VOL. 18 NO.

Electronic Design

5

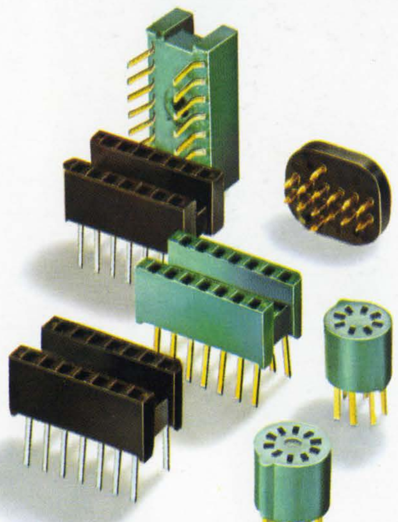
FOR ENGINEERS AND ENGINEERING MANAGERS

MARCH 1, 1970

New twist in plated-wire memories now makes it possible to alter stored information with electronic signals. Read cycle times are 125 ns, and access times can be as fast as 70 ns. Capacities range from 20,000 to 164,000 bits, at costs between 5 and 10 cents per bit. Writing speed is approximately 1 us. See p. 95.

CINCH PRECISION MINIATURE SOCKETS

INSURE EQUIPMENT DEPENDABILITY



Actual size

Equipment design frequently involves problems of field maintenance or circuit updating. Cinch component sockets provide inexpensive and effective solutions without compromising reliability.

DIP sockets for 14 and 16 lead DIP's are typical of Cinch specialized miniature sockets. Available in GP black phenolic or SDGF diallyl phthalate, they have extremely high resistance to shock, vibration, humidity and corrosive atmospheres. Contacts are gold or cadmium plated beryllium copper with low contact resistance.

IC sockets for 6, 8 and 10 pin TO-5 cased devices, miniature *NIXIE Tube* sockets and *Subminiature relay* sockets are just a few of the other component sockets Cinch manufactures.

For information on DIP sockets and other Cinch interconnection devices, write to Cinch Manufacturing Company, 1501 Morse Avenue, Elk Grove Village, Illinois 60007. C-6818

CINCH

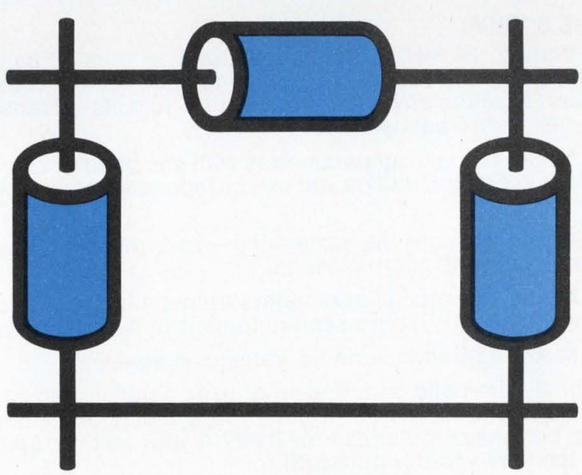
DIVISION OF UNITED-CARR

CINCH MANUFACTURING, CINCH-GRAPHIK, CINCH-MONADNOCK AND CINCH-NULINE DIVISIONS OF UNITED-CARR INC., A SUBSIDIARY OF TRW INC.

INFORMATION RETRIEVAL NUMBER 202

HP announces the world's first low-frequency PIN diode: 99¢

For the first time Hewlett-Packard offers the VHF/UHF communications industry current-controlled resistors with the high performance that was never before available at low frequencies.
This new HP product will attenuate or switch RF signals as low as 1 MHz and do it with exceptionally low distortion. It will also handle signals up to 1 GHz with the same clean performance. You can measurably improve constant-impedance AGC circuitry and electronically-controlled RC and RL circuits for CATV amplifiers, IF amplifiers and other radio equipment.



HEWLETT hp PACKARD

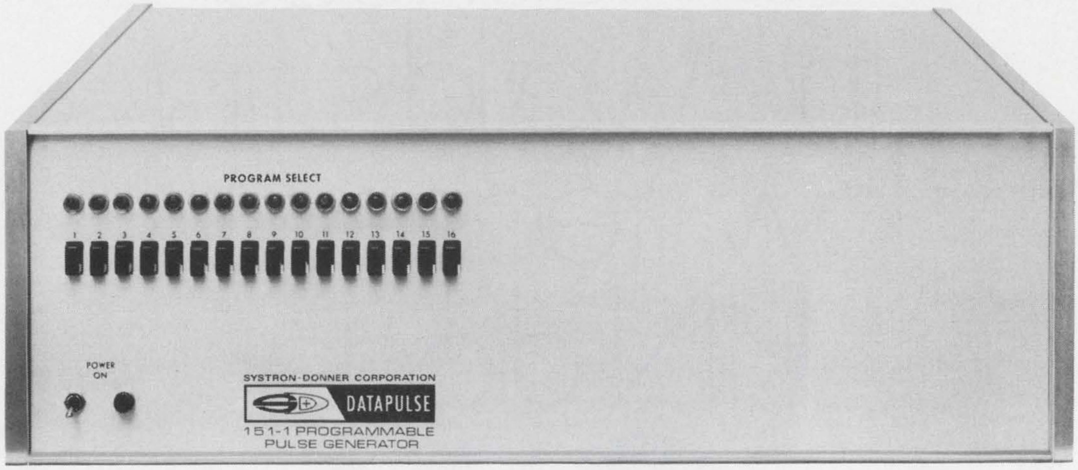
SOLID STATE DEVICES

01002

HP's new low frequency PIN diodes, 5082-3080, are available from stock: 99¢ each in 10K quantities, less if you order more. For quotes, call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe; 1217 Meyrin-Geneva, Switzerland.

INFORMATION RETRIEVAL NUMBER 2

GUARANTEE



If your new Datapulse 150 series pulse generator doesn't pay for itself in 90 days, we'll take it back.

If your pulse generator just sits on your work bench and you reach over now and then to turn a knob or two—the Series 150 is not for you.

But, if you're like everybody else, your pulse generator is part of some test set-up. You perform several different tests and you repeat them several times. **You can't afford anything else.**

HERE'S WHY!

Rep Rate to 50 MHz—Delay and Duration from 10 nanoseconds to 10 milliseconds—Pulse Amplitude to ±10 volts with top and baseline anywhere from + to −10 volts—Transitions take less than 5 nanoseconds.

The Model 151 sets all parameters with **one punch** of a button. You pocket all the dollars you used to spend for manual set-up time.

The Model 152 does the same thing—and transition times are variable out to 10 microseconds.

The Model 153 sets all parameters from digital input information if you already have a semi-automatic or automatic system.

The Model 154 adds variable transitions again.

Optional automatic sequencing and/or parallel manual control round out the picture to give you a choice of 16 different units. Let one of them pay for itself in your test set-up. After that, the time saved is pure profit.

Prices start as low as $1,000.

For more information, address Datapulse Division, Systron-Donner Corporation, 10150 W. Jefferson Blvd., Culver City, California 90230. Phone 213-836-6100 or TWX 910-340-6766.

DATAPULSE
DIVISION
SYSTRON DONNER

INFORMATION RETRIEVAL NUMBER 3

VOL. 18 NO. 5

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

MARCH 1, 1970

NEWS

TECHNOLOGY

PRODUCTS

Departments

Cover: A plated-wire memory plane made by Memory Systems, Inc., of Hawthorne, Calif. Photographed by Henry Ries.

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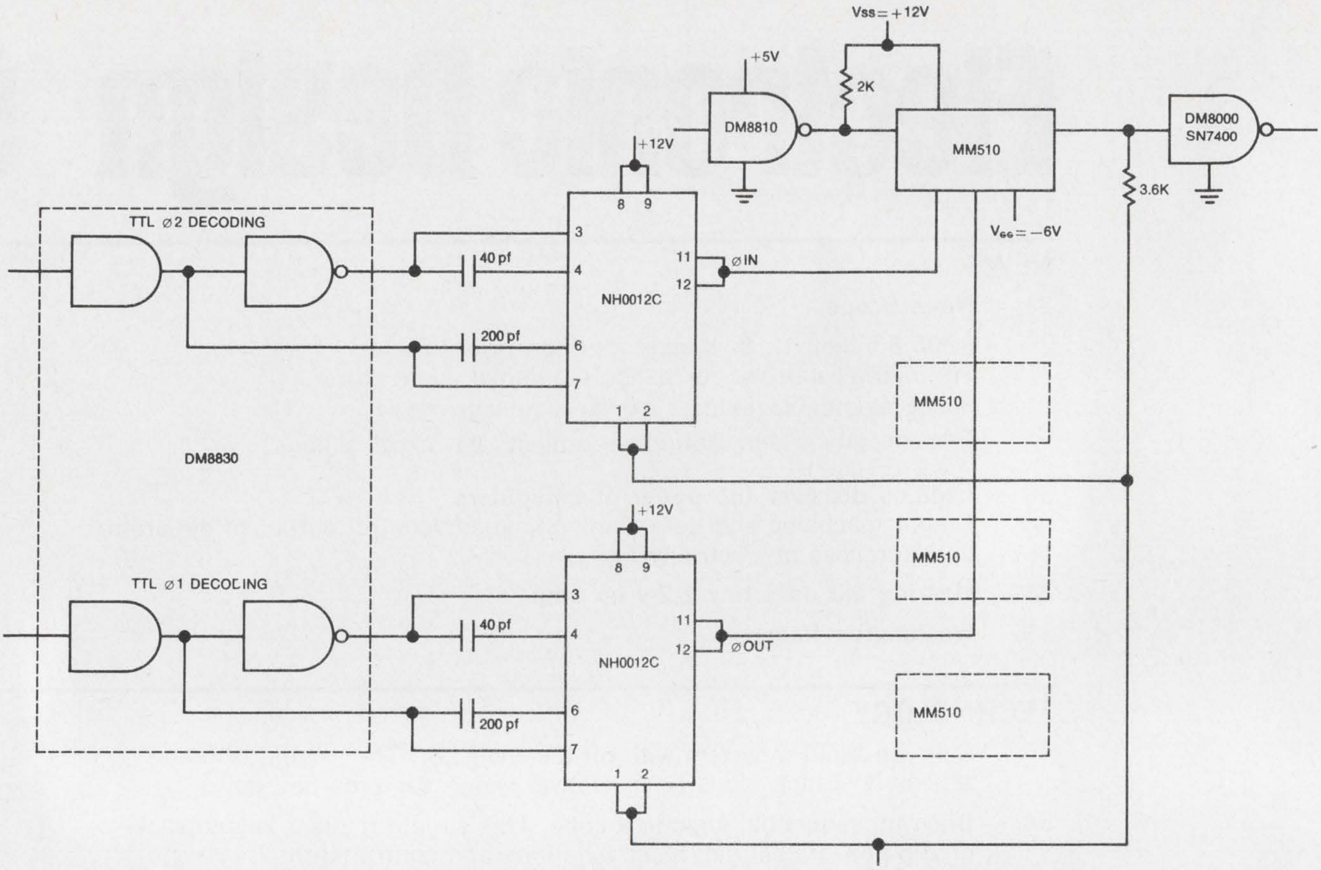
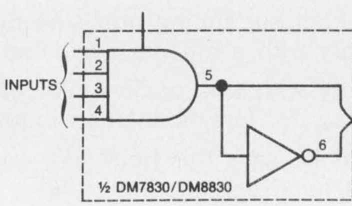
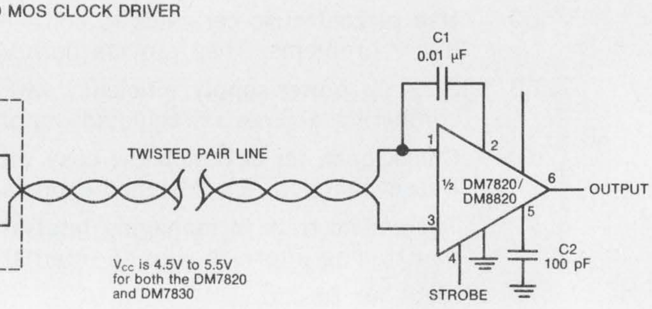


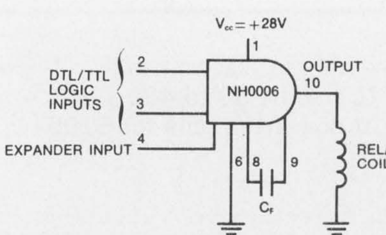
HIGH SPEED MOS CLOCK DRIVER



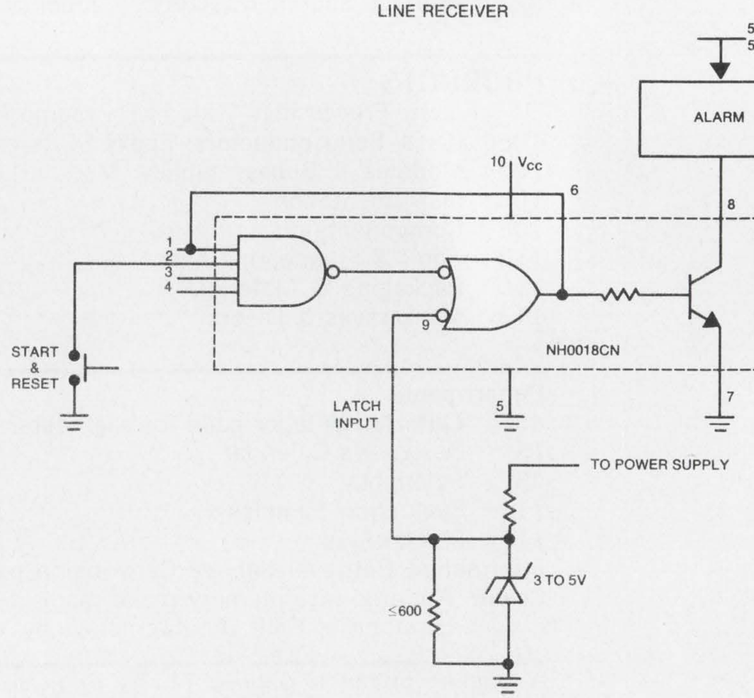
LINE DRIVER



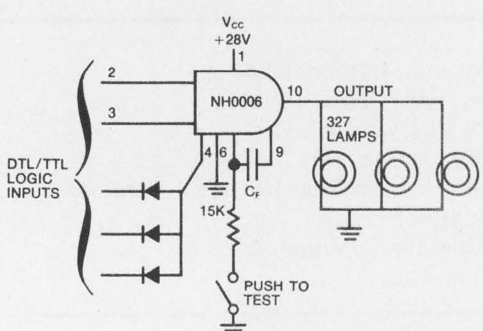
LINE RECEIVER



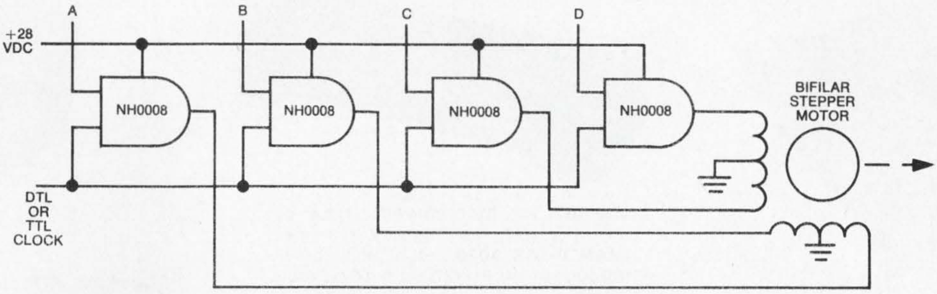
RELAY DRIVER



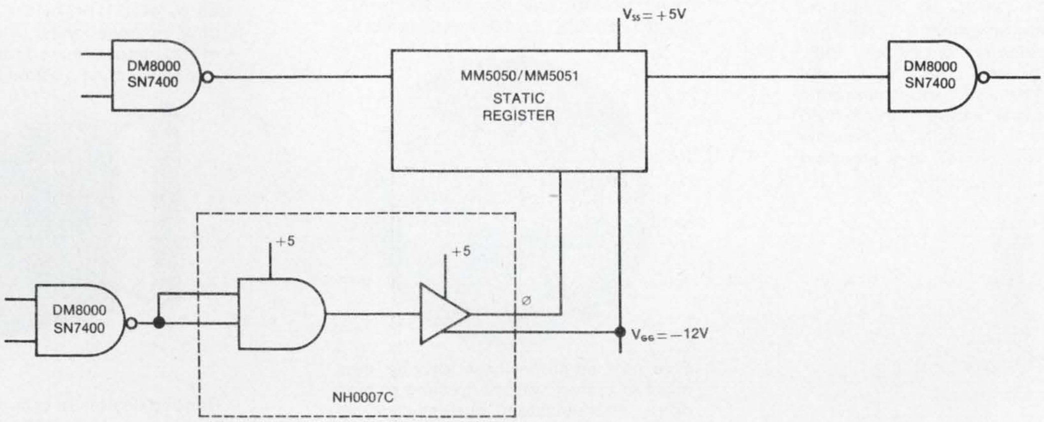
POWER SUPPLY MONITOR



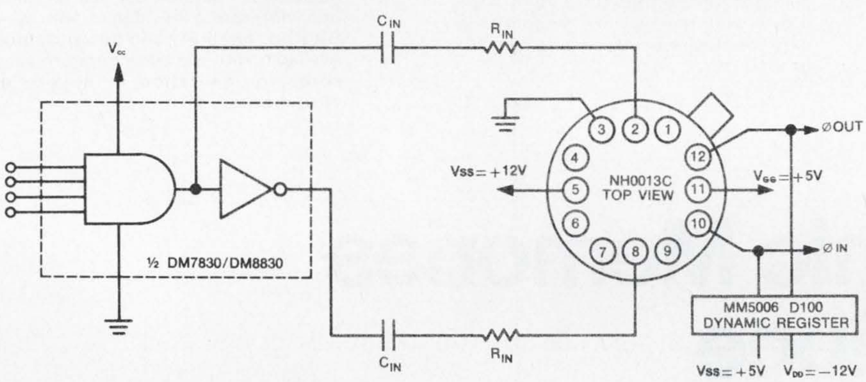
LAMP DRIVER WITH EXPANDED INPUTS



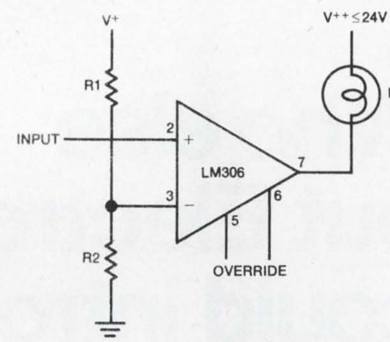
CONTROLLER FOR CLOSED LOOP STEPPER MOTOR



DRIVING STATIC MOS REGISTERS



DRIVING DYNAMIC MOS REGISTERS



LEVEL DETECTOR AND LAMP DRIVER

Leave the driving to us.

Interface at the output of a TTL system calls for circuits capable of handling up to 1 amp or 100 volts. From there, you can drive a line, trigger a relay, control a motor or light your lamps. Similarly, your MOS memory requires MOS clock drivers to deliver precision pulses to registers for a completely compatible TTL system (our registers are already TTL compatible at data input/output).

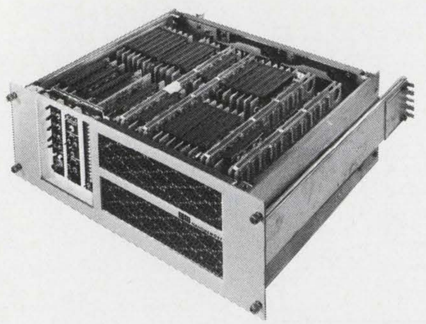
For total digital systems—DTL, TTL or MOS, National drivers come in TO-5s or molded silicone dual in-lines.

They're part of the National scene, low cost and ready to go from distributors' stocks.

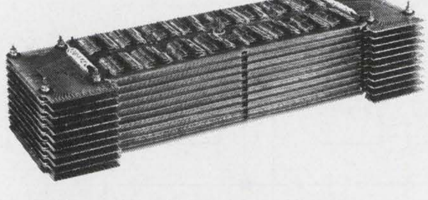
Call, write, TWX or honk for our drivers guide with charts, specs and applications notes. National Semiconductor, 2900 Semiconductor Drive, Santa Clara, California 95051 (408) 732-5000 TWX: 910-339-9240 Telex: 346-353 Cables: NATSEMICON.

National/Digital

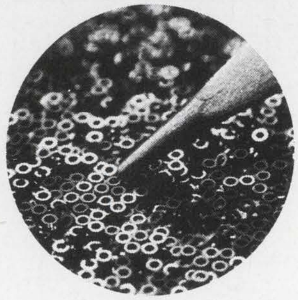
INFORMATION RETRIEVAL NUMBER 4



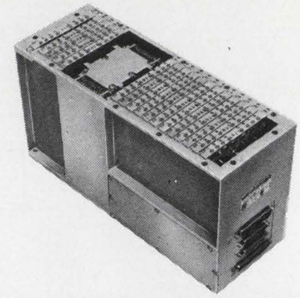
High speed commercial memory system — **NANOMEMORY 2600**. Full cycle time of 600 nanoseconds, and word capacities of 16K by 18 or 8K by 36. It's all done with a second-generation 2-1/2D drive system with efficient circuit and logic design, for reduced component count and high MTBF, and wide operating margins—the real feature of the 2-1/2D configuration. It is easily expandable in the field, and comes in a standard 19″ rack.



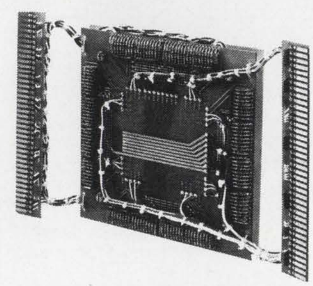
Perfect for high speed, large capacity mainframe memory systems... **NANOSTAK 3020**...technology breakthrough in 3W, 2-1/2D stacks. Stackable, compact size is an amazing 25% of competitive planar stacks and offers a significant advantage in form factor for system packaging. Extremely fast 650 nanosecond cycle time for 8K or 16K by 40, or 32K by 20 word memories.



Five new memory cores for your next stack or system. All are medium or high drive, all coincident current, and all are fast switching for your high speed applications. Four new cores available in 18 mil, 20 mil, and two types of 30 mil sizes for use from 0° to 70°C. Also, a new wide temperature range 18 mil core for severe environments of —55° to +100°C.



Compact, ATR compatible memory system **SEMS-6** for use in military and rugged commercial aircraft applications. Reliable performer is optimized around 8K or 16K with maximum capacities of 8K by 40 or 16K by 20. Full cycle time of 2 microseconds, with access time of 700 nanoseconds. Meets MIL-E-5400, low power consumption and lightweight.



Rugged design for ground based mobile equipment, **NANOSTAK 020** commercial memory stack. High speed 850-nanosecond full cycle time for 4K memories. Features 3W, 3D organization with word capacities to 16K by 40. Built-in reliability and dependability. Available with wide temperature range cores for operation in severe environments.

Who else but Electronic Memories could introduce five brand spanking new memories—at once

Only Electronic Memories, the technology leader, could introduce five important new memories at once. Each one offers significant advances to provide you with faster, more reliable, and lower cost memories. Each one is loaded with outstanding new design features to give you faster access, larger capacity, and more economical operation. From cores and stacks to megabit memories, Electronic Memories has the memory products for your next, faster, more powerful computer system. For more facts and figures, just write.

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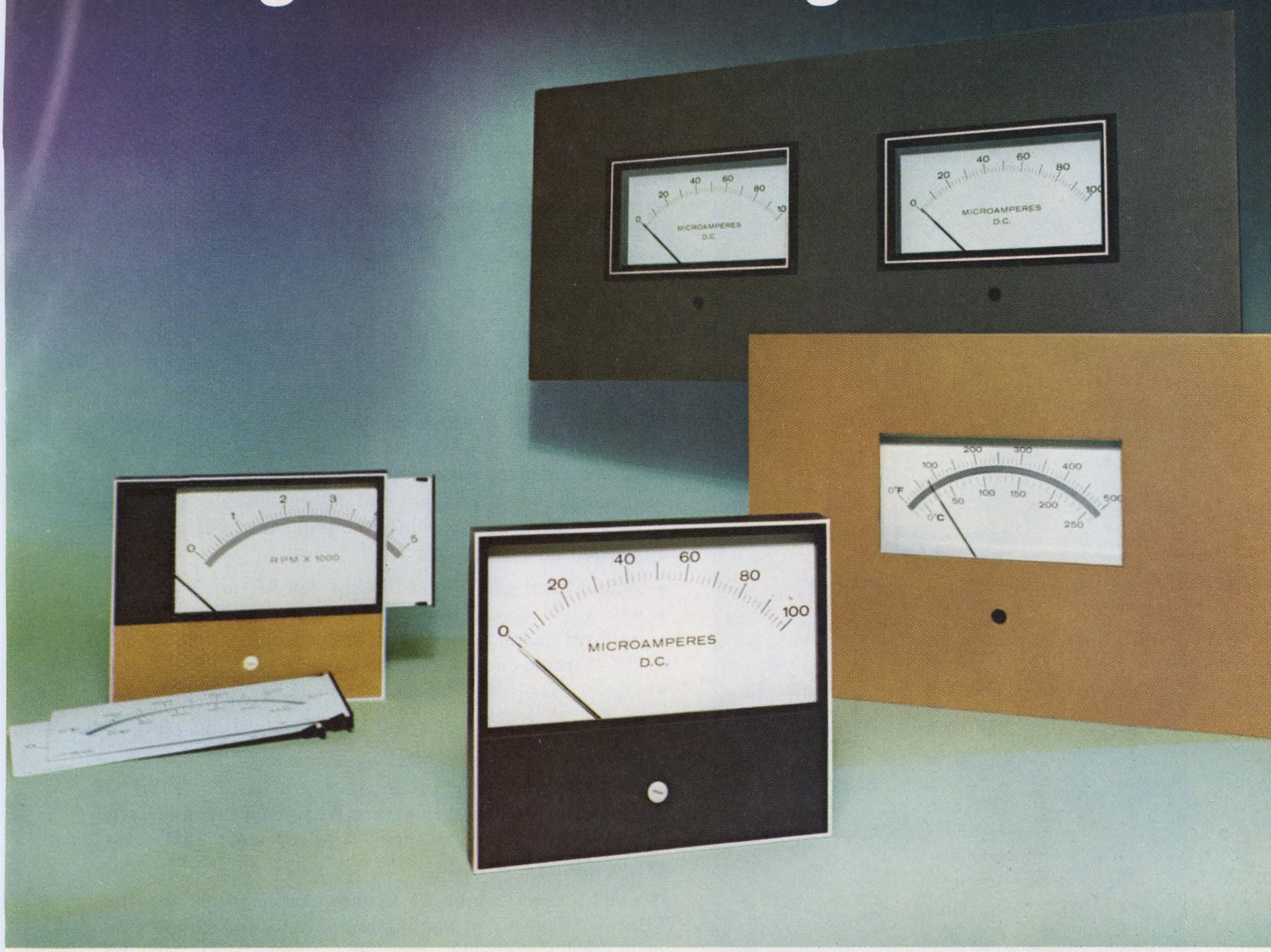
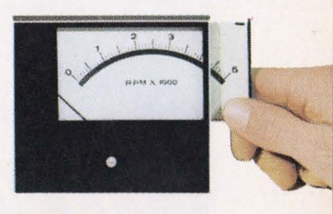
INFORMATION RETRIEVAL NUMBER 5

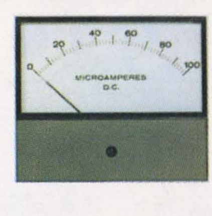
INFORMATION RETRIEVAL NUMBER 6 ▶

You get all these design choices



...with one new API meter





■ API Series 7000 panel meters, styled for the '70s, offer the greatest versatility ever built into a single meter design. You can front mount, bezel mount or lens mount. Change the slide-in scale in the field, without damage, to reduce inventory requirements. Enhance your panel design with "stick-on" front color plates. ■ Taut band and 1% tracking are standard in the most popular DC ranges. Phenolic cases incorporate glass windows that are scratch-proof, free of static electricity. Low OEM quantity prices. ■ ***Ask for Bulletin 67.***

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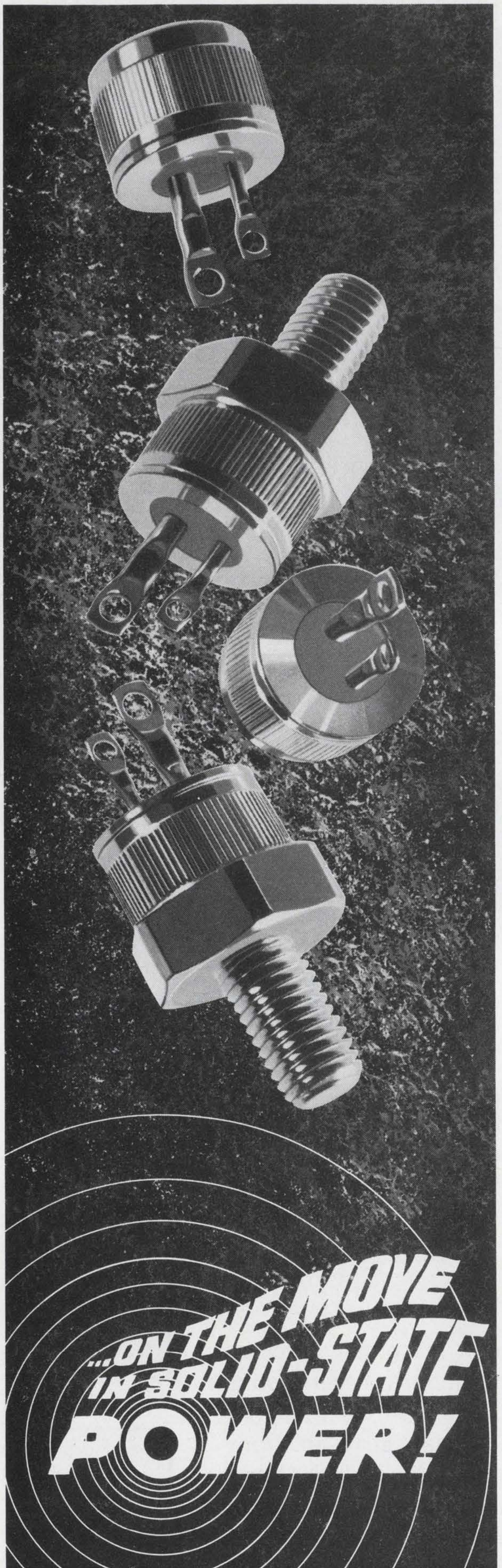


Control Full-Wave Power To 6,000 W+ With Rugged, New MAC35 Triacs!

