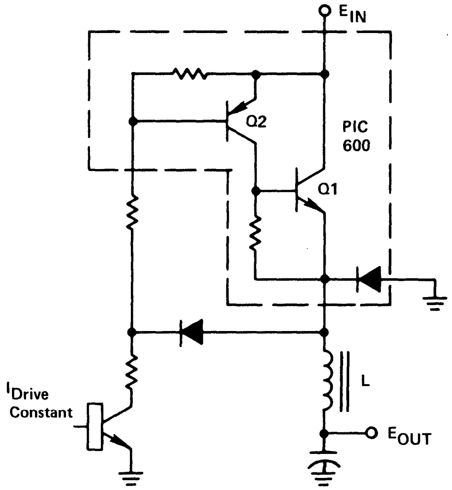


Fig 5 Simple Clamped Circuit

The circuit shown in Figure 5 reduces the overall storage time of the PIC 600 to less than 100nSec without complicating the drive circuit, at the expense of increased $V_{CE(SAT)}$. When the ratio of the input to output voltage is high (factor of $\sim$ 3 or more) the DC loss in a transistor is low compared to other losses when operating at frequencies above 100 KHz (see Fig.6). The maximum operating frequency is determined by the storage time. In general, the maximum operating frequency of a switching regulator for a given storage time can be determined by the equation;

$$f\ max = \frac{0.2 \times E_{out}}{E_{in(max)} \times t_{s(max)}}$$

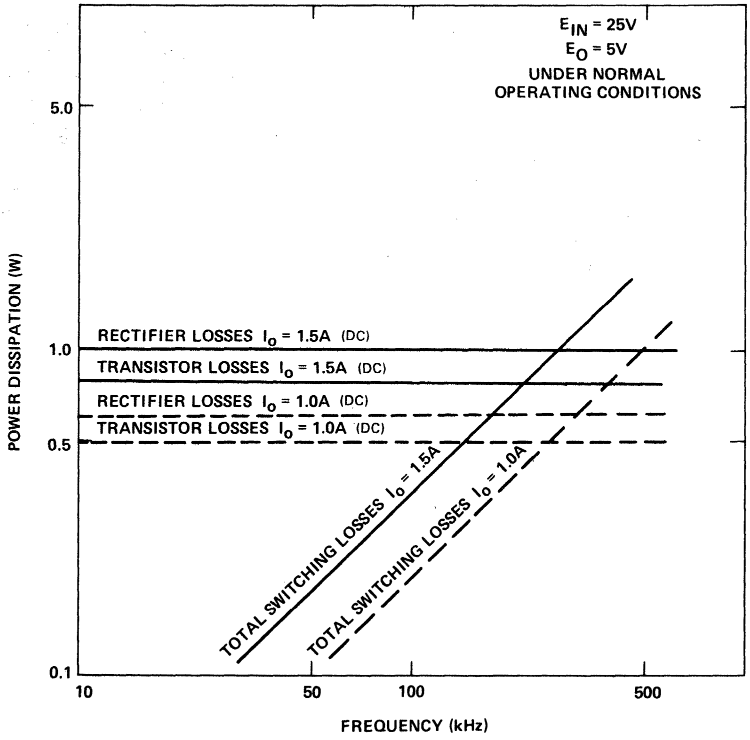


Fig. 6 Switching Losses in a Transistor and Rectifier of a PIC600 Switching Regulator Output Stage

For a 100nSec storage time, the maximum operating frequency will be 400KHz where E_O = 5V, E_{in} = 25V.

3.3 Fall Time

MOSFET devices will provide faster fall time than bipolar devices providing the drive current is large enough to discharge the input capacitance quickly. However, as pointed out earlier, in a low voltage switching regulator the switching loss during the fall time is a very small percentage of the total power losses.

3.4 $E_{S/B}$ and $I_{S/B}$

Since the inductive load is clamped by diode, the bipolar pass transistor does not experience reverse bias second breakdown ($E_{S/B}$) in a buck switching regulator. Forward bias second breakdown can be prevented by providing adequate drive current and by preventing the core of the inductor from saturating.

3.5 QUASI-SAT LOSSES.

The output device of a PIC600 is highly interdigitated which minimizes operating in the QUASI-SAT region. Thus turn-on losses during QUASI-SAT are avoided.

4. OTHER CONSIDERATIONS.

4.1 Magnetics

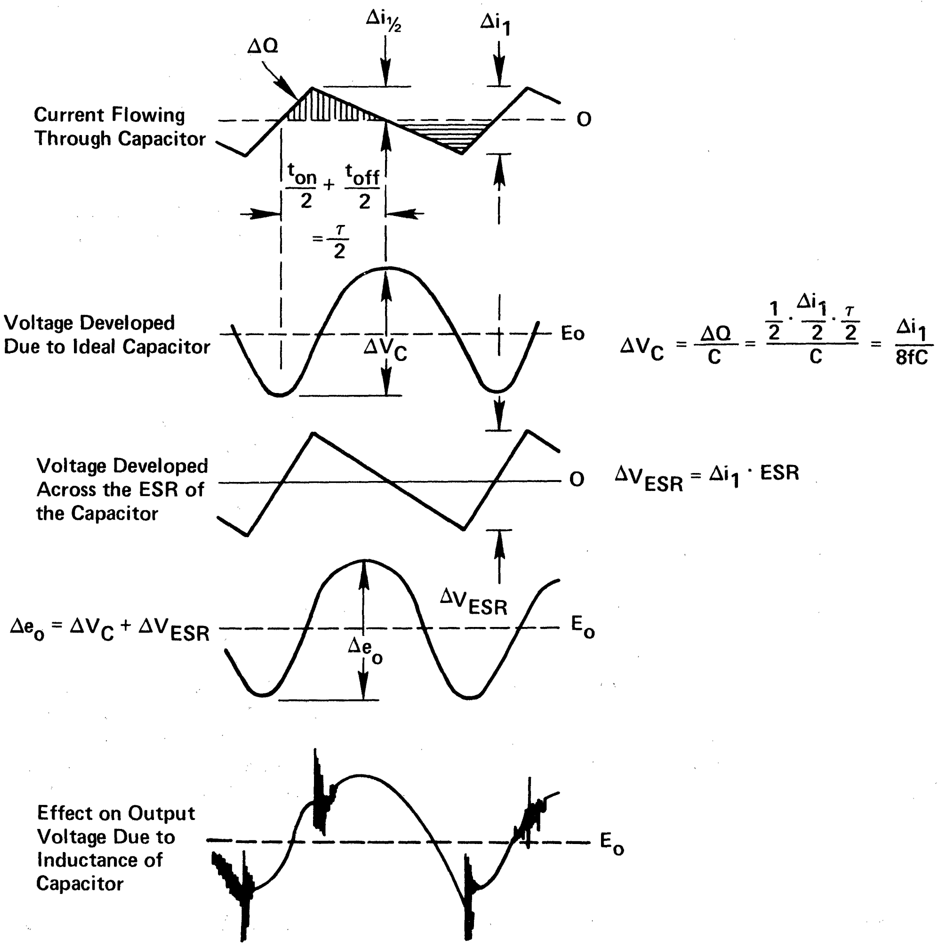
Generally, hysteresis losses in the magnetic material will increase significantly when an inverter is operating at a higher frequency because of the wide variation of the magnetic flux over the period of a cycle. To minimize the hysteresis losses and leakage inductance losses, proper selection of a core shape magnetic material is required.

However, the hysteresis losses in the magnetic components of a buck type switching regulator are low compared to those in an inverter because the change in the flux is limited over a period of a cycle. Furthermore there are no leakage inductance losses in the buck regulator. The selection of the inductor and its' shape for a buck type switching regulator is therefore, less critical. To minimize the radiation due to the changing magnetic field in the filter inductor, it is advisable to use a gapped pot core or a toroid.

4.2 Capacitor

The output ripple voltage of a switching regulator depends not only upon the value of the capacitor, but also on its effective series resistance (ESR). The ESR of the capacitor is inversely dependent upon the value of the capacitor. Since the output ripple voltage depends upon the ESR of the capacitor, paralleling capacitors is helpful. This, however, may affect the transient response of the switching regulator.

At higher frequencies, the inductance of the capacitor becomes significant. The equivalent circuit of the capacitor (C_{out})is shown in Figure 1. The effects of the ESR and inductance of the capacitor can be observed at the instant when an abrupt change in di/dt occurs (see Fig 7). A solid tantalum or electrolytic capacitor has a higher ESR than a high frequency bypass capacitor like metallized polypropylene, polystyrene foil and ceramic. However, the value of the capacitance available in these types is low compared to solid tantalum or electrolytic capacitors. When switching regulators are operated at a higher frequency , the output ripple voltage is more dependent upon the ESR and the inductance of the capacitor than its capacitance.



$$\Delta V_C = \frac{\Delta Q}{C} = \frac{\frac{1}{2} \cdot \frac{\Delta i_1}{2} \cdot \frac{\tau}{2}}{C} = \frac{\Delta i_1}{8fC}$$

$$\Delta V_{ESR} = \Delta i_1 \cdot ESR$$

Fig. 7 Effect on the Output Ripple Voltage Due to Parasitics of the Output Capacitor

4.3 Circuit Layout and RFI

Circuit layout is another important consideration in a high frequency switching regulator. Every inch of wire adds 20nH to the circuit. Any extra lead length of the wire produces unwanted ringing and also radiates energy into the environment. The length of the high di/dt path should be kept to a minimum and, where necessary, bypassed with a ceramic capacitor. Twisting the wire of the transformer and arranging the high current paths such that they oppose each other will reduce the radiated energy to the environment. The layout of the circuit should be designed such that it minimizes the ground loop problems by separating the high current path from the small signal circuit current.

5. CIRCUIT DESCRIPTION

The circuit described in this section provides a simple and economical design of a buck type switching regulator operating at 250KHz with an existing bipolar device (PIC600). The main advantages of operating a switching regulator at a higher frequency are (a)reduction in the size of the inductor required to obtain low output ripple voltage, (b) improved transient response and (c)reduction in cost, size and weight.

The complete circuit is shown in Figure 8. It converts unregulated 25V input voltage into a regulated +5V output voltage. Significant improvement in the storage times and voltage fall time is achieved with a clamping diode, D1 and resistors R1 and R2. Since the Unitrode PIC600 operates with a constant current base drive, a fixed voltage drop is developed across R_2.

The voltage is clamped across the collector to emitter of the output device by the clamping diode, D_1, and is given by the equation:

$$V_{CE} \text{ clamped} = I_{drive} \times R_2$$

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Under normal operating conditions, the important operating parameters of the PIC600 at output current of 1A and 2A are listed below:

	I_O=1A	I_O=2A
Voltage Rise Time	24nSec	24nSec
Voltage Fall Time	36nSec	56nSec
Current Rise Time	28nSec	40nSec
Current Fall Time	66nSec	84nSec
Storage Time	76nSec	160nSec
Diode Forward Drop V_F	0.74V	0.82V
Saturation Voltage $V_{CE(SAT)}$	2.5V	2.5V

The switching losses at 250KHz are less than 0.5W, so that the overall efficiency of the PIC600 is greater than 78%.

The constant base drive current to the PIC600 switching regulator output stage is provided by operating transistor Q_1 and the output transistor of the SG1524 in series as an AND gate. The base of the transistor Q_1 is connected to the reference output voltage (+5V) of the SG1524, PWM voltage regulator integrated circuit. The amount of drive current to the PIC600 is determined by resistor value R_3 and is given by the equation:

$$I_{drive} = \frac{3.5V}{R_3}$$

The current limit is achieved with current sense resistor R_{10} and transistor Q_2.

There is sufficient gain in the error amplifier of the SG1524 to operate up to 500 KHz. The fixed dead-band period of the SG1524 is not adversely effected in buck type switching regulator applications.

Capacitor C_1 improves the high frequency response and provides stability in the circuit.

6. CONCLUSION

The circuit described in this application note provides an economical approach to the high frequency buck type switching regulator using a bipolar device instead of a MOSFET device. The circuit operates with a simplified drive circuit and provides improvement in a transient response and reduction in size, cost, and weight. The circuit efficiency is greater than 78% and provides control over output ripple voltage without a large inductor.

The PIC625 switching regulator output stage can be operated at a 5A level at an operating frequency of 250-500KHz.

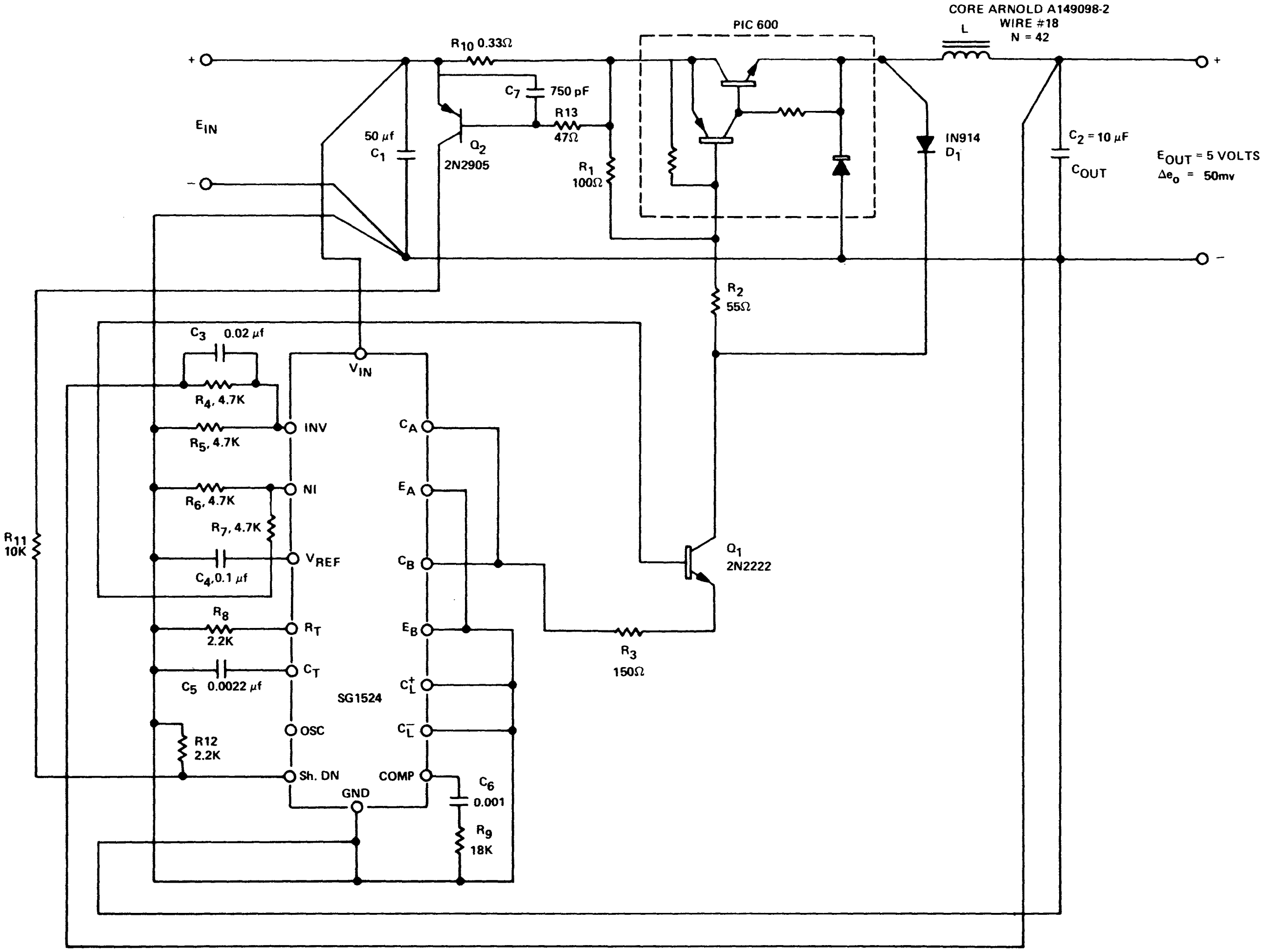


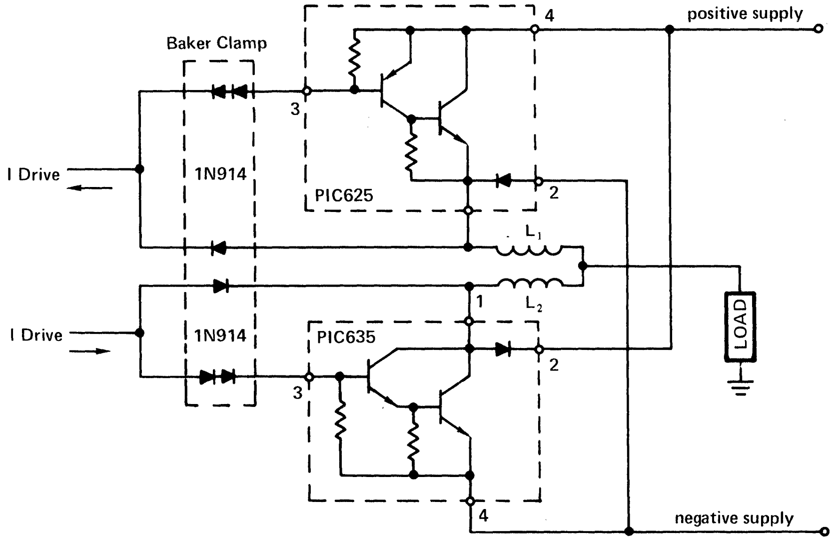
Fig. 8 Complete Circuit Diagram

MINIMIZING STORAGE TIME WHEN USING UNITRODE SWITCHING REGULATOR POWER OUTPUT CIRCUITS (PIC600 SERIES)

In some applications (such as a reversing motor drive, for example: stepper motor) where storage time is an important consideration in the design, the normal storage time of PIC600 series (approximately 600ns) can be reduced to acceptable level.