There's only one way to go for compact, economical, stepless control of 60 cycle AC for your demanding industrial/military designs — rugged, new MAC35/36 Triacs!

Rated at a full 25 amperes RMS, this "heavy muscle" series will easily handle 6,000 watts (240 V) and higher in light dimmers, power supplies, heating, A/C and motor controls, welding equipment and power switching systems, to name a few. And provide these important performance advantages:

- symmetrical gating and holding for AC applications
- low, 1.5 V (max) on-state voltage at 35 A
- uniform characteristics through all-diffused junctions
- 225 A peak one-cycle surge current protection
- 4 mA (max) peak blocking current @ V_{DRM}

Turn-on time is a scant 1.0 μs, too, assuring efficient switching in all applications.

Even when cost is the prime consideration, the MAC35 series ensures optimum balance between price and continuous control performance — prices start as low as $1.70, 100-up!

If you're now looking at Circuit Applications for the Triac, we have a new application note by the same name we'll send along with complete technical data on the MAC35/36. AN-466 discusses basic theory with control methods and circuit applications — a comprehensive guide to new and better ways to control power in today's thyristor circuits . . . with Triacs!

See your franchised Motorola distributor for stud or pressfit evaluation units now . . . or any of 155 other Motorola standard power thyristors!

Series	Package	V_{DRM} Range V	$I_{T(RMS)}$ A	I_{GT} (typ) mA	I_H (typ) mA
MAC35-1 to -7	Pressfit	25 to 500	25	20	10
MAC36-1 to -7	Stud				

–where the priceless ingredient is care!

MOTOROLA
Power Thyristors

SPERRY RAND

150 WATT GaAs LASER DIODE ARRAY. HIGHEST POWER DENSITY AVAILABLE.

Sperry now offers a 150 watt gallium arsenide laser diode array—offering the highest peak power density available today. This high peak power density ideally suits the array to such applications as fuzing, optical radar, intrusion detection, communication, tracking and guidance, and beacon devices.

The 150 watt, 0.050" diameter source—that needs no cooling—provides the following characteristics:

- 150 watts peak power minimum
- package diameter 0.50 inch
- pulse width of 80 nanoseconds
- output beam 22° diameter (f/2.6)
- infrared output at 9100Å
- prf at nominal ambient over 1500 Hz.

This unit is matched to the Sperry standard 150 amp. solid-state modulator which also powers our 10 to 25 watt line of gallium arsenide devices.

For additional information, write to *Electro-Optics*, Sperry Gyroscope Division, Great Neck, New York 11020 (Telephone: 516-574-2598).

SPERRY
GYROSCOPE DIVISION

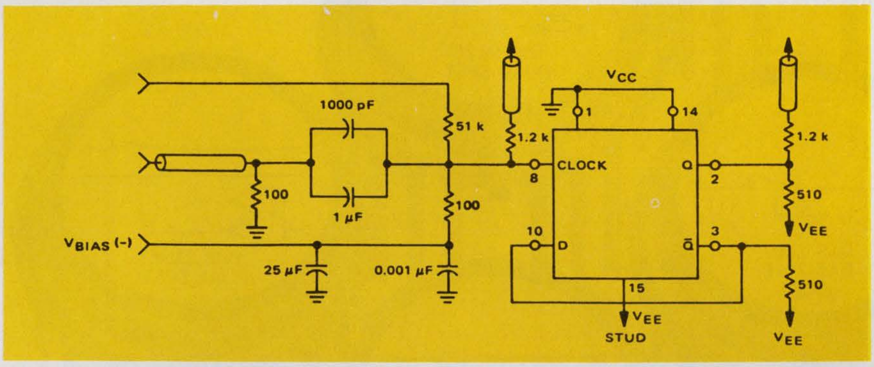
INFORMATION RETRIEVAL NUMBER 8

Need a fast, accurate solution to an IC problem? E-H Research Laboratories, Inc. teams up with Iwatsu Electric Company, Ltd. to offer you the ideal test instrumentation.

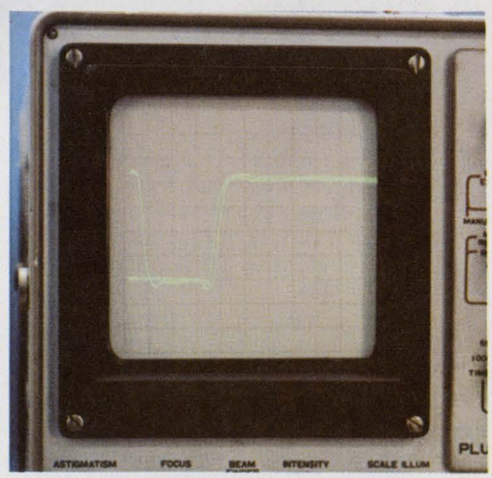
E-H breaks through with the **E-H 129 pulser** which is capable of driving the fastest digital logic circuits. Until this compact, all solid-state instrument came along, no practical commercial pulse generator offered repetition frequency capability beyond 200 MHz. The E-H 129 offers 500 MHz, 2-volt pulses with less than 500 ps risetime and such extras as baseline offset, pulse-top/baseline inversion function, and synchronous gating.

And the ideal mate for this instrument is the **Iwatsu 5009B sampling scope** which allows you to observe and control the waveforms you generate. The Iwatsu 5009B with 18GHz bandwidth lets you evaluate fast circuits with high accuracy—in fact, direct measurements on 100 ps edges with less than 2% display error. Features include less than 20 ps risetime, sensitivity from 10mV/cm, dual-trace performance with seven operating modes, separate miniature sampling heads, big CRT and triggering to full bandwidth for extra convenience.

If these two instruments can't solve your problems, E-H can offer you E-H and Iwatsu instrumentation that can. Contact an E-H representative and get a fast solution. Today.



E-H the fast solution



E-H RESEARCH LABORATORIES, INC.

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In Japan: Iwatsu Electric Company, Ltd., 7-41, 1-Chome Kugayama Suginami-Ku, Tokyo 167, Japan

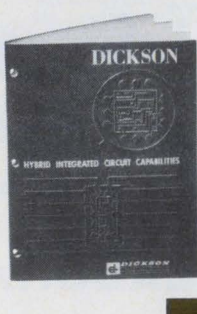
INFORMATION RETRIEVAL NUMBER 10

Seven new hybrid analog switches from DICKSON

MODEL NUMBER	TYPE	LOGIC LEVEL	R_{on} Ω	t_{on} μsec	V_{out} volts	PACKAGE	PRICE 100-999
DAS 2107	SPST	high-level inverting	50	.3	5	TO-5 6 lead	$ 5.50
DAS 2110	SPST	high-level inverting	30	.3	10	TO-5 6 lead	$ 8.00
DAS 2114	SPDT/ DPST	high-level alternating	30	.9	10	TO-8 12 lead	$15.00
DAS 2126	SPDT/ DPST	low-level alternating	30	1.5	10	TO-8 12 lead	$18.00
DAS 2128	QUAD SPST	high-level inverting	30	1.0	7	TO-8 16 lead	$30.00
DAS 2132	DUAL SPST	low-level non-inverting	30	0.5	10	TO-5 10 lead	$18.00
DAS 2136	DUAL SPST	low-level inverting	30	0.5	10	TO-5 10 lead	$18.00

These versatile Dickson hybrid analog switches may be just the circuits you need for your data transmission systems. They offer a variety of functions in standard 6, 10, 12 and 16 lead packages.

Models DAS 2126, 2132 and 2136 operate directly from DTL, RTL or TTL logic. The other four switches require a 0 to +15V drive signal. All of these standard Dickson units provide fast switching speeds, handle AC signals through 1 MHz, and have the quality and dependability you expect from a leading supplier of high-reliability semiconductors. Shipments are being made from stock. *Custom analog switches are also available.* For complete specifications, use this publication's reader service card.



COMPLETE DETAILS ON CUSTOM HYBRID CAPABILITIES

For your copy of a 16-page brochure giving complete information on Dickson custom hybrid capabilities and a copy of the Dickson Hybrid Specifications Guide, use this publication's reader service card.

DICKSON
ELECTRONICS CORPORATION

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INFORMATION RETRIEVAL NUMBER 11

Designer's Calendar

MARCH 1970						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

For further information on meetings, use Information Retrieval Card.

Mar. 23-26
IEEE Convention and Exhibition (New York City) Sponsor: IEEE. H. L. Nicol, The Institute of Electrical and Electronics Engineers, 345 E. 47th St., New York, N. Y. 10017

CIRCLE NO. 321

APRIL 1970						
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Mar. 31-Apr. 2
International Symposium on Submillimeter Waves (New York City) Sponsor: IEEE et al. J. Fox, Microwave Research Institute, Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn, N. Y. 11201

CIRCLE NO. 322

Mar. 31-Apr. 2
Symposium on Law Enforcement Science and Technology (Chicago) Sponsor: U.S. Dept. of Justice. IIT Research Institute, Law Enforcement Science & Technology Center, 2024 West St., Annapolis, Md. 21401

CIRCLE NO. 323

Apr. 7-9
Reliability Physics Symposium (Las Vegas) Sponsor: IEEE. K. H. Zaininger, RCA Laboratories, Princeton, N.J. 08540

CIRCLE NO. 324

One of a series of quick guides for design engineers.

A quick guide to magnetic drives: torque transmitters that work when other methods won't.

Magnetic drives offer you some relatively inexpensive solutions to difficult torque transmission problems. For instance, a magnetic drive can transmit torque through a non-magnetic barrier without using any mechanical connection. And because the system completely eliminates seals, it eliminates problems of leakage, maintenance and contamination.

3 basic types of magnetic drives.

1) *Synchronous drives* are equivalent to a shaft connection. Two basic arrangements are axial and radial. Axial drives consist of two Indox magnets or two Alnico side pole rotor magnets. Axial thrust is a maximum at zero load and diminishes as more torque is applied.

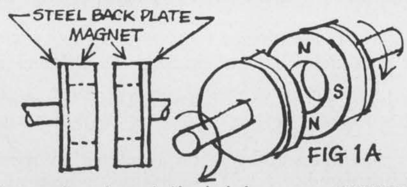

FIG 1A

Radial drives consist of two ring magnets and have no axial thrust. Because of starting inertia, the outer magnet normally drives the inner one.

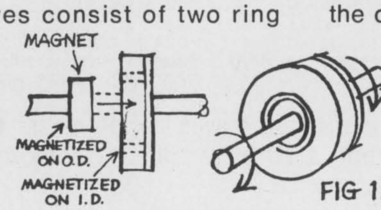

FIG 1B

When the maximum torque of a synchronous drive is exceeded, the driven member stops. This can offer important protection in event of overloading. And you never have to replace shear pins or worn frictional surfaces.

2) *Eddy current drives* use the field of a rotating permanent magnet to induce eddy currents in a conducting material. Interaction between these currents and the magnetic field gives rise to the torque of the coupling. Torque varies with the relative speed of the members. Eddy current drives use driven members of aluminum or copper in the form of cups, tubes or discs depending upon the configuration needed.

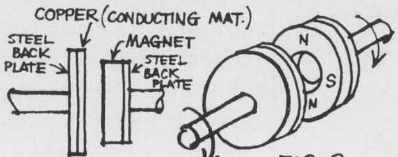

FIG 2

3) *Hysteresis drives* use the magnetic field of a rotating permanent magnet to drive the material of the hysteresis member through its hysteresis loop. The unit is synchronous provided the maximum torque isn't exceeded. Beyond this point the torque is independent of the slip speed and remains constant.

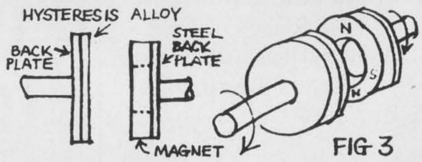

FIG 3

Hysteresis drives operate at close gaps. But unlike eddy current drives, hysteresis drives transmit constant torque.

Design aids available free.

The basic factors to consider in magnetic drive design include:

- radial or axial gap configuration
- relationship of torque to slip speed
- ambient operating temperature
- non-magnetic material through which torque must be transmitted
- maximum torque to be transmitted
- critical nature of the alignment.

We're anxious to help answer your questions. And we would like to send you some useful aids that include graphic presentations of important factors in magnetic drive design. Just write Indiana General, Magnet Products, Valparaiso, Ind. 46383.

indiana general

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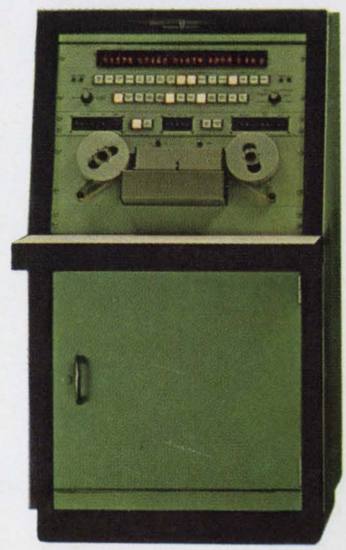
INFORMATION RETRIEVAL NUMBER 13

INFORMATION RETRIEVAL NUMBER 14 ►

THE ASTONISHING CIRCUIT ANALYZER THAT SAVES A FORTUNE IN MANUFACTURING

Checks 100,000 terminations as easily as one



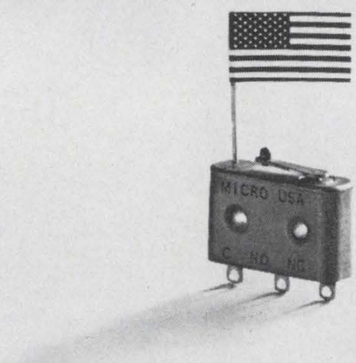
Rapid low cost testing of complex circuitry with up to 100,000 terminations is within your production capability with OmniTester. So is increased product quality. And OmniTester offers forward scan failure isolation and error print out, automatic tape search and rewind, and manual or automatic operation. It's also available with computer controlled interface.

What's more, this accurate high speed system has the ability to generate its own test programs. A feature which not only reduces costs of manual program preparation and de-bugging, but also insures the reliability of each production unit.

This astonishing circuit analyzer not only pays for itself in a short time, but through the continuous saving it brings to production operations, it becomes a sound investment that lowers overall product manufacturing costs.

TeleSciences, Inc. 351 New Albany Road, Moorestown, New Jersey 08057/(609) 235-6227

Little Fort Knox.



Our new HM miniature has its own reserve of gold. Reliable gold contacts give the operational dependability required for low-energy applications.

The HM, and our slightly larger HS, are hermetically sealed for all-weather, multi-environment applications.

The metal-to-metal and glass-to-metal construction is specifically designed for military/aerospace use.

We've also given a new look to our environmentally-sealed SE and XE subminiatures. More updated design. More functional reliability.

And all four switches meet the applicable requirements of MIL-S-8805.

For more information, contact your MICRO SWITCH Branch Office, or write for Catalog 52.

MICRO SWITCH
FREEPORT, ILLINOIS 61032
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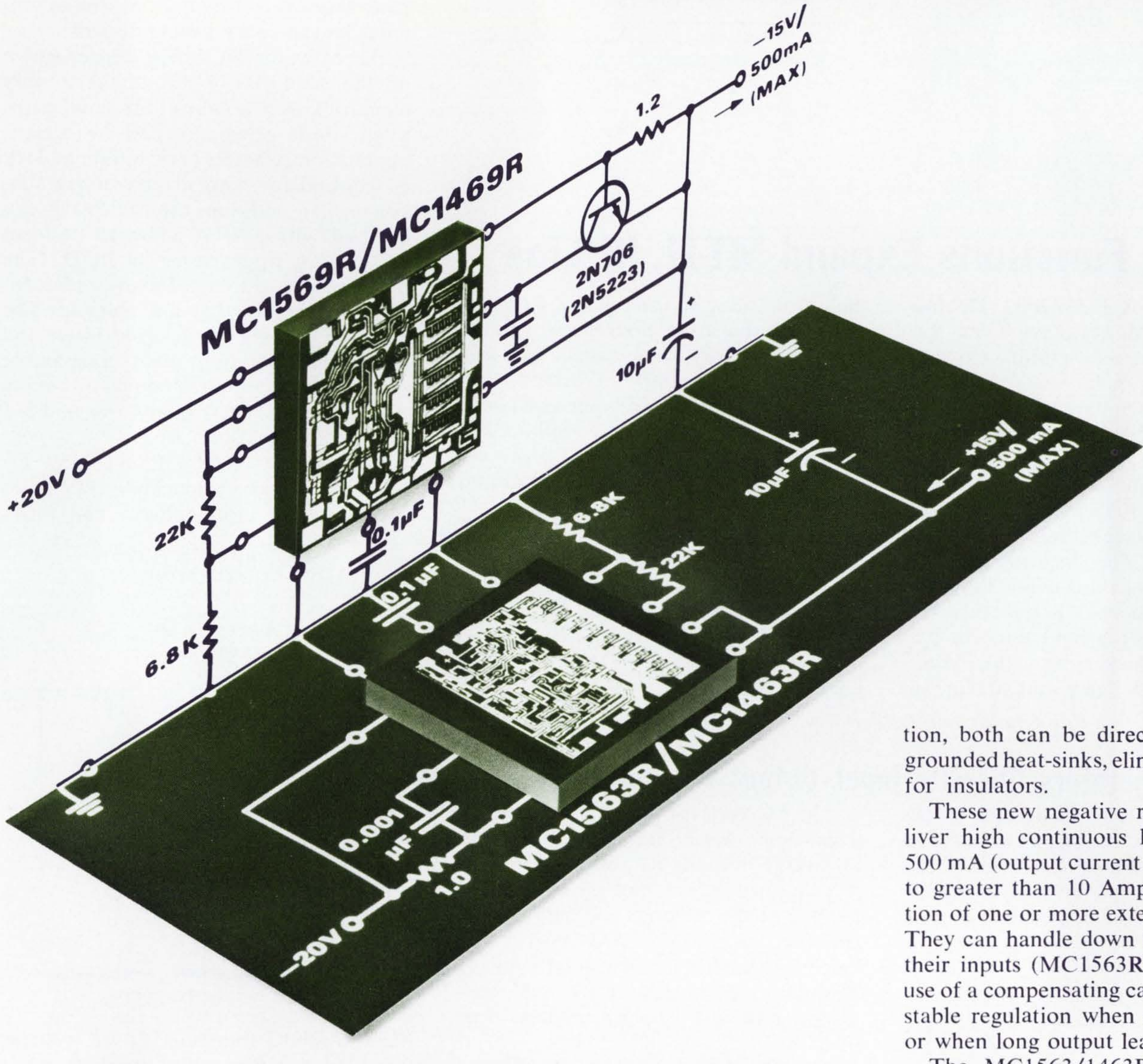
INFORMATION RETRIEVAL NUMBER 15

No. 8-70

SEMICONDUCTOR newsbriefs

PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.



"Minus-Mate" Joins "Plus-Partner" To Form Top IC Regulator Combo

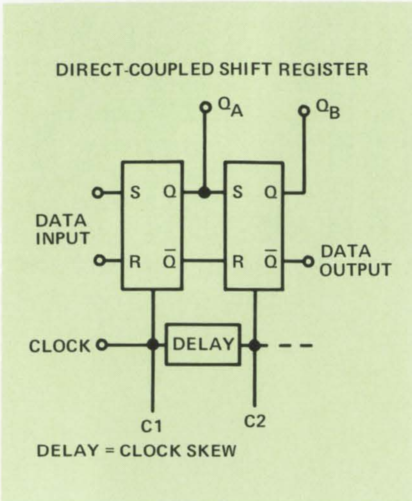
Designers can now work from either "plus" and/or "minus" power supplies with the advent of Motorola's **MC1563/1463 negative voltage regulator ICs!** The new units have nearly identical specs and performance features as the recently-introduced MC1569/1469 *positive* voltage regulators. And since the MC1563 and MC1569 are complementary, they can be combined to offer the added advantage of operating with a common input "ground" (see illustration). In addition, both can be directly mounted on grounded heat-sinks, eliminating the need for insulators.

These new negative regulator ICs deliver high continuous load currents to 500 mA (output current can be increased to greater than 10 Amps with the addition of one or more external transistors). They can handle down to −40 Volts on their inputs (MC1563R), and allow the use of a compensating capacitor to assure stable regulation when current-boosting or when long output leads are required.

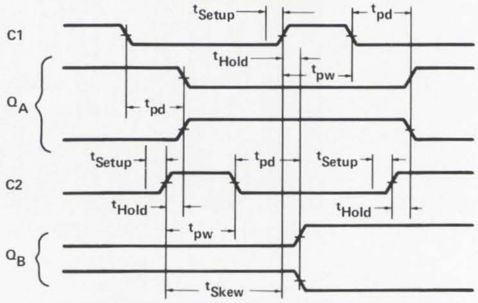
The MC1563/1463R possess many other attributes of their "clan" such as: built-in electronic "shut-down" and "short-circuit" protection.

Both the −55 to +125°C version, the MC1563R, and the 0 to +75°C MC1463R (in the 9-pin, TO-66 style case) are in your Motorola distributor's warehouse now. They're 100-up priced at $6.95 (MC1463R) and $16.95 (MC-1563R).

For details circle Reader Service No. **211**



DOUBLE-EDGE-TRIGGERED MASTER-SLAVE TYPE D FLIP-FLOP



MAXIMUM CLOCK SKEW = $t_{pd} - t_{Hold} + t_{pw}$

MINIMUM CLOCK PULSE WIDTH (t_{pw}) = t_{Hold}

MINIMUM CLOCK PERIOD = $t_{Setup} + t_{pd} + t_{pw}$

(with $t_{pw} = t_{Skew} + t_{Hold} - t_{pd}$)

$= t_{Setup} + t_{pd} + t_{Skew} + t_{Hold} - t_{pd}$

$= t_{Setup} + t_{Skew} + t_{Hold}$

$$f_{max} = \frac{1}{t_{Setup} + t_{Skew} + t_{Hold}}$$

6 New Functions Expand MTTL III Line

Led by the MC3153/3053 Double-Edge-Triggered Master-Slave Type "D" Flip-Flops, Motorola's rapidly expanding MTTL III family now counts six more functions (with at least nine others on the verge of joining them). They come in both −55 to +125°C and 0 to +75°C temperature ranges.

The MC3153/3053 proves invaluable for solving clock skew, note typical system illustrated. The maximum clock skew is the propagation delay from the falling edge of the clock to the output of flip-flop A minus the hold time of flip-flop B plus the clock pulse width. Minimum propagation delay and maximum hold time must be used in the skew calculations. Since the clock pulse width is part of the clock skew calculation, system clock skew can be adjusted to any value the designer feels necessary by adjusting the clock pulse width. The ability to adjust clock skew gives the system designer freedom from maximum allowable clock skew restrictions.

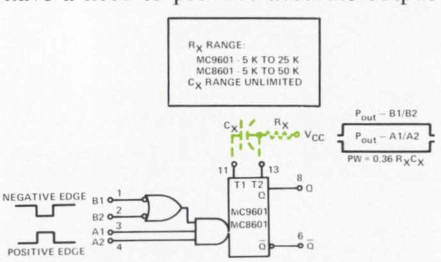
Call your local Motorola franchised distributor for off-the-shelf delivery!

MTTL III TYPE	EQUIVALENTS	FUNCTION	PRICES (100-up)/(1K-up) −55 to +125°C/0 to +75°C
MC3153L,F/3053P	NONE	Double-Edge-Triggered Master Slave Type D Flip-Flop	$9.10/$3.00
MC3116L/3016P	54H30J/74H30N	8-Input NAND Gate	4.40/ 1.40
MC3123L/3023P	54H51/74H51	Dual AND-OR-INVERT Gate	4.40/ 1.55
MC3132L/3032P	54H53/74H53	Expandable 4-Wide AOI Gate	4.40/ 1.55
MC3133L/3033P	54H54/74H54	4-Wide AOI Gate	4.40/ 1.55
MC3134L/3034P	54H55/74H55	2-Wide AOI Gate	4.40/ 1.55

For details circle Reader Service No. **212**

New Multivibrators Alleviate Input-Output Pulsing Problems

Motorola's latest additions to its MTTL complex-function lines, the **MC9601/8601** Monostable Multivibrators, are bound to please designers who have a need to produce accurate output



pulses (having a wide range of pulse-widths) from either the positive or negative edge of an input pulse. The output pulse-width is determined by an external resistor/capacitor network, across pin 11 (see illustration).

The MC9601/8601 are retriggerable. Their logic levels are compatible with all MDTL families as well as with other MTTL members. They have an input loading factor of "one" and output loading factors of "six" (MC9601) and "eight" (MC8601). Their total package dissipation is 75 mW (typ) and they display a typical propagation delay time of 25 ns.

The MC9601 comes in the TO-86 ceramic flat-pack (F suffix) or the TO-116 ceramic dual in-line package (L suffix), while the MC8601 is also available in the P suffix, TO-116 plastic encapsulated version. Prices: MC9601F/L – $13.40 (100-up); MC8601L/F – $6.65 (100-up); MC8601P – $4.30 (1,000-up).

They're available locally for your immediate evaluation.

For copies circle Reader Service No. **213**

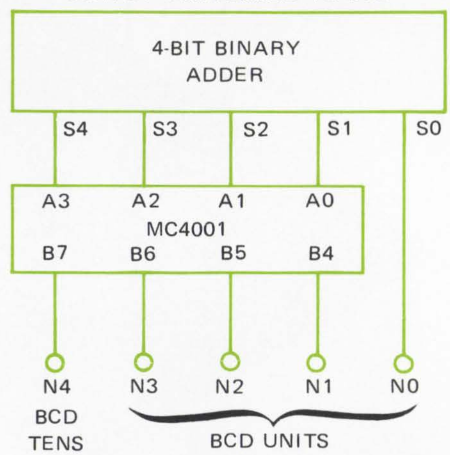
More MTTL MSI Headed By XC170/171 R.O.M. Derivative

The MC4001P, a Binary-To-BCD (and vice-versa) number converter, heads three new memberships to Motorola's complex-function "club." It, and its can-count cutting cousins, the MC-4042P quad predriver and the MC4043P dual line selector, are a sure way to beat "the high-cost-of-living" in mini-computer and memory system designs!

Basically, the MC4001P is a derivative of the XC170/171 128-bit read only memories. It is a natural for small computer, desk calculator and instrument applications where a basic building block is required for number conversion subsystems. In addition, the MC4001P can be used with a 4-bit adder to perform arithmetic operations in BCD (see illustration), just one of many code conversion schemes that are possible. The MC4001P offers the designer faster and lower-cost operations than comparable number conversion techniques – having address times of less than 45 ns and a 1 K-up price of just $5.10.

The MC4042P/4043P are ideal for magnetic memory applications being less expensive yet more reliable and faster

4-BIT BINARY ADDER OUTPUT CONVERTED TO BCD



than discrete transistor driver systems (the MC4042P is priced at $4.00, while the MC4043P is $6.00 in 1 K-up quantities). In addition to memory systems, they are also useful as relay or lamp drivers and high fan-out gates.

Data sheets on these three new standard MTTL complex-functions as well as on the XC170 and XC171 computer-customized MSI Read-Only Memories will prove invaluable aids to the designer of high-speed systems.

For details circle Reader Service No. **214**

New Static Shift Registers Up MOS Line's Versatility

The addition of two new *static* shift registers – one is a dual 100-bit MOS P-channel enhancement-mode IC, the **MC1160G;** the other **(MC1161G)** is a dual 50-bit version – to Motorola's rapidly growing MOS IC line, now gives memory systems' designers greater flexibility and lower "per-bit" costs. For example, the MC1160G sells for less than 10¢/bit, in 100-up quantities (roughly 5¢/bit in production volume)!

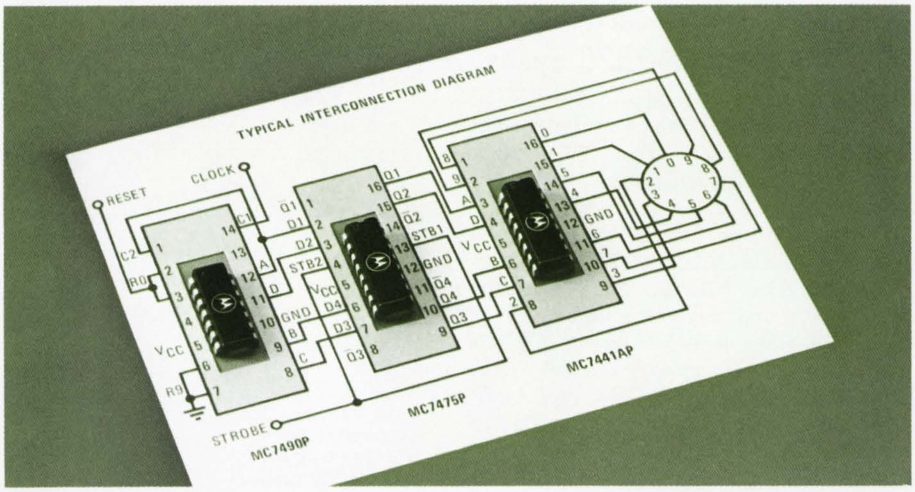
These static shift registers operate at negative logic levels (i.e., "1" = −10V; "0" = −2V) and data from the "clock" lines may be stored indefinitely, or shifted at will by a simple change in clock modes. They operate over a wide dc-to-2.0 MHz frequency range; have non-inverting buffered outputs and diode protected inputs (which are independent of each other); and, common "supply" and "clock" lines. They are spec'd for either single or cascade applications.

The **MC1125G,** a Quad Type-T Flip-Flop (with Q outputs), also joins Motorola's expanding MOS "parade." It is ideally suited for use in frequency-synthesis applications such as organs, digital dividers and counters. It operates from dc to over 1.0 MHz; has a noise immunity of over 1.0V; P_D = 75 mW(typ); 2.5 pF(typ) input capacitance; and, less than 1.0% "crosstalk."

These new MOS ICS, plus the MC-1170L, are available from your distributor.

MDS TYPE	FUNCTION	PRICES (100-UP)
MC1160G	Dual, 100-Bit Static Shift Register	$18.00
MC1161G	Dual, 50-Bit Static Shift Register	14.00
MC1125G	Quad, Type T Flip-Flop	2.45
MC1170L	64-Bit Random Access Memory	13.70

For data sheets circle Reader Service No. **215**



Four New 54/74 TTL Functions Headed By Top Decade Counter

You can now completely integrate your most sophisticated "readout-systems" using a combination of the new **MC5490/7490** Decade Counter, paired with a MC5441A/7441A BCD-to-Decimal Decoder/Divider. And, by adding a Quad Latch (MC5475/7475), which allows the decade counter to follow the input sequence, you can design a readout-system that is not continuously cycling and is easier to read. (See illustration showing a typical hook-up.)

Also freshly available, the **MC5491A/7491A** 8-Bit Shift Register, is composed of eight R-S master-slave flip-flops, an input AND gate, and a clock driver. The clock inverter-driver is common to all eight flip-flops and allows information to be shifted to the output on the positive edge of the input-clock-pulse. The MC5491A/7491A can also be used as an 8-bit delay line in data handling and control networks.

It will pay you to evaluate the **MC54107/74107** for simple registers and counters, where multiple J and K inputs are not required. Operating on the master-slave principle, they are negative-edge-clocked dual J-K flip-flops.

The **MC5403/7403** Quad 2-Input NAND Gates (with open collector), having no output pullup circuitry, are ideal for use where the Wired-OR function is required.

In addition to thorough data sheets covering all four of these new functions, Motorola offers a comprehensive "Design-Kit" which provides detailed applications information for direct digital displays.

TYPE NO.	PRICE (100-up)	FUNCTION
MC5490F,L MC7490P	$12.90 4.15	Decade Counter
MC5491AL MC7491AP	14.30 7.00	8-Bit Shift, Register
MC54107L MC74107P	8.25 2.90	Dual J-K Flip-Flop
MC5403L MC7403P	3.15 1.09	Quad 2-Input NAND Gate (with open collector)

For the set circle Reader Service No. **216**

4 More MECL III Types Bring List To 16, In 2 Case Options

The addition of Triple, 2-Input, Exclusive OR and NOR gate functions – in both high Z and low Z versions (50 kohm and 2 kohm input pull-down resistors, respectively) – now bring the total of MECL III types available to 16! And, these four new units – the **MC1672-75** – come in a choice between the ¼" x ⅛" ceramic "stud" flat-pack and the 16-lead ceramic dual in-line case.

For applications requiring the fastest possible speeds, designers can specify the flat-pack versions. Or, if 100 psec slower switching times(typ), along with about 5-to-10mV lower noise immunity and 10mV more positive logic levels can be tolerated, the ceramic dual in-line packaged types, which are both lower in cost (by roughly 15%) and easier to use, may be just what the "doctor ordered."

The four new types, along with their older brothers and sisters, are on your local Motorola franchised distributor's shelves right now just awaiting your "call for speedy-action!"

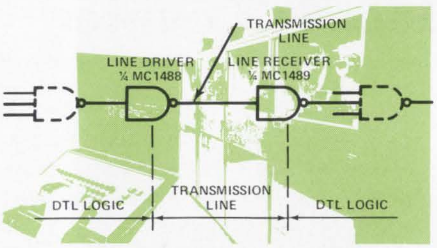
MECL III TYPE NO.	100-UP PRICES "S" PACK	100-UP PRICES "L" PACK	FUNCTION
MC1672 (High Z) MC1673 (Low Z)	$12.50	$10.50	Triple 2-Input Exclusive OR Gate
MC1674 (High Z) MC1675 (Low Z)	$12.50	$10.50	Triple 2-Input Exclusive NOR Gate

For details circle Reader Service No. **217**

Line Driver/Receiver ICs 1st To Meet RS-232C Specs

The industry's first monolithic IC line driver **(MC1488L)** and receiver **(MC1489L),** to conform to EIA-Standard RS-232C specifications, are now available.

These high-performance integrated circuits have been developed for interfacing systems between Data Terminal equipment and Data Communications gear. *To date, no other monolithic ICs have been able to qualify for this application to the stringent EIA standards!* For example, the MC1488L Line Driver features a current-limited output of 10mA (max), with an output resistance of 300 ohms at $V+ = V- = 0$. This circuit also provides simple slew-rate

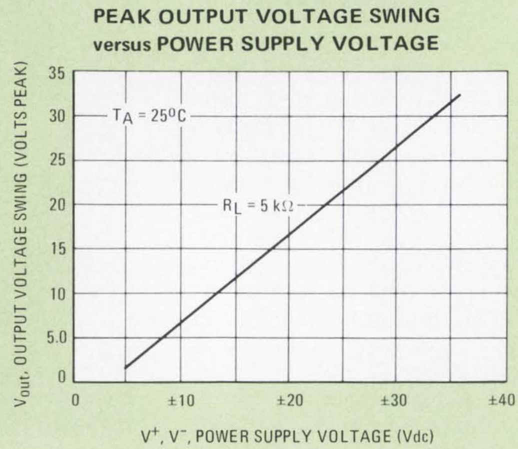


control (with an external capacitor), as well as a flexible operating supply range.

The MC1489L "Quad" Line Receiver also boasts outstanding performance features such as: input resistance of 3.0kΩ-to-7.0kΩ; ±30V range; "logic threshold" and noise-filtering response; control and, built-in input-threshold hysteresis.

Both circuits are designed to operate over the 0 to +75°C range. They come in the TO-116 ceramic 14-lead dual in-line package at 100-up prices of $9.00 (MC1488L) and $8.00 (MC1489L).

For details circle Reader Service No. **218**



The MC1536/1436 offer twice the voltage of previous OP Amp ICs without a sacrifice in performance.

Now IC Op Amps With Double The Output Voltage Swing!

With one sweeping development – the **MC1536/1436** – Motorola doubles the maximum supply voltage available to Op Amp users (±40Vdc)! And, while these unique monolithic ICs can operate safely from ±36V supplies (with peak-to-peak minimum output swings of 60 Volts), they still offer such advantages as typical input bias-currents of just 8.0 nA and offset currents down in the 1.0 nA region. In addition, they're internally compensated; have a fast slew rate of 2.0V/μs; and A_{VOL} of 500k (both typical). And, their gain is independent of supply voltage variations from ±5V to ±36V.

The application opportunities made possible by these high-voltage, low-current Op Amps are practically limitless! For example, control systems, including servo-amplifier designs, need no longer be restricted by low-voltage requirements. They are also ideal for high-voltage differential amplifiers and high-impedance differential buffers, as well as directly-driven Op Amp regulators. And, they can serve as wide-range "sampling" and "hold" circuits.

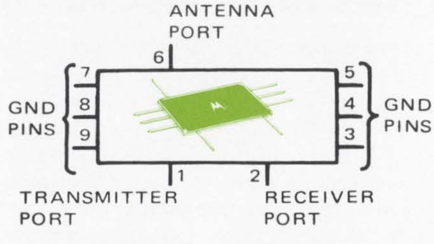
The MC1536G and its low temperature version, the MC1436G, are available in the 8-pin, TO-99 metal-can package from distributor stock. 100-up prices are: MC1536G – $39.00; MC1436G – $18.00.

For data circle Reader Service No. **219**

First Solid-State Duplexer For UHF Designs To 500 MHz

More out of less . . . that's what you get with Motorola's new MCH5890 Thick-Film UHF duplexer–more space-savings, more economy and more design adaptability for applications like land-mobile and hand-held two-way radios! *This unique hybrid IC is the first solid-state multiplexing circuit capable of operating between 400 MHz and 500 MHz while handling a maximum power input of 40 Watts.* It can take the place of cumbersome and bulky coaxial relays (up to 100 times heavier) which have been used to permit a single antenna to both receive and transmit.

Consisting of two step-recovery diode chips and a quarter-wave transmission



line (deposited copper) on a ½" x 1" alumina substrate, the MCH5890 may be thought of as a SPDT switch which can operate in either a "transmit" or "receive" mode, depending on biasing. It isolates the receiver in transmit-mode and it disconnects the transmitter when in the receiver-mode. Using the receiver "port," it can also monitor frequency, or be used as the sampling circuit in AFC or AGC networks. Its 10-99 price is $13.50.

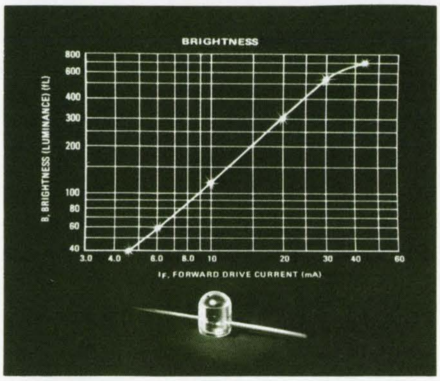
Type	Transmit-Receive Port Isolation (typ)	Transmit-Antenna Port Insert. Loss (typ)	Antenna-Receive Port Insert. Loss (typ)
MCH5890	25 dB @ 460 MHz	0.1 dB @ 460 MHz	0.4 dB @ 460 MHz

For details circle Reader Service No. **220**

New Red-LED Gets "Green Light" For Economy Radiation Designs!

Remember all those high-performance solid-state light-radiation designs you've had to hold at the starting gate because of prohibitive costs, limited availability and performance parameters that left much-to-be-desired. Now you can turn them loose on a fast track – the $1.45 (1K-up), volume-produced, Motorola Mini-T plastic **MLED600 Red LED is here to the rescue!**

A lab curiosity just a few years ago (and priced accordingly), the LED has come a long way in both cost and performance. And, Motorola's MLED600 – the first red light-emitting diode designed for high-volume low-cost stripline production – offers high visibility, low driving requirements and fast response time. For example, it requires only 45 mA (typ) of forward drive current to produce 700 foot-lamberts of luminance (see curve): it exhibits response-times in the nanosecond region; has a high visible-red intensity of 660 nm(typ); and a typical leakage current value of just 100 nA at 4V/1.0 megohm.



The MLED600 provides exceptionally high brightness levels at low drive currents.

Its passivated, gallium-arsenide-phosphide die structure assures reliable and stable ultra-long life expectancy. And, its voltage/current requirements are compatible with the low-level outputs of most ICs.

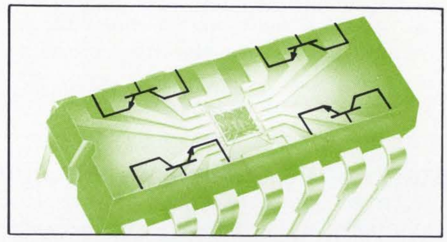
The MLED600 can be combined with Motorola's MRD450 photo detector in applications such as: punched card and tape readers, shaft encoders, panel and circuit condition indicators, alpha-numeric readouts, coding of digital data on film, calibrating photo-multiplier tubes, photo-scintillators, optically-coupled isolators, counting, sorting, switching and inspection designs. It can also be used to eliminate "ground-loops" in a-to-d conversion systems and to provide isolated AGC in industrial communications gear.

All-in-all, volume-production availability, an economical price and reliable performance parameters, make the MLED600 a must-look-at value for most anybody.

For an application note and data sheet – circle Reader Service No. **221**

Now TO-116 "Quads" Lower Memory Driver Costs

Until now ceramic flat-packed "quad" transistor memory drivers were rather expensive, but offered small package size advantages and reduced can-count (over individual transistors). Motorola's 14-lead Unibloc TO-116 plastic dual in-line MPQ3725 core driver and MPQ3303 plated-wire driver offer designers the



benefits of "quad" construction, plus drop-in automatic assembly convenience – all at the low prices of $8.50 (MPQ3725) and $8.25 (MPQ3303) in 100-up quantities, with virtually no sacrifice in performance!

For example, MPQ3725 has a maximum t_{on} and t_{off} of 35 ns and 60 ns @ I_C = 500 mA — faster than similar "quads" at four times the price! MPQ3303 has even faster switching speeds at twice the current level – t_{on} = 15 ns, t_{off} = 20 ns (max) @ I_C = 1.0 A.

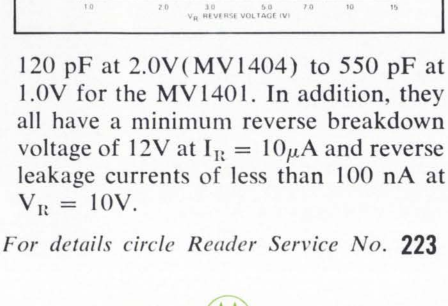
BV_{CEO} is 40 V min. (MPQ3725) and 12 V min. (MPQ3303) @ 10 mA. Other characteristics are: C_{ob} = 10 pF @ 10 V and 5 V; maximum $V_{CE(sat)}$ = 0.45 V @ 500 mA (MPQ3725) and 0.70 V @ 1.0 A (MPQ3303).

For details circle Reader Service No. **222**

Hyper-Abrupt-Junction VVC Diodes Offer Tuning Ratios Of Over 10:1

Been looking for reliable, high-performance, solid-state tuning devices that would cover wide-frequency ranges – from the AM band all the way up into the lower RF region – such as required for automatic direction finders, two-way radios, and general AFC applications? *Your search is now coming to an end!*

Motorola's **MV1401-03-04-05** hyper-abrupt-junction voltage-variable capacitance diodes can do just that, and more! These tuning diodes provide capacitance changes of greater than **ten-to-one** for a bias change ranging from two-to-ten volts (see illustration). They all have a high figure of merit (Q) of over 200 at V_R = 2.0V. And, you have a choice of nominal capacitance values ranging from



120 pF at 2.0V(MV1404) to 550 pF at 1.0V for the MV1401. In addition, they all have a minimum reverse breakdown voltage of 12V at $I_R = 10\mu A$ and reverse leakage currents of less than 100 nA at V_R = 10V.

The MV1403-04-05 are packaged in DO-7 "glass" axial-leaded cases, while the MV1401 comes in the slightly larger bodied DO-14 version. All this, yet their prices are *not prohibitive* – just $5.95, for any of the four types, in 100-up quantities. Your distributor has local stock available for immediate requirements.

Type No.	C_T, Diode Capacitance @ 2.0Vdc (Nom)	Q, Figure of Merit @ 2.0Vdc (Min)	TR, Tuning Ratio C_2/C_{10} (Min)
MV1401	550 pF @ 1.0Vdc	200	14 (C_1/C_{10})
MV1403	175 pF	200	10
MV1404	120 pF	200	10
MV1405	250 pF	200	10

f = 1.0MHz

For details circle Reader Service No. **223**

NEW PRODUCT BRIEFS

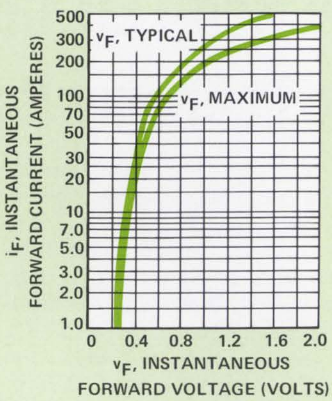
FIRST 50 AMP HOT CARRIER RECTIFIER

– Reduces Power Loss, Raises Operation Efficiency

A new level of efficiency for higher current power-rectification designs can be achieved with Motorola's unique MBD5500 "hot-carrier" diode! Featuring a 0.65 V maximum forward voltage-drop at 100 amps (peak-current), it provides 50% less power-loss than conventional alloyed or diffused silicon types. Because of its "majority-carrier" operation, it is suitable for applications requiring extremely low stored-charge or where commutation transients exist . . . allowing good efficiency even at VHF frequencies. The "Schottky-Barrier" low-resistivity, metal-to-silicon junction technique makes the MBD5500 perfect for use in low-voltage, high-current mode power supplies and other applications involving ultra-low power-loss. Advantages like top rectification efficiency, high surge-handling capability, low leakage values, and passivated junctions make the MBD5500 the optimum choice for stringent low-voltage requirements.

Immediately available from distributor stock. 100-up price: $8.50.

For details circle Reader Service No. **224**



STATE-OF-THE-ART MM4049 PNP CURRENT-MODE SWITCH

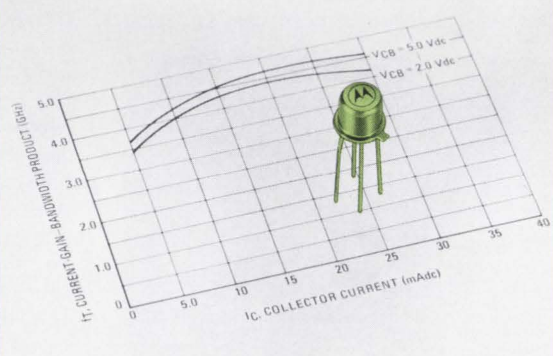
– Extends Silicon Frequency Range All The Way To 4 GHz!

Combining an ultra-high current-gain – bandwidth product of 4.0 GHz min. at 12 mA/5V (see illustration) with low capacitance values – maximum C_{ob} and C_{ib} = 1.25pF at 100 kHz – Motorola's MM4049 also delivers a low $rb'C_C$ of less than 15ps at 15mA/5.0V, to usher in a whole new era in current-mode switching. It will find its primary usage in digital test equipment (pulse generators, counters) and special purpose computers. Its low $rb'C_C$ also makes it attractive for many UHF linear designs. And, having such a high f_T, it has a high neutron radiation tolerance.

Other characteristics of interest include: A minimum BV_{CEO} of 10 Volts at 2.0 mA; maximum leakage current (I_{CBO}) = 10 nA at 10V; and an h_{FE} of 20 to 80 at 25 mA/2.0V. It has a continuous collector-current rating of 30 mA.

All this, yet the MM4049 (4-leaded TO-72 package) is priced at just $8.75 in 100-up quantities.

For details circle Reader Service No. **225**



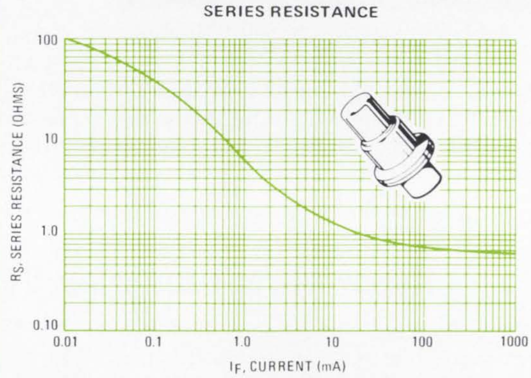
P-I-N MICROWAVE POWER SWITCHING DIODE

– Operates Below 0.4pF, Over a Wide Series-Resistance Range

Motorola's new silicon-oxide-passivated 200-Volt P-I-N diode, the MPN3202, is ideal for a wide assortment of critical RF power control applications. For example, it can serve as a phase-shifter, duplexer, voltage-controlled attenuator, modulator and, of course, a microwave power switch.

Highlighted among its many peak-performance characteristics are a maximum capacitance of only 0.4pF at V_R = 50V/f = 1.0 MHz and a dynamic series resistance range of 0.75 to 100 ohms(typ). In addition, the MPN3202's long minority carrier lifetime of 150 ns(typ), allows it to operate down in the 5 MHz region before reacting to an RF signal. Its compact package, the popular pill-with-prongs, is particularly suited for microwave designs, and provides a maximum thermal resistance of only 25°C/W. And, it has a high minimum reverse breakdown of 200 Volts at a 10 μA current level. The MPN3202 is only the first in a series of P-I-N diodes, including higher voltage types.

For data sheet circle Reader Service No. **226**



MICRO-T ECONOMY '70 SERIES

– Break The Small-Quantity-Pricing "Dollar" Barrier

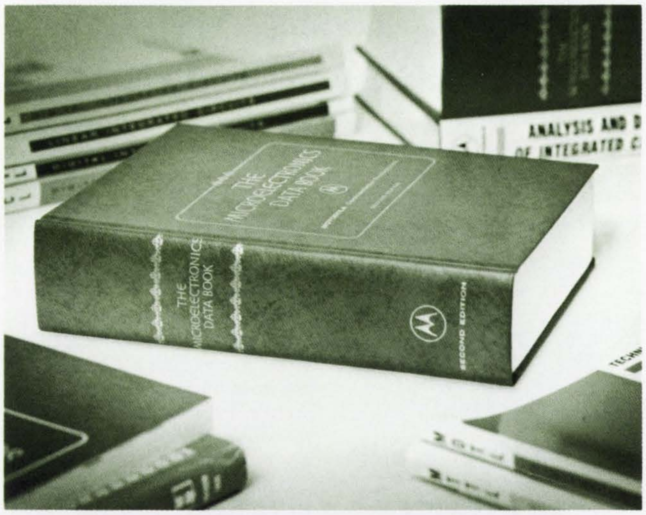
Seven transistors and a switching diode make up Motorola's first introductions in a new economy line of Micro-T's. All are priced well under *one-dollar,* even at 100-up quantities (see table).

They cover a wide spectrum of requirements. For example, the MMD70 is a switching diode with a high (50 Volts) breakdown voltage and low 1.2 pF(typ) capacitance. The NPN MMT70 and PNP MMT71 are low-level, low-noise amplifiers with the latter showing only a 1.0 dB(typ) noise figure at 1.0 kHz and a typical C_{ob} of just 2.0 pF at 5V. A high f_T of 1.0 GHz(typ) at 4.0 mA along with a low typical C_{cb} of 1.0 pF at 10V and a typical G_{PE} of 14 dB at 1.5 mA/10V/450 MHz, qualifies the MMT74 for a multitude of high-gain, low-noise RF amplifier, oscillator, or mixer designs. The MMT72/73 units are high-speed switches. And, the MMT75/76 general-purpose types can be used in complementary configurations. Their gain is spec'd at two current levels.

For data sheets circle Reader Service No. **227**

TYPE	DESCRIPTION	PRICES (100-up)
MMD70	50 V Switching Diode	45¢
MMT70	NPN Low-Level, Low-Noise AMPLIFIER	46¢
MMT71	PNP Low-Level, Low-Noise AMPLIFIER	58¢
MMT72	NPN High-Speed Switch	65¢
MMT73	PNP High-Speed Switch	65¢
MMT74	NPN High-Gain, Low-Noise RF Ampl./Osc./Mixer	90¢
MMT75	PNP Gen. Purpose Ampl./Switch (complement to MMT76)	61¢
MMT76	NPN Gen. Purpose Ampl./Switch (complement to MMT75)	52¢

NEWSBREAKS



Doubled-Sized 2nd Edition Of IC Data "Bible" Just Published

Renamed "The Microelectronics Data Book," the 2nd edition of the most comprehensive integrated circuits data compilation in the industry is now ready to serve as your specifications guide for digital and linear ICs.

Almost twice the size of the first-edition, the current issue consists of almost 1800 pages containing applications information and test criteria, as well as detailed data covering all standard Motorola digital families and linear categories. A complete alpha-numerical listing identifies each circuit type by its family group.

It carries a single copy price of $4.95 (the same as its companion "The Semiconductor Data Book"). A supplemental service is also available for just $2.00 (a minimum of two supplements will be published).

Use special coupon in this issue to order

Answers to Digital Display Problems Found in New TTL Systems Design Kit

Digital display system designers will find immediate use for Motorola's new TTL Design Kit #1. The single-source file provides IC encoding and driving solutions for greater design flexibility. Basic readout techniques, as well as multiplexing, are discussed. Included in the Kit are application notes and data sheets for devices mentioned in the suggested designs. A "special offer" sheet enables designers to order featured devices (MC7490, MC7475, MC7441A) at evaluation costs.