At lower output currents, the excess storage time is a result of the driver stage operating well under saturation, while at higher output currents it is a result of the output transistor operating into quasi-saturation region.

The storage time can be reduced to less than 100ns by utilizing a Baker Clamp technique as shown in the circuit below:



The Baker Clamp will increase the $V_{CE(sat)}$ losses but this disadvantage will be more than offset by the improved switching speed.

The Baker Clamp circuit varies the drive current of the PIC600 series for optimum switching speed at any given load current. The drive current required to the Baker Clamp can be unregulated, as long as it is greater than 30mA.

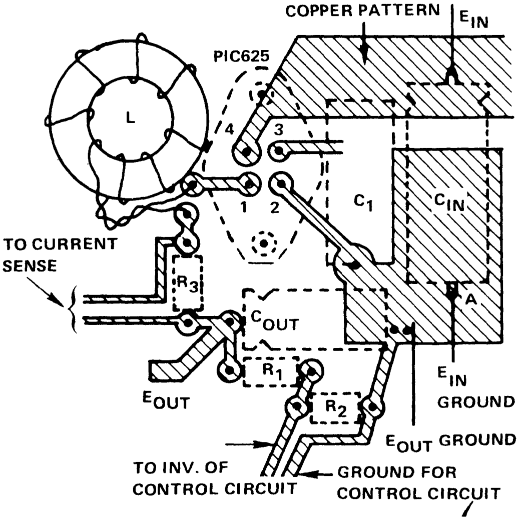
The small value of the inductor L_1 and L_2 (5 to 10 μH) stops cross conduction during the switching of PIC600 series.

AVOIDING SPURIOUS OSCILLATION WHEN USING UNITRODE SWITCHING REGULATOR POWER OUTPUT CIRCUITS (PIC600 SERIES)

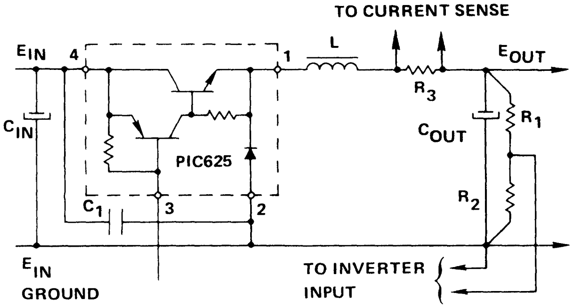
Avoid spurious oscillation due to ground loops and RFI when using a Unitrode Switching Regulator Power Output Circuit (PIC600 Series) in a switching regulator.

The Unitrode switching regulator power output stage (PIC600 Series) is a high frequency fast switching device. Its control circuitry must also operate at high frequency and high gain. Therefore, it is necessary to avoid any ground loops and RFI for stable circuit operation.

The high frequency roll-off of the control circuit should be adjusted properly with a compensation network. The typical layout of the power circuit is shown in the figure below.



PC BOARD LAYOUT OF POWER CIRCUIT



CIRCUIT DIAGRAM

Capacitor C_1 (0.2 μf) reduces the RFI generated due to the reverse recovery current spike of the catch diode, and should be physically located near pin 4 and pin 2 of the PIC625. The capacitor should be a high frequency by-pass capacitor, such as Polystyrene.

The current sense resistor R_3 should be a non-inductive (carbon) type. The current sense signal should be picked up right across this resistor.

If the switching regulator is operated at the higher end of the input voltage, the inductor should be shielded with an electrostatic shield, grounded to Point A. The case of PIC625 should also be connected to Point A.

HOW TO SAFELY CHECK SUSTAINING VOLTAGE ON POWER TRANSISTORS

One of the most important parameters for any power transistor, particularly in switching applications with inductive loads, is the sustaining voltage. Many manufacturers specify only open base sustaining voltage ($V_{CEO(SUS)}$) at a low current level (10 to 200mA); and, even where sustaining voltage with resistive bias ($V_{CER(SUS)}$) or voltage bias ($V_{CEX(SUS)}$) is specified on a data sheet, the chances are that it will not be specified under the exact conditions that will be required by a specific application. Because of this, many designers select a transistor based on its $V_{CEO(SUS)}$ rating, since V_{CER} or V_{CEX} will always be greater than V_{CEO} (see Figure 1 for a graphical explanation of the relationship among V_{CEO}, V_{CER} and V_{CEX}).

By choosing a transistor based upon its V_{CEO} rating, the designer may be using a higher voltage device than necessary. If he could determine the voltage under the actual conditions of his application, it is possible that a lower voltage device could be used, resulting in considerable cost savings. Figure 2 presents a test circuit that can be used to safely measure sustaining voltage under any bias condition at collector currents up to 5A.

> PLEASE NOTE: SUSTAINING VOLTAGE SHOULD NEVER BE READ ON A CURVE TRACER, EVEN AT LOW CURRENT LEVELS, SINCE POWER RATING OR REVERSE-BIASED SECOND-BREAKDOWN RATING ($E_{S/b}$) MAY BE EXCEEDED, RESULTING IN PERMANENT DAMAGE TO THE TRANSISTOR.

The test circuit of Figure 2 may also be used to check a transistor's $E_{S/b}$ rating if the zener clamp is removed. $E_{S/b}$, under a specified bias condition of R_{BB} and V_{BB}, is related to collector current and inductance as follows:

$$E_{S/b} \text{ (joules)} \cong 1/2 L i^2$$

Where i is the peak collector current flowing at the time the transistor is turned-off.

It should be noted, however, that the transistor is not protected without the zener clamp, and the device may be damaged or destroyed if it does not meet its $E_{S/b}$ rating.

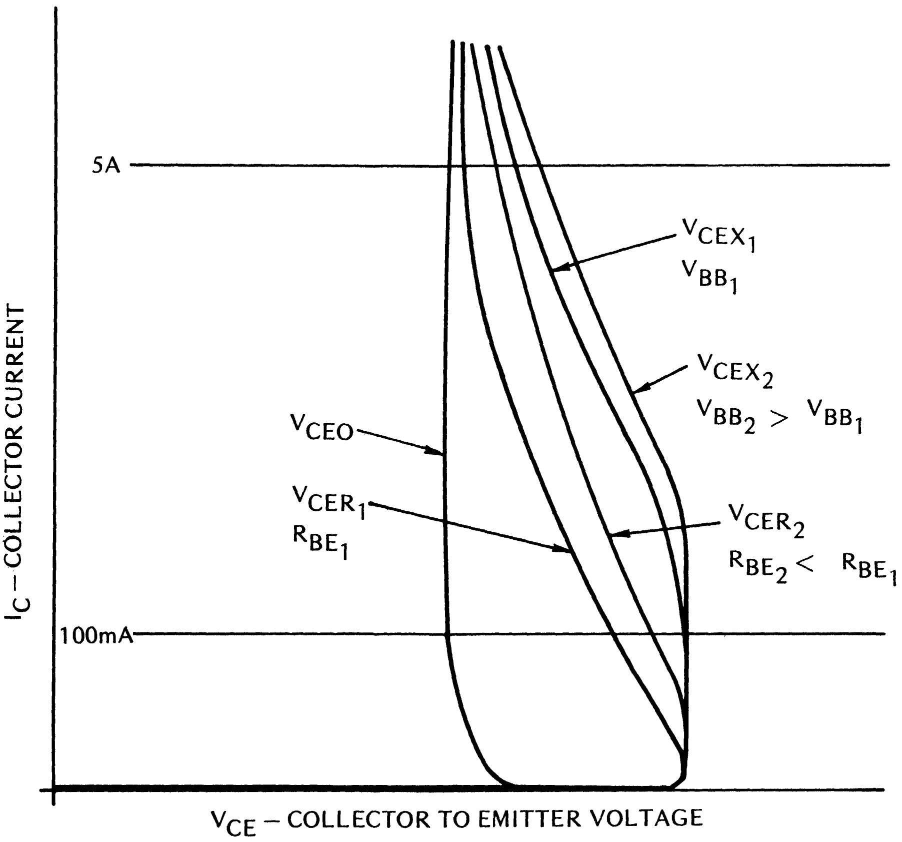
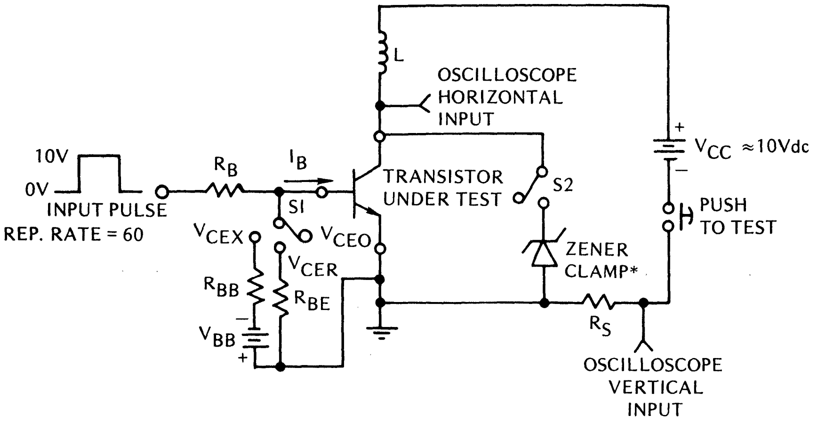


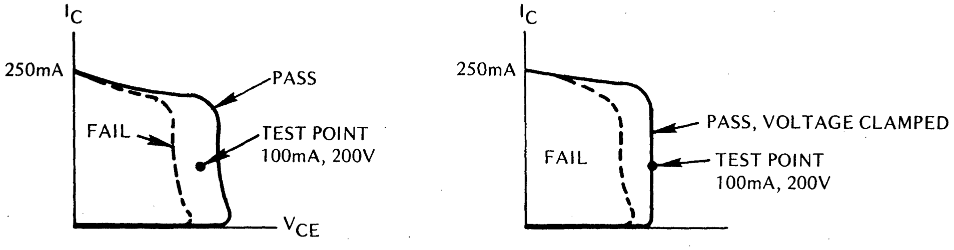
Fig. 1. Relationship among $V_{CEO(SUS)}$, $V_{CER(SUS)}$, $V_{CEX(SUS)}$
(Not to Scale)



*ZENER CLAMP VOLTAGE SHOULD BE EQUAL TO THE MINIMUM SPECIFIED VALUE OF THE V_{CEO}, V_{CER} OR V_{CEX} VOLTAGE BEING CHECKED.

VOLTAGE RATING (V_{CEO}, V_{CER}, V_{CEX})	TEST CURRENT (I_C)[1]	INDUCTOR (L)	CURRENT SENSE (R_S)	I_B	INPUT PULSE WIDTH
⩽80V	⩽50mA	50mH	10Ω	0.1(I_C)	350μSec
	50mA–200mA	20mH	5Ω	0.1(I_C)	525μSec
	200mA–1.0A	2mH	1Ω	0.1(I_C)	250μSec
	1.0A–5.0A	0.5mH	0.2Ω	0.1(I_C)	325μSec
80V–200V	⩽50mA	100mH	10Ω	0.1(I_C)	800μSec
	50mA–200mA	40mH	5Ω	0.1(I_C)	1.0mSec
	200mA–1.0A	4mH	1Ω	0.1(I_C)	550μSec
	1.0A–5.0A	1mH	0.2Ω	0.2(I_C)	650μSec
⩾200V	⩽50mA	200mH	10Ω	0.1(I_C)	1.5mSec
	50mA–200mA	80mH	5Ω	0.1(I_C)	2.0mSec
	200mA–1.0A	10mH	1Ω	0.2(I_C)	1.25mSec
	1.0A–5.0A	2mH	0.2Ω	0.2(I_C)	1.25mSec

1. THE ZENER CLAMP SHOULD ALWAYS BE USED WHEN TESTING AT COLLECTOR CURRENT VALUES ABOVE 200mA SINCE THE REVERSE-BIASED SECOND-BREAKDOWN ($E_{S/b}$) RATING OF THE TRANSISTOR UNDER TEST MAY BE EXCEEDED.



REPRESENTATIVE SCOPE TRACE FOR UNCLAMPED TEST AT I_C = 100mA

REPRESENTATIVE SCOPE TRACE FOR CLAMPED TEST AT I_C = 100mA

Fig. 2. Test Circuit for $V_{CEO(SUS)}$, $V_{CER(SUS)}$, $V_{CEX(SUS)}$

OPERATING THE SWITCHING REGULATOR OUTPUT CIRCUIT (PIC600 SERIES) AT LOW FREQUENCIES

The Unitrode switching regulator power output circuit consists basically of a power transistor switch and a catch diode. The appropriate data sheets in the Unitrode Semiconductor Databook provide the necessary information for determining junction temperature and power dissipation at frequencies above 10 kHz.

This Design Note provides a method for determining the junction temperature and maximum allowable power dissipation for the transistor switch and catch diode when the switching regulator is operated at frequencies under 10 kHz, where the switching losses are negligible and can be safely ignored.

The method of determining safe power dissipation requires a detailed transient thermal analysis, since the junctions of the transistor and diode are subjected to temperature excursions due to the applied pulse power.

When the device is subjected to a train of periodical power pulses, the maximum power dissipation and junction temperature can be calculated from the effective pulse thermal resistance (θ_p) as follows:

$$\theta_p = R_T \times D + (1-D)\ r(t+\tau) - r(\tau) + r(t)$$

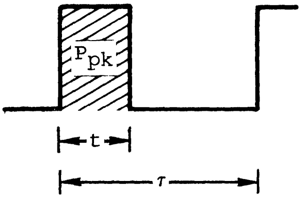


Figure 1. Power Pulses

where: t = pulse width

τ = period

Duty cycle $D = \frac{t}{\tau}$

Peak Power, P_{pk} is peak of an equivalent square power pulse

$r(t+\tau)$ = transient resistance at time $t+\tau$

$r(t)$ = transient thermal resistance at time t

R_T = DC thermal resistance (from data sheets)

1. Calculating the Junction Temperatures (Pulse Train)

A. Power Transistor Switch

The peak junction temperature of the transistor switch under repetitive peak power pulse conditions is calculated as follows:

$$T_{j\,(peak)} = T_{CASE} + P_{pk} \times \theta_{p}$$

$$T_{j\,(peak)} = T_{CASE} + V_{CE} \times I_{C} \times \left[R_{T} \frac{t_{T}}{\tau} + \left(1 - \frac{t_{T}}{\tau}\right) \times r(t_{T} + \tau) - r(\tau) + r(t_{T}) \right]$$

The transient thermal impedances $r(t_T + \tau)$, $r(\tau)$, $r(t_T)$ are obtained from the transient thermal impedance plot for the transistor (see Figure 2),

t_T = transistor on-time

B. Catch Diode

The peak junction temperature of the catch diode under repetitive peak power pulse condition is calculated as follows:

$$T_{j\,(peak)} = T_{CASE} + I_{F} \times V_{F} \left[R_{T} \times \frac{t_{D}}{\tau} + \left(1 - \frac{t_{D}}{\tau}\right) r(t_{D} + \tau) - r(\tau) + r(t_{D}) \right]$$

where:

t_D = diode on-time

The Transient thermal impedances $r(t_D + \tau)$, $r(\tau)$, $r(t_D)$, are obtained from the transient thermal impedance plot for the catch diode (see Figure 2).

C. Power Dissipation

The maximum allowable power dissipation in either the transistor or the diode is determined by the maximum junction temperature of 150°C:

$$P_{pk(max)} = \frac{150°C - T_{CASE}}{\theta_p}$$

2. Calculating the Junction Temperature (Single Shot Power Pulse)

For a non-repetitive power pulse, the rise of junction temperature can be calculated as follows:

$$T_j = P_{pk} \times r(t) + T_{CASE}$$

For a pulse with less than 100 millisec, the case temperature is assumed to remain at ambient temperature.

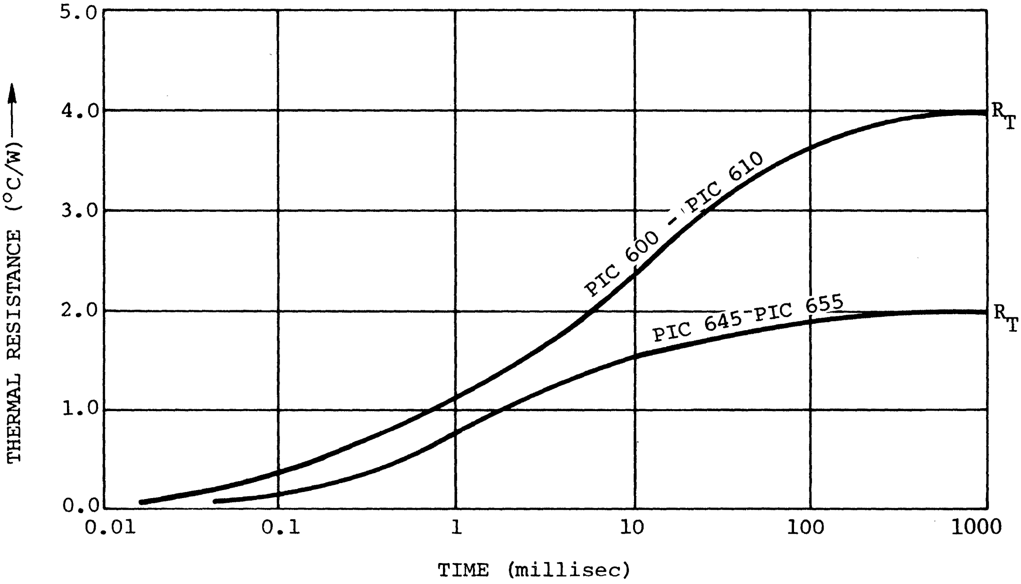


Figure 2. Transient Thermal Resistance — Power Transistor or Catch Diode

DESIGN NOTE DN-7

THE UNITRODE SCHOTTKY RECTIFIER — A NEW DESIGN TOOL FOR SWITCHING POWER SUPPLY ENGINEERS

1. Advantages of Schottky Rectifiers Over Conventional PN Junctions.

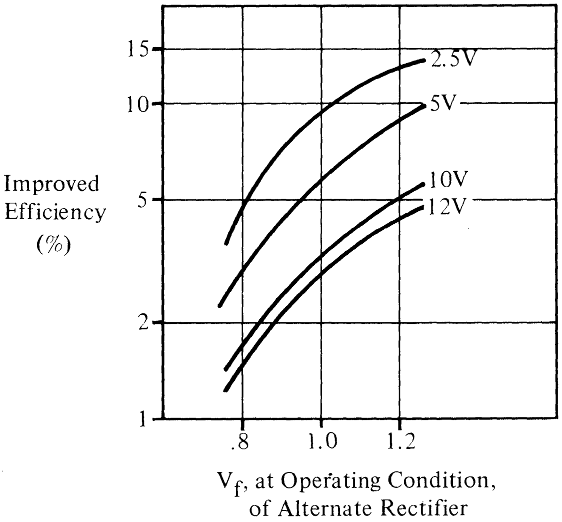
In today's power supplies with low DC output voltages the Schottky rectifier provides the opportunity to achieve the highest efficiency possible. This is due to its naturally lower forward voltage than P-N silicon junctions and, for "switching" supplies where it is most often used, very low recovery times and recovered charge.

The primary benefits of higher efficiency are, of course, reduced heat sink requirements, less heat generated and less power wasted. An additional feature is the rather soft recovery characteristic which will often keep voltage "spiking" and generated EMI low.

As a "catch" diode for buck-type 20 kHz switching regulators the improvement in efficiency with the use of a Schottky rectifier is directly related to diode on time, $t_{D(on)}$. This, in turn, increases as the difference between input and output voltage increases, i.e.,:

$$t_{D(on)} = \frac{V_{in} - V_o}{V_{in}} \times \frac{1}{f}$$, where f is the switching frequency.

When used as an output rectifier for inverter circuits, however, one finds the largest improvement efficiency (see curve below). For all applications, the improvement is most significant when the output voltage is low.



Advantage of Schottky over alternate rectifier choices due to lower V_F, – used as output rectifiers for inverters with DC output as shown. This example is based on 100A output and 125 C junction temperatures.

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2. Advantages of Unitrode Schottky.

The search for extended temperature performance and higher reliability has continued since Schottky power rectifiers were first introduced.

Unitrode Corporation has introduced devices which have the lowest reverse current yet offered at high temperature. Furthermore, change in reverse current with temperature is much less than with conventional devices or other Schottkys. This behavior substantially raises the threshold of thermal runaway, even when limited heat transfer is provided (high $R\theta_{CA}$ as with a relatively poor heat sink). Additionally, our high conductivity design, using a heavy copper top post and low series resistance, ensures cool terminal operation and low dynamic impedance.

Reliability is further enhanced by materials and construction which provide thermal-fatigue-free life through many thousands of cycles.

3. Measurement Considerations and Precautions.

A. TRANSIENT DAMAGE

Greater caution must be used because Schottkys are more sensitive to voltage transients and to high rate of rise of applied reverse voltage (dv/dt) than PN junction rectifiers. Even a non-repetitive, one-tenth microsecond transient can cause permanent damage.

When measuring reverse current never exceed the reverse voltage rating or the dv/dt rating, even on a transient basis. Sudden application of a voltage on the device in a test set-up may overstress it with a transient too "fast" to be observed. It is therefore advisable, when measuring reverse current (or observing the reverse characteristic on a curve tracer) to use a 1KΩ resistor in series with the device and *never* "switch on" an open circuit voltage *exceeding the rated PRV.* Even when "sweeping out" reverse voltage on a curve tracer *do not exceed PRV.*

B. REVERSE CURRENT MEASUREMENTS

Do not expect the reverse current at room ambient to be of orders of magnitude lower than at rated high temperature, as is common with PN junction rectifiers. While Unitrode Schottky devices change *less* with temperature than competitive devices, they may exhibit higher reverse currents at room temperature. The high temperature reverse current is the significant parameter, however, since it reflects actual operating conditions. *At elevated temperatures, the Unitrode Schottky rectifier will have lower reverse currents than other manufacturers.*

To obtain values which correlate with the manufacturer's published data, it is necessary to measure reverse current under specified (low duty) pulsed conditions, rather than with DC applied.

C. FORWARD VOLTAGE MEASUREMENTS

At low current and room temperature the forward voltage may be higher than other manufacturers. The low dynamic impedance, however, makes this voltage more uniform as current increases. At higher current, even at room temperature, the Unitrode forward voltage compares very favorably. *At expected operating conditions the Unitrode Schottky rectifiers will have a more favorable low and uniform forward voltage.*

All forward voltage measurements should be made with the Kelvin 4-terminal method, to nullify the error otherwise due to test clip contact and test lead resistance, and with specified low duty pulses to maintain desired junction temperatures. (Note that pulsed base current on a curve tracer does *not* maintain low duty on a rectifier, – a pulsed collector supply must be used).

A 350 WATT SWITCHING REGULATED OUTPUT POWER SUPPLY FOR MULTIPLE OUTPUTS UTILIZING UNITRODE SEMICONDUCTOR COMPONENTS

There are many ways a switching power supply can be designed to obtain regulated output voltages. When multiple outputs are desired, such as ±5 volts and ±12 volts, the circuit described below provides the basis for an efficient, economical, and reliable power supply. It consists of a pulse width modulated buck regulator and a synchronized "H" (full bridge) inverter, each leg of which operates at 50% duty cycle. The block diagram of the power supply is shown in Figure 1.

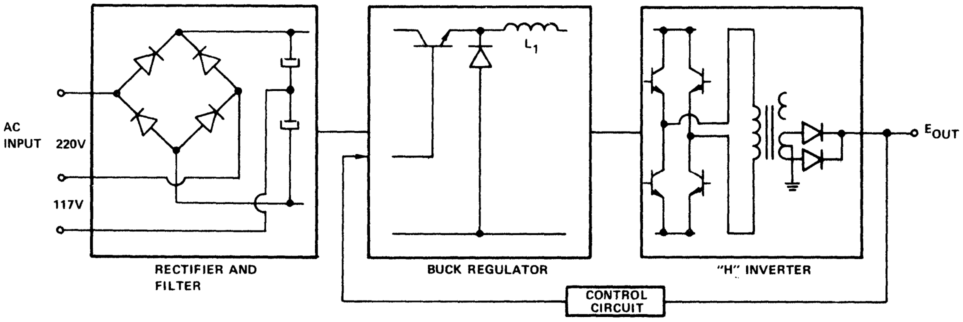


Figure 1. Block Diagram

The advantages of this design approach are as follows:

1. Numerous inductors (normally needed when pulse-width modulating an inverter) are not required. No filter inductor is required in the output which lowers costs. Minimum load bleeder resistors are not needed, thus improving efficiency and excessive heat generation. These features result from the "H" inverter operating at 100% duty cycle.
2. A high voltage, low ESR capacitor in series with the power transformer is not required. The problem of excessive collector current in an "H" inverter stage due to "walking of core flux" on a saturated B-H curve is eliminated.
3. There is no possibility of high current or forward-biased second breakdown in the inverter bridge transistors when they are simultaneously on during switching periods. The "cross-current" is limited by the inductor, L_1, (the buck regulator acts as a constant current source) which increases reliability. Furthermore, the transistors are in saturation during cross conduction again improving efficiency, and reducing heat generation.

4. Only one high voltage switching transistor is required for either 110 or 220V input.
5. There is no possibility of forward-biased second breakdown in the bridge transistor during initial turn-on ("start-up").
6. No expensive high voltage filter capacitor is needed. Filtering is achieved with a low voltage output capacitor.

Description of the Circuit:

The buck regulator, "H" inverter and control circuit is described in brief in this section. The detailed schematic of the circuit is shown in Figure 2.

A. Buck Regulator:

The output stage of a buck regulator consists of a Unitrode Barrier transistor^{TM} UMT1009 and a fast recovery (50 nanoseconds) high voltage catch diode, the Unitrode UES1306. The buck regulator is operated at 50 kHz, twice the operating frequency of the "H" inverter, with very low switching losses. Operating the buck regulator at higher frequency reduces the cost of the filtering inductor, L_1.

The output voltage is regulated in this stage by employing a pulse-width modulation technique using a Silicon General Monolithic integrated circuit SG1524. The output of the filter inductor is clamped below the BV_{CEO} of transistors used in an "H" bridge with a Unitrode zener diode UZ4212. This diode absorbs the energy stored in inductor L_1 during the period when energy is not coupled into the secondary due to the leakage inductance of power transformer T_3. Notice that there is no output filter capacitor in the buck regulator. This design feature limits excessive cross conduction collector current in the transistors of the "H" inverter.

The base drive current to the pass transistor is provided with a unique transformer coupled drive circuit. It provides base drive current up to 100% duty cycle if required. Furthermore, a small amount of energy stored in a ferrite bead in the base drive circuit provides assistance in turning off the high voltage pass transistor.

B. "H" Inverter:

The "H" inverter operates at 25 kHz, with a 50% duty cycle in each leg, synchronized with the buck regulator. It utilizes four low voltage 2N6354 transistors. Low voltage transistors offer low $V_{CE(SAT)}$, high gain and fast switching times. Due to high gain, the base drive current required is low.

The switching losses are kept to a minimum by switching the transistors when inductor, L_1, current is at a minimum. The storage time of the transistor is kept to a minimum by reducing the base drive just prior to transistor turn-off. (The base drive current is highest when transistor is turned on and reducing linearly.)

The diodes $D_1 - D_4$ provide the path for magnetizing current at lower output current as well as the path for energy stored in the leakage inductance of the power output transformer.

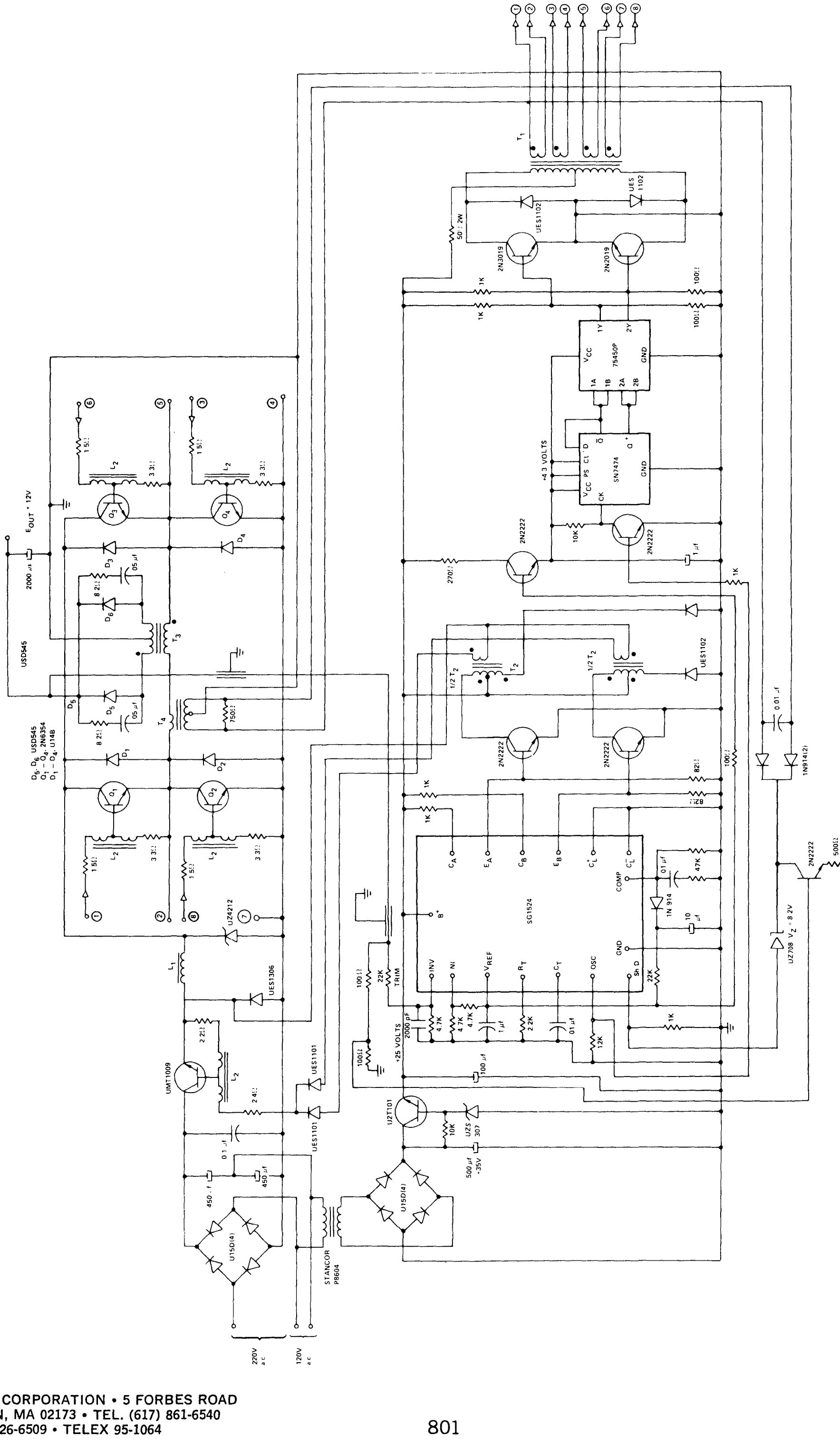


Figure 2. Detailed Schematic of 350 Watt Switching Regulated Output Power Supply

XIV

Current limiting is obtained with a current transformer. The level of the current limit is maintained constant regardless of temperature by effectively using two diodes in series with an 8.2 volt zener (Z_2) UZ708. Only one driver transformer is used for all four transistors. The transistor turn-on and turn-off is enhanced with a ferrite bead in the drive circuit.

The output is rectified with Unitrode USD545 Schottky Rectifiers which provide the advantages of low V_F at high current and minimum change in leakage current with temperature. The snubber network across the Schottky diodes prevent reverse bias breakdown from the large voltage spikes due to leakage inductance in the power transformer, and reduces RFI.

C. Control and Drive Circuits:

The regulation function is achieved with a Silicon General SG1524 P.W.M. monolithic integrated circuit. The synchronizing pulses from the integrated circuit drive the D-Flip Flop, SN7474. The output of this D-Flip Flop drives the logic circuit 75450P which provides drive current to low cost 2N3019 NPN transistors. Line isolation is maintained with a driver transformer.

The control circuit (SG1524) is inhibited in a slow start mode to prevent large current and voltage transients.