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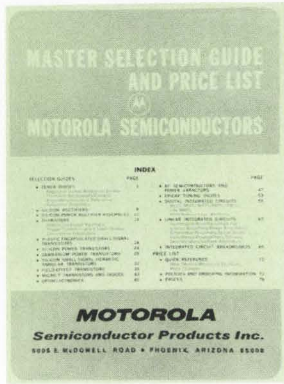

Included in the first edition (effective Dec. 1, 1969) are selector guides covering 17 major semiconductor categories. This section, which spans 80 some pages, is followed by a complete price list covering all of Motorola's current product lines, including a quick reference to new devices, price revisions, deletions and ordering information.

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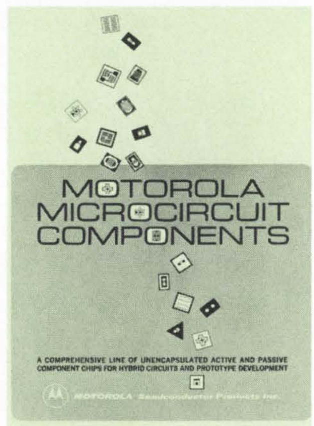
Almost 450 "standard" Motorola discrete active and passive unencapsulated chips are described in this Microcircuit Components Perpetual Data Brochure.



Included are silicon transistors (amplifiers, switches, general purpose, RF, FET, power, and switching diode types), beam-lead microwave resistors and capacitors, thin-film inductors, and some 122 zener diode types.

Introductory pages describe standard carrier packages, optional shipping methods for chips and wafers, plus vital inspection criteria. Ideal for the designer of hybrid circuits.

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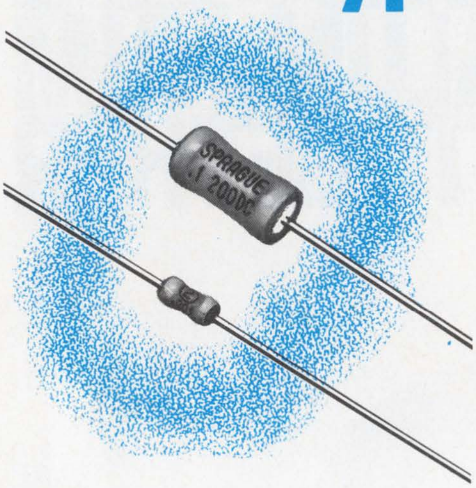

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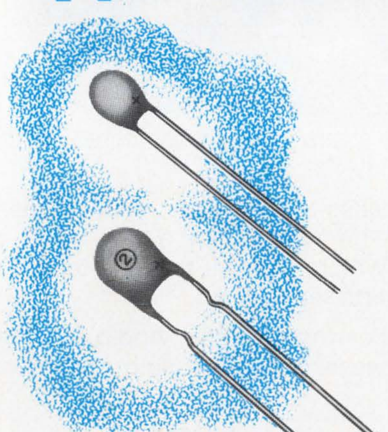

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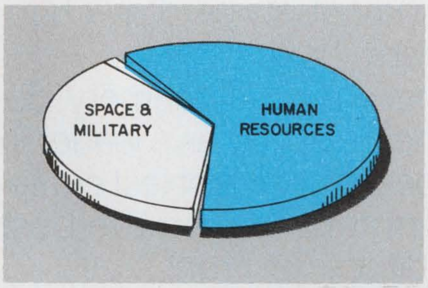
Highlighting THE ISSUE



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Inflation and economy are the major forces underlying President Nixon's $200.8-billion request.

Defense gets the smallest share of the federal budget in 20 years, and NASA's funds are cut so that many new space missions will be postponed and some facilities closed.

Benefiting from this reshuffle will be projects to curb crime, pollution and the disintegration of the nation's airways system.

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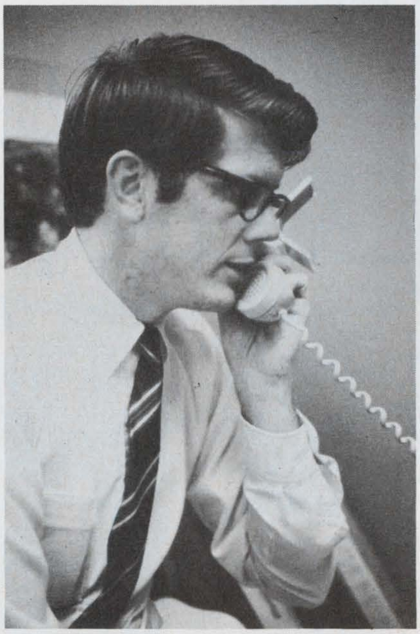

There are specialists in the electronics industry who answer the question "Should systems companies design their own chips?" with a query of their own: Why go custom at all? In most cases, these specialists argue, it would be cheaper to build a system, such as a computer, from standard parts.

Other systems and semiconductor specialists interviewed by ELECTRONIC DESIGN are not convinced that this is feasible.

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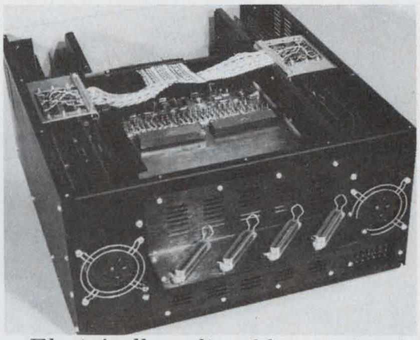

Electrically alterable read-only memories may be a new phrase for the seventies and, perhaps, will mean a new era in memory technology. From Memory Systems, Inc., comes a new family of plated-wire memories that can read at speeds as fast as 125 ns, and yet can be written into at the not-so-moderate rate of 1 μs.

Immediate applications for the new electrically alterable read-only memory include variable control storage for central processing units, and character generation and display format control for CRT terminals.

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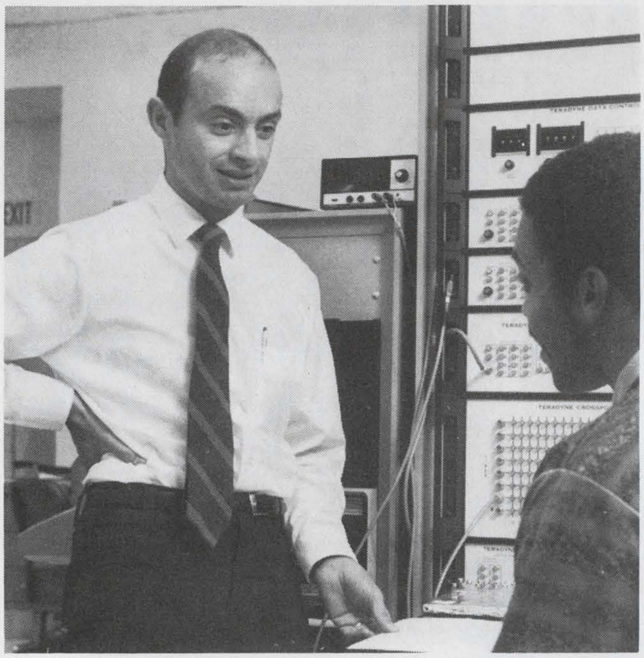
Why Intel uses Teradyne J259's to test memory devices

When we asked Intel's test supervisor, Les Vadasz, what he liked most about the Teradyne J259 computer-operated IC test system, he smiled and said: "It runs."

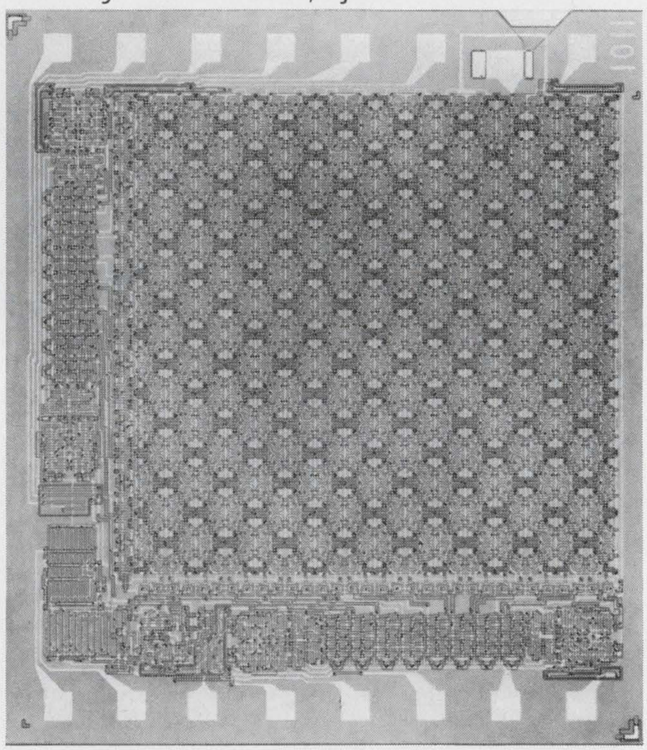


"Just running" is no small matter, as any IC producer can tell you. It's especially vital when you're testing 256-bit silicon-gate MOS memories like Intel's. When your devices are that exotic, you want the most unexotic test system you can find. One that doesn't go off the air once a week. One that doesn't need periodic calibration. One that "just runs."

How dependable are Intel's J259's? So dependable that Intel finds it hard to put a number on downtime, but estimates that less than *1 percent* of its test-facility downtime is attributable to the Teradyne systems.

And Intel's J259's work hard. They make as many as 10,000 functional and parametric tests on each 256-bit MOS memory. They also test all of Intel's new Schottky-barrier bipolar memories. They test packages. They test wafers. They classify devices. They datalog test results. They generate test summary sheets and distribution tables. Since everything is done on a time-shared basis, it all adds up to an awesome test capability per J259, hour after dependable hour.

Intel's new lines of memory devices mark the company as a leader in its field. So does its choice of test equipment—equipment that, in the best Teradyne tradition, "just runs."



Teradyne's J259 makes sense to Intel. If you're in the business of testing circuits—integrated or otherwise—it makes sense to find out more about the J259. Just use the reader service card or write to Teradyne, 183 Essex St., Boston, Massachusetts 02111.

Teradyne makes sense.

News Scope

Electronic network proposed to monitor global pollution

A world-wide monitoring system to detect changes in the air, water and soil was proposed last month at a meeting of the U. S. International Biological Program in Washington, D.C. Computers, earth satellites, electronic counters and sensors and communication links would be used in such a network.

Chairman of the Task Force for Global Network for Environmental Monitoring, Dr. Glen R. Hilst, says he hopes that such a program would be implemented through an international agency. He mentioned UNESCO or the International Council for Scientific Unions, which sponsors the International Biological Program.

Equipment is available for collecting atmospheric samples, evaluating them and transmitting such data from remote stations to a central computer, says William Gusey, Wildlife Specialist at Shell Chemical who participated in the meeting. Nothing is available now for electronically monitoring terrestrial species, but some aquatic life forms can be checked by electronic instruments, he says.

Gusey estimates that some 20 major manned monitoring stations and several hundred satellite stations would be needed. An even larger number of remote stations would transmit information back to primary monitoring stations, he says.

The proposed network will be designed to evaluate particulate matter, sulfur dioxide, nitrogen, oxygen, heavy metals, carbon dioxide, trace elements, radioactivity, incident light, and a variety of organic compounds including pesticides.

Gusey says that the method of linking the monitoring stations together has not yet been considered. At the Washington meeting, he notes, there was no representation from the computer sciences or data-communication area. However, these subjects will be considered at the next meeting of the Task Force, to be held May 14 and 15, in Boston at the headquarters of the American Meteorological Society.

In addition to permanent monitoring stations, Hilst suggests that transocean ships and aircraft could be equipped with the instrumentation to measure air and water samples at various points on the earth. This information could be transmitted to a central point.

The capabilities of earth satellites, according to a report of the Committee on Global Monitoring, shows great promise. The satellite systems available are highly sensitive to change of reflectance (for example, in vegetation) and are more sensitive than the human eye.

Nimbus 3, a weather satellite, is now in orbit, and an earth-resources satellite will be put in polar orbit in 1971, according to the report. This would scan the globe every 18 days. It would also query data-obtaining sites twice a day and feed this data to a collecting center.

Fifty-seven nations are participating in the International Biological Program. The Task Group headed by Hilst will present its finding to the Congress of the IBP in Rome next September.

F-15's missile sensor tests are under way

Tests have begun at Holloman Air Force Base, N.M., to evaluate five contenders for the terminal guidance system for the short-range, air-to-air AIM 82 missile that will arm the Air Force F-15 fighter aircraft.

The companies, whose breadboard seeker/tracker systems are being evaluated, are Bendix, Hughes Aircraft, North American, General Dynamics/Pomona, and the Aeronautronics Div. of Philco-Ford.

Winner of the contract will be chosen by the project officer from data the Directorate of Guidance Tests at Holloman will collect over the next six to nine months. The systems are being flown on the nose of a C-130 cargo plane.

All of the systems utilize the same technique. The seeker finds its target by detecting a high contrast in light intensity between the enemy aircraft and its background. The sensor will track the target by feeding guidance corrections to a logic device that actuates the missile's aerodynamic controls.

The portion of the spectrum used ranges from ultraviolet to infrared or a combination of the two. Infrared is handy because it can be used at night. On the other hand, it homes on the jet exhaust trailing the enemy plane rather than on the plane itself.

A contractor for the missile portion has not been let.

Medical electronics to be legislated?

Legislation to protect patients from electronic equipment failures is essential, HEW's Assistant Secretary for Health and Scientific Affairs Dr. Roger Egeberg said at a press conference at the Second National Conference and Exposition on Electronics in Medicine in San Francisco early last month. He stressed, however, that such legislation must be framed in order not to discourage individuals to be exploratory in the development of new electronic devices.

He also stressed the necessity for gathering enough information on the problem before devising such legislation and pointed out that a governmental committee of manufacturers and users had been set up to study the problem.

Many accidents occur for reasons other than equipment failures, he said. For example, they may be caused because of improper use of equipment by inexperienced medical personnel or because of wiring problems in the hospital building. In one hospital, he said, it was discovered that there was enough difference in potential between the electrical ground line and the water pipes to produce a slight shock. And even a small voltage through a catheter inside the patient's body could have serious results, he said.

He also stressed the need for adequate reporting of accidents by hospitals and private physicians.

Navy develops radar for shipboard guns

The Navy will test the feasibility of teaming up the Army's Vulcan 20-mm Gattling gun with a brand-new radar being developed by General Dynamics/Pomona and putting the system on a guided-missile destroyer leader. The weapon's mission will be to defend the ship against low-flying cruise missiles and, hopefully, air-to-surface missiles.

Formerly known as Phlanax and now called simply a "close-in weapon system," the weapon's radar will operate in the X-band, says a Navy spokesman. He adds, "It will work on a principle different from that used by the Hawk missile radar," which also must acquire low-flying targets quickly.

The system's reaction time must be extremely fast to intercept missiles that fly as low as the Russians' Styx missile—about 300 feet.

Cost of ICs reduced by new BTL technique

A simplified technique for making integrated circuits may cut manufacturing costs by a factor of two. Called Tri-Mask, the new technique announced last month by Bell Telephone Laboratories in Murray Hill, N.J., uses lateral transistors to reduce the number of photomasking steps.

Instead of having transistors in which carriers flow perpendicular to the surface, Bell Labs' new process uses transistors in which the carriers flow parallel to the surface. The collectors and emitters for these transistors are diffused in one masking operation.

"Because we have reduced the number of processing steps from seven to three, we may cut manufacturing cost by a factor of two," says Harry J. Boll, supervisor, exploratory devices, at Bell Labs. He emphasized that the reduction in the number of masking steps is the reason for expecting to increase the yield of good circuits.

The Tri-Mask method has been used to build integrated circuit logic gates with fewer masking steps than are now used in making individual transistors, according to Bell Labs. A transistor in such a circuit occupies less than one-millionth of a square inch.

Performance is said to compare favorably with the MOS integrated circuits now in use.

The structure gives good isolation between transistors because the substrate (silicon) has a high resistivity, and the emitter and base regions are encircled by a collector region.

Boll says there are no plans to go into preproduction testing of the new system at the present time.

Solar eclipse to aid propagation prediction

The elaborate preparations being made by the Air Force Cambridge (Mass.) Research Laboratory to cover the solar eclipse on March 7, in specially instrumented KC-135 cargo planes, rockets and ground stations, are not merely to satisfy scientific curiosity.

Knowledge of the atmospheric changes that occur during the few minutes the energies of the sun are suddenly blocked by the moon is expected to help scientists learn how to predict the propagation performance of optical and radio surveillance and detection systems.

The information gathered from Mexico to Cape Cod will be used to formulate software for a computerized prediction system that will be placed in operation this year. And the new system's capabilities will be expanded over the years as scientists uncover more correlates between solar energy variations and specific atmospheric effects.

TRW gets contract for Jupiter probes

The National Aeronautics and Space Administration has awarded a $38 million contract to TRW Inc., Redondo Beach, Calif., to start work on two Jupiter-bound spacecraft Pioneers F and G, to be launched in 1972 and 1973.

The two spacecraft will take the first close-up pictures of the giant planet, explore the environment and atmosphere of Jupiter and send back data for the first time on the "interplanetary medium beyond the orbit of Mars."

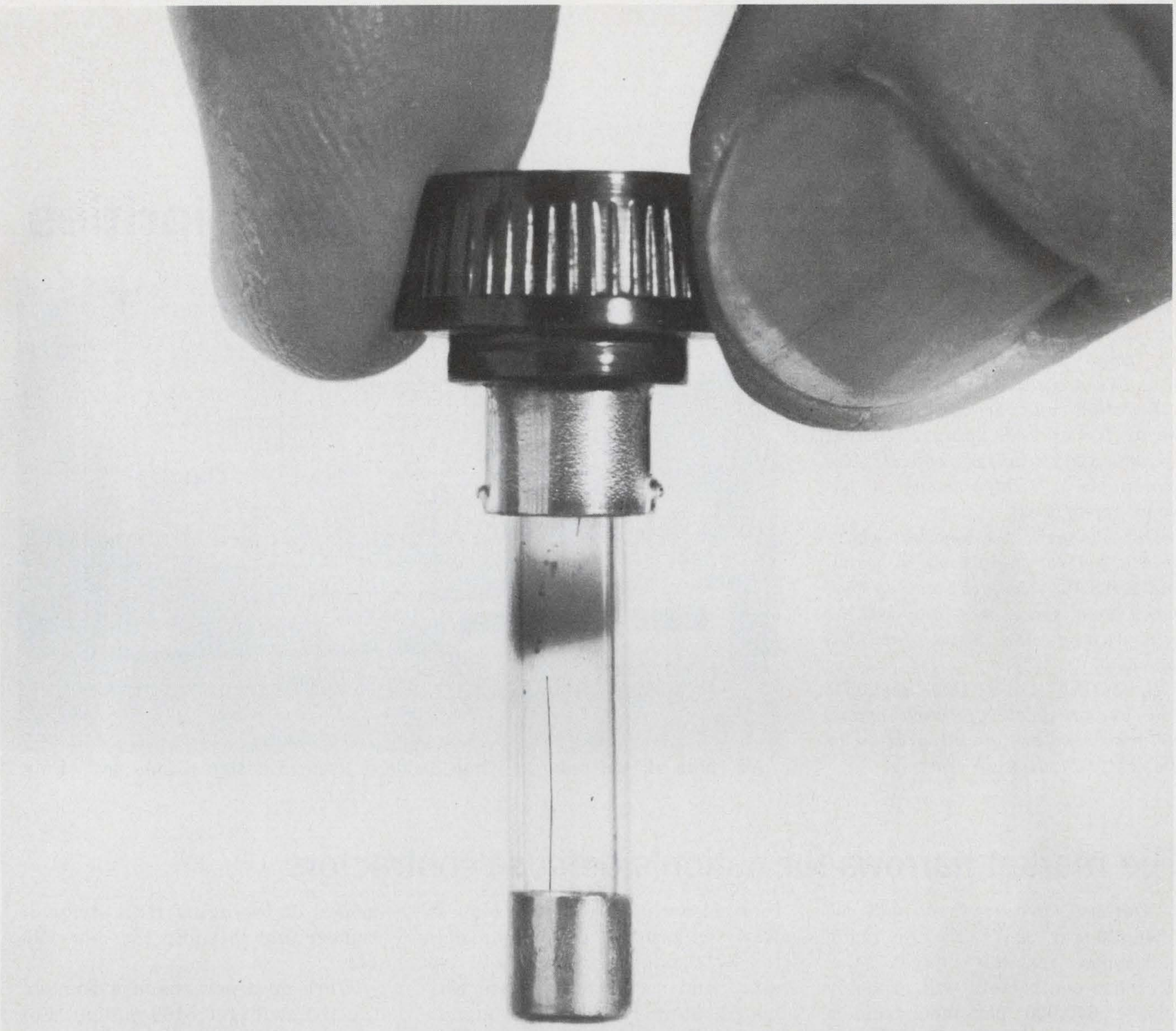
Memory devices to be explored at conference

The serious challenge to core memories posed by the newer semiconductor and plated-wire memories—as well as by magnetic domain or "bubble" memories—will be explored at the 1970 International Magnetic Conference (INTERMAG) to be held April 21-24 at the Statler Hilton in Washington, D.C.

The conventional core memory is at a turning point, says conference co-chairman Daniel H. Schull, Jr., of Bell Telephone Laboratories, in Winston-Salem, N.C. He says that semiconductor memories have already taken over in small buffers where cores are used.

As for magnetic bubbles, their storage capacity may reach the tremendous theoretical limit of 100 million bits per square inch, according to Andrew H. Bobeck, of Bell Labs who will deliver a paper on magnetic bubbles.

A session on plated-wire memories organized by C. J. Kreismann of Ferroxcube, Saurgerties, N. Y., will consider whether plated-wire memories will be able to maintain or expand their established niche in the main-frame memory access times between 1 μs and 100 ns. At longer access times cores dominate, while at shorter times semiconductor memories currently have the advantage.



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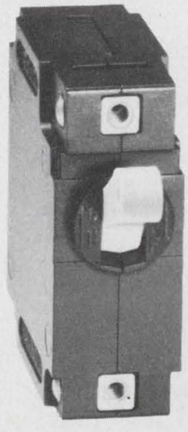

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INFORMATION RETRIEVAL NUMBER 19

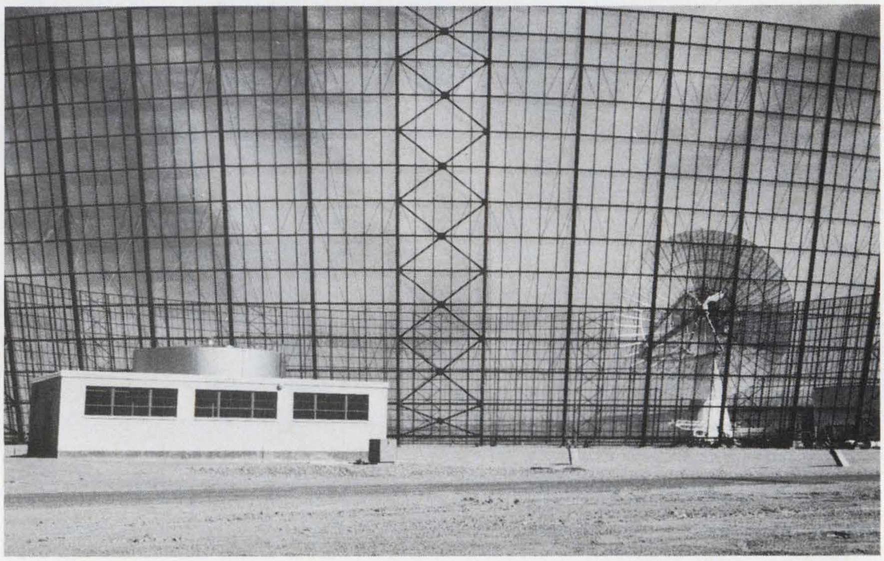
$200.8-billion U.S. budget shuffles priorities

The federal budget for fiscal 1971 is down to firm flesh and muscle. Great chunks of fat, including some protective layers, have been pared away.

Inflation and economy are the major forces underlying President Nixon's $200.8-billion request. Also evident is a readjustment of national priorities.

Defense gets the smallest share of the federal budget in 20 years, and NASA's funds are cut so that many new space missions will be postponed and some facilities closed.

Benefiting from this reshuffle will be prospects to curb crime, pollution and the disintegration of the nation's airways system.



Air Force uhf-vhf radar at White Sands is used to design ICBMs and ABMs.

The market narrows for nation's defense contractors

"Defense procurement will be down 30 per cent," the Pentagon spokesman for the budget says. "Defense contractors will probably release 640,000 personnel, and a substantial number of military bases will close."

As for piecemeal supplemental budgets later on—a device used during the McNamara years to bail the Pentagon out from inadequate budget requests—"there's no such thing in this Administration," the spokesman says.

In hard cash, defense outlays for fiscal 1971 are down $6.9-billion below the 1969 total—or, if a hike in Defense Dept. salaries is not counted, a painful $12.8-billion. The larger figure is closer, of course, to the actual cut in money spent for hardware, services and R&D.

But it remains a substantial defense budget nevertheless. Market analysis and attention to what the military actually needs will undoubtedly be keener this year than ever before.

Total obligational authority (new appropriations plus money left over from previous years) amounts to $72.9-billion—14.8 per cent below the 1970 budget request. New obligational authority comes to $71.3-billion—down 14.3 per cent. And actual outlays are estimated at $71.8-billion—a significant drop from last year's $81.6-billion.

Of the $71.8-billion in new obligational authority, according to estimates made by Electronic Industries Association in Washington, D.C., the electronics industry will get $9.7-billion.

Global defense spending up

Money for strategic forces, built to deter or wage a nuclear war, is being increased by $400-million. Minuteman III missiles are replacing Minuteman I types, and Polaris-launching submarines are being converted to handle the larger, multiple-warhead Poseidon system.

The Safeguard antiballistic missile system is getting $1.5-billion. This will go toward finishing construction of the first two sites, initiating construction of additional sites and continuing R&D.

Short-range attack missiles will be bought to add power to late models of the aging B-52 strategic bomber and to equip the new FB-111.

Work on a new manned bomber, the B-1, will get $100-million. For air defense, a new over-the-horizon radar will be developed, and Awacs, the program to develop an airborne warning and control system, will finally get off the ground.

Non-nuclear forces are down

General-purpose forces (non-nuclear) are listed for $3.1-billion below the funds provided for this category in 1970 and $6-billion below the 1969 figure.

Ship construction and conversion do not drop, however, remaining at about $2.6-billion. Three very fast nuclear-attack submarines are to be bought, plus a nuclear-powered guided-missile frigate and six of a new class of antisubmarine destroyers. Three nuclear-powered Nimitz carriers are in the works, with new money going into long lead-time items for the third.

Development of the ASW carrier-based S-3A aircraft will continue, as will new, land-based patrol planes, the F-14A fighter-interceptor and the EA-6B electronic-warfare aircraft. Studies will be funded for a destroyer-based helicopter.

The Air Force is funded for development of its F-15 fighter and the completion of the FB-111 bomber and C-5 logistic transport, as well as for a sizable number of A-7 attack aircraft. Studies and preliminary development will continue on an advanced aerial tanker and an improved air defense interceptor.

The Army is to get a medium antitank assault weapon, called Dragon, to replace the 90-mm recoilless rifle. Major emphasis will continue on night vision devices. More Chaparral missiles, improved Hawk missiles, will be bought, and the Nike-Hercules missile system will be improved.

The Army will get money for "reliable, rugged, mobile tactical communications to achieve command and control over dispersed forces and weapon systems." Also, there are funds for the worldwide defense communication system.

Aircraft purchases will be down by 470 this year. A total of 1465 planes are to be bought—1009 helicopters and 456 fixed-wing. The total cost is put at $6,449,000,000, of which $1.6-billion is to go for electronics, according to the EIA. Research development, testing and evaluation (RDT&E) of aircraft calls for $1,598,000,000 more.