The circuit described herein provides conversion efficiency up to 85%. This design approach achieves an efficient and economical switching-regulated power supply when multiple outputs are desired. The output filter capacitor is smaller in size because each leg of the "H" inverter operates at 50% duty cycle.

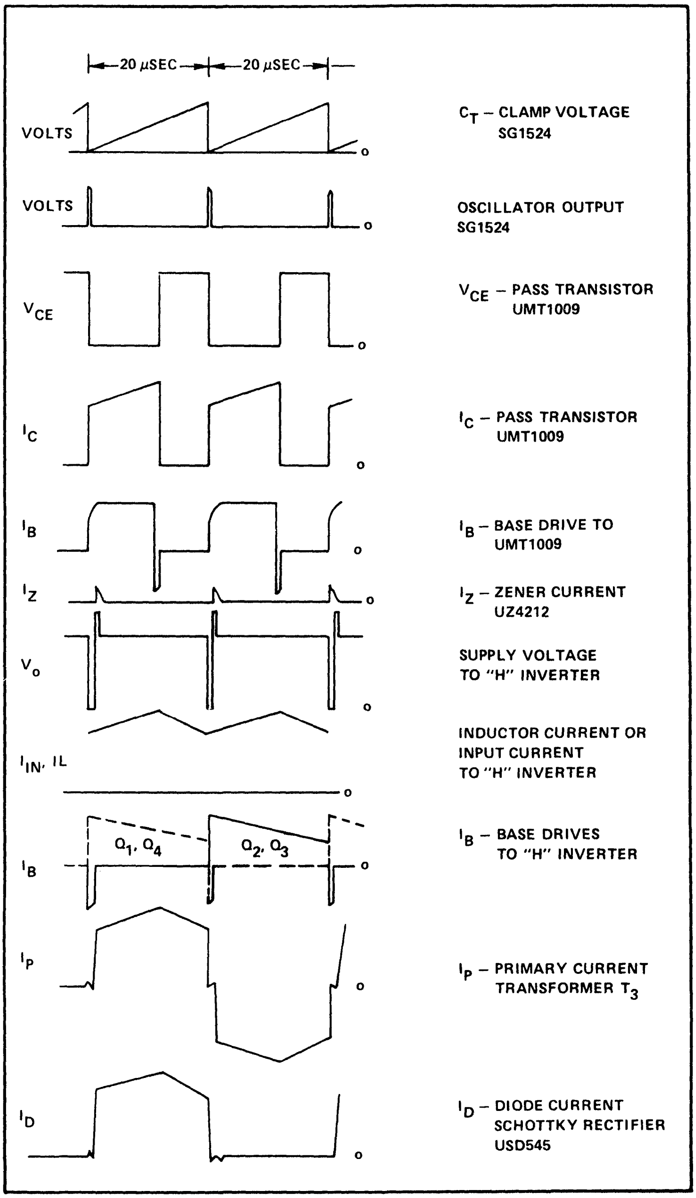
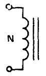


Figure 3. Basic Waveforms

TRANSFORMER AND INDUCTOR DETAILS

L_1. Filter Inductor;

core: Ferroxcube IF-19

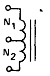


$N = 198$ turns, wire size AWG #16

Air gap = 0.2 inches

L_2. Ferrite Bead;

core: Stackpole #57-1552 Ferrite Bead

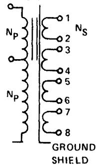


$N_1 = 2$ turns, wire size #32

$N_2 = 2$ turns, wire size #32

T_1. "H" Inverter Driver Transformer;

core: Ferroxcube 376U250-3C8, 376UB250-3C8

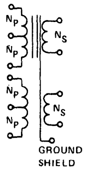


$N_P = 90$ turns, wire size AWG #32

$N_S = 15$ turns, wire size AWG #32

T_2. Buck Regulator Driver Transformer;

core: Ferroxcube 78E272-3C8, 782B272-3C8



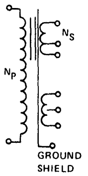
$N_P = 90$ turns, wire size AWG #34

$N_S = 15$ turns, wrie size AWG #28

Two transformers wound on same core, over outside legs of E-I core.

T_3. Power Output Transformer;

core: Ferroxcube EC-52



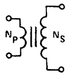
$N_P = 32$ turns, wire size #16

$N_S = 4$ turns, wire size #26, 36 wires twisted together

NOTE: Secondary is designed for +12 volts output. For multiple output total copper area of secondary should be 0.30 x Total Window Area.

T_4. Current Transformer;

core: Ferroxcube 376U250-3C8, 376B250-3C8



$N_P = 2$ turns, wire size AWG #16

$N_S = 60$ turns, wire size AWG #32

DESIGN NOTE DN-10

SQUIB-FIRING CIRCUIT PROVIDES FOR RELIABLE FIRING, FROM LOW LEVEL INPUTS

The design of reliable squib-firing circuitry often presents particular problems. Squib functions are typically quite critical, and the initial triggering source for these systems is, by nature, usually minute.

Conventional transistor squib-firing circuits usually require several gain stages, together with a power transistor to handle the squib-firing current. Mechanical squib switches, on the other hand, cannot be operated repetitively to allow for complete testing of the device and associated circuitry during check-out.

The high sensitivity planar Silicon Controlled Rectifier (SCR) can be triggered directly from low-level input circuitry, with significant reduction in circuit complexity and size. Reliability is thus considerably enhanced.

The unique characteristics of the planar SCR have resulted in wide usage of this semiconductor component in squib-firing circuits for rocket engine ignition, detonation, and explosive bolt applications. Compared with conventional transistor techniques or mechanical squib switches, this proven approach has significant reliability advantages, with circuit simplicity, size reduction, mechanical ruggedness and elimination of electrical contacts.

An SCR, with surge current ratings at 100°C of 5 amperes-50 milliseconds or 20 amperes-1 millisecond can easily handle the current required for firing most squibs. Input circuits can be designed to trigger reliably at levels below 100 microamperes and 1.0 Volt, making the SCR particularly well-suited for direct drive from low level control logic circuits and simple RC time delay networks. In addition, the bistable properties of the SCR enable it to be triggered on by a pulse input—remaining in the "ON" state until reset. This inherent "memory" is frequently used to advantage in arming circuits.

Two circuits typical of squib firing applications are shown in Figures 1 and 2. Both will operate from −65°C to over 125°C.

In Figure 1, Capacitor C_1 is charged to +28 Volts through R_1 and stores energy for firing the squib. A positive pulse of 1 mA applied to the gate of SCR_1 will cause it to conduct, discharging C_1 into the squib load X_1. With the load in the cathode circuit, the cathode rises immediately to +28 Volts as soon as the SCR is triggered on. Diode D_1 decouples the gate from the gate trigger source, allowing the gate to rise in potential along with the cathode so that the negative gate-to-cathode voltage rating is not exceeded. This circuit will reset itself after test firing, since the available current through R_1 is less than the holding current of the SCR. After C_1 has been discharged, the SCR automatically turns off—allowing C_1 to recharge.

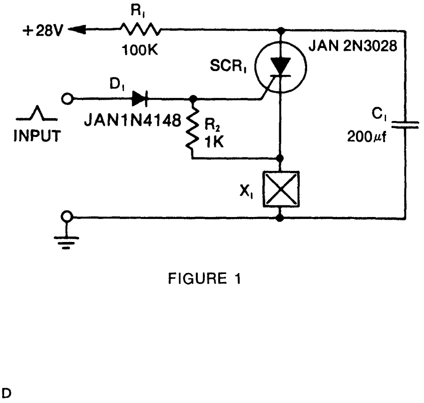


FIGURE 1

In Figure 2, energy for firing the squib is supplied directly from the +28 Volt supply. Caution must be exercised when arming this type of circuit. If anode voltage is applied too rapidly, the SCR may fire. This dv/dt effect acts through the SCR anode-gate capacitance (15 pf), which couples current to the SCR gate (in proportion to anode dv/dt). The effect is negligible if dv/dt is under 1 Volt/μs—as in Figure 1, where it is limited by the charging of C_1. Faster rates of rise can be safely handled by increasing the SCR gate bias.

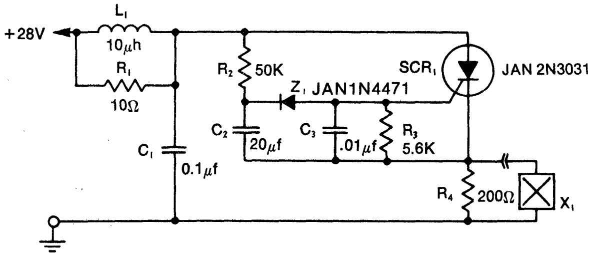


FIGURE 2

In Figure 2, the LRC input network limits the anode dv/dt to a safe value—below 30 Volts/μs. R_1 provides critical damping to prevent voltage overshoot. While a simple RC filter section could be used, the high current required by the squib would dictate a small value of resistance and a much larger capacitor. Resistor R_3 provides DC bias stabilization, while C_3 provides stiff gate bias during the transient interval when anode voltage is applied.

In this circuit the SCR is fired one second after arming by means of the simple R_2 C_2 Z_1 time delay network. R_4 provides a load for the SCR for testing the circuit with the squib disconnected—limiting the current to a level well within the continuous rating of the SCR. The circuit can be reset by opening the +28 Volt supply and then re-arming.

COMBINED AC-DC LOAD CONTROL SIMPLIFIES SCR RESET

Silicon Controlled Rectifiers (SCRs) are finding increased use in a wide variety of control circuit and power switching applications. They offer an economical way to achieve high switching gain, efficiency and blocking voltage.

When the inherent memory or "latching" feature is not desired, AC anode supply is often used, allowing the SCR to turn off automatically upon removal of the gate control signal. With an AC anode supply, an additional benefit is derived—the SCR doubles in function as a rectifying element. Thus, it is possible to operate DC loads directly from an AC power source, often eliminating the need for separate bulky and expensive DC power sources.

When SCR latching action is desired, DC anode supply is commonly employed. Here, however, reset can be a problem, since "brute force" reset techniques must normally be used. This involves an additional switching element, to either open or shunt the load voltage, and current from the SCR.

The circuit of Figure 1 retains the advantages of operating loads directly from an AC power source. Latching action is provided with no need for brute force reset techniques. The DC source needs to provide only a few milliamps of SCR holding current, since load power is drawn from the AC source.

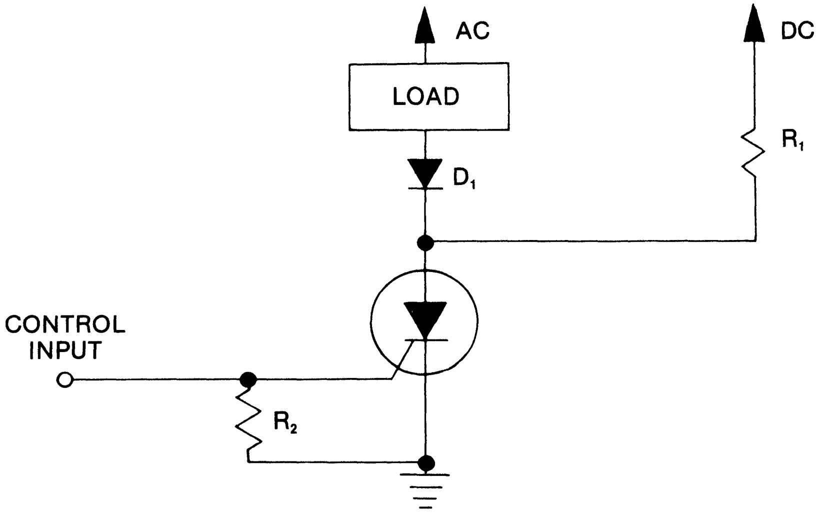


FIGURE 1

When the SCR is on, a half-wave rectified voltage waveform is applied to the load. During each positive half-cycle of the AC source, diode (or rectifier) D_1 and the SCR conduct the load current as well as the DC holding current provided through R_1. During each negative half-cycle, D_1 blocks the negative voltage from the AC supply, allowing the SCR to remain in conduction. Resistive loads such as heaters and incandescent lamps are driven satisfactorily with the half-wave rectified output of this circuit. DC loads that are less tolerant of this waveform can easily be operated by using shunt capacitors or other filtering methods. Shunt free-wheeling diodes should be employed across inductive loads.

Reset is simply accomplished by interrupting the holding current provided from the DC supply through R_1. The reset interval must, of course, be longer than one half-cycle of the AC line frequency, or it must be timed to occur during the negative half-cycle, since load current will keep the SCR latched on during the entire positive half-cycle. The reset interval must exceed the device gate recovery time which ranges from less than 0.5 μs for the higher speed SCRs to 50 μs for the slower SCRs.

The DC supply voltage level is not critical and can be less than equal to, or greater than the peak AC supply voltage. When it is less than the peak AC, however, D_1 will conduct for a portion of each half-cycle when the SCR is off, causing a current pulse to flow from the AC to the DC supply through R_1.

D_1 must have a blocking voltage capability greater than the sum of the peak AC voltage plus the DC supply voltage. The SCR voltage rating must be at least equal to the peak AC *or* DC supply voltage, whichever of these is greater.

When many identical or similar circuits are used in a single system (as in a band of SCR incandescent lamp drivers), multiple reset is easily accomplished by simultaneously interrupting the DC source and resetting all circuits connected to that source.

DESIGN NOTE DN-12

THERMAL DESIGN CONSIDERATIONS

For Lead Mounted Rectifiers and Zeners, for 5 types of mounting.

Determining The Power Rating for Your Application. The information given in this section is presented for straight-forward use by the designer. The value given in this table is $R_{\theta JA}$, the "Total" thermal resistance of the diode and mounting together;. no other graphs or tables are needed.

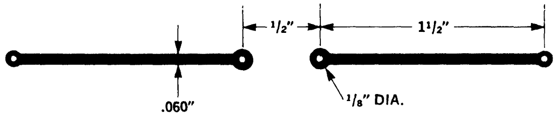
$$P_{max} = \frac{T_{Jmax} - T_{Amax}}{R_{\theta JA}}$$

Where: P_{max} is the maximum power that can be dissipated in the device reliably. T_{Jmax} is the maximum of the operating temperature range, usually 175°C, unless derated for a military or hi rel application.

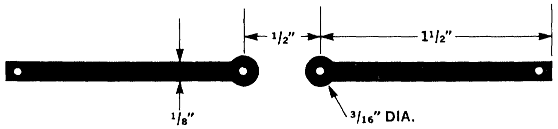
T_{Amax} is the max temp that the ambient reference (air below the device) will reach during operation.

Alternately,

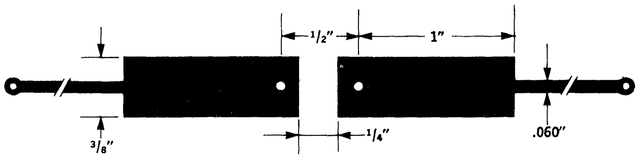
Junction Temp Rise $= PR_{\theta JA}$



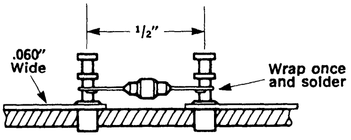
TYPE 1 PC BOARD, LIGHT



TYPE 2 PC BOARD, MEDIUM

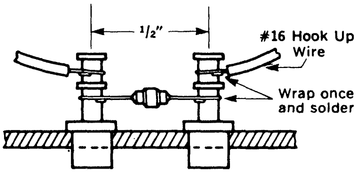


TYPE 3 PC BOARD, HEAVY



.060 Epoxy Glass
.060" dia. x 3/8" high
Terminals are per MS 17122-7

TYPE 4 PC BOARD WITH CHESSMEN TERMINALS



.060 Epoxy Glass
.125" dia. x 1/2" high
Terminals are per MS 17122-8

TYPE 5 TERMINALS AND HOOK-UP WIRES

$R_{\theta JA}$
Total Thermal Resistance in Degrees C/Watt

	Mounting Type				
Type	1	2	3	4	5
1N3611-3614	105	92	75	97	65
1N4245-4249	105	92	75	97	65
1N4461-4489	105	92	75	97	65
1N4736-4764	140	127	110	132	100
1N4942-4946	98	85	68	90	58
1N4954-4996	75	62	45	67	35
1N5063-5117	94	81	64	86	54
1N5186-5189	75	62	45	67	35
1N5186-5190	72	59	42	64	32
1N5550-5553	75	62	45	67	35
1N5614-5622	93	80	63	85	53
1N5802-5806	94	81	64	86	54
1N5807-5811	75	62	45	67	35
TVS 505-528	75	62	45	67	35
UES1101-1106	94	81	64	86	54
UES1301-1306	75	62	45	67	35
UR105-125	142	129	112	134	102
UR205-225	98	85	68	90	58
UT236-347	127	114	97	119	87
UT249-363	110	97	80	102	70
UT251-364	105	92	75	97	65
UT261-268	98	85	68	90	58
UT2005-2060	97	84	67	89	57
UT3005-3060	85	72	55	77	45
UT4005-4060	80	67	50	73	40
UTR01-61	127	114	97	119	87
UTR02-62	98	85	68	90	58
UTR10-60	176	163	146	168	136
UTR2305-2360	97	84	67	89	57
UTR3305-3360	85	72	55	77	45
UTR4305-4360	80	67	50	72	40
UTX105-125	142	129	112	134	102
UTX205-225	98	85	68	90	58
UTX3105-3120	85	72	55	77	45
UTX4105-4120	80	67	50	72	40
UZ706-140	94	81	64	86	54
UZ4706-4120	75	62	45	67	35
UZ5706-5140	75	62	45	67	35
UZ7706L-7710L	73	60	43	65	33
UZ8706-8120	140	127	110	132	100
UZS 306-440	94	81	64	86	54

DESIGN NOTE DN-13

TURN-OFF METHOD FOR SCRs MINIMIZES EFFECT OF DV/DT

SCRs can be turned off by reducing the magnitude of the anode current to a level below that of the holding current, either by opening the anode circuit or by driving the anode negative. Forward blocking voltage cannot be reapplied until after the minority carrier charge stored in the device as a result of previous forward conduction has been dissipated to a level that can be controlled by the gate bias, otherwise the SCR will self-trigger on again.