Only 24,431 missiles are to be bought in 1971, a drop of nearly 15,000 from the previous year. Missile procurement is listed for $3,203,000,000, with $1.4-billion going for electronics, according to the EIA. A total of $2,230,000,000 is earmarked for missile RDT&E.

Procurement of ships is up, from 19 vessels last year to 29 for 1971. The cost: $2,579,000,000. RDT&E for ships and small craft comes to $379-million.

Over-all, the Pentagon is trying to remain optimistic—at least publicly. If the 1971 defense request is converted to the value of the dollar in 1964, it says, the total is actually bigger by $3.5-billion than 1964's outlay.

Total authority for major defense programs

Program	Dollars (millions) 1971	1970	Up or down
Conversion of Polaris subs for Poseidon	1,680	1,713	−33
Safeguard antiballistic missile system	1,500	892	+608
F-14A Navy fighter	938	442	+496
Minuteman III ICBM	797	948	−151
C-5A Air Force cargo plane	624	909	−285
F-111 Air Force fighter	567	931	−364
SSN, nuclear-attack submarine	476	611	−135
DX, destroyer	460	341	+119
M55 Sheridan vehicle	400	421	−21
F-15 Air Force fighter	370	175	+195
S-3A Navy ASW aircraft	310	150	+160
A-7D Air Force attack plane	253	396	−143
DXGN, nuclear-guided missile destroyer	221	270	−49
EA-6B, Navy electronic warfare aircraft	198	238	−40
MK 48 torpedo	160	154	+6
CVAN, nuclear attack carrier	152	377	−225
DLG, guided-missile destroyer	150	18	+132
A-7E Navy attack plane	133	164	−31
Phoenix, Navy air-to-air missile	100	18	+82
B-1 bomber	100	0	+100
Awacs, airborne warning and control system	87	40	+47
MBT-70 tank	77	40	+37
Aegis surface-to-air missile	75	35	+40
Condor, Navy air-to-surface missile	52	8	+44
ULMS underwater launched missile system	44	24	+20
UH-1N, Navy helicopter	21	43	−22
Shillelagh, Army surface-to-surface missile	6	56	−50

Space agency spending sinks to a nine-year low

NASA's fiscal 1971 budget of $3.4-billion is the lowest in nine years. The austere plan calls for the first Apollo funding level below $1-billion since fiscal 1962, glum space officials note.

The space agency originally proposed a budget level of over $4-billion, but this was cut by $500-million in early reviews by the Administration. An additional $200-million slash was made in mid-January, at the request of the President.

When NASA was in its heyday, it had a clear goal: a moon landing before the end of the decade. Now there is no long-term plan—only proposed projects, subject to year-to-year Executive approval. It's also evident that Congressional pressure to "balance" the civil space program has been successful—the funding levels for applications satellites and aeronautical research are significantly higher.

NASA Administrator Dr. Thomas O. Paine says: "The space program of the 60s wisely gave this nation—and the American space team—a bold and dramatic single-point challenge." Over the years, he notes, the nation developed a broad aerospace capability and built a strong base from which to move in the future.

"The new space program of the 70s is quite different," Dr. Paine continues. "We are putting into motion with this budget a program which does not advance toward a single climatic event." Nor, he

(budget, continued)

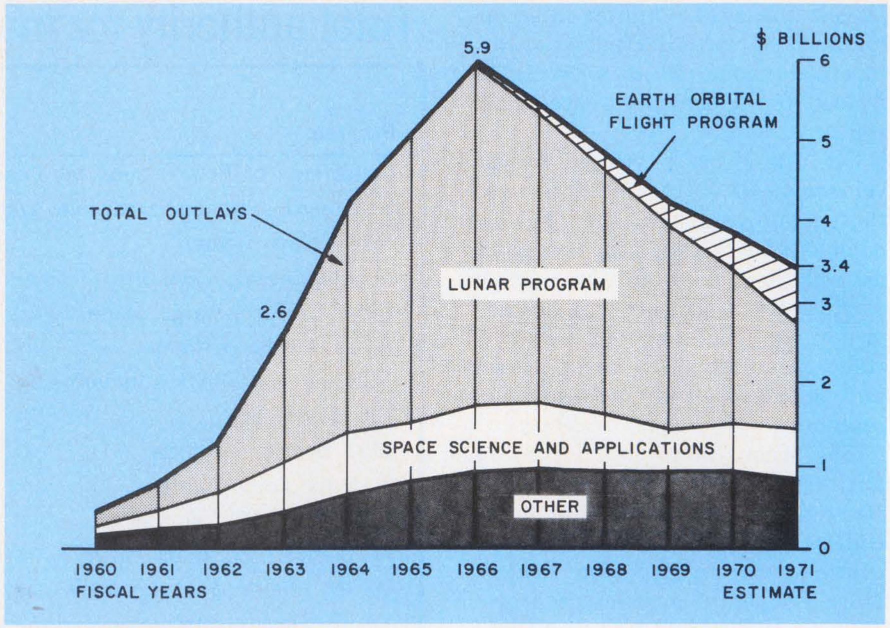
adds, does it "take advange of our capability."

NASA is listed for appropriations of nearly $1.5-billion for manned space flight. This is to continue the Apollo lunar landing program and pump new money into research for space stations and a recoverable space shuttle. But nowhere in the budget is there evidence of a plan to fill the gap in manned flights between the end of the Apollo program in 1974 and the scheduled first shuttle operation in 1978, Dr. Paine admits.

After the Apollo 13 flight next month, six more lunar missions are planned at roughly six-month intervals—except in 1972. The scene shifts during that year to deployment of the Saturn-V workshop in earth orbit and the use of Apollo spacecraft to move a three-man crew to and from the laboratory. The workshop and its associated large telescope will require $364-million next year.

The first large funding, $110,-million, is sought in the coming year for design verification work on the space shuttle and a 12-man modular space station. The shuttle effort includes extensive study of onboard and support electronic systems. For the station and shuttle, NASA originally asked $250-million. The sharp reduction delays the operational date from 1977 to 1978, Dr. Paine says.

The budget request for space applications is $167-million, an increase of nearly $39-million over last year. This will support a series of weather satellites, including a new synchronous craft, and a move toward development of two large Application Technology Satellites for advanced communications experiments in 1973 and 1975.



NASA's budget decline closely parallels the decrease in outlays required for manned space flight programs. In fiscal 1971, Apollo drops to below $1 billion and the expanding earth orbital program has only a year-to-year assurance of support.

Of equal import is a request for $52.5-million to expand the earth resources survey. This program involves $41.5-billion for development of two Earth Resources Technology Satellites (ERTS) for launching in 1972 and 1973. The remaining $11-million is for support of an aircraft program currently employed to test and evaluate sensor devices and measurement techniques for ERTS. In addition, $2-million in construction money is being asked to build an Earth Resources Technology Laboratory at the Goddard Space Flight Center, Greeenbelt, Md.

For the planetary program, the budget shows a small decline to roughly $145-million. This will support Mariner vehicles instrumented to orbit Mars in 1971 and to fly by Venus and Mercury in 1973. The Viking program, which involves dual vehicles to both orbit and land on Mars, has been stretched to delay the launching from 1973 until 1975. There will also be two Pioneer flights past Jupiter in 1972 and 1973.

In other NASA programs, the budget calls for expenditures of $116-million for physics and astronomy, $264-million for advanced research and technology, and $298-million for tracking and data acquisition. No funding was allowed for the sustaining university program ($7-million in fiscal 1970).

Transportation and anticrime projects get extra billions

A dramatic increase in new budget authority is being asked of Congress by the Dept. of Transportation: expenditures of $7-billion and spending authority of $11.2-billion.

The bulk of the increases are for expansion of the U.S. airport-airways system and for urban public transportation. The heaviest electronic expenditures will be by the Federal Aviation Administration. Its budget figures, however, are unsettled because the total appropriations requested depend on legislative passage of the proposed Airways and Airports Development Act, a 10-year, $2.5-billion effort.

In commenting on his department's 42% increase over last year's budget, Transportation Secretary John A. Volpe notes: "Despite this Administrations austerity program in the very real fight against inflation, we have been able to convince the Bureau of the Budget that the key to a great many of our national problems is a massive upgrading of our transportation capability." A total of $22-million is being sought for independent transportation planning and R&D.

The FAA budget request totals nearly $1.8-billion, up nearly $500-million over last year's figure, and it includes $47.5-million for R&D, $290-million for supersonic transport development and $190-million for procurement. Under the im-

*(**budget,** continued)*

pending Airways and Airport Development Program, the FAA wants an additional $292-million for the new year plus $57.5-million in supplemental funds for use in the current year.

R&D needs include over $34-million for air traffic control systems, with the goal of doubling the present capacity of the airways and airports by 1980 and obtaining a factor-of-five improvement by 1995. Another $5-million will be applied to development of improved long and short-range navigation aids and landing systems, and $5-million to promote aviation safety—that is for instruments to warn of clear air turbulence and impending midair collisions.

The greatest procurement outlays—a total of $125-million—will go to improve air traffic control centers. A total of $113-million is earmarked for the purchase of automation equipment, including computers and controller aids. Over $11-million will go to purchase long-range radars, with scanning ability up to 185 miles.

For the Airways and Airport Development Project, $60-million will go for facilities and equipment (instrument and landing systems and primary and secondary radars), $12.5-million for R&D and $220-million for airport grants-in-aid to states and local governments (these funds to be matched equally by those that receive the grants).

The Coast Guard request includes $24-million for R&D and $104.7-million for procurement and construction.

A total of $13.5-million is asked to continue the National Data Buoy Development Project in the next year; this will lead to deployment of instrumented buoys for testing in 1972 and 1973. Smaller expenditures will be required to develop a radar system for all-weather harbor approach and navigation, and to look into search and rescue approaches for non-military submersibles. Coast Guard oceanography efforts will center on arctic ice research and will include evaluation of aircraft sensors designed to measure ice-flow characteristics.

Nearly $30-million is requested to automate lighthouses, replace

Nearly $2.5 billion will be spent in the next decade to expand the U.S. airport-airways system and for urban transportation.

obsolete Loran equipment and improve three Loran-A stations and one Loran-C.

The Federal Highway Administration is requesting an R&D budget of $61-million. Its Bureau of Public Roads wants over $15-million to develop and apply new techniques and systems for traffic control and traffic operations. In the High-Speed Ground Transportation Program, nearly $22-million in R&D money is being sought. This is to be used to develop control and communications systems and specialized safety instruments for hazard detection and warning.

Federal plans for the war on crime read like a miniaturized national defense program. The President seeks $1.26-billion for domestic crime reduction, up $310-million over last year.

The funding is broad—14 Executive agencies require outlays of more than $1-million, topped by the Justice Dept. at $830-million. About 41% of all spending will be for direct assistance to state and local governments.

The bulk of grants to states and local governments will be drawn from the rapidly growing Law Enforcement Assistance Administration, an arm of the Justice Dept. It seeks appropriations of $368-million but requires new obligational authority of $480-million. The agency plans to spend $13.5-million on procurement of intelligence and information systems for these support programs.

The Law-Enforcement Assistance Administration also directs crime research, the development of information systems and sophisticated special devices. For R&D, it is requesting $43.2-million. In addition to the prototype development of crime information networks connecting federal, state and local law-enforcement agencies, the law-enforcement agency is seeking a variety of new electronics, including nighttime viewers, voiceprint devices and improved portable and fixed police radios.

Other agencies are assisting in this advancement development: the FBI (automated fingerprint identification techniques); the AEC (neutron-activation analyses); and NASA (specialized sensors and detection techniques). ■■

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Utilities discover the power of computers

Digital machines and data communications control output of generators and purchase of electricity

Milton J. Lowenstein
Technical Editor

Is there a place for the electronic engineer in the utility business? Ten years ago the answer would have been no. Now the computer has changed the picture significantly.

The advent of the digital computer has opened a new interface between electronics and power generation. The utilities have turned to the computer because it can save money; in the case of Consolidated Edison Co. in New York, the savings approach 2% of production costs which runs well into 6 figures.

Several other benefits accrue from the use of the computer. More efficient use of facilities makes more power available from existing plants. The fuel saving resulting from the higher efficiency reduces the relative amounts of pollutants emitted for the same amount of power output. Complex intersystem power exchanges can be set up more easily. System reliability can be improved, by constant data monitoring and centralized allocation of the utility's generating capacity.

Computers cannot be used, however, unless a great deal of background information is available. This information, called the data base, is used to set up an operating strategy. According to L. G. Lesniak, industry manager-public utilities of the International Business Machines Commercial Region, Princeton, N. J., typical items in the data base are incremental power costs, transmission costs and daily and annual load patterns.

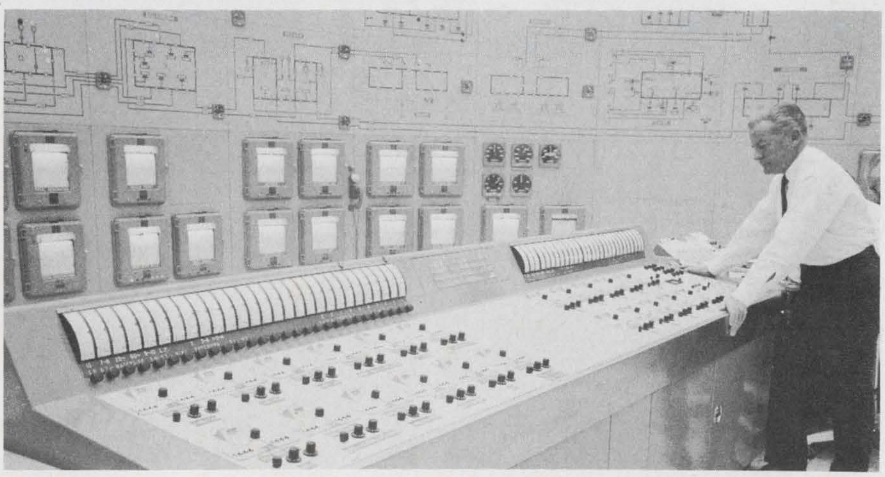
Fortunately utilities are good record keepers, so the data base for a new computer installation is usually quite complete. Once the computer is on line, it becomes the keeper of new data and continually updates the data base. In addition the computer shows power reserve status, transmission economics, system status and alarm conditions.

The utilities that are now using computers routinely in power production include American Electric Power in the Midwest, New Orleans Public Service, Middle South Utilities, Iowa Public Service and Connecticut Yankee Atomic Power.

An early user of computer system control has been Consolidated Edison, which serves one of the most concentrated power markets in the country—New York City. Con Ed operates over a dozen different plants that contain about 30 different generating units, each of which consists of an alternator, turbine and boiler. The units range from quite small to the largest single alternator in the country, Ravenswood No. 3, with a nameplate rating of 1030 megawatts. Some are old, some recent; most generate 60 Hz, three-phase power, and some produce 25 Hz three-phase for subways and 25 Hz single-phase for railroads. There are tie lines to several surrounding utilities, which result in interconnections to the New York State power pool and other nearby power pools like New England and PJM (Pennsylvania-Jersey-Maryland).

Power can be generated locally or purchased. If surplus power is available, it can be sold. All of the transactions are in real time: electric power cannot be stored—it must be generated to meet demand.

The trade-offs implicit in all of these transactions used to be evaluated by a large group of men, the load dispatchers, who worked in a big room with the outputs of all the units continuously on display in front of them. Some of the evaluators were so far from the instruments that they had to use binoculars to read the meters. These men, working with pencil, paper and slide rules, made the computations that determined which units were to carry the load and how the load was to be apportioned on the tie lines.



The control board of the Consolidated Edison computer has provisions to set the desired level of each generating unit. Maximum and minimum levels may also be set. Actual output is displayed on a bank of meters (left), and deviation from the set point is also displayed (right).

Computer to the rescue

But the advent of larger units and bigger tie lines began to overwhelm their abilities. A control system vendor, Leeds & Northrup, working with the utility came up with a supervisory control system in 1966 that used a 24-bit General Electric 4060 computer with 16K of core and 128K of drum memory.

The system operates on-line in

(continued on p. 32)

Hearing aid uses tiny 1.2-V op amp

A broadband operational amplifier that operates from a 1.2-V supply—about one-fourth the voltage required by the lowest-power op amp on the market today—is being used in a new hearing aid manufactured by Electone, Winter Park, Fla.

The packaged op amp, which is manufactured by Qualidyne Corp., Santa Clara, Calif., is only 1/8 × 1/8 inch. Most op amps are packaged in either a TO-5 can or a 1/4 × 1/4-inch flatpack—roughly four times the area of this package.

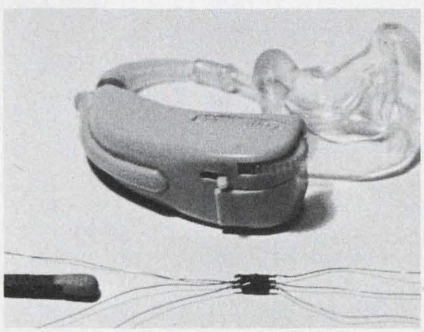
The voltage gain of the Qualidyne device remains constant at 70 ±4 dB over a range of supply voltages from 1.2 to 20 V and of frequencies from dc to 300 kHz.

The op amp can be used in any battery-operated equipment where low power and small size are required, says Dan Hauer, marketing manager for Qualidyne.

"Medical electronics is one obvious application," he points out. "For example, it's small enough to mount in a pressure or temperature sensor and implant inside the patient's body along with the miniature battery that powers it."

The circuit is essentially a two-stage amplifier with constant-current sources (a series of lateral PNP transistors) and internal feedback for gain stability.

The op amp is not available as a standard product, Hauer says, but can be made custom at a competitive price. ■■



The Qualidyne operational amplifier is shown here beside a conventional hearing aid and a match stick. About three-fourths of the conventional hearing aid consists of electronics, which could be replaced by a single operational amplifier.

(Utilities, ***continued*****)**

real time. It receives data inputs from all the generating stations, tie lines and distribution substations via leased telephone lines, and it transmits pulsed commands back to the units.

According to Con Ed's division engineer, Karl O. Sommer, the control of the generating units is analog, based on load and frequency. A receiver at the station verifies the incoming information and then drives the governor motor on the generating unit to make the desired correction.

Sommer notes that only four men control the entire system and they have a much better feel for the system than before. Data logging is very important in achieving this result. Remote readings of voltage, current, power and reactive power levels are coded into audio tones for transmission and are smoothed for presentation at intervals on the computer console in an Energy Control Center. Other computed results can be obtained on demand.

The initial system of software was developed by General Electric, Leeds & Northrup and Con Ed, all working together. GE supplied the basic monitor program, and the remainder was a 50-50 operation with L & N, according to Sommer.

Software is homemade

At the time of installation, Con Ed sent several employees to school to learn to program in Fortran. Now the utility supplies most of its own new requirements for software.

Talk to a typical Con Ed programmer, and he indicates that the software is becoming most sophisticated. "We program in Fortran II, assembly language and machine language," says programmer Steve Dixon. "The problems of debugging software designed for use on a real-time, on-line system are quite involved, because we cannot allow programming mistakes to interfere with operations."

One solution to the debugging problem is to try out new software on the computer after disconnecting it from the system. This can be done conveniently only during off-peak load hours.

Not all of the restraints imposed on the system are obvious. This is evident in the operation of Ravenswood No. 3. Although the rating of this unit is over 1000 megawatts, it cannot be used above 800 megawatts. The constraint is the ability of the New York State power pool to pick up the load should this machine go out of service suddenly. There must be a "spinning reserve" (reserve power available in five minutes) to replace the possible loss of the largest machine in the pool. The maximum spinning reserve that can be provided by the New York State power pool limits Ravenswood No. 3 to the lower output. The apportionment of the spinning reserve among the utilities in the pool is another function of the computer.

Spinning reserve rules vary

How big the spinning reserve must be a question that is answered by the rules imposed by a power pool. Interpretation of the rules can be done by a computer.

In Con Ed's case, the New York State power pool specifies the capacity of the largest machine in the system. Ed Dussinger, industry marketing representative for

STA	MAX CAP	SHT CAP	GEN	OPR RES	SPN RES
AK	840	815	778	62	20
AST	1338	1321	1174	164	92
ER	501	501	274	227	99
HG	263	263	197	66	66
HA	391	391	213	178	132
IP	280	280	271	9	9
RAV	1647	1600	1560	87	32
SC	82	82	59	23	23
WAT	412	412	334	78	11
59TH	72	65	72	0	0
74TH	133	133	86	47	22
KENT	0	0	0	0	4
GT	210	210	0	210	210

MAX CAPACITY = 6169
SHT CAPACITY = 6073
GENERATION = 5018
LOAD = 5057
OPERATING RESERVE = 1151
SPINNING RESERVE = 712

TRANSACTION NEXT HOUR

	MW	LAMBDA
DECRMNT	—400	3.6
	—300	3.7
	—200	3.9
	—100	4.0
NET LOAD	4559	4.1
INCREMNT	100	4.2
	200	5.2

1. **A typical printout of system status** lists all the generating stations, their maximum and shaft capacities, actual generation, and operating and spinning reserves. Also listed are the same quantities for the entire system. A computed result is given in this printout of lambda, the incremental cost of power. It is listed for the current level (4.1 $/MWH) and for increments and decrements of 100 MW.

Now, phototransistors that hang in there

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TI is quietly creating new opportunities for designers with standardized devices like this new NPN line. Standardized, yet the only line in its class that gives you a choice of 5 specific light current sensitivity ranges. All off-the-shelf.

TYPE	TIL63	TIL64	TIL65	TIL66	TIL67
MIN	0.4	0.4	1	2.5	6
MAX		1.6	4	10	
UNIT	mA	mA	mA	mA	mA

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TEXAS INSTRUMENTS
INCORPORATED

(**utilities,** *continued*)

public utilities, IBM Corp., Princeton, N.J., points out that this is not always the case. "Spinning reserve requirements are based on system characteristics, particularly the speed with which more power can be generated," he says. "Hydro, pumped-storage and gas-turbine units can increase power generation rapidly, while steam, whether fossil-fueled or nuclear, is slower. Therefore systems with a higher proportion of fast response units require a lower spinning reserve."

Joseph Coletta, an electrical engineer with Con Ed, whose system is mainly steam, says: "System reliability is very important to a utility. We must be prepared for all possible contingencies. Besides the spinning reserve, we have an operating reserve, which is power available in 30 minutes. The computer is always ready to print out both the spinning reserve and the operating reserve at any time [Fig. 1]. This is a great help to the system operator, who is ultimately responsible for the system and who may override the computer at any time if he thinks it necessary."

In addition to computing the operating characteristics of the power system, the computer also provides a great deal of economic data over and above its primary function of allocating units economically. The quantity "lambda" is the measure of incremental production costs in mils per kilowatthour or dollars per megawatthour.

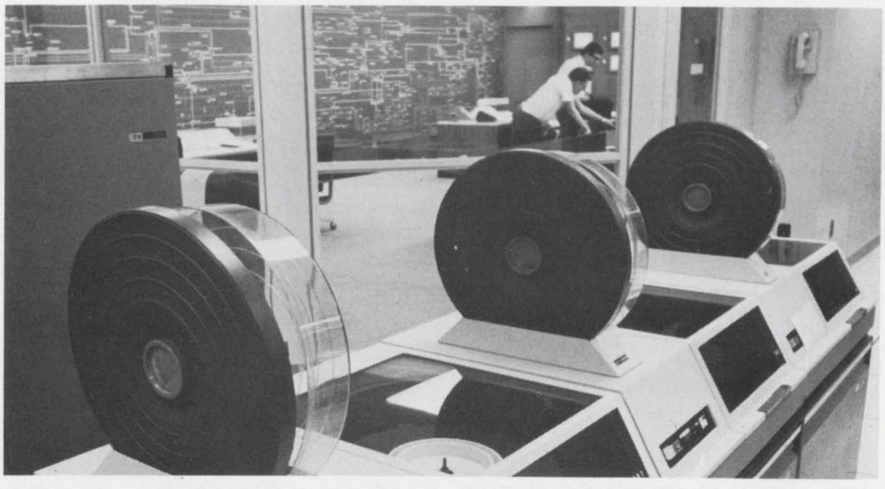
Since there is no over-all economic control of the New York State power pool at present, the system controller must decide whether it is cheaper to purchase power or produce it. This is the utility equivalent of the make or buy decision. The system controller has a chart of the cost of purchased power. The computer can give him a printout of lambda (Fig. 1) for any amount of increase or decrease in system power level.

Load swings reduced

The bane of the utility is load variation—long-term and short-term. Long-term variations are usually seasonal and related to weather conditions, and so are not easily changed. However, daily variations can be smoothed by encouraging users to make use of off-peak periods. The encouragement is usually some rate adjustment.

Some industrial loads can be scheduled in accordance with power availability, provided that up-to-date information is at hand.

A digital machine can compute load demand on a system and determine whether excess capacity exists. It can then transmit this information over suitable data links to the customer. Typically, the information is updated at 10-minute intervals. This time period is enough for certain customers, such as electrochemical industries, to vary their processes, so they can take advantage of the cheaper power.



The control room of the PJM (Pennsylvania, New Jersey, Maryland) interconnection contains the power dispatch computer. The board in the background is a diagram of the system.

Computer use to widen

At Con Ed today a large supervisory computer controls a system with individual analog controllers. But both Sommer and John Deegan, manager of operations at the Con Ed Energy Control Center, agree that wider use of computers is coming. They foresee the replacement of analog controls with minicomputers that will operate stepping motors on the generating-unit governors. Minicomputers are also slated to replace large blocks of hard-wired logic, which now oversee substation and tie-line operations.

None of these improvements is expected soon, because of the satisfactory operation of existing equipment. They will most likely appear on equipment now being designed. One area in which they are almost a necessity is in nuclear power-plant operation. Here performance of the reactors is based on adequate monitoring of their parameters and heat balance. Most reactor manufacturers base their performance gaurantees on controlling rod position by computer.

Utilities are also making use of the computer off-line. Models are being constructed to simulate the effects of air and thermal pollution. Performance profiles are based on weather conditions and fuel types. This particular application is in an embryonic stage, but it is expected to become significant in time.

Of course, computer terminals are also used by engineers to solve design problems. The biggest computers owned by utilities are those used for commercial data processing, such as billing customers. Spare time on these machines is used for batch processing of design problems. The customer information service, which relies on the commercial machine, is also used to indicate system status at the local level. The input here may be a phone call from a customer complaining about poor service. Even in this era of automatic data logging, a complaint is sometimes the best way to locate a fault. ■■

Navy is seeking better electronics

Even though the 1971 defense budget has been cut, there's still opportunity for enterprising electronics companies to improve existing equipment for the military. The Navy, for example, has several complaints about airborne equipment that it would be happy to see corrected.

Badly wanted at the Point Mugu Missile Range in California is a portable ground checkout unit for testing PCM telemetry units in aircraft. At present the telemetry pod must be removed from the aircraft and taken to a maintenance room.

Another recurring and very serious problem there involves the MK-4 gun on the F-4 fighter plane. When a faulty round is fed into the gun, the gun jams and is out of commission until the plane lands. An electronic sensor that could detect the troublemaker before it was pulled into the gun could alert the pilot to pull the bad round through manually.

A handier radar asked

Radar maintenance at Point Mugu is a further headache. The Westinghouse APG-59, installed in the F-4J, must be removed from the aircraft every time it is adjusted or repaired. The Navy wants a radar that repairmen can get to without disassembling it from the aircraft.

The Navy's missile test facility at the White Sands Missile Range, N.M., would like to fly its drones in formation, but present controls aren't sophisticated enough to allow this: Only one drone can be flown at a time. The challenge to designers: Build the controls so that a half dozen of the unmanned aircraft can be flown in close formation and electronic warfare equipment can be switched on and off at will.

In addition present drones are not capable of maneuvering realistically and cannot fly safely below 1000 feet. The Navy wants a drone that can hug hilly terrain to simulate a low-flying cruise missile. ■■

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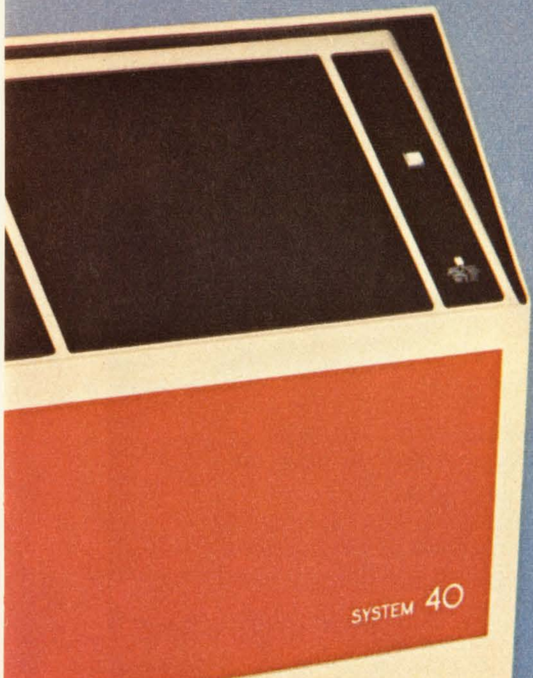

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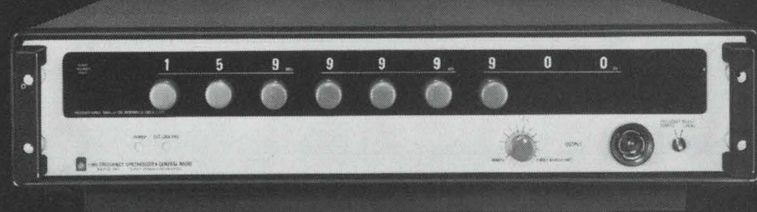

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Buying a frequency synthesizer has been something like buying a car. There's a confusion of models, options, and price ranges. Except – there has never been a so-called "intermediate"-model synthesizer. That's because price and performance ranges of synthesizers have tended to cluster just at both ends of the spectrum. The choice was between lower-cost, limited-frequency-range models and those with everything, including a sky-high price tag. So, the buying decision was one based on either trade-off or over-capability.

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INFORMATION RETRIEVAL NUMBER 26

Washington Report

CHARLES D. LA FOND, WASHINGTON BUREAU

Congress presses for new oceanographic agency

Moves to create a single federal agency to direct all marine science and engineering activities are snowballing. Such an independent authority, to be called the National Oceanic Atmospheric Agency (NOAA) was a major recommendation made in a panel report last year by the blue-ribbon Commission on Marine Science, Engineering and Resources. To date the Administration has made no proposal supporting this plan nor offered an alternative approach to unify the present fragmented marine programs administered by 14 federal agencies.

A bill led by Rep. Alton Lennon (D-N.C.) to establish the new agency is progressing rapidly in the House. Hearings for a similar bill are under way before the new Senate Subcommittee on Oceanography, chaired by Sen. Ernest Hollings (D-S.C.). Opposition has been voiced by nearly all Executive departments and agencies pursuing marine science and engineering programs.

But, say Congressional staff informants, NOAA proponents are deriving strength from the division that exists within the Executive. Reportedly, a proposal has been tendered to the White House to establish a new slot within the Interior Dept. for meteorology and oceanography, and to rename Interior as the Dept. of Natural Resources and Environment. Stiff resistance to that proposal is voiced by the Dept. of Commerce because it might lose its Environmental Sciences Services Administration.

Environmental science center is proposed

Anticipating steadily expanding programs for improvement of the environment, Rep. F. Bradford Morse (R-Mass.) has introduced a bill for the establishment of a National Laboratory for Environmental Science. His bill would implement a recent recommendation of the National Academy of Sciences for establishment of a federal laboratory to carry out systematic research on the total environment.

Although not a part of his proposed legislation, he can be expected to influence the use of NASA's Electronics Research Center in Cambridge—to be closed in June—as a site for the new lab. Under the bill, the laboratory would be contractor-operated and draw its funding from each federal agency with responsibilities for environmental research.

R&D budget request suffers slight drop

Government-wide expenditures for R&D were cut by only $200-million in the new budget, although many activities associated with electronics suffered severe reductions. Total expenditures in fiscal year 1971 are estimated at $15.7-billion, with the largest outlays for Defense; NASA; Health, Education and Welfare; the Atomic Energy Commission; and the National Science Foundation. Nearly half of R&D expenditures are for defense systems, and over one-fifth for NASA.

But there are interesting increases for blanket R&D outlays. For example, government support of R&D in colleges and universities is up slightly to nearly $1.5 billion. The National Science Foundation has been raised to $307 million. Marine science and technology programs show a marked increase to $540 million—and this excludes an additional $20 million the Navy will spend for development of surface-effects ships, such as air-cushion vessels.

Civil and military space programs are down over $600 million, bringing the total funding to just over $5 billion. Pentagon informants point out that the bulk of space cuts was absorbed by NASA. Despite its loss last year of the Manned Orbital Laboratory (a $1/2-billion program), military space R&D is still funded at about $1.7-billion, a drop of only $100-million.

Safeguard ABM battle to be renewed

Despite pleas by leaders of Armed Forces committees in both houses to minimize defense appropriations debate, Safeguard ABM opposition forces are expected to resist Administration proposals for expansion of the system. President Nixon is requesting Phase II funding for the Army program, which would probably lead to deployment at up to 12 sites, including the nation's capital. Phase I involved only two sites.

The new budget asks nearly $1.5 billion, $600 million of which is needed for Phase II R&D and deployment. Pentagon officials make no attempt to allay fears of further increases in ABM spending. And Senate critics contend that their worst fears of last year are now justified—that the present expansion is just another step in the ultimate goal of the Joint Chiefs of Staff to attain a "thick" ABM defense with a price tag up to $40-billion.

Role of communications policy office unclear

The White House announcement of its request to Congress for approval of a new Office of Telecommunications Policy provides meager details on the extent of its authority or its impact on the FCC. Establishment of such an office was prematurely revealed early in January by Rep. Joseph E. Karth, (D-Minn.), who made public a confidential White House memo concerning the plan. No opposition of consequence is expected from either house, Capitol informants predict.

The new office is expected to come into being early in April to replace the present Director of Telecommunications Management in the Office of Emergency Preparedness. The White House says the new policy group would avoid regulatory disputes but would strengthen Administration involvement in determining policy.

Initially, the new policy office would establish guidelines for the use of federal communications and would review all frequency allocations reserved for federal use.

British metric expert scores U.S. delay

"By 1975, we shall have achieved what nearly 200 years ago—in July, 1790—Jefferson proposed for the new United States, a rational system of measurement," declared Lord Ritchie-Calder, chairman of the British Metrication Board. Speaking recently here before a Government industry group, he noted the irony of the fact that America—the first to employ metric currency—is one of the last two nations in the world to change to metric measurement.

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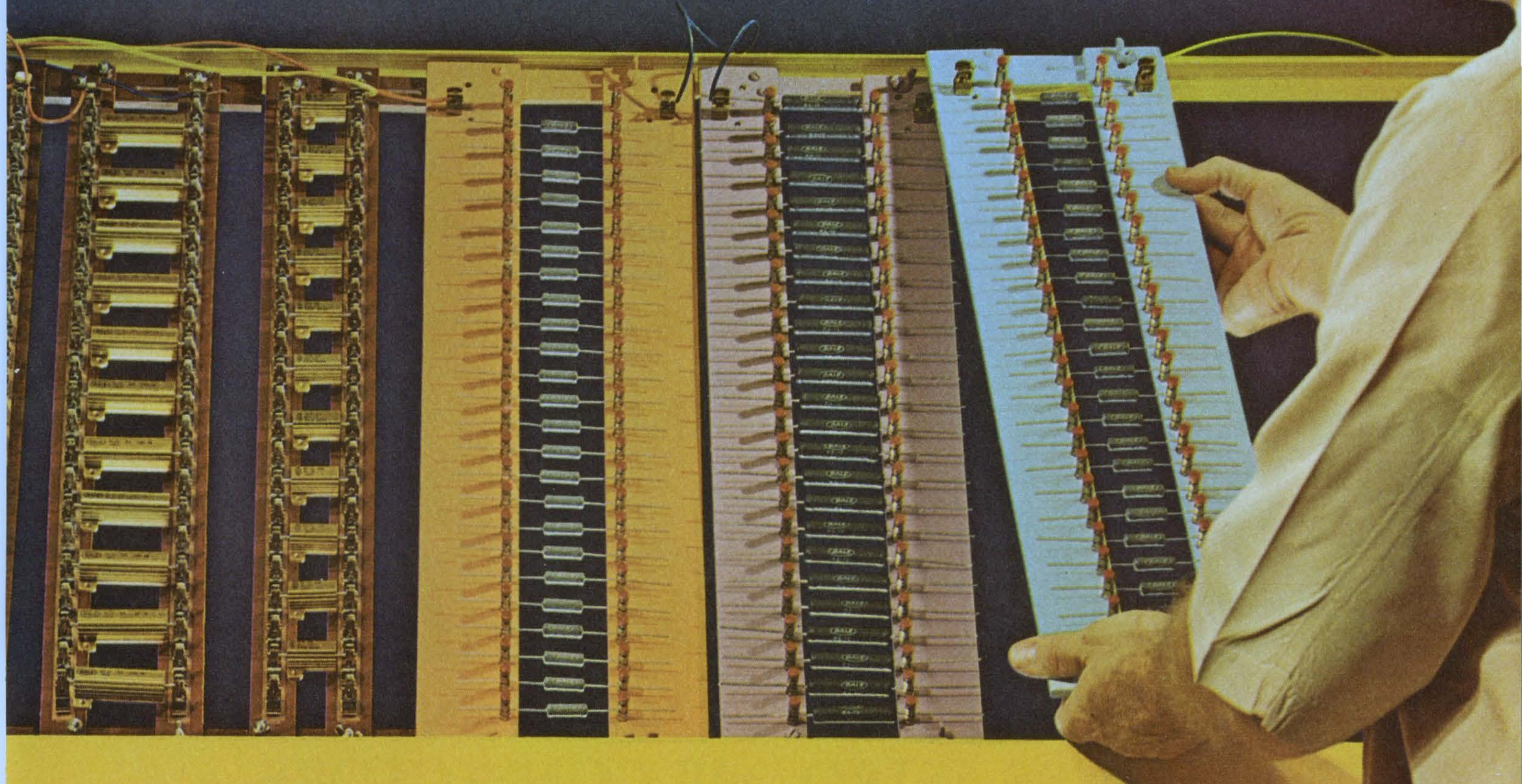

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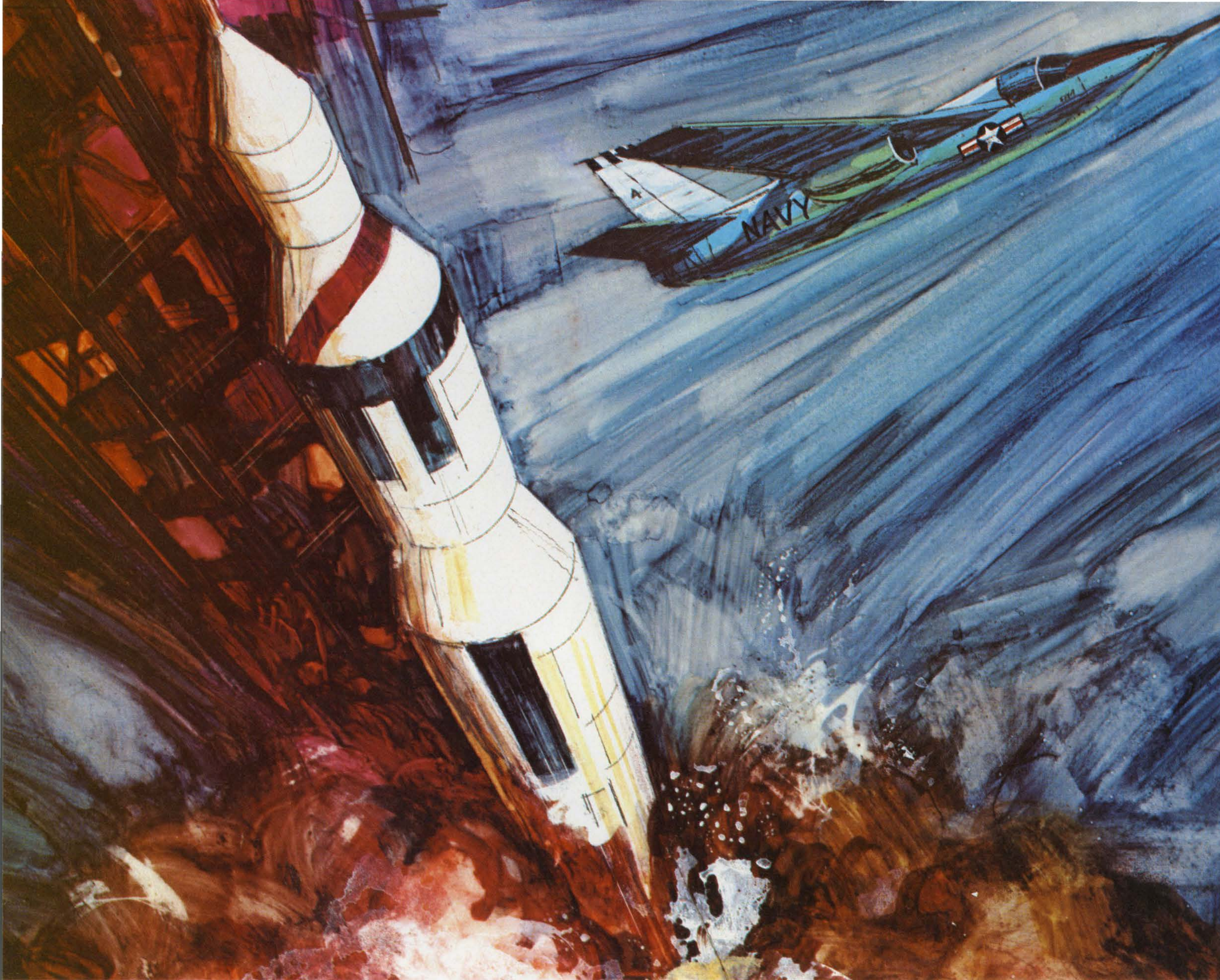

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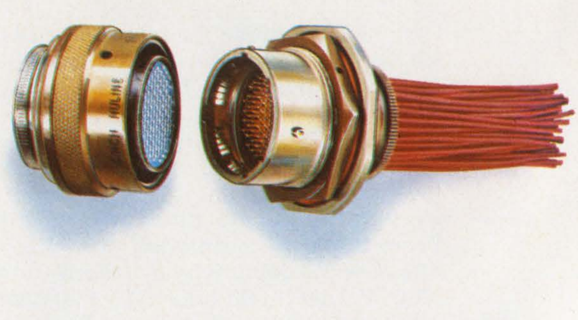

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Hughes hostess houses visiting EEs

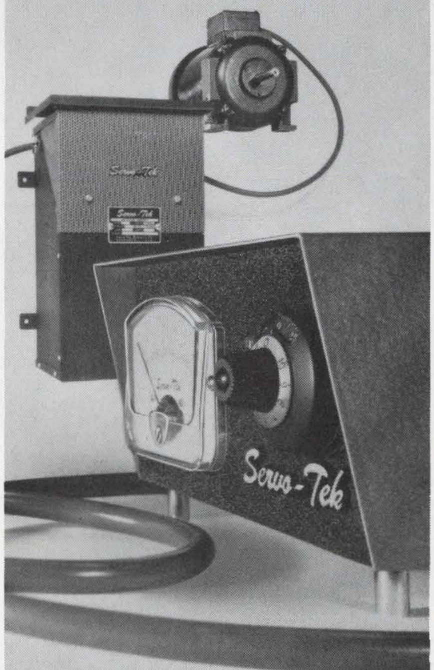
With one secretary, a company car and no budget, a Los Angeles housewife, Mrs. Donna Harris, has successfully managed to find homes for over 130 foreign engineers and their families during the last 15 months.

The visitors, EEs from 10 nations, have been coming to El Segundo, Calif., to learn the Hughes Aircraft method of designing the Intelsat IV communications satellite (see story on p. 72). Mrs. Harris, a Hughes receptionist, was chosen for the job of hostess because she has lived in the area for 30 years; has a home and children; and can sympathize with the visitors' needs.

Her main problems were with some American business people who tried to make a fast buck—until they realized an American was in charge. The refunds came fast. There were no serious problems with her "wards." She was able to steer the German contingent to a "Deutsche bakery" that stocked hard bread and water rolls (they thought American bread too soft), and place the Belgian children in a school where there were two French-speaking nuns.

"It was a joy to help them all," says Donna. "They loved everything from Death Valley to Disneyland."

Donna Harris with some of the foreign engineers she welcomed to the Hughes Aircraft Co. in El Segundo, Calif.

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EDITORIAL

A labor guild for engineers? The idea has possibilities

Arguments both for and against labor organizations for engineers have appeared in this space in the last year and they have elicited a consensus from our readers. Most engineers appear to favor organization—or at least most who write letters to editors. If there is wide opposition to the idea, it is a "silent majority."

It's easy to see why many engineers might lean toward organized bargaining to achieve better working conditions and higher pay. For one thing, the nation has been on an inflationary binge, with $60-a-week raises and higher being won by unions representing teamsters, newspapermen, teachers, construction workers and others. The average engineer, being unorganized, hasn't done as well in the last few years. Moreover whereas "job security" is a union staple, engineers—particularly in the defense industry—are continually haunted by the specter of layoffs. These factors contribute to a strong feeling that organization might improve the lot of the engineer.

Not so easy to obtain agreement on, however, is the matter of what type of labor organization would best suit the needs of engineers.

Three types suggest themselves: (1) An established union; (2) The professional society; (3) An organization that is neither of these and perhaps best termed a guild.

For some engineers, the professional society is the least desirable. Epitomized by the National Society of Professional Engineers, it cannot serve the needs of the engineer in industry, the critics reason, because it is owned and operated by and for the consulting engineer and land surveyor.

The established union is also unsatisfactory to many engineers, because it includes nonengineering personnel, like draftsmen and technicians, whose objectives do not coincide with those of the more highly trained engineers. A conglomerate membership often leads to jurisdictional squabbles and a dilution of the vitality of the organization.

The third possibility, the guild, appears promising, if only as a compromise. Membership could be limited to employed engineers only. There would be a unanimity of backgrounds. Guild members could be assigned to chapters around the country, and each chapter could negotiate its own salaries and conditions of employment. The national character of the guild would permit the preservation of pensions, insurance and other benefits, irrespective of job shifts made by individual engineers.

Only one thing is holding up the establishment of a new engineering guild—and it's a big thing. Leadership. So far it's been all talk but no action by those in favor of organizing.

MILTON J. LOWENSTEIN

Can you build a system

By Elizabeth de Atley, West Coast Editor

Second of two articles

There are specialists in the electronics industry who answer the question "Should systems companies design their own chips?" with a query of their own: Why go custom at all? In most cases, these specialists argue, it would be cheaper to build a system, such as a computer from standard parts.

At least two major semiconductor companies—Intel of Mountain View, Calif., and National Semiconductor of Santa Clara—suggest the use of standard LSI parts. With this approach, they point out, the relationship between the systems and semiconductor companies would remain as simple and clear-cut as heretofore; only the chips and the data sheets would get more complex.

Other systems and semiconductor specialists interviewed by ELECTRONIC DESIGN are not convinced that this is feasible.

"It can't be done," they insist. "As the amount of circuitry that can be put on a chip increases, you can't go on indefinitely identifying bigger and bigger pieces of logic that can be used as standard parts in a variety of systems."

How, for example, they ask, can you put an LSI chip that contains half a calculator into a computer? Or even into another calculator? That much of a system has to be custom, they insist.

"That's true," say both Intel and National Semiconductor, "but only if you continue to perform all control functions with gates."

If, instead, the designer uses microprogramed read-only memories for control, he can build the logic system from standard parts, which can be made more and more complex as yields allow. In the limit, Intel and National Semiconductor point out, each LSI part would be a computer-on-a-chip, microprogrammed to meet the customer's specific need.

The two companies concede that this approach will require a basic structural reorganization of the logic system. But the impetus for making the change, they say, is a potentially far lower cost for the system.

ELECTRONIC DESIGN asked seven specialists for their views on whether standard LSI could be used to make the system. Their replies can be summarized as follows:

	Build System Out of Standard Parts	Maybe, but . . .
Dr. Robert N. Noyce, president, Intel, Mountain View, Calif.	x	
Floyd Kvamme, microcircuit product manager, National Semiconductor Corp., Santa Clara, Calif.	x	
Gene Carter, MOS/LSI product manager, National Semiconductor	x	
Lee Boysel, president, Four-Phase Systems, Inc., Cupertino, Calif.		x
Don Farina, president, Integrated Systems Technology, Inc., Santa Clara, Calif.		x
John Hulme, manager IC applications, Hewlett-Packard, Santa Clara, Calif.		x
Tracy Storer, division engineering manager, Hewlett-Packard Computer Div., Cupertino, Calif.		x

with off-the-shelf LSI?

LSI is changing the traditional roles of systems companies and semiconductor manufacturers, and some specialists agree that as more and more of the logic system goes into a single chip, the distinction between chip design and system design blurs. As a result, some systems specialists believe systems companies must take over chip design, and possibly even wafer processing, or lose control over their operations. Most semiconductor specialists see no need for such extremes. They believe that designers in two separate companies can—and, in fact, do—work together effectively on the same design, despite communication problems. The conflicting views were presented in "LSI Poses Dilemma for Systems Designers," ED 3, Feb. 1, 1970, pp. 44-52.

Read-only memories are customized by final metalization. (National Semiconductor Corp. photo)

While each of the seven specialists was interviewed separately, their views are presented here as if they were all sitting together on a panel:

NOYCE (Intel): The computer historically has been put together with gates and flip-flops—a one-to-one hardware implementation of Boolean equations. Now, as chips get more complex, we run into a dilemma: How can we find standard pieces that contain 100 or more gates? There are the universal functions like registers and memories, of course, but the problem is the control. This has to be custom because everybody's computer does different things. But it's very difficult to build custom arrays of logic gates. They're not arranged in any orderly fashion. In fact, they look like a rat's nest. They're difficult to lay out, difficult to test, and difficult to spot errors in, because of their nonuniformity. What's the solution? Well, it's possible to put all these control functions into read-only memory [ROM] which can be designed specifically to make variability cheap. Because ROMs are highly regular, they're easy to lay out, easy to test and easy to spot errors in. Furthermore, turnaround time is short. The manufacturer can build them in volume up to the final metal layer that contains the custom wiring. Then when he receives an order for a special wiring job, all he has to do is take the ROMs off the shelf, deposit the final metal layer, test and ship them.

KVAMME (National Semiconductor): We agree wholeheartedly with this approach. The ROM is usually thought of as a look-up table or memory, but it can just as well be used to generate the truth table of a logic function. The customer tells us what the outputs should be for each of the input combinations, based on the truth table of the function he wants to perform, and we wire the ROM so that it generates this truth table. ROMs can perform the most complex logic functions.

NOYCE: The real beauty of this approach is that it allows a high degree of standardization. You can build the whole computer out of just three LSI components: random-access memory, data-manipulation registers and read-only mem-

"It won't be long before someone will put the whole computer on one chip...and microprogram them especially for every customer's needs"

ories. The data-manipulation registers would be universal units capable of performing all of the jobs you want a register to do—add, subtract, shift left, shift right, etc.—under different input control instructions. If you want to change the function it performs, you simply change the pattern of ones and zeros on the input lines. These lines would be under the control of a microprogram written into read-only memory. The microprogram would instruct the register to add, subtract, etc. In fact, the entire system would be under the control of microprograms at various places in the read-only memory. For example, a given microprogram in read-only memory might contain instructions to take the contents of one register and put them into another, or take the data out of a certain address in memory and put it into another register. All the registers in the system would be these universal registers.

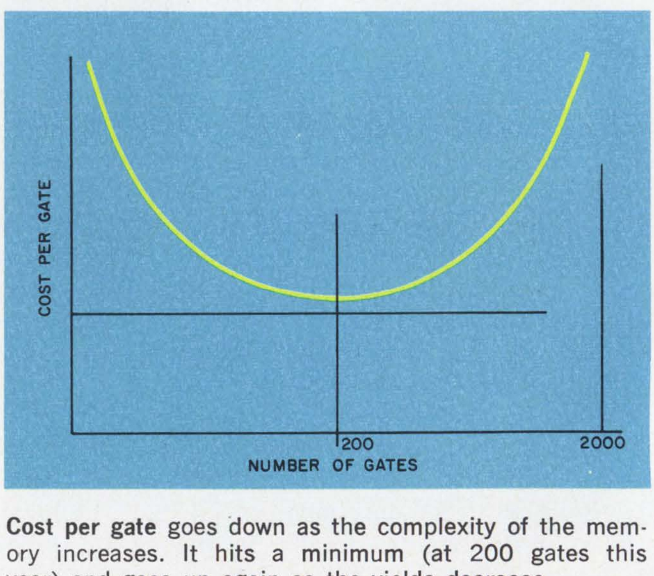
ELECTRONIC DESIGN: Does anybody make a universal register now?

NOYCE: I understand Sylvania has made something of the sort for the new Raytheon computer, and I suspect the semiconductor companies will begin to build such units as they see the need. Microprograming is being used in a number of small computers now, and it looks to us as if it will be more and more widely used in the future—partly because it lends itself so beautifully to standardization in LSI and partly because it is a powerful way to organize a computer.

BOYSEL: (Four-Phase Systems): I agree that microprograming is a powerful way to organize a computer. In fact, that's how we've organized our nine-chip computer at Four-Phase.* But if you're going to standardize, why stop with a universal register? It won't be long before someone will put the whole computer on one chip, stockpile batches of them and microprogram them especially for every customer's needs.

NOYCE: I've no doubt that's true. But we see this as an evolutionary process. At the moment our yields generally are good enough to let us integrate a universal register of the type we've been talking about. As yields improve, it will become practical to put more function into the registers, then to put more than one register on one chip and so on. A whole calculator may contain two thousand or more equivalent gates. We couldn't put that on a chip at reasonable cost today. But we can break it up into universal pieces, which we can use to build calculators and computers with different amounts of complexity. The question is, How big should the pieces be? If you look at the curve of cost per equivalent gate vs the number of gates per chip [see figure] the cost hits a minimum at around 200 gates. As you put more on a chip, the cost goes down toward this minimum because the packaging and assembly costs go down. Then as the number of gates continues to increase, the cost goes up again because yields get prohibitively low. The question is, Where is the minimum? That's where you should work at a given time.

KVAMME: One of the things you want in a "universal" register is the capability of accepting data from several input lines, all under the control of the microprogram. At National, we're developing an MSI block of data-flow gates that can be attached to any register and used to control the flow of data into and out of the register. So instead of one "universal" LSI register, we use two MSI-level blocks—a register and this block of data-flow gates.



Cost per gate goes down as the complexity of the memory increases. It hits a minimum (at 200 gates this year) and goes up again as the yields decrease.

*The entire central processor of Four-Phase Systems' minicomputer is contained on nine MOS chips.

"We've found it's usually cheaper to build the system out of standard parts, even if you have to use some ICs"

ELECTRONIC DESIGN: Could you build an entire computer out of read-only memory and these MSI-level blocks? Would there be any logic functions that could not be put into ROM?

BOYSEL: You bring up a good point. Theoretically you can replace any random-logic function with ROM. But to replace flip-flops—counters, status information, etc.—would take a prohibitively large amount of ROM. For example, each flip-flop in the machine causes the whole machine to run in two slightly different states—one with the flip-flop set and one with it not set. If you want to put that flip-flop into read-only memory and keep the same controls, that means you have to repeat the control loop twice—once for each state of the flip-flop. And you have to do this every time you add a flip-flop to the ROM. For example, suppose you have four status flip-flops that slightly alter the machine operation and it takes a thousand bits of ROM to control them. If you want to effectively replace those four status flip-flops with ROM and yet keep the same control, then you have to put 2 to the 4th times as many bits or 16 K bits into ROM. And that just wouldn't be practical.