In addition, even after the SCRs have recovered, reapplication of anode supply voltage may cause self-triggering due to dv/dt.

Self-triggering of a SCR due to dv/dt is caused by a capacitive current equal to the product of the anode-gate (C_{AG}) capacitance of the SCR and the rate of rise (dv/dt) of applied anode voltage. Sensitivity of a SCR to dv/dt effects can be controlled by the use of a gate-cathode resistor or a current bias. The SCR will self-trigger only if the capacitive current is too large to be controlled by the bias resistor. The smaller the bias resistor, the higher will be the critical rate of rise of anode voltage. However, if the anode-gate capacitance is fully charged before the supply voltage is reapplied across the SCR, the device will be immune to dv/dt effects.

A simple SCR switching circuit is shown in Figure 1. When switch S1 (which can be a relay or a transistor) is in the closed position, the SCR will fire upon the application of a gate trigger pulse of the appropriate magnitude and duration. Switch S1, when opened, will turn off the SCR. After switch S1 is opened, the anode-gate capacitance will charge through the load resistor and the 100K between gate and ground. When the SCR has recovered, S1 can be closed, and no capacitive current will flow since C_{AG} is already charged to the full anode supply voltage.

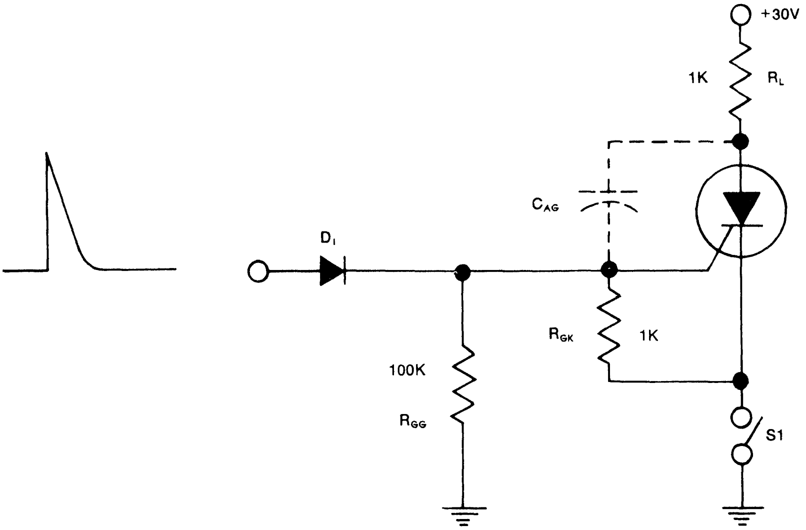


FIGURE 1

When the cathode circuit of a conducting SCR is initially opened, a large reverse gate current can flow which may damage the gate-cathode junction of the device. Reverse gate current should be limited to 3 ma for safe operation of most SCRs. The bias resistors shown in Figure 1 accomplish this objective, while affording bias stabilization over the operating temperature range. Bias resistor R_{GK} removes all of the internally supplied gate current out through the gate terminal. Under this condition, the internal gate current cannot flow across the gate junction; the device is cut-off, and self-triggering cannot occur. If R_{GK} was connected to the ground side of the switch, when the switch opened the reverse gate current would be about 15 mA — far exceeding the maximum reverse current rating for most SCRs. R_{GG} takes over from R_{GK} when the switch is opened, limiting the reverse gate current to less than 0.3 mA. Diode D_I decouples the gate trigger source from the SCR when the cathode switch is opened. This prevents a low impedance supply from drawing excessive reverse gate current.

For the situation where the anode supply voltage may be subjected to transient pulses or voltage spikes, a small capacitor C_{GK}, connected in parallel with R_{GK} will absorb the transient charging current. If we assume C_{AG} is 100 pf then a C_{GK} of 0.002 μf will form a 20:1 voltage divider requiring a 10V pulse on the anode to result in the required 0.5V (at 25 °C) to trigger the SCR.

NANOSECOND SCR SWITCH FOR RELIABLE HIGH CURRENT PULSE GENERATORS AND MODULATORS

The design of reliable modulator and pulse generator circuitry often presents the design engineer with seemingly conflicting requirements. In order to obtain fast rise times, "hard tubes" or hydrogen thyratrons are often used. This results in a large system which consumes considerable power and has relatively low conversion efficiency. Reliability, jitter, and stability are also common problems in these systems.

To improve reliability, as well as decrease standby power consumption and improve conversion efficiency, semiconductor devices are a natural choice. However, at the voltage and current levels most often encountered in these applications, conventional semiconductors are usually too slow.

The nanosecond SCR switch developed by Unitrode allows the designer to upgrade high current, high voltage modulator and pulse generator circuitry. A single device (GA201 or GA301*) is capable of operating in circuits with supply voltages up to 100 Volts DC and pulsed load currents in excess of 50 Amperes. It can be triggered directly from logic level signals (1 Volt, 200 microamps) and exhibits a rise time of less than 10 nanoseconds to 1 Ampere with only 10 milliamps of drive signal. Single switches operated in this mode can be used as high current replacements for avalanche transistors, modulators, and harmonic wave form generators.

Special circuity has been developed to apply these nanosecond switches in applications where supply voltages exceed the forward blocking capability of a single device. The simplest of these is shown in Figure 1.

The 1 meg-ohm resistors act as a voltage-sharing network to insure that no single device is overvoltaged because of unequal leakage currents. Turn-on is accomplished by applying a trigger signal to the primary of the pulse transformer, T1. The capacitor, which has been charged to the supply voltage through R_C, discharges through R_L, and the string of SCRs. This circuit is useful until the number of stages used requires a pulse transformer that becomes objectionably bulky. Beyond that point the circuit of Figure 2 or 3 is used.

Figure 2 illustrates an approach that uses a pulse transformer to trigger only part of the string, while the rest of the devices in the string are supplied with gate drive through the zener diodes. With a supply voltage of 360 Volts DC, a 95 Volt ±5% zener diode across each SCR in the string prevents unequal voltage distribution. When SCR_3 and SCR_4 are triggered, 360 Volts appear across SCR_1 and SCR_2 causing zener diodes Z_1 and Z_2 to conduct. Since D_1 and D_2 are back-biased, the current must flow through the gate-to-cathode junctions of SCR_1 and SCR_2, thus driving them on. Up to eight stages can be stacked in this manner using a pulse transformer to drive only the bottom two SCRs in the string. Driving three SCRs with a pulse transformer allows stacking sixteen stages, which can switch a 1440 Volt load using a pulse transformer that needs to have a dielectric isolation rating of less than 300 Volts.

Figure 3 uses no pulse transformer and can be extended to virtually any number of stages. When SCR_1 is triggered, the cathode of SCR_2 drops from +100 to essentially 0 Volts. Capacitor C_1 discharges into the gate of SCR_2 causing it to conduct, and this process is repeated for SCR_3 and SCR_4. This circuit has the added feature of providing negative bias to the SCRs during recharge of the load in order to minimize the effect of dv/dt. As the voltage rises on the anode of SCR_4, current flows through the path consisting of C_4, R_4, C_3, R_3, C_2, R_2, etc. This provides negative bias for the gate-to-cathode junctions of the SCR in the string, making them less sensitive to dv/dt triggering. This allows the use of rapid recharge circuits which permits operation at higher repetition rates. Either resonant recharge or active (SCR) rapid recharge techniques may be used with these circuits.

*GA201 recommended for military, GA301 for commercial applications.

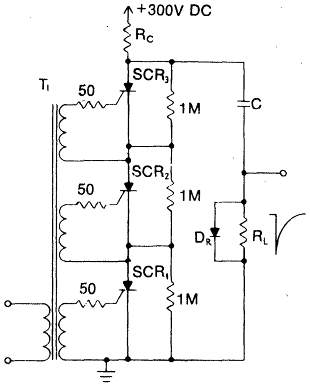


FIGURE 1

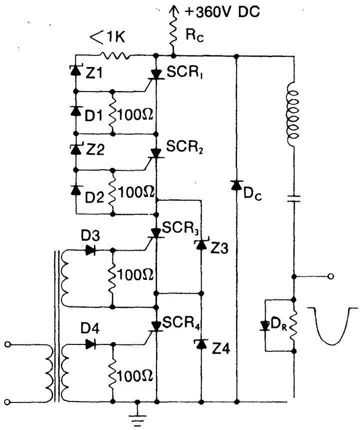


FIGURE 2

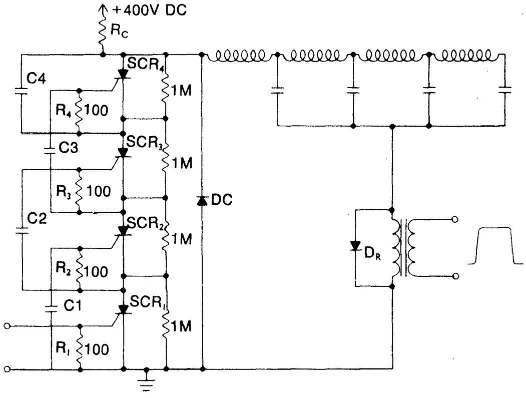


FIGURE 3

If the energy storage element(s) and load consist only of R and C components, the charging resistor must be large enough to limit the DC current to a value less than the minimum holding current of the SCRs in the string. When the load contains an inductive component, as is usually the case in modulator circuits, the network can be designed to "ring" in order to reverse-bias the SCR string momentarily, permitting the SCRs to regain their forward blocking capability even though R_C allows more than the minimum holding current to flow. Diode D_R may be used in all circuits so that the recharge current will not flow through the output element. In Figures 2 and 3, D_R shunts the reverse "ringing" current around the output element. Diode D_C must be used in circuits that contain inductive elements to protect the string from being excessively back-biased due to circuit ringing.

DESIGN NOTE DN-15

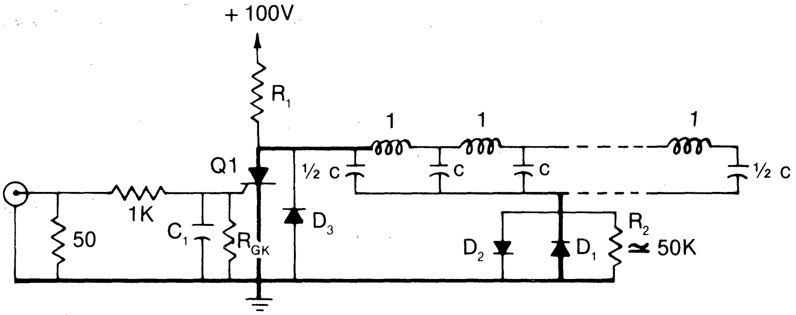
NANOSECOND SCR FOR LASER DIODE PULSE DRIVER

The use of pulsed gallium-arsenide lasers requires a reliable high speed, high current switch to drive these devices. In the past the only solid state devices that could be used in this application were avalanche transistors and fast medium power transistors. Avalanche transistors presented reliability problems, while the standard medium power transistors available were too slow. The GA200 series "Nanosecond SCR" with a rise time capability of 10 nsec to 1 Amp or 20 nsec to 30 Amps provides a solution to both the reliability and the speed problems and appears to be ideal for this type of application.

The circuit shown in Figure 1 utilizes a GA201 device along with a lumped constant delay line to generate the desired square current pulse. For simplicity, a single capacitor could be used instead of the delay line. The delay line, however, has the advantage of producing a square pulse that provides sharp turn-off, which limits the excess power dissipation that would occur in the laser diode if the pulse fell exponentially. The impedance of the delay line ($= \sqrt{L/C}$) is chosen to produce a slight mismatch, which produces overshoot on the trailing edge of the pulse. This overshoot acts as a reverse bias on the anode of the SCR, assisting in turning it off. A typical value for the delay line impedance would be 1 to 2 ohms, which approximates the impedance of the load formed by the SCR and laser diode in series. The time duration of the pulse ($= \sqrt{L/C}$ per section) can be made as short as desired with a value of 50 to 100 nsec being typical.

With the SCR in the off state, the delay line will charge to the supply voltage (100 Volts with GA201). A gate current at the input of as little as 200 μA will trigger the SCR. The delay line will then discharge, producing a square current pulse through the gallium-arsenide laser diode. R_1 and R_{GK} are chosen so that the current, after the delay line discharges, will be less than the holding current of the GA201 (= 3 mA with R_{GK} = 100 ohms.) C_1 should be about .001μf and is necessary to prevent false triggering through noise or through dv/dt commutation. D_2 provides a charging path for the delay line, while $R_2 \cong 50K$ provides a stable ground reference. Diode D_3 insures that the reverse breakover voltage of the GA201 will not be exceeded during the turn-off period.

The forward current level will depend upon the total impedance of the GA201 and the laser diode and the charging voltage used. With a 100 Volt device and a practical minimum circuit impedance of about 1 ohm, it is possible to develop peak currents of up to 100 Amps. (See Figure 2 for Time vs Current curve for GA200/GB200 Series.) Pulse of 60 Amps with rise times of approximately 30 nsec have actually been achieved. For improved performance at high current levels, the SCRs may be operated in parallel or in series. Parallel operation is achieved by providing equal series resistors to the gates of the devices and driving them from the same source. By overdriving the gates with 50 to 100 mA, simultaneous turn-on is guaranteed. Parallel operation results in lower forward voltage drop and faster rise time at high current levels. Series stringing techniques can be used in circuits with a higher total impedance where higher voltages are needed to obtain the desired current levels. For a description of series operation see Design Note 14.



Q1—GA201/GB201, GA301/GB301

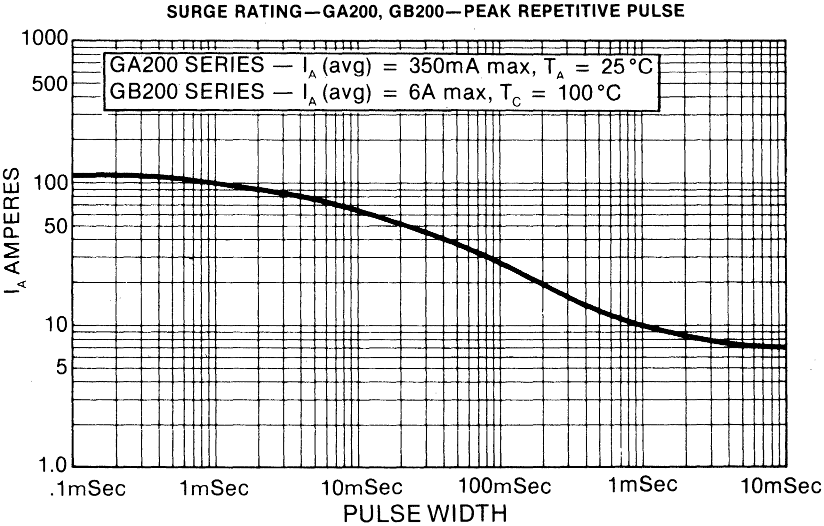
D_1 —Gallium-Arsenide Laser Diode

D_2 —JAN 1N5802 or 1N5807* (Alternative: UES1101 or UES1301)

D_3 —JAN 1N5804 or 1N5809* (Alternative: UES1102 or UES1302)

Note: Heavy lines indicate braided connections for reduced inductance and resistance.

Figure 1



Note: For MIL and high Rel series applications, use GA/GB 200/201 and JAN Diodes.

For high rep rate (high average current), use GB series with 1N5809 or UES1302 rectifiers.

GA300 and UES series are intended for commercial applications.

Figure 2

DESIGN NOTE

DN-16

LEAD MATERIALS

Unitrode offers a wide choice of lead materials for soldering or welding because the leads are attached to the pins outside the glass seal. Since the leads do not pass through a glass-to-metal seal, there is no need to match the thermal coefficient of expansion of the leads to the glass.

Solderable Leads — Silver plated copper is the standard lead material. These leads meet the solderability requirements of MIL-STD-202C Method 208A.

Solid silver leads meeting the requirements of MIL-S-13282 Grade A are available on special order.

Weldable Leads — Three types are available to meet the welding requirements of MIL-STD-1276A. The pure grade A nickel leads meet the requirements of type N-1. The gold-plated nickel leads meet the requirements of type N-2. Gold-plating is in accordance with MIL-G-45204, Type 1.

The copper leads (tin-coated) meet the requirements of type C. Types N-2 and C are solderable as well as weldable.

The following table lists standard lead lengths and materials. Weights of the diodes with various leads are also shown. In the event other lead materials are required, please consult Unitrode.

Body	Material	Usage	Lead		Suffix Letter	Typical Weight Body Plus Leads (mg)
			Length (in.)	Dia. (in.)		
.030	Silver	Solderable	1.0	.020	None	—
	Dumet	Solderable or weldable	1.0	.014	*	—
A .045	Silver plated Copper (standard)	Solderable	1.0	.028	None	260
	Silver	Solderable	0.7	.028	M	215
	Copper, tinned	Solderable or weldable	1.0	.028	S	260
B .090 and C .125	Silver plated Copper (standard)	Solderable	1.0	.040	None	740
	Silver	Solderable	1.0	.040	P	740
	Copper, tinned	Solderable or weldable	1.0	.040	Q	740

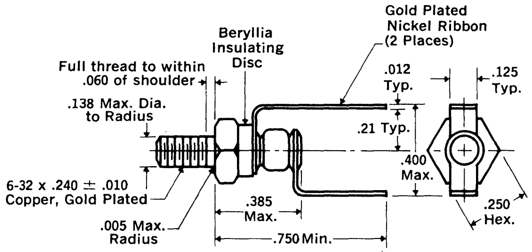
*Available on 1N5767 and 1N5957 only.

DESIGN NOTE **DN-17**

INSULATED STUD PACKAGES

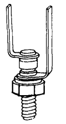
Unitrode's three stud-mounted devices, 10W high-surge zener diodes, 12A standard recovery rectifiers, and 9A fast-recovery rectifiers, are also available as shown here with insulated studs having the same high ratings as the standard non-insulated devices.

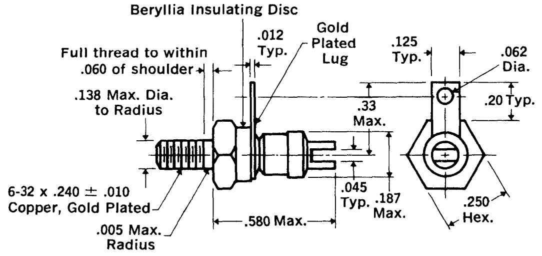
MECHANICAL SPECIFICATIONS



Dimensions in inches.

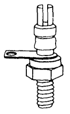
Style W





Dimensions in inches.

Style V



Part Identification: Style W: Part number printed on ribbon lead. Style V: Part number printed on body. Numerals are unique and indicate 10W Zener Series (UZ), 12A rectifier series (UT), or 9A fast-recovery rectifier series (UTR).
Polarity: Cathode to stud end.
Max. Weight: Styles W & V: 2.3 grams.
Installation Precautions: Maximum unlubricated stud torque: 36 inch-ounces.
Note: Do not use a screwdriver in turret slot for installation purposes, or damage may result.

ORDERING INFORMATION

The type numbers that apply to the standard studs also apply to the insulated studs with the addition of suffix W or V for style W or V (see outline drawings). For example, to specify insulated stud style W for a 6.8V zener, order UZ7806W; for a 50V 12A rectifier, order UT8105W; and for a 100V 9A fast-recovery rectifier, order UTR6410W.

DESIGN NOTE

DN-18

HR-201 SCREENING

Unitrode semiconductors are inherently high-reliability devices; however, some users may want the ultimate assurance of reliability. The HR-201 screening specification is intended to satisfy this need. It should be emphasized that, although these tests are not likely to stress a Unitrode device to failure, they are recommended for those applications which require extreme degrees of reliability assurance — such as man-rated space vehicles, special weapons systems, or other critical applications.

Specific screening specifications and the products to which they are applicable follow:

Product	Specification	Specification with Delta's
Rectifiers	HR201	HR201-D
Zeners	HR201Z	HR201Z-D
Surge Suppressors	HR201S	HR201S-D
Transistors	HR201T	
Switching Regulators	UL101T1 & T3*	UL101T3*
	UL102T1 & T3*	UL101T3*

*Includes lot qualification

All units are subject to 100% screening tests per above specifications as follows:

1. **Reverse Bias Operation** — Full rated PIV for rectifiers and switching regulators (80% of minimum voltage for zeners and surge suppressors; 80% of V_{CEO} for transistors) applied for 168 hours at 125°C. Temperature is then reduced to 25°C over a period of not less than one hour with full voltage maintained.
2. **Thermal Fatigue** — Ten cycles. Each cycle consists of 15 minutes at 200°C ambient, immediate transfer to —65°C ambient for 15 minutes, and immediate return to 200°C. For switching regulator temperature extremes are —55°C to 150°C.
3. **Case Integrity** — 100 p.s.i. is applied while submerged in a fluorescent dye such as Zygol ZL-1C for 30 minutes. After rinsing in clear water, the device is examined under ultraviolet light for evidence of a defective seal. For switching regulator, helium and fluorocarbon test methods are used.
4. **Power Operation**
   Rectifiers — Each rectifier is subjected to 5 seconds overload current as follows:
   2A through 0.75A rated, Body A — 5 Adc applied
   4A through 2A rated, Body B — 8 Adc applied
   12A through 7.5A rated, Body C — 8 Adc applied
   Zeners — Each zener diode is subjected to 168 hours of direct current operation in avalanche at $T_A = 25°C$ with sufficient power to raise the junction temperature to 175°C.
   Surge Suppressors — Each device is subjected to 10 pulses at the rate of one pulse per minute at 25°C at rated surge current.
   Transistors — Each device is operated at rated power at 25°C ambient for 168 hours.
   In each of above situations, the device is mounted on 1-inch center clips.
   Switching Regulators — Each device is operated in a pulse circuit at rated free air power rating for 40 hrs.
5. **Room Temperature Measurements** — All parameters are measured to ensure conformance with specification. All diodes are 100% oscilloscope-tested to ensure controlled-avalanche characteristics. Any parts exceeding specified limits or exhibiting unusual characteristics are removed from the lot.

JANTX, and JANTXV DEVICES — A number of rectifiers, zeners, transistors, and SCRs plus some rectifier assemblies and surge suppressors are available with JANTX and JANTXV screening and visual inspections. See the JAN page in the Product Selection Guide, that lists all of Unitrode's qualifications.

HIGH RELIABILITY SEMICONDUCTOR REPORT
Unitrode's High Reliability Semiconductor Report is available upon request. Device design, failure modes, environmental tests and their effects, and stress screening are all presented. A summary of failure rate data is given, as is list of major programs and systems in which Unitrode devices have been used.

HIGH VOLTAGE MULTIPLIERS

The voltage multiplier is an efficient power conversion device used to generate high voltage DC, from a lower level AC potential. This is accomplished with a network of silicon rectifiers and capacitors which rectifies the AC voltage and additively charges the capacitors to a desired high voltage level. High voltage power supply designs can be simplified by the proper selection of a voltage multiplier circuit that can optimize the critical parameters of the application.

Recent technological advances in high voltage silicon rectifiers, high voltage capacitors and packaging techniques have resulted in the development of ultra high reliability voltage multipliers. These High Voltage Devices (HVD) innovations allow voltage multipliers to be supplied as a basic component which can meet the exacting requirements of commercial, industrial and HI-REL military applications.

Lack of manufacturing control of the basic components in a multiplier can make user fabricated devices costly and with marginal technical performance.

A comprehensive knowledge of high voltage multipliers provides a complete service from design, to prototype through production quantities. High performance devices can be developed and tested to meet virtually any electrical specification and mechanical configuration, with production units supplied at a very minimum of cost.

The major factors that guarantee the technical performance and reliability of our production assemblies are:

COMPLETE "IN HOUSE" SILICON RECTIFIER FABRICATION

CORONA FREE CERAMIC CAPACITORS

100% SCREENING OF DISCRETE COMPONENTS PRIOR TO ASSEMBLY

CORONA FREE PACKAGING

EXTENDED OPERATING AND STORAGE TEMPERATURE CAPABILITY

CIRCUITRY SELECTED TO MEET SYSTEM REQUIREMENTS

INCLUSION OF FILTERS, BLEEDERS, DIVIDER NETWORKS AND SPECIAL TERMINATIONS WITHIN THE MULTIPLIER PACKAGE

Consideration of these major factors gives a greater insight to their importance in obtaining high reliability voltage multipliers.

COMPLETE "IN HOUSE" SILICON RECTIFIER FABRICATION

The "MULTIVOLT" silicon rectifiers are engineered for often overlooked parameters that are essential for reliable multiplier design. Capacitor charging currents require high repetitive surge and conservative steady state current ratings while reverse voltage must be high enough to compensate for overload and transient conditions. Closely matched fast recovery junctions with low reverse leakage and minimal junction capacitance directly affect efficiency, particularly in high frequency applications. The "MULTIVOLT" rectifiers meet all of this criteria. Proprietary innovations in manufacturing technique incorporating cylindrical die construction, metallurgical bonds and corona free packaging minimize electrical and mechanical stress and insure the production of high reliability voltage multipliers.

CORONA FREE CAPACITORS

The most important parameter measurable in high voltage capacitors that is directly related to reliability, is corona. Technological advances in design and manufacturing provide corona free, High K dielectric ceramic capacitors specifically for voltage multiplier applications. Their temperature characteristic, capacitance, voltage coefficient and dissipation factor are also devised to guarantee that each multiplier will technically perform within the required environmental conditions.

100% SCREENING OF DISCRETE COMPONENTS PRIOR TO ASSEMBLY

The individual rectifiers, capacitors and resistors incorporated into each multiplier are selected and 100% tested to meet the specific requirements of the application. "On line" lot control through final assembly with verification in final test, guarantees technical performance.

CORONA FREE PACKAGING

High voltage multiplier packaging is as critical as the initial selection of reliable components. Component positioning to minimize electrical gradients and inter-element coupling are a necessity. Encapsulating materials are most critical and must exhibit expansion coefficient compatibility to allow operation over the specified temperature range. The encapsulents have to adhere to all components, require high dielectric strength, low dielectric constant, high thermal conductivity, low thermal expansion, low leakage and be relatively easy to process for assurance of a corona free device.

EXTENDED OPERATING AND STORAGE TEMPERATURE CAPABILITY

Technological advances incorporated in HVD's silicon rectifiers and capacitors coupled with the availability of compatible packaging materials allows the manufacture of HI-REL voltage multipliers that can operate from -65° to +100°C ambient temperature.

CIRCUITRY SELECTED TO MEET SYSTEM REQUIREMENTS

Each multiplier application has to be evaluated on the basis that the customers system is to meet specific electrical, mechanical, environmental and cost design criteria. A comprehensive understanding of high voltage multiplier applications permits the suggestion, design, testing and manufacture of devices that meet or exceed the user's system requirements. A multiplier tailored to a system, rather than a system "designed around" a device, results in ultra high reliability.

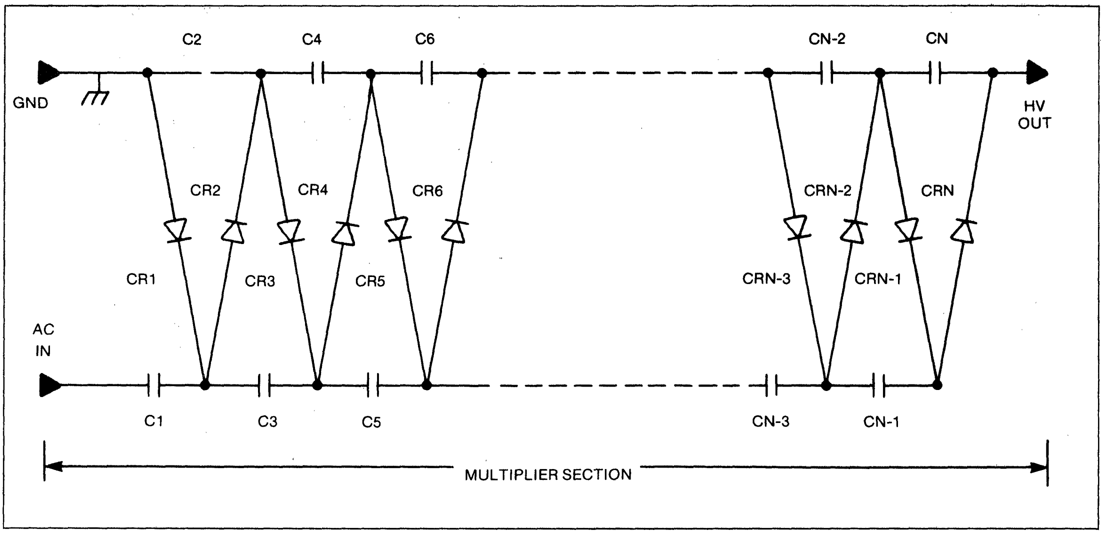
INCLUSION OF FILTERS, BLEEDERS, DIVIDER NETWORKS AND SPECIAL TERMINATIONS WITHIN THE MULTIPLIER PACKAGE

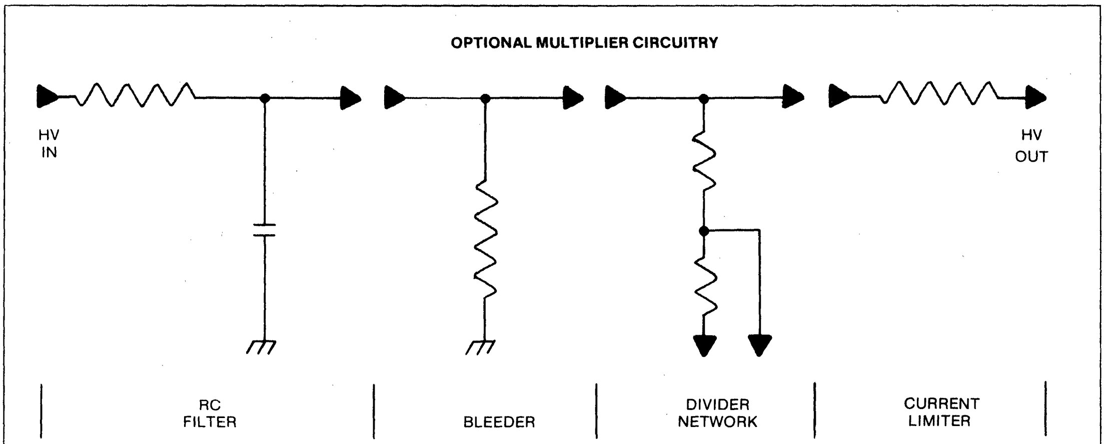
Voltage multipliers designed to include ripple reduction filters, bleeders, precision TC and ratio matched divider networks and special terminations, enhance the device as a "basic component". The ability to incorporate these components within the assembly, eliminates potential corona sources, simplifies a system's mechanical design and provides another edge in the quest for reliability.

VOLTAGE MULTIPLIER CIRCUITS

There are numerous circuits available to the designer which perform the function of voltage multiplication. The most commonly used are the basic series, parallel or a hybrid of the two.

Voltage multiplier circuits can be designed to accept sine, squre or single ended (flyback) input wave forms. In any multiplier, a stage (N) is considered to be one rectifier and capacitor unit which multiplies one times the peak input voltage. The relative merits of the basic circuits are outlined in the following.





The circuits shown can be included, in any combination, within a series, parallel or hybrid voltage multiplier assembly.

THE SERIES MULTIPLIER

A typical half wave series multiplier, as illustrated with optional associated circuitry, is the most commonly used and economical type circuit. Low cost is achieved by capacitor and rectifier voltage rating only required to be the equivalent of the peak to peak input voltage.