KVAMME: No. In fact, that's why we stress the importance of making MOS compatible with DTL and TTL. Sometimes you want to take advantage of counters or adders that are available in bipolar. But we've found it's usually cheaper to build the system out of standard parts, even if you have to use some ICs. The argument for saying that custom is the way to go normally relates to chip size. The fact that you can sell a standard chip for $4 must mean you can sell a custom chip of the same size for $4. But that just ain't so, and there are a lot of reasons why it isn't so. For one thing, the fact that a chip is standard means that all the handling procedures are standardized. Whereas making custom chips is a job-shop operation, and job-shop operations are never as inexpensive as standard, regardless of the fact that chip size may be the same. You've got a different mask for every custom chip.

Floyd Kvamme, microcircuit manager at National Semiconductor, who believes the read-only memory makes it possible to build computers from standard LSI.

CARTER (National Semiconductor): Testing is a very big problem, too. Every device has to have a different probe setup because it has a different pad layout. It takes a girl several hours to set up each one. So if the manufacturer has 75 different custom products to be tested, that's 75 different probes he has to have set up and waiting, because there just isn't time to change them. And that's going to keep the price of custom circuits up.

KVAMME: That's right. But perhaps the biggest reason why the standard chip will always cost less than the custom is competition. When 12 guys are making a circuit, the customer gets a good deal.

NOYCE: Our philosophy at Intel is very similar to National's, except that we don't feel MSI-level components will be the most economical size unit to standardize on. When the cost of packaging a unit and assembling it into a system begins to exceed the cost of manufacturing the unit itself—and this is already the case with MSI—then it makes sense to build a new unit that is more complex and does more, yet costs the same amount to assemble and package. That's why we suggest designing the computer around a universal data manipulation register with about four times the complexity of today's MSI—or about 200 gates.

ELECTRONIC DESIGN: Dr. Noyce, a question here, please. A few minutes ago Mr. Boysel remarked that flip-flops are costly, area-wise, to implement in ROM. Where would they go in your system?

NOYCE: Hopefully most of them would go in-

"Down the road you might envision all kinds of data-entry systems.... And I think it will be an important area for custom LSI"

to the universal registers.

ELECTRONIC DESIGN: You wouldn't have to build any part of the system out of ICs?

NOYCE: You'd probably still have to use ICs for gating in and out of the registers. In the end you might incorporate all the gating inside the register, but this would be an evolutionary process.

BOYSEL: (Four-Phase Systems): But you haven't explained what you'd do with the status flip-flops. I agree completely with the idea of a universal register. In fact, that's what our arithmetic logic chip really is. It adds, shifts and so on, and it's decoded to take direct inputs from the ROM. But there are some parts of the system you just couldn't implement this way. Like the status flip-flops. Or the odds and ends of logic in the input controller that control the over-all on/off of the machine. All this amounts to maybe only 3 or 4% of the total gates in the system. But you'd just have to customize them or use ICs.

NOYCE: Yes, that's true.

FARINA (Integrated Systems Technology, Inc.): Another place where I don't feel ROMs and standard LSI parts would be appropriate is in the area of peripheral systems and data entry. Things like this just don't lend themselves to standard parts. And down the road you might envision all kinds of data-entry systems—credit card systems, voice communication, outputs from some kind of medical electronic gadget that monitors the pulse rate or temperature—this is going to be the next electronic explosion. And I think it will be an important area for custom LSI.

NOYCE: As the applications expand, there will always be new areas where no standard components exist to do the job. But if you drop back from that forefront a little, there probably will be a group of standard circuits to do most of the jobs that are following behind. Custom, after all, implies something that isn't available. If we ask what is available today in standard LSI, the answer is nothing. The universal register is not available; so if you're going to make it now it will have to be a custom job. But off in the future it will be available. And the same thing will happen, I believe, in the peripheral area. Certainly nothing standard is available there now. But if you build a phone-line interface, it could be used every time you attach the computer to a phone line—regardless of the type of computer. And the same is true of a teletype system. Now I don't want to draw too arbitrary a line between custom and standard. That would be like saying, "Look, we don't like what you're doing; so please do what we're doing instead." And that's not the idea. In fact, Intel is actively soliciting custom business. We're doing this because we want to learn by working very closely with customers what they need to do their job. Hopefully, by working with several customers in the same area, we can find the commonality that everybody seems to need, and then we can build that as a standard part. And once it exists as a standard part, the cheapest way for a guy to go will be to use it, because he will have all the advantages of a production-line flow that is already established. Whereas if he starts over again with something new and different, he will have not only all the design costs but also all the costs involved in running a small-volume production, as Floyd and Gene have pointed out.

ELECTRONIC DESIGN: About the idea of using ROMs for control: It's very intriguing. But do you people think it will catch on very fast? After all, it does require a basic configuration of

Tracy Storer, engineering manager at Hewlett-Packard, who sees advantages to using the standard LSI approach —but some potential shortcomings as well.

"The ROM is well adapted to large-volume production, but it would be shallow competition to carry this approach to the final degree"

the system, and we're all creatures of habit.

KVAMME (National Semiconductor): True, you have to reconfigure the system. But that's the biggest advantage of this approach. I just plain don't believe that a system that was originally laid out to use DTL or TTL is configured in the best way to take advantage of MOS. A lot of people tried to force-fit transistor designs into ICs, too, but it didn't work. Circuit configuration had to change with ICs. And I think that system configuration will have to change with LSI.

NOYCE (Intel): I've no doubt there will be a great deal of argument against this approach, just as there was in the first days of building flip-flops. The user then said, 'How can I use one standard flip-flop when I have 30 different flip-flops in my system.' And, in fact, IC flip-flops didn't come into general use until they could be bought for less than it cost to build them out of discrete components. And I think the same thing will happen here—the universal registers won't come into general use until it's cheaper to use them than to build the system out of standard ICs and MSI components.

BOYSEL (Four-Phase Systems): If you're going to build a system in high volume, I think it's always going to be cheaper to customize it.

NOYCE: That's the essential point here. It's not really a question of custom vs standard. It's a question of small volume vs large. If you're going to build a million systems, then it may be much cheaper to take the design time—which is long—and pay the tooling costs for going custom rather than standard. But it isn't going to be the cheapest way to do it for more limited production runs. The only reason to try to get standardization is to get large volume. Now when you talk about any of the major computer companies, they have enough volume so they can get circuits designed to their standards at reasonable costs—but that's not because it's custom vs standard. It's high volume vs low.

HULME (Hewlett-Packard): The ROM is well adapted to large-volume production, but it would be shallow competition to carry this approach to the final degree. If everyone uses the same parts, no one company can emerge as the winner. Let's say two companies both subscribe to this for six months, and they both compete in the same market, selling the same kind of computers. Then it's all a matter of who does the best marketing job. But if one of these companies comes along and says "We have a better keyboard," they have an advantage. And if the other says, "We still use these same economical circuits. But we've found the most critical place in our entire system where we can use a very high-speed gate, and it doubles the speed," then they have a very major advantage. In other words, there's always the need for innovation.

STORER (Hewlett-Packard): I think microprograming will be very important in the control portions of instruments as well as computers. But we should bear in mind that we don't have much experience in implementing microprogrammed machines in production—that is, in evaluating the flexibility of production changes. As the ROM begins to contain more and more of what used to be software—for example, as you take things like multiply routines that used to be in software and put them into hardware—you're committing yourself to that particular set of micro-instructions. If you want to change it, you now have to change the hardware. We haven't lived with this much in the industry yet, and we need to know how such hardware changes will affect the reliability of the whole system.■■

A 'universal register'

Sylvania Electronic Components of Woburn, Mass., has manufactured an adaptive four-bit shift register that is used extensively in the new Raytheon AS-80 LSI computer. According to Joseph Nola, manager of new product planning, the register shifts right or left, counts up or down, clears, holds, reads in parallel data and complements—all under the control of three input lines.

The devices were manufactured under Sylvania's "unicell approach," in which wafers containing repetitive patterns of basic gate functions are interconnected to perform a customer's requirement by depositing up to three layers of metalization.

Dr. Robert N. Noyce, president of Intel, says this is essentially the "universal register" he has in mind, except that he would like to see some of the arithmetic functions included in it.

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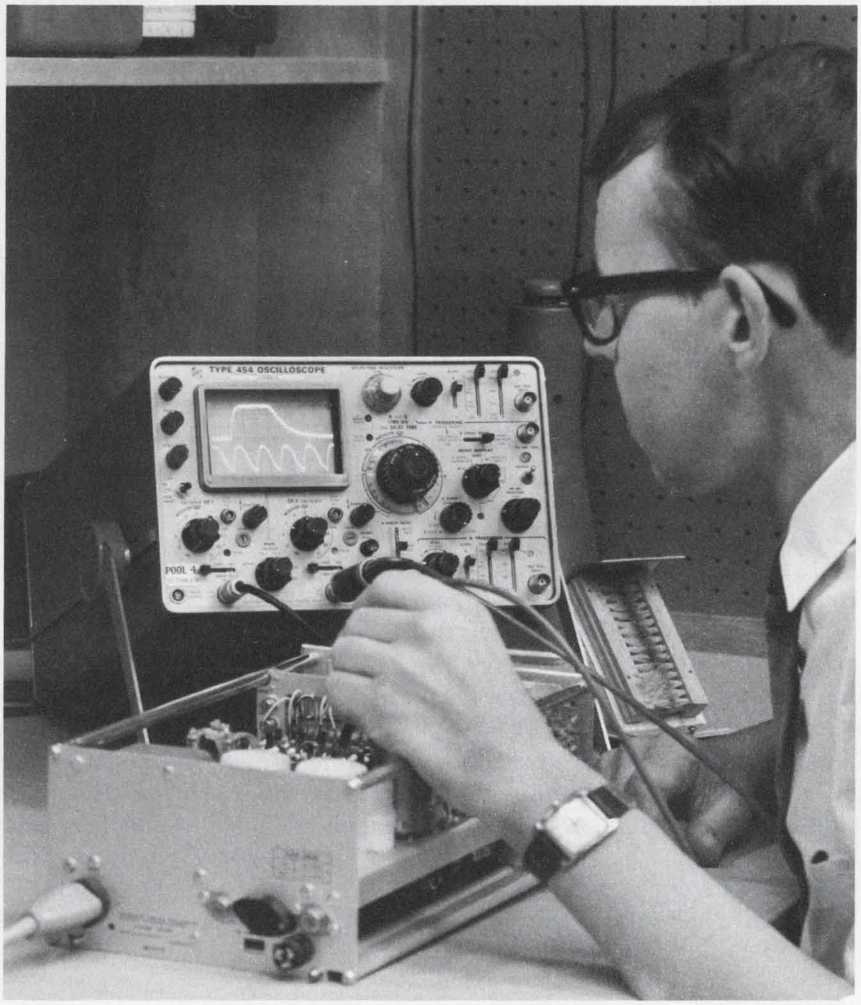

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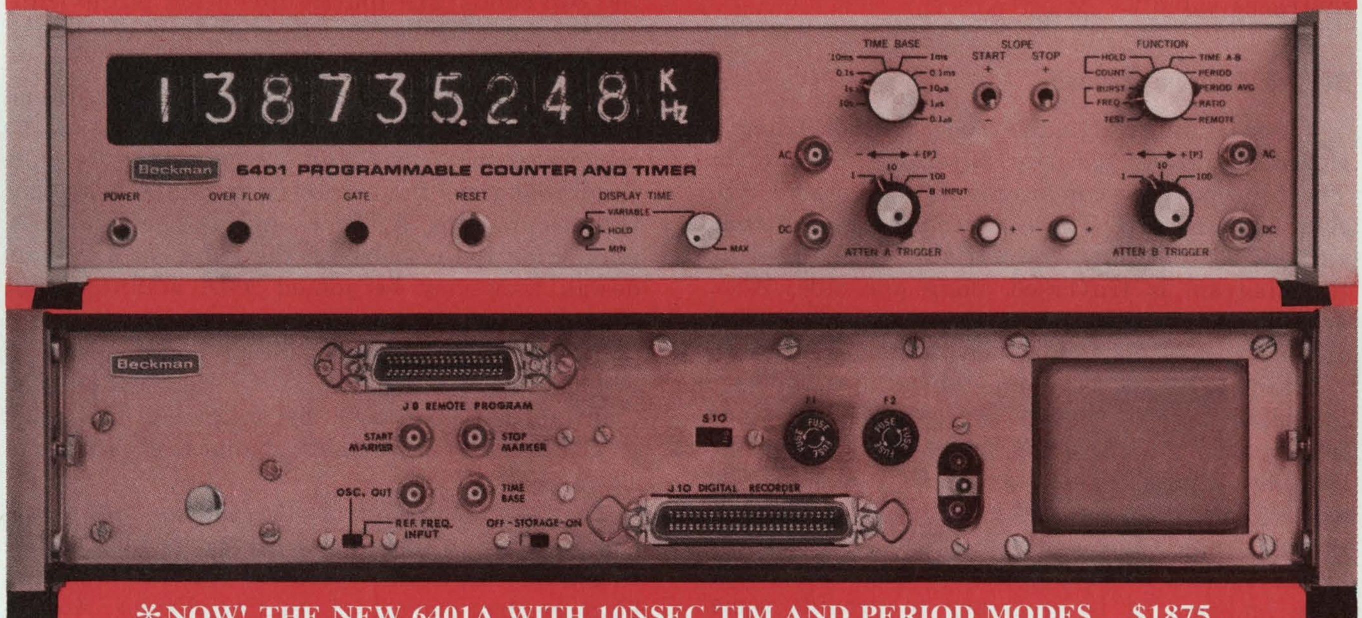

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Diagram sequential logic on a cube.

This simple method keeps track of flip-flop states, set/reset functions and control stimuli.

A cube diagram is a precise method of presenting the states of memory elements in a sequential system. This graphical representation conveys detailed information on inputs and timing, and is easily translated into hardware.

The term "cube diagram" applies, strictly, only to systems with three variables; each of the eight possible states occupies one corner of a cube. However, two variables can be diagramed on the corners of a square. Four variables require the use of two linked cubes for their 16 possible states. Any number of variables can be accommodated, but the complexity of the diagram increases rapidly.

Square diagram is basic

Figure 1 illustrates the basic method, using a square diagram for two flip-flops, A and B. The four possible combinational states are: AB, $A\bar{B}$, $\bar{A}B$, and $\bar{A}\bar{B}$. These are placed at the four corners so that only one variable is changed as the diagram is traversed along one side. Also, only A is changed when moving horizontally, and only B is changed when moving vertically.

The progression between stable states is determined by signals that set or rest the flip-flops in response to commands from logic circuits or external stimuli. The signals that change the states of the flip-flops are indicated in the diagram as inputs to the stable states at the corners of the square, as in Fig. 2a.

In addition, it is necessary to provide some means to control an external event at each point of the sequence. This would be indicated on the diagram as an output.

When a sequential system is being designed a block diagram must be developed. Figure 2b is the block diagram of the square in Fig. 2a. The logic gates that control the setting and resetting of the flip-flops must be carefully designed.

In order to avoid a race condition where two conflicting signals arrive simultaneously, one rule must be strictly followed: A set or reset function must not contain itself as a condition. That is, the logic that controls setting or resetting A cannot contain an A or $\bar{A}$ signal.

Gerardo J. Fiedler, Apparatus Div., Texas Instruments, Inc., Houston, Tex.

A cube extends the technique

The cube diagram is an extension of the square. The same basic rules are followed, but now there is a third dimension along which the third variable is allowed to change.

A fourth variable can be accommodated by using two cubes and permitting an intercube jump to occur between corresponding corners of the two cubes. The fourth dimension is the transition between cubes that changes only the fourth variable.

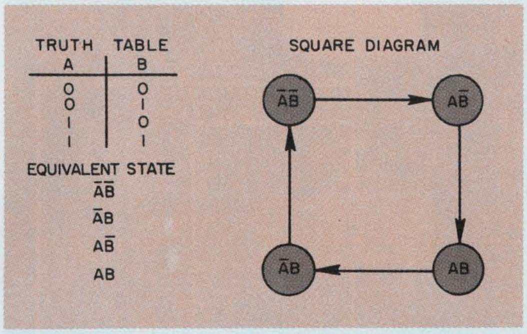
The diagram in Fig. 3 shows the transitional states for the three variables A, B and C at the corners of two cubes, and one possible intercube jump that steps the fourth variable, D. Note that the designations A, B, C and D are arbitrary names for the corners of the cube. In a system design they may be joined with actual output signal names.

Five variables have 32 possible states and so would require a diagram with four cubes. The diagram can be drawn by following the basic rule that only one variable changes in each transition.

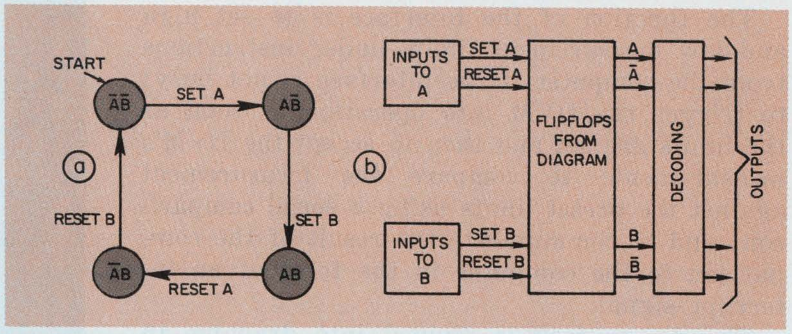
The logic that controls the setting and resetting of the flip-flops must recognize that a particular set or reset operation may be initiated by more than one set of input conditions. An OR gate will then be needed to control the set/reset operation, with all the control signals as inputs to the OR gate.

The method is shown in action

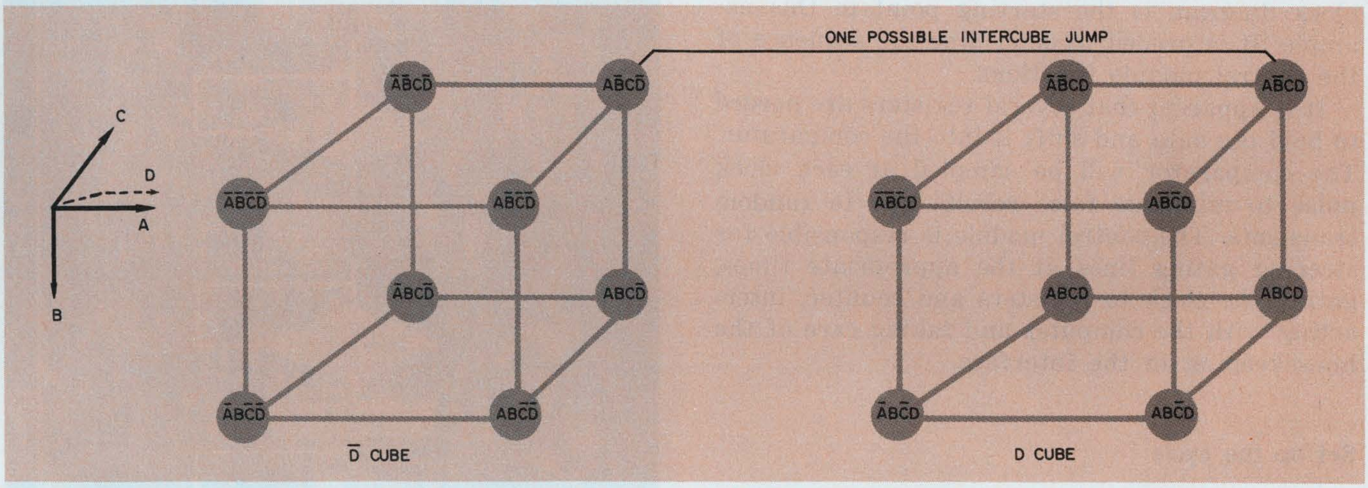
In order to visualize a cube logic application and the general approach to a problem, a control module for an interface between a computer and a digital voltmeter (DVM) will be designed (Fig. 4). The DVM is to be used to monitor the output of a unit under test. The entire system is referred to as the device.



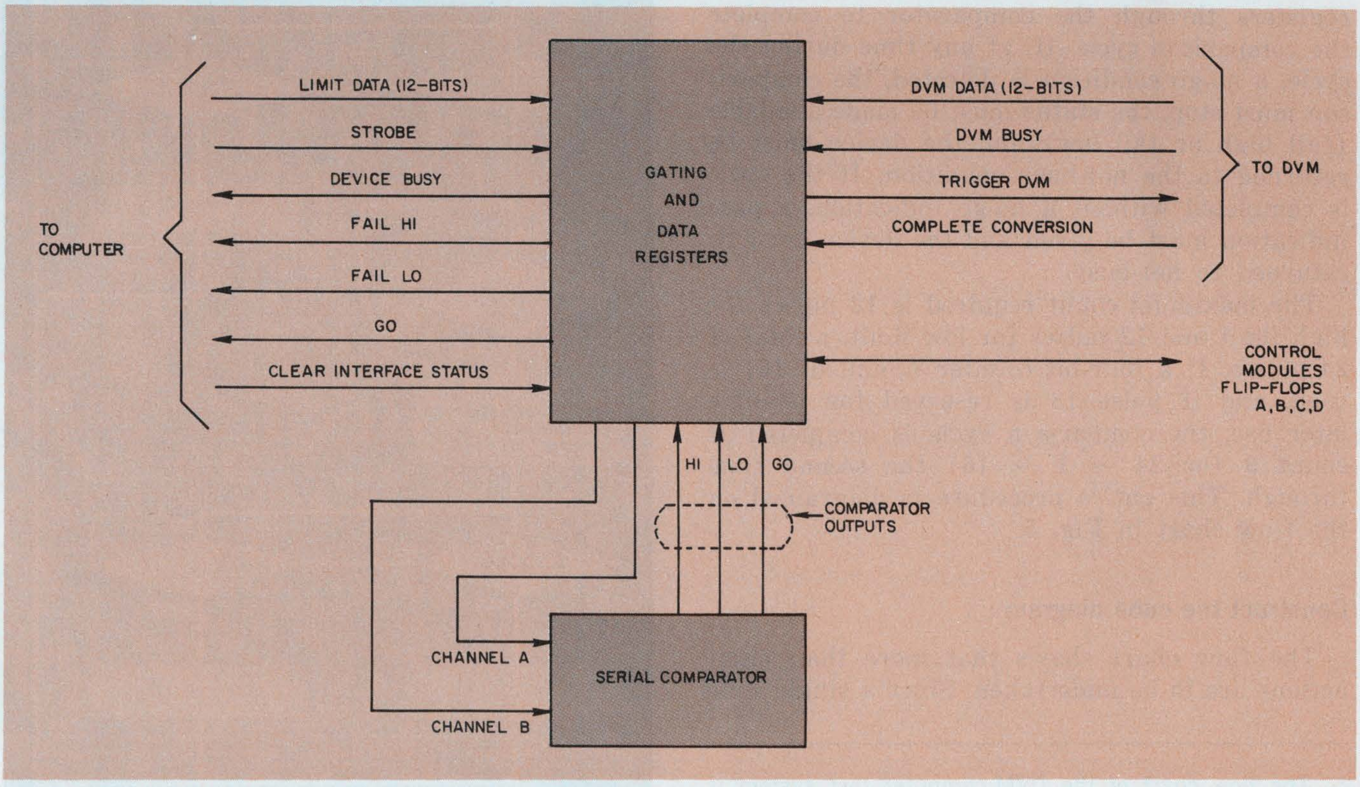
1. **The truth table for two flip-flops** is translated into its equivalent square logic diagram.



2. **The square diagram** in (a) contains external stimuli. The equivalent block diagram in (b) indicates the hardware implementation.



3. **A cube logic diagram** can accommodate three variables—and two cubes can handle four variables, as shown here. Intercube jumps are permitted only between corners of each cube.



4. **A digital voltmeter-computer test system** shows how cube logic can be applied. This is the block diagram.

The function of the interface is to set high and low measurement limits under instructions from the computer if the interface is not busy; to trigger the DVM into operation as soon as the limits are set and then to accept the DVM's measurement; to compare the measurement against the preset limits using a serial comparison; and to communicate the result of the comparison to the computer in the form of an interrupt signal.

The design task is divided into drawing an over-all block diagram of the interface, determining its timing and flow diagrams, and laying out the control module with cube logic. The block diagram is the starting point in this example. It is needed to determine the sequence of the control module functions.

It is apparent that several registers are needed to hold the data and shift it into the comparator. The comparator will be sampled at each clock pulse to minimize false results due to random transients. The control module is responsible for steering gating lines at the appropriate times, gating the clock to registers and counter, interacting with the computer and taking care of the housekeeping in the interface.

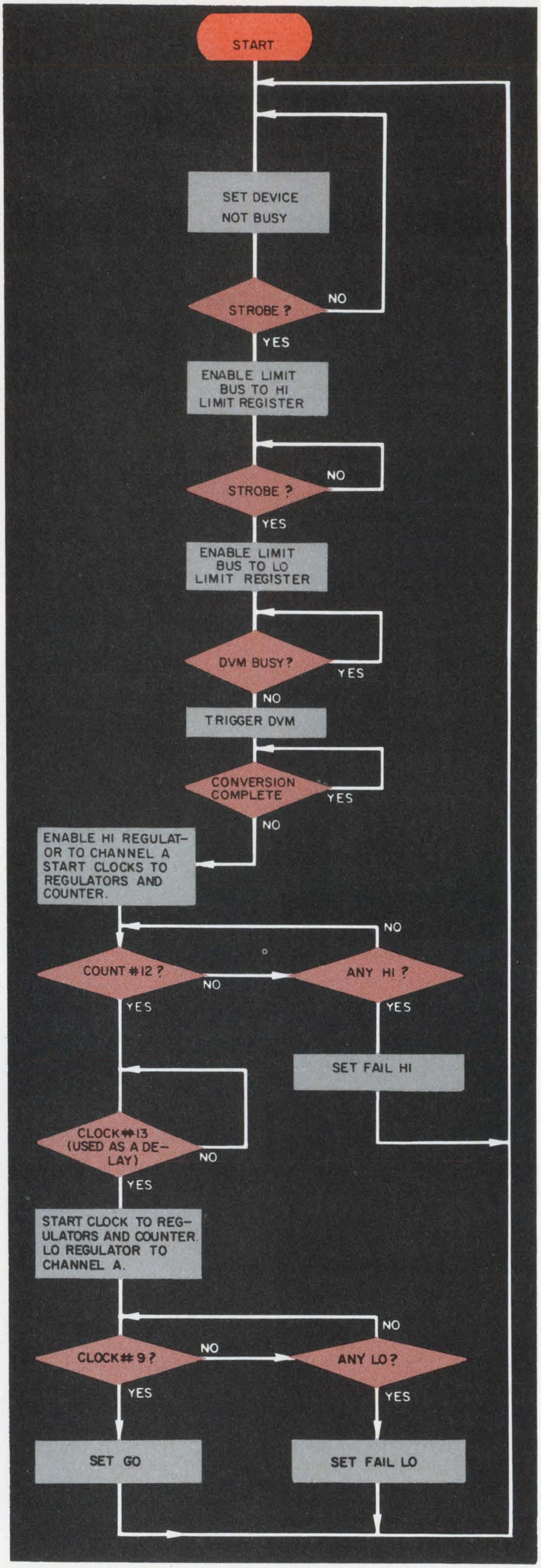
Set up the cycle

A timing sequence is now assumed: the high-limit register and the DVM register will shift through the comparator during 12 clock pulses. If a no-go (high-limit) condition is not detected, it is necessary to shift the low-limit and DVM registers through the comparator to complete the comparison cycle. If, at any time during the cycle, a no-go condition is detected, the comparison must stop, the status must be made available (fail high or fail low) and the device must be returned to the not-busy condition. If the cycle is completed without a no-go indication, a pass indication must be given and the device must be returned to not-busy.