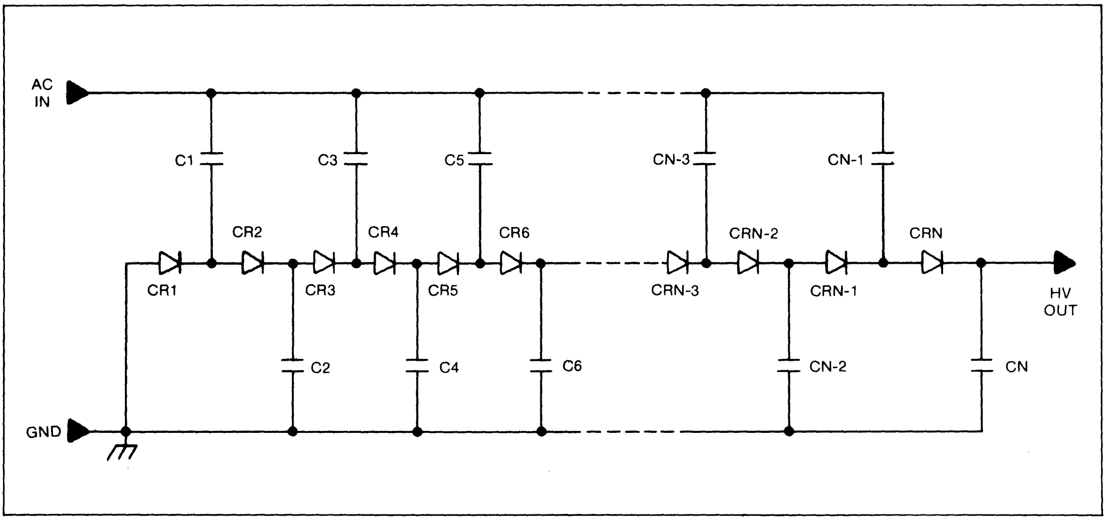
Performance and multiplication efficiency is governed by regulation and ripple being proportional to the number of stages (N) utilized to the third power (N^3) and squared (N^2), respectively. High multiplication factors are restricted by a rapid increase in internal impedance which limits its useable output current capability.

THE PARALLEL MULTIPLIER

The parallel voltage multiplier shown offers many technical advantages over other circuits. Each rectifier sees the equivalent peak to peak input voltage while the capacitors in each succeeding stage (N) sees a higher voltage, being equal to the peak input voltage times the number of stages (N).

Regulation is proportional to the number of stages (N) and ripple is independent of them, the value of the capacitors being the determining factor. Low internal impedance provides greater efficiency, minimal power dissipation and higher useable output current capability.

The parallel circuit can achieve higher multiplication ratios with the added advantage of smaller size packages, an important consideration for portable and airborne electronic systems.



SPECIFYING A CUSTOM VOLTAGE MULTIPLIER

The selection of a voltage multiplier circuit for a specific application is dependent upon the systems overall operating parameters and cost. Each custom design requires detailed information about the application in order to determine the proper approach. The HVD "MULTIPLIER DESIGN INFORMATION SHEET" was developed to assist a customer in describing his multiplier requirement, providing us with the basis for recommending a specific design.

A review of the "MULTIPLIER DESIGN INFORMATION SHEET" will reveal its self explanatory format.

Attention to detail in the information initially provided, will assure an accurate and prompt response from our applications department. Particular attention should be given to mechanical considerations. Where non standard shapes are required, include sketches or drawings whenever possible.

Copies of the "MULTIPLIER DESIGN INFORMATION SHEET" can be obtained from our representative or from the factory.

MULTIPLIER DESIGN INFORMATION SHEET

COMPANY NAME ______________________

ADDRESS ______________________

____

TELEPHONE ______________________

ENGINEER (Ext) ______________________

PURCHASING (Ext) ______________________

SALES ENG ______________________

DATE ______________________

CUSTOMER P/N ______________________

HVD P/N ______________________

QUANTITY (time span) ______________________

PROGRAM ______________________

APPLICATION ______________________

1. Power Supply System - Regulated ______ Unregulated ______
2. Type of Multiplier - Series ______ Parallel ______ Other (Supply Schematic) ______
3. No. of Stages (Optional) ______ **(Each rectifier and capacitor unit represents one stage).**
4. Input Characteristics
   - Wave Form - Sine ______ Square ______ Fly Back ______ Other ______
   - Frequency ______________________.
   - Nominal peak to peak A.C. input voltage ______________ Max. ______________
5. Output Characteristics
   - Polarity - Positive ______ Negative ______
   - No load output voltage with nominal input ______________ Max. ______________
   - Nature of load - Resistive ______ Capacitive ______ Inductive ______ Other ______
   - Full load output current ______________________
   - Minimum output voltage at full load ______________________ (Or % regulation required)
   - Maximum peak to peak A.C. ripple at full load ______________ Preferred ______________
6. Mechanical
   - Size - Preferred W ______ L ______ H ______ Max. W ______ L ______ H ______ (include sketch)
   - Terminations - Wire ______ Terminals ______ Connector ______ (Include sketch and preferred locations)
   - Mounting Requirements ______________________ (Specify locations and ground planes)
7. Environmental
   - Temperature range - Operating ______________ Non-operating ______________
   - Type of Environment ______________________
   - Other requirements ______________________
8. Miscellaneous
   - Voltage taps (specify voltage and current) ______________________
   - Divider/Bleeder network ______________ Temperature co-efficient req. ______________
   - Filter ______________________
   - Current Limiting ______________________
   - Special Requirements ______________________

CUSTOMER SPECIFICATION SHEET FOR SPECIAL RECTIFIER ASSEMBLIES

Date ____________
Company Name ____________ Phone ____________
Address ____________ City ____________ State ____________
Engineer ____________ Ext. ________ Buyer ____________ Ext. ________
________ New Application, ________ Existing Application, Presently Using ____________
Quantities to Quote ____________

ELECTRICAL REQUIREMENTS

Rectifier Application:

1. Circuit: ________ Half Wave ________ Center Tap ________ Doubler ________ Bridge
2. AC Input: ________ Volts ________ CPS ________ Phase ________ Wave Shape
3. DC Output: ________ Volts ________ Amps At ________ °C
4. Max. Transient Voltage: ____________ Volts
5. Max. Fault Current: ________ Amps For ________ Sec.
6. Type of Load ____________

Modulator Application:

1. Use ____________
2. Peak Voltage ____________ V
3. Wave Shape ____________
4. Rise or Switching Time ____________ Sec.
5. Peak Pulse Current ________ Amps At ________ °C
6. Pulse Duration ____________ Sec.
7. Average Current ____________ Amps
8. PRF ____________ PPS

ENVIRONMENTAL REQUIREMENTS

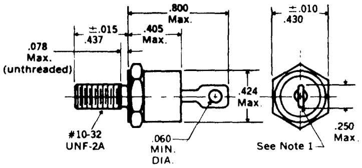
Operating Medium ____________
Operating Temperature Range ____________
Storage Temperature Range ____________
Other Requirements ____________
____

MECHANICAL REQUIREMENTS

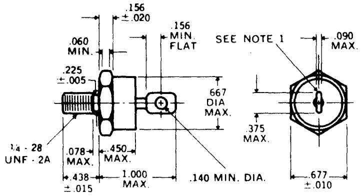
Maximum Size ____________
Maximum Weight ____________
Terminal Provisions ____________
Mounting Provisions ____________

MECHANICAL SPECIFICATIONS

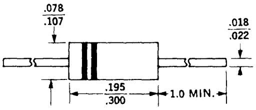
DO-4



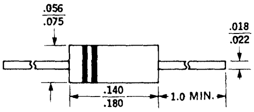
DO-5



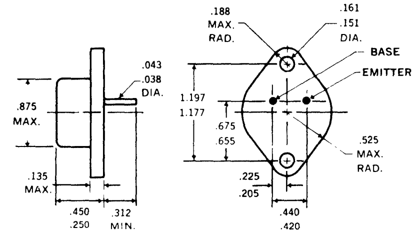
DO-7



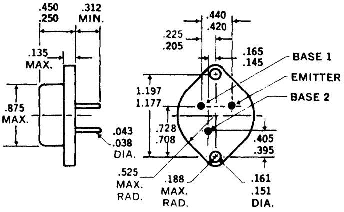
DO-35



TO-3

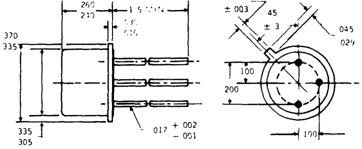


TO-3 (3 PIN)

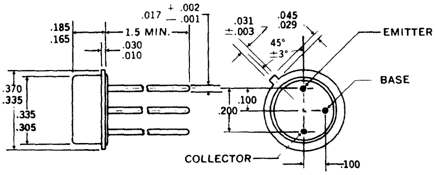


COLLECTOR CONNECTED TO CASE

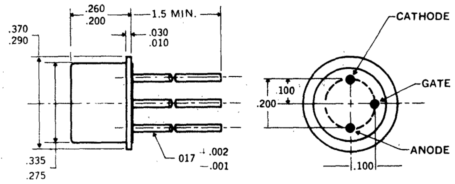
TO-5



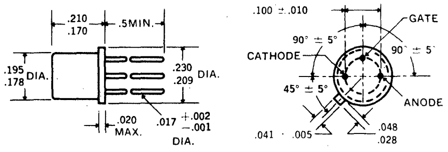
Pancake TO-5



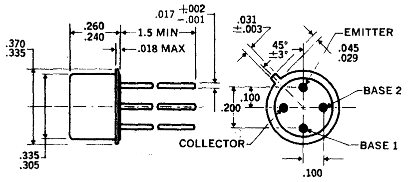
TO-9



TO-18

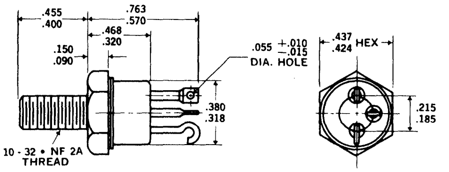


TO-33

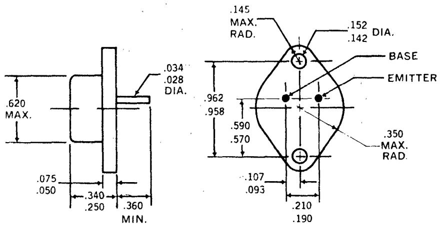


COLLECTOR CONNECTED TO CASE

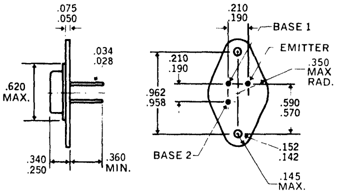
TO-59



TO-66

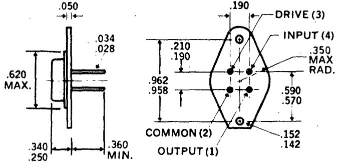


TO-66 (3 PIN)

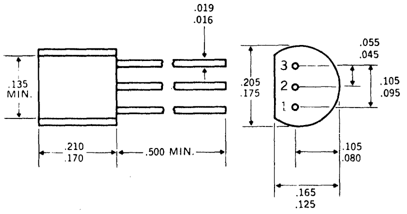


COLLECTOR CONNECTED TO CASE

TO-66 (4 PIN)



TO-92



SCR	PUT	TRANSISTOR
3 — Anode	3 — Cathode	3 — Collector
2 — Gate	2 — Gate	2 — Base
1 — Cathode	1 — Anode	1 — Emitter

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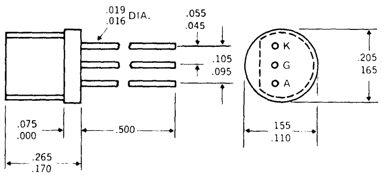
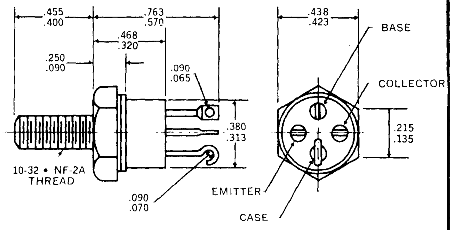
MECHANICAL SPECIFICATIONS

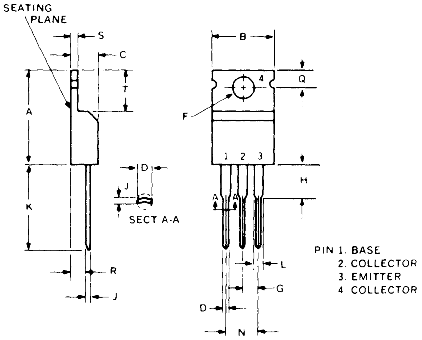
TO-98



TO-111



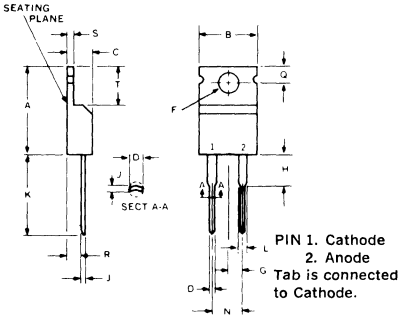
TO-220



PIN 1. BASE
2. COLLECTOR
3. EMITTER
4 COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9 66	10.66	0 380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1 14	0 020	0.045
F	3.531	3 733	0 139	0.147
G	2 29	2.79	0.090	0.110
H	—	6.35	—	0.250
J	0 38	0.64	0.015	0 025
K	12 70	14 27	0 500	0 562
L	1.14	1.77	0.045	0 070
N	4 83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0 080	0.115
S	1.14	1.39	0 045	0.055
T	5.85	6.85	0.230	0.270

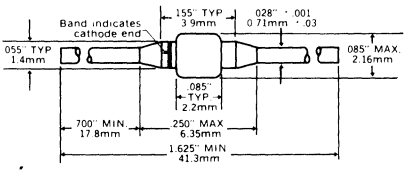
SIMILAR TO TO-220



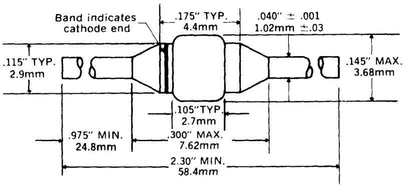
PIN 1. Cathode
2. Anode
Tab is connected
to Cathode.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H	—	6.35	—	0.250
J	0.38	0.64	0.015	0.025
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	1.14	1.39	0.045	0.055
T	5.85	6.85	0.230	0.270

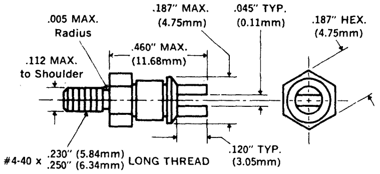
A



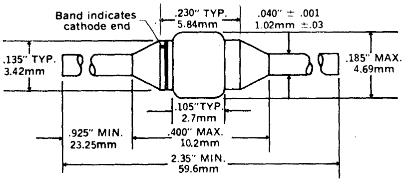
B



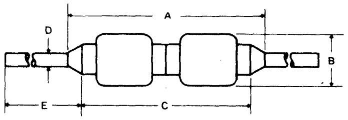
C



CL

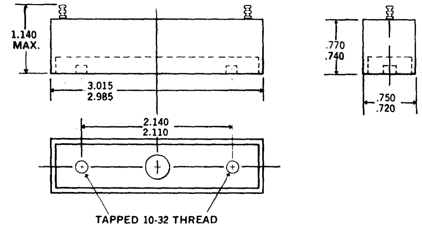


AA,BB,CCL

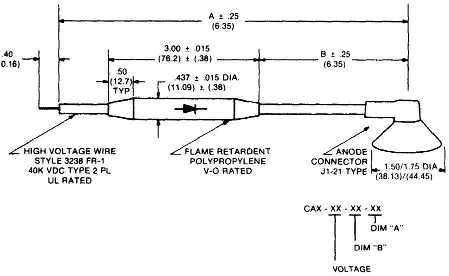


AA	AA	BB	CCL
1 Watt UDZ8807 Series	3 Watt UDZ807 Series	5 Watt UDZ5807 Series	6 Watt UDZ7807 Series
A. .475" max.	A. .450" max.	A. .500" max.	A. .600" max.
B. .104" max.	B. .085" max.	B. .145" max.	B. .185" max.
C. .300" typical	C. .275" typical	C. .325" typical	C. .430" typical
D. .028" ± .001"	D. .028" ± .001"	D. .040" ± .001"	D. .040" ± .001"
E. .975" min.	E. .700" min.	E. .975" min.	E. .925" min.

BE

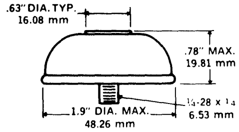


CAX

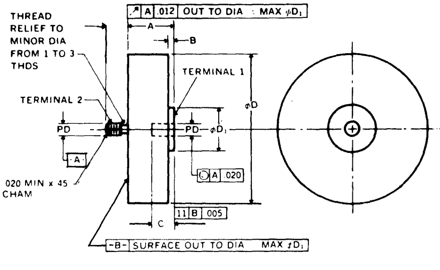


Dimensions in inches and (millimeters)

DD



DE,DF



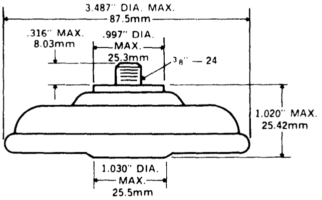
DE

Ltr	Dimensions in inches with metric equivalents (mm) in parentheses		NOTES
	Minimum	Maximum	
A	.73 (18.54)	.83 (21.08)	8
B		.080 (2.03)	
C	.240 (6.10)	.264 (6.71)	2,6
C_1	.265 (6.73)	.400 (10.16)	4
ϕD	1.85 (46.99)	1.95 (49.53)	
ϕD_1	.57 (14.48)	.67 (17.02)	

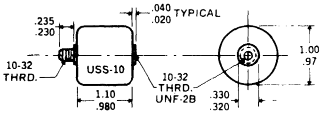
DF

Ltr	Dimensions in inches with metric equivalents (mm) in parentheses		NOTES
	Minimum	Maximum	
A	.970 (24.64)	1.020 (25.91)	8
B	.050 (1.27)	.080 (2.03)	
C	.307 (7.80)	.317 (8.05)	3
C_1	.318 (8.08)	.400 (10.16)	5,7
ϕD	3.450 (87.63)	3.650 (92.71)	
ϕD_1	.95 (24.13)	1.250 (31.75)	

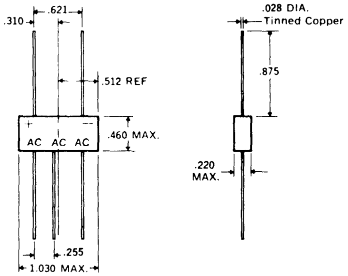
DG



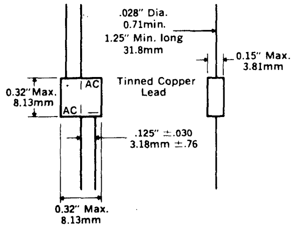
DH



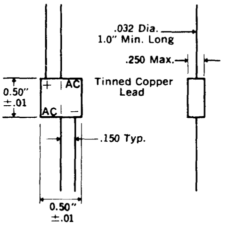
F



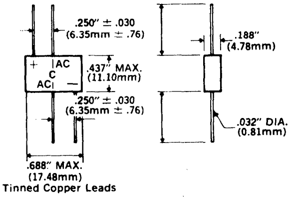
G



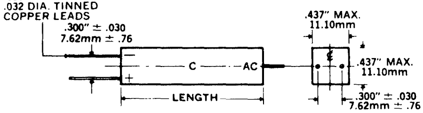
GA



GH



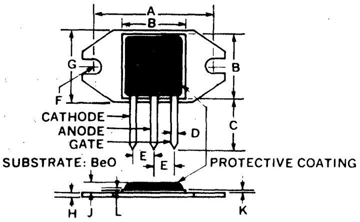
HJ,HK,HL,HM,HN,HO,HP



MAX. LENGTHS

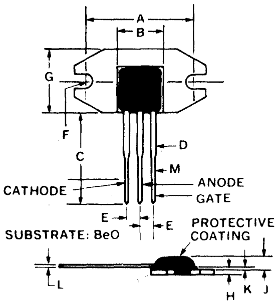
J	K	L	M	N	O	P
.562" 14.27mm	.688" 17.48mm	.875" 22.23mm	1.125" 28.58mm	1.25" 31.75mm	1.375" 34.92mm	1.625" 41.28mm

L1



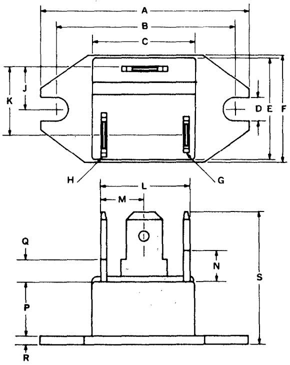
L1 with Flange		
	INS.	**mm**
A	1.176 – 1.196	29.87 – 30.38
B	.650	16.51
C	.500 NOM.	12.70 NOM.
D	.060	1.53
E	.200	5.08
F	.078 R. TYP.	.20 R. TYP.
G	.690 – .710	17.52 – 18.04
H	.050	1.27
J	.150	3.81
K	.025	.64
L	.020	.51

L2



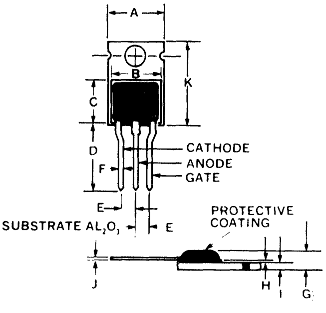
L2 with Flange		
	INS.	**mm**
A	1.176 – 1.196	29.87 – 30.38
B	.500	12.70
C	1.0 NOM.	25.4 NOM.
D	.060	1.53
E	.150	3.81
F	.078 R. TYP.	.20 R. TYP.
G	.690 – 710	17.52 – 18.04
H	.050	1.27
J	.150	3.81
K	.025	.64
L	.020	.51
M	.040	1.02

L3



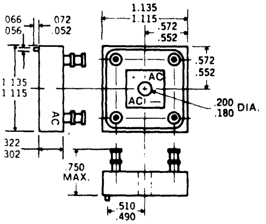
	DIMENSIONS	
	Ins.	mm
A	1.395	35.43
B	1.187	30.15
C	.675	17.15
D	.156 (TYP.)	3.96 (TYP.)
E	.675	17.15
F	.700	
G	.187 (.032 THICK) (GATE)	17.78 (0.81 THICK) (GATE)
H	.250 (.032 THICK) (2 PLACES)	6.35 (0.81 THICK) (GATE)
J	.290	7.37
K	.442	11.23
L	.580	14.73
M	.280	7.11
N	.218	5.54
P	.360	9.14
Q	.156 (2 PLACES)	3.96 (2 PLACES)
R	.050	1.27
S	.875 (TYPICAL)	22.23 (TYPICAL)

L7

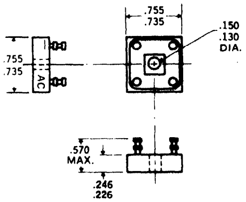


L7 with Flange		
	INS.	**mm**
A	0.4	10.16
B	.350	8.89
C	.300	7.62
D	.500 MIN.	12.70 MIN.
E	.100	2.54
F	.032	.82
G	.150	3.81
H	.015	.39
I	.020	.51
J	.020	.51

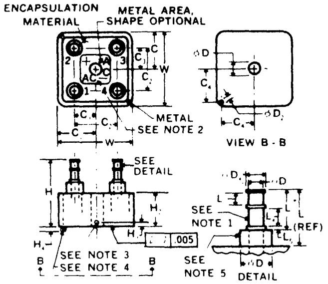
MA



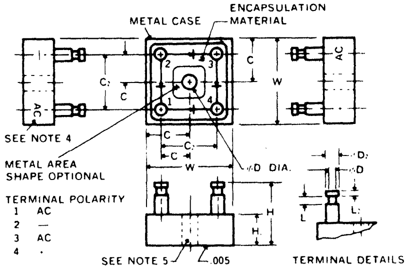
MB



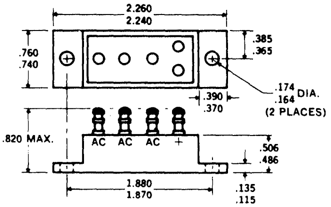
MC



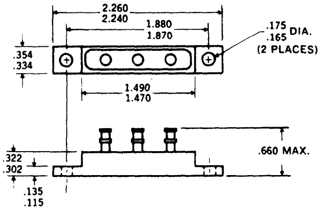
MD



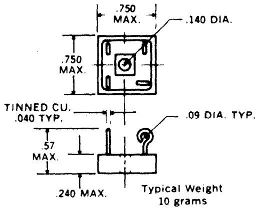
ME



MF

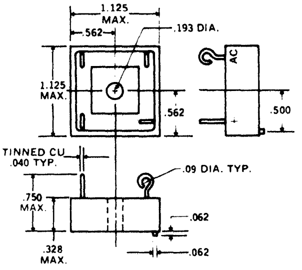


NA

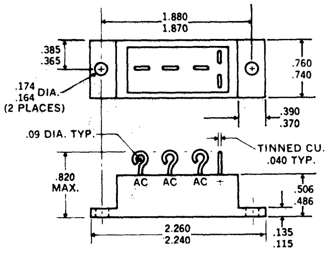


Typical Weight
10 grams

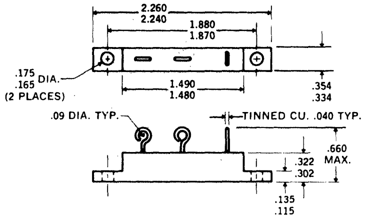
NB



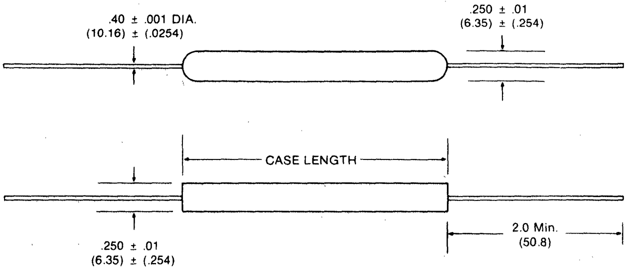
NC



ND



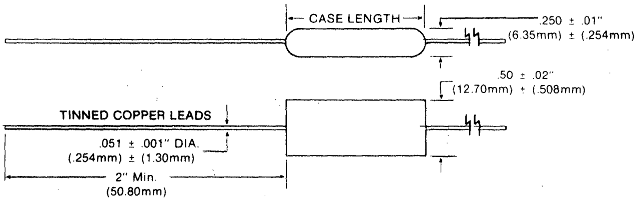
PA



CASE LENGTH	
Ins.	MM
1.5 ± .02	38.1 ± .508
2.0 ± .02	50.8 ± .508
2.5 ± .02	63.5 ± .508
3.0 ± .02	76.2 ± .508
3.5 ± .02	88.9 ± .508

Dimensions in inches and (millimeters)

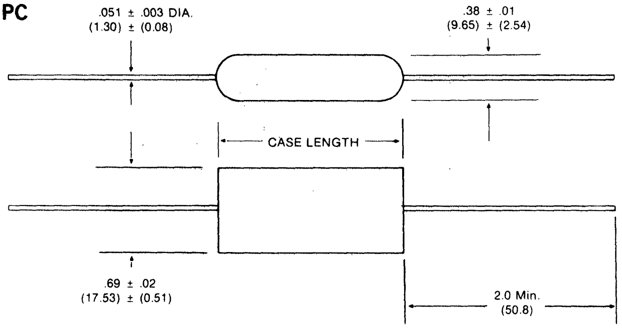
PB



CASE LENGTH	
Ins.	MM
1.125 ± .02	28.58 ± .508
1.625 ± .02	41.28 ± .508
2.000 ± .02	50.80 ± .508
2.375 ± .02	60.33 ± .508
2.750 ± .02	69.80 ± .508
3.500 ± .02	88.90 ± .508
4.250 ± .02	107.95 ± .508

Dimensions in inches and (millimeters)

PC

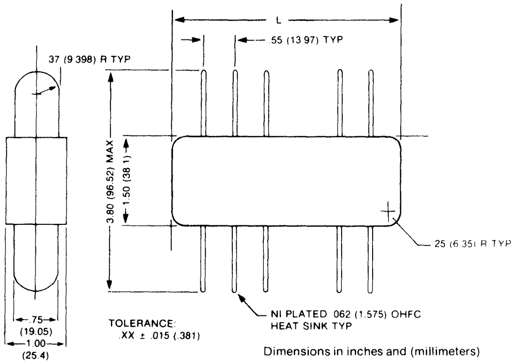


CASE LENGTH	
Ins.	MM
1.5 ± .03	38.10 ± 0.76
2.5 ± .03	63.50 ± 0.76
3.5 ± .03	88.90 ± 0.76
4.5 ± .03	114.30 ± 0.76
5.5 ± .03	139.70 ± 0.76
6.5 ± .03	165.10 ± 0.76

Dimensions in inches and (millimeters)

MECHANICAL SPECIFICATIONS

PMA



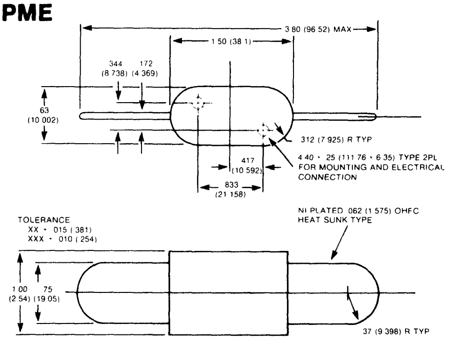
TOLERANCE:
.XX ± .015 (.381)

Dimensions in inches and (millimeters)

CASE LENGTH	
Ins.	MM
1.65 ± .030	41.91 ± 0.76
2.20 ± .030	55.88 ± 0.76
2.75 ± .030	69.85 ± 0.76
3.85 ± .030	97.79 ± 0.76
4.95 ± .030	125.73 ± 0.76
6.05 ± .030	153.67 ± 0.76
7.15 ± .030	181.61 ± 0.76
8.25 ± .030	209.55 ± 0.76
9.35 ± .030	237.49 ± 0.76
10.45 ± .030	265.43 ± 0.76
11.55 ± .030	293.37 ± 0.76
13.75 ± .030	349.25 ± 0.76

For mounting and electrical spacing, refer to individual data sheets.

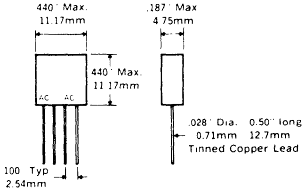
PME



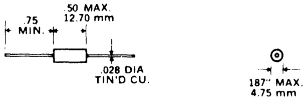
TOLERANCE
.XX ± .015 (.381)
.XXX ± .010 (.254)

Dimensions in inches and (millimeters)

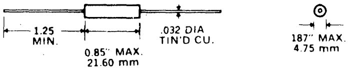
S



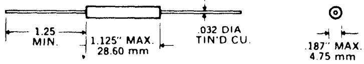
SA



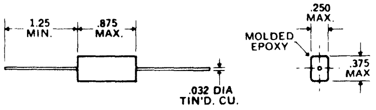
SB



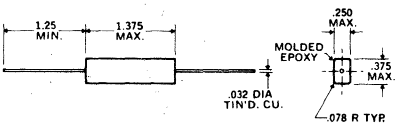
SC



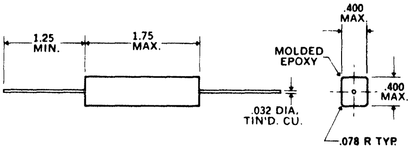
SD



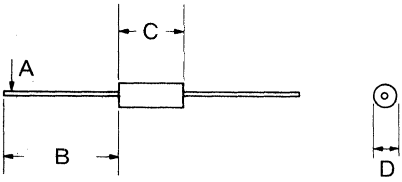
SE



SF



SG, SH, SJ, SK SL, SM, SN

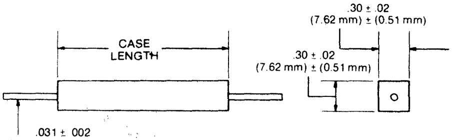


Dimensions in inches and (millimeters)

	SG		SH		SJ		SK	
	Ins.	**MM**	**Ins.**	**MM**	**Ins.**	**MM**	**Ins.**	**MM**
A	.020 ± .001	0.51 ± 0.03	.020 ± .001	0.51 ± 0.03	.031 ± .002	0.79 ± 0.05	.031 ± .002	0.79 ± 0.05
B	.73	18.54	.73	18.54	1.12	28.4	1.12	28.4
C	.400 ± .005	10.16 ± 0.13	.225 ± .005	5.72 ± 0.13	.410 ± .005	10.41 ± 0.13	.200 ± .005	5.08 ± 0.13
D	.125 ± .002	3.18 ± 0.05	.090 ± .002	2.29 ± 0.05	.140 ± .005	3.57 ± 0.13	.100 ± .005	2.54 ± 0.13

	SL		SM		SN	
	Ins.	**MM**	**Ins.**	**MM**	**Ins.**	**MM**
A	.040 ± .003	1.016 ± 0.76	.093 ± .003	2.36 ± 0.76	.020 ± .001	0.51 ± 0.03
B	.40	10.16	.40	10.16	.60	15.24
C	.400 ± .015	10.16 ± .381	.375 ± .015	9.52 ± .381	1.500 ± .015	38.1 ± .381
D	.300 ± .015	7.62 ± .381	.500 ± .015	12.7 ± .381	.235 ± .005	5.97 ± 0.13

SP



.031 ± 002
(0.79 mm) ± (0.05 mm)
TINNED COPPER LEADS
LENGTH 1.500" (38.1 mm) MINIMUM

CASE LENGTH	
Ins.	**MM**
1.50 ± .03	38.1 ± 0.76
2.00 ± .03	50.8 ± 0.76
2.50 ± .03	63.5 ± 0.76

Dimensions in inches and (millimeters)

UNITRODE