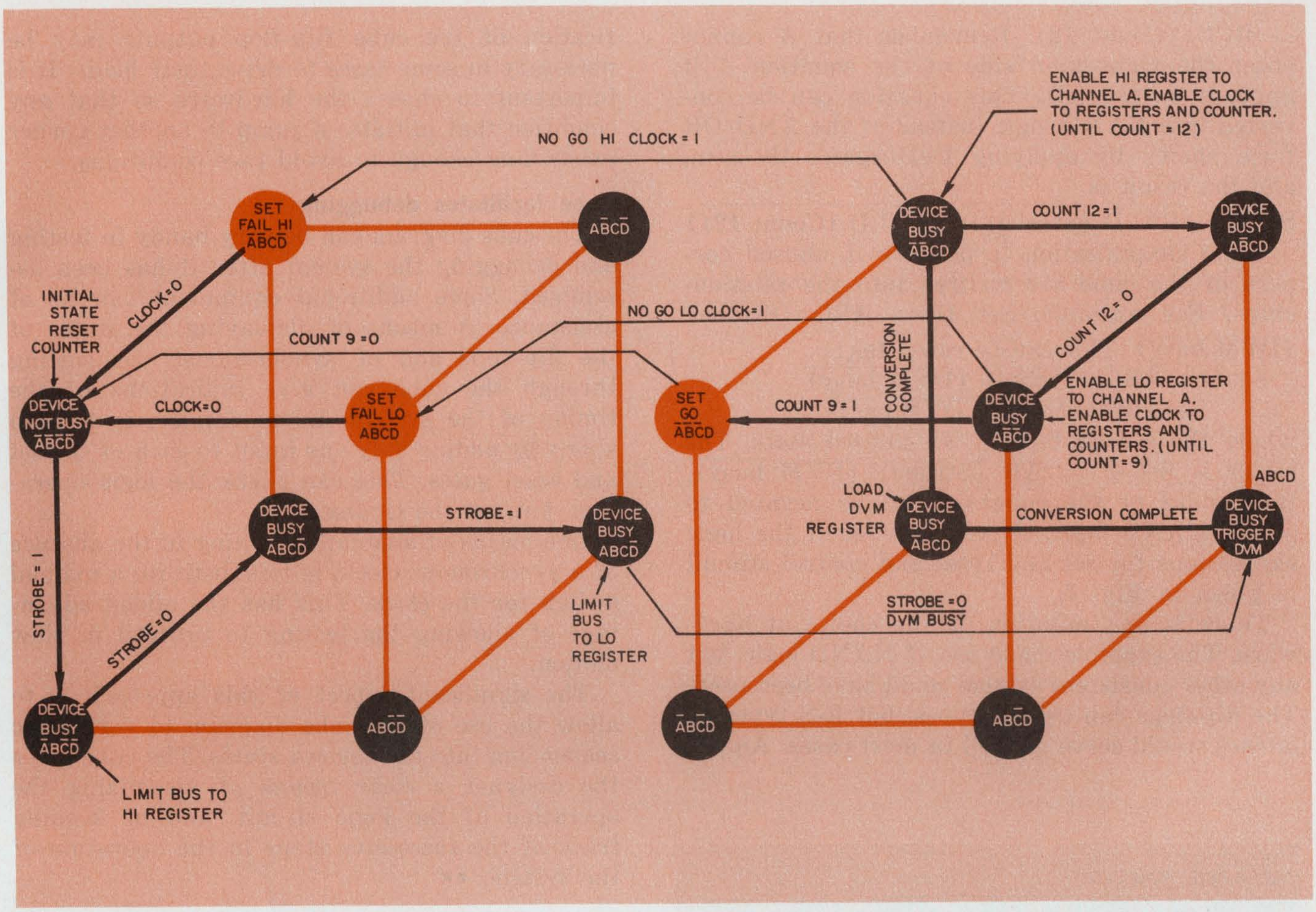
The maximum count required is 12 pulses for high limit and 12 pulses for low limit, a total of 24 pulses. If a four-bit counter (count of 16) is used, and if pulse 13 is reserved for possible later use, the comparison cycle is completed at count 9 (or 24 + 1 − 16) the second time through. This entire procedure is diagramed on the flow chart in Fig. 5.

Construct the cube diagram

The flow chart shows that more than eight actions are to be undertaken. Since a single cube



5. **The flow chart** of the DVM-computer test system is used as the basis of the cube logic diagram.



6. **The logic diagram** of the test system uses linked cubes. The stimuli and outputs are shown on the transition lines.

with eight corners can accommodate only eight actions, two cubes will have to be used. Not all of the 16 available corners are needed, but some of the unused corners may be handy to provide separation between events, to accommodate hardware restraints or to aid in logic simplification.

The most convenient method of laying out the cube is to start at the end of the cycle and work backward. The last actions in the cycle are "Set Fail Hi," "Set Fail Lo" and "Set Go." Any of these three can return to the initial state. They are shown in color in the cube diagram in Fig. 6.

After the final steps of the cycle have been entered on the cube diagram, the steps of the flow chart are followed in order to build the remainder of the cube. The impetus for a jump from one corner to the next arises from a signal input as listed in the flow chart (Fig. 5).

At a later stage, it is necessary to implement these transitions with hardware, and it may then be necessary to make some changes to accommodate limitations in the hardware. However, the outline of the solution is made clear by the cube diagram, and changes can be made easily. The procedure to follow is this: start with a well defined problem and tie the beginning (Device Not Busy) and end (Set Fail Hi, Set Fail Lo, Set Go) together. Then proceed to fill the gaps in between.

Refer to Figs. 5 and 6 to see how the intermediate steps of the flow chart have been incoporated into the cube diagram. Note that extraneous steps have been added to the cube to simplify some transitions by assigning values to unused or don't-care states. This is the reason that the pulse (count 12) is added to bridge the gap between $\overline{A}\overline{B}CD$ and $A\overline{B}\overline{C}D$, and (count 9) is added between $\overline{A}\overline{B}\overline{C}D$ and $AB\overline{C}\overline{D}$.

Implement the hardware

Once the cube diagram has been completed, the hardware design can follow. It is necessary to establish the set and reset functions for the four control module flip-flops: A, B, C, D (Fig. 4), and to decode the control stimuli at the corners of the cube to relate to external signals.

Flip-flop A is to be set (Fig. 6) when it is in $\overline{A}BC\overline{D}$ and Strobe = 1 (lower left, rear corner of cube on left) or when it is in $\overline{A}\overline{B}CD$ and Count 12 = 1 (upper left, rear corner on cube on right). Therefore, Set A = $BC\overline{D}$ (Strobe)

+ BCD (Count 12). Remember that A cannot enter the right-hand side of the equation if it appears on the left. This equation can be converted into NAND logic instead of the AND/OR form shown by applying DeMorgan's theorem, and the result is

$$\overline{\text{Set A}} = \overline{\text{B C }\overline{\text{D}}\text{ (Strobe))}} \cdot \overline{\text{(}\overline{\text{B}}\text{ C D (Count 12))}}$$

Some simplification is possible if unused corners of the cube are written into the relationships. For example, Set D = ABC $\overline{\text{(Strobe)}}$ $\overline{\text{(DVM busy)}}$. This can be rewritten:

$$\text{Set D} = \text{ABC } \overline{\text{(Strobe)}}\ \overline{\text{(DVM busy)}} + \text{ABC } \overline{\text{(Strobe)}}\ \overline{\text{(DVM busy)}},$$

where the second term is an unused state. The result is Set D = AB $\overline{\text{(Strobe)}}$ $\overline{\text{(DVM busy)}}$. Both sides of the equation can be negated to obtain NAND logic. A complete set of the logic expressions for set and reset and control stimuli is given in Fig. 7.

There is no limitation on the choice of hardware. The example made use of NAND logic, but any other consistent system could have been used. The flip-flops can be J-K types, but R-S types or latches would serve as well in most cases. Amplification of the cube flip-flop outputs may be necessary in some cases to drive their loads. It is important to choose the hardware so that any condition that initiates a jump to another corner exists long enough to avoid race conditions.

SET & RESET FUNCTIONS

$\overline{\text{SET A}} = \overline{(\text{B.C.}\overline{\text{D}}\text{.STROBE})} . \overline{(\overline{\text{B}}\text{.C.D.COUNT 12})}$

$\overline{\text{RESET A}} = \overline{\overline{\text{B}}.\overline{\text{C}}.\overline{\text{D}}\text{.Clock}} . \overline{\overline{\text{B}}.\overline{\text{C}}\text{.D.Count 9}} . \overline{\text{B.C.D.CONV COMPL}}$

$\overline{\text{SET B}} = \overline{\overline{\text{A}}.\overline{\text{C}}.\overline{\text{D}}\text{.STROBE}}$

$\overline{\text{RESET B}} = \overline{\overline{\text{A}}\text{.C.D.}\overline{\text{CONV COMPL}}}$

$\overline{\text{SET C}} = \overline{\overline{\text{A}}\text{.B.}\overline{\text{D}}.\overline{\text{STROBE}}}$

$\overline{\text{RESET C}} = \overline{\text{A.}\overline{\text{B}}\text{.D.}\overline{\text{COUNT 12}}} . \overline{\overline{\text{A}}\text{.B.}\overline{\text{D}}.\overline{\text{CLOCK}}}$

$\overline{\text{SET D}} = \overline{\text{A.B.}\overline{\text{STROBE}}.\overline{\text{DVM BUSY}}}$

$\overline{\text{RESET D}} = \overline{\overline{\text{A}}.\overline{\text{B}}\text{.C.HI.CLOCK}} . \overline{\overline{\text{A}}.\overline{\text{B}}.\overline{\text{C}}.\overline{\text{COUNT 9}}} . \overline{\text{A.}\overline{\text{C}}\text{.LO.CLOCK}}$

CONTROL STIMULI

DEVICE BUSY = $\overline{\overline{\text{A}}.\overline{\text{B}}.\overline{\text{C}}.\overline{\text{D}}}$.

RESET COUNTER = $\overline{\text{A}}.\overline{\text{B}}.\overline{\text{C}}.\overline{\text{D}}$

LIMIT BUS TO HI REG = $\overline{\text{A}}\text{.B.}\overline{\text{C}}.\overline{\text{D}}$

LIMIT BUS TO LO REG = $\text{A.B.C.}\overline{\text{D}}$

TRIGGER DVM = $\overline{\text{A.B.C.D}}$

HI REG TO CH A = $\overline{\text{A}}.\overline{\text{B}}\text{.C.D}$

LO REG TO CH A = $\text{A.}\overline{\text{B}}.\overline{\text{C}}\text{.D}$

LOAD DVM REG = $\overline{\text{A}}\text{.B.C.D}$

ENABLE CLOCK TO CONTER & REG's = $\overline{\text{A}}.\overline{\text{B}}\text{.C.D} + \text{A.}\overline{\text{B}}.\overline{\text{C}}\text{.D}$

$= \overline{\overline{\overline{\text{A}}.\overline{\text{B}}\text{.C.D}} . \overline{\text{A.}\overline{\text{B}}.\overline{\text{C}}\text{.D}}}$

SET GO = $\overline{\text{A}}.\overline{\text{B}}.\overline{\text{C}}\text{.D} + \overline{\text{A}}\text{.B.}\overline{\text{C}}\text{.D} = \overline{\text{A}}.\overline{\text{C}}\text{.D}$

SET FAIL HI = $\overline{\text{A}}.\overline{\text{B}}\text{.C.}\overline{\text{D}} + \text{A.}\overline{\text{B}}\text{.C.}\overline{\text{D}} = \overline{\text{B}}\text{.C.}\overline{\text{D}}$.

SET FAIL LO = $\text{A.}\overline{\text{B}}.\overline{\text{C}}.\overline{\text{D}} + \text{A.B.}\overline{\text{C}}.\overline{\text{D}} = \text{A.}\overline{\text{C}}.\overline{\text{D}}$

$\overline{\text{A}}\text{.B.}\overline{\text{C}}\text{.D}$, $\text{A.}\overline{\text{B}}\text{.C.D}$ and $\text{A.B.}\overline{\text{C}}.\overline{\text{D}}$ are unused states which are included to simplify the expressions

7. **The system logic** is read directly from the cube diagram. All set/reset functions and control stimuli are listed here.

Cube facilitates debugging

The cube diagram can be very handy in testing and debugging the system after it has been assembled. Some additional equipment can be of assistance. A means of displaying the states of the flip-flops and of synchronously sequencing through the cube can give indications of the timing of the system. Even simpler, is to step singly by adding only one input to each of the set and reset gates. This can check the logic operation, but not the timing.

One means of simulating timing in the absence of a synchronous clock, is to substitute a manual switch for the clock. This has the added advantage of allowing the testing to proceed in slow motion.

The significant aspect of this approach is to allow the use of the cube diagram to verify the sequencing into the desirea states. The cube gives the designer a clear means of visualizing the operation of the logic cii :uit, and of keeping track of the successive steps in the operation of the system. ■■

References:

1. Marcus, M. P., *Switching Circuits for Engineers*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 2nd Edition, 1967

2. Maley, Gerald A., Earle, John, *The Logic Design of Transistor Digital Computers*, Prentice-Hall, Inc., Englewood Cliffs, N.J. 1963 pp 72-111

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What is the basic rule for progressing from one corner of the cube to the next?

2. When using multiple cubes, what governs intercube jumps?

3. What use may be made of otherwise unused corners of a cube logic diagram?

4. What determines the number of cubes required?

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TRIPLETT

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INFORMATION RETRIEVAL NUMBER 33

Use piezoelectric ceramics to solve your electromechanical transducer problems. Their variety and flexibility make a tempting combination.

Are you looking for the right transducer for that sticky application? A custom solution can perhaps be provided by piezoelectric ceramics, which have superior design flexibility over their naturally occurring crystal counterparts. Ceramic transducers can be produced in almost any desired size or shape, while mechanical and electrical axes are determined by the direction of a high-voltage dc poling field.

But how to select the best piezoelectric ceramic for your specific application? You can go to a manufacturer, but you will have to be able to talk the language of this technology, and know the physical and electrical parameters that each piezoelectric material possesses.

Poling determines piezoelectric properties

Ceramic material is given piezoelectric characteristics during manufacture through exposure to a high-voltage dc electric field (poling). The ceramic powder formulation, plus the electric field intensity, combine to provide desired properties in the finished product.

For example, consider a simple polycrystalline ceramic disc with an electroded surface on both sides and note the electromechanical actions available from this material. The axes are assigned direction as shown in Fig. 1. During the initial poling process, when a high dc voltage is applied to the electrodes, the ceramic disc will obtain a permanent growth or dimensional increase in the direction of the poling (along the Z axis), while a contraction or dimensional decrease will result in a direction parallel to the electrodes (along the X and Y axes).

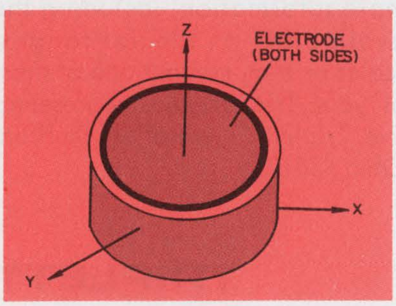
In conventional applications, such a piezoelectric element is used to produce the direct (generator) piezoelectric effect or the converse (motor) effect. The generator effect is achieved when a compressive force is applied along the poling direction (Z axis), developing a voltage between the electrodes with the same polarity as the original poling voltage. The polarity of the voltage produced between the electrodes can be inverted by reversing the applied force.

The motor effect results when a dc voltage of the same polarity as the poling voltage, but of smaller magnitude, is applied between the electrodes. The element experiences temporary expansion in the poling direction (along the Z axis) and contraction parallel to the electrodes (along the X and Y axes). The ceramic body then returns to its original poled size when the voltage is removed. Every ceramic shape has a mechanical resonance, and when the applied voltage frequency is equal to it, electromechanical resonance occurs.

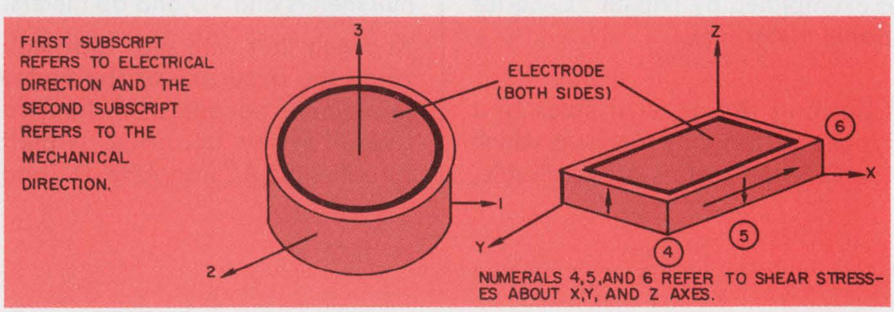
Operating modes explained

Piezoelectric ceramic elements are manufactured in various configurations, and each design

James G. Copland, Product Engineer and **Carl T. Durham,** Development Engineer, General Electric Co., Salem, Va.



1. **Axes nomenclature** defines ceramic disc planes.



2. **Tensor notation** identifies piezoelectric electrical/mechanical axial relationship within piezoelectric materials.

Commercially available piezoelectric ceramics

Material-company	K_3	Loss Tan α	Curie Temp °C	k_{33}	d_{33}	d_{31}	g_{33}	Q_m	Features
Barium titanates									
HD-11 Gulton	600	0.006	135	0.45	86	−30	16	800	Original materials
801 Linden	730	0.007	145	0.44	110	−40	17	350	based on $BaTiO_3$
802 Linden	730	0.005	145	0.50	120	−38	19	500	
803 Linden	600	0.007	145	0.50	112	−36	21	400	
EC-57 Electro-ceramics	600	0.006	140	0.38	87	−30	16	600	
1011 Erie	700	0.006	145	0.51	107	−38	17	350	
LBC Transducer	500	0.010	145	0.40	120	−35	27	500	
Typical	630	0.006	143	0.45	106	−35	19	500	
HS-21 Gulton	1150	0.015	125	0.51	148	−50	16	300	low aging
EC-31 Electro-ceramics	1170	0.007	115	0.48	152	−59	15	400	
EC-51 Electro-ceramics	1250	0.005	130	0.47	51	−56	14	400	
EC-55 Electro-ceramics	1220	0.005	115	0.46	150	−58	14	550	
501 Linden	1800	0.009	120	0.50	190	−80	12	400	
502 Linden	1800	0.006	120	0.48	188	−78	12	650	
601 Linden	1200	0.009	120	0.48	145	−56	13	350	
602 Linden	1200	0.007	120	0.50	150	−60	16	580	
701 Linden	1400	0.009	133	0.50	150	−60	13	350	
702 Linden	1400	0.008	133	0.52	160	−65	14	550	
1005-Erie	1700	0.008	120	0.47	188	−77	12	380	
1006-Erie	1200	0.009	120	0.48	146	−56	14	360	
1008-Erie	1200	0.005	115	0.55	154	−60	13	600	
1009-Erie	1400	0.008	135	0.52	160	−62	13	360	
BT-1 Transducer	1800	0.010	120	0.48	180	−90	11	400	
BC-1 Transducer	1200	0.010	120	0.42	160	−65	15	500	
Typical	1300	0.008	122	0.49	154	−65	13	445	
Lead metaniobates									
278-GE	240	0.010	550	0.40	75	−12	35	5	Highest Curie point,
302-GE	265	0.006	550	0.35	70	−24	30	15	lowest Q_m, good g_{33}
G-2000 Gulton	250	0.006	550	0.38	80	−10	36	15	
Typical	250	0.007	550	0.37	75	−15	33	12	
Lead zirconium titanates									
PZT-4 Clevite	1300	0.004	328	0.70	289	−123	26	500	Good driver, low loss,
EC-64 Electro-Ceramic	1300	0.005	320	0.65	280	−120	25	400	good d_{33}
HDT-31 Gulton	1300	0.006	330	0.66	280	−120	23	500	
102-Linden	1200	0.005	310	0.67	260	−112	25	230	
LTZ-1 Transducer	1100	0.006	350	0.73	284	−122	29	500	
Typical	1300	0.005	320	0.67	280	−120	25	400	

Material-company	K_3	Loss Tan α	Curie Temp °C	k_{33}	d_{33}	d_{31}	g_{33}	Q_m	Features
Lead zirconium titanates (continued)									
PZT5A Clevite	1700	0.02	365	0.71	374	−171	25	75	Good receiver, low Q_m, fair g_{33}
EC-65 Electro-Ceramic	1725	0.02	350	0.70	355	−160	25	100	
G-1500 Gulton	1700	0.015	360	0.69	370	−166	25	80	
101-Linden	1700	0.015	350	0.69	340	−150	23	80	
LTZ-2 Transducer	1900	0.0015	360	0.74	405	−179	25	75	
HST-41 Gulton	1800	0.022	270	0.69	360	−157	22	70	
LTZ-13 Transducer	1300	0.020	370	0.70	370	−170	25	80	
Typical	1700	0.020	370	0.70	370	−170	25	80	
PZT5H Clevite	3400	0.02	193	0.75	593	−274	24	65	Highest d_{33} but low Q_m
EC-70 Electro-Ceramic	2600	0.016	220	0.74	480	−225	21	75	
G-1512 Gulton	2600	0.018	240	0.72	500	−232	20	70	
G-1278 Gulton	3300	0.02	190	0.75	585	−270	19	70	
LTZ-2M Transducer	2500	0.0015	230	0.75	510	−268	23	72	
LTZ-2H Transducer	3400	0.0015	195	0.75	590	−280	20	70	
Typical	3000	0.015	220	0.75	530	−250	21	70	
PZT8 Clevite	1000	0.004	300	0.62	218	−93	24	1000	Best driver
EC-69 Electro-Ceramic	1050	0.005	300	0.62	220	−95	24	960	
G-1408 Gulton	1000	0.003	300	0.60	200	−80	22	1200	
Typical	1000	0.004	300	0.61	215	−90	24	1000	
PZT-7 Clevite	425	–	350	0.66	150	−16	49	600	Good g_{33} but high Q_m
G-53 Gulton	720	0.022	330	0.60	190	−84	30	140	
LTZ-5 Transducer	500	0.007	350	0.63	155	−35	35	700	
Typical	600	0.01	330	0.61	170	−50	33	300	
Sodium potassium niobate									
Bausch & Lomb	450	0.015	195	0.53	160	−49	45	240	

Addresses of piezolectric ceramic suppliers

General Electric Co.
Industry Control Dept.
1501 Roanoke Boulevard
Salem, Va. 24153

Linden Laboratories Inc.
P.O. Box 920
State College, Pa. 16801

Electro-Ceramics
2645 South 2nd West
Salt Lake City, Utah 87115

Gulton Industries, Inc.
Microceramics Div.
Metuchen, N.J. 08840

Clevite Corp.
Piezoelectric Div.
232 Forbes Road
Bedford, Ohio 44146

Bausch & Lomb
Scientific Instruments Div.
87969 Bausch St.
Rochester, N.Y. 14602

Transducer Products
95 Wolcott Avenue
Torrington, Conn. 06790

Erie Technological Products Inc.
Technical Materials Div.
Post Office Box 677
State College, Pa. 16801

has its own particular modes of operation. A disc, for example, will resonate in either of two modes; namely, the thickness mode and the radial mode. When subjected to an alternating voltage between its electrodes, it will vibrate at the frequency of the applied voltage, and will undergo thickness and radial dimensional variations. Thickness changes are allotted to the thickness mode, while radial strains are attributed to the radial mode. The greatest variation in thickness will occur when the applied voltage frequency equals the disc's mechanical resonant frequency (motor effect). Conversely, the maximum alternating voltage that can be produced occurs when the disc is vibrated along the thickness axis at its resonant frequency (generator effect).

When operated in the radial mode, greatest vibrations are developed from alternating voltages or mechanical pressures applied to the disc at its radial resonant frequency.

Dimensional changes along the length of a plate or rod occur in the longitudinal mode, while plates subjected to shear stresses are operated in either the face shear or thickness shear mode.

Tensor notation eases identification

Once the piezoelectric effect and operational mode required are established, the electrical and physical properties of available ceramic materials are compared to establish necessary design parameters. The key properties of piezoelectric materials are written as tensor components with two digit subscripts (Fig. 2). This is the accepted method for identifying axial directions and simplifies the problems created because each piezoelectrical material has different electrical mechanical axial orientations.

First digit subscripts (1, 2, and 3) reference the electrical X, Y, and Z axes. Second digit subscripts (1, 2, and 3) indicate mechanical stress parallel with the X, Y, and Z axes, while 4, 5, and 6 refer to the shear planes around the X, Y, and Z axes. For example, a subscript of 33 denotes that electrical charge developed along the Z axis is a result of a mechanical stress in the same direction. Subscript 15 means electrical charge along the X axis is due to mechanical shear stress along the Y axis.

Constants reflect design considerations

Among the important properties of piezoelectric materials is the strain constant, d, the voltage constant, g, and the electromechanical constant, k. These constants represent an important means for comparing different ceramic materials.

The d constant is the ratio of the electric charge developed, per unit area. It is an indication of piezoelectric ceramic sensitivity.

The g constant is the ratio of electric field developed per unit area to the applied mechanical stress per unit area. The electromechanical coupling constant k is a measure of the piezoelectric material's ability to change energy from one form to another. It is expressed as the square root of the ratio of electrical energy output to mechanical energy input.

Another key property is the dielectric constant, K, which is a measure of the electric charge a piezoelectric shape can retain compared to the charge stored by equivalent electrodes separated with an air dielectric. Ceramic elements usually have a high dielectric constant, which directly affects their electrical impedance. However, considerable electrical losses associated with some materials are detrimental to their power-handling capabilities. These losses, termed the materials' dissipation factor and expressed as tangent α, are the ratio of effective series resistance to effective series reactance.

Another property, the mechanical quality factor, Q_m, indicates the internal mechanical damping ability of a piezoelectric material. Materials with a low mechanical Q_m have a high internal mechanical damping ability. Formulation modifications have resulted in lead zirconate titanates with a Q_m of 65, while lead metaniobate displays a surprisingly lower value (between 5 and 15). This makes lead metaniobate ideal for many ultrasonic applications, where minimum ringing of returning pulse echoes is essential. It is also ideal for use in wide bandwidth sensors.

Curie point sets operating limit

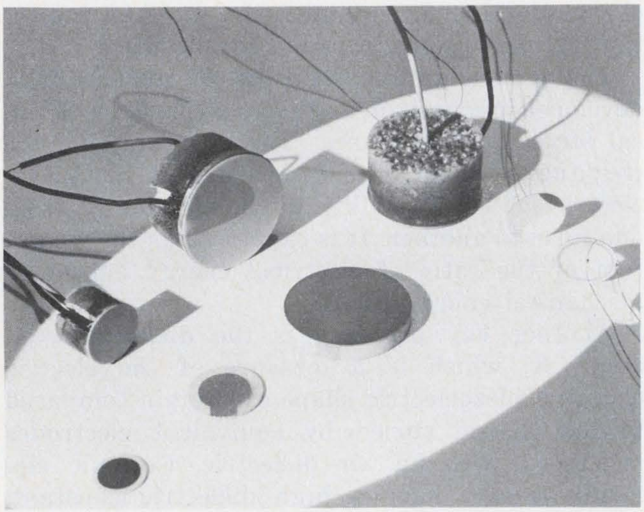
If a piezoelectric material is heated above a certain temperature, it will lose its piezoelectric activity permanently. This critical temperature is called the Curie point. Here the crystal lattice dipole arrangement is no longer directional, but haphazard. Actually, the effective operating range of a piezoelectric body is somewhat below the Curie point, because at elevated temperatures most electrical and mechanical properties are degraded and the aging process is speeded up.

It should be noted that most aging occurs during the first 48 hours after piezoelectric poling. After this, degradation becomes logarithmic with time. Many devices, such as filters, are pre-aged before shipment.

A comparison of commercially available piezoelectric ceramics is given in the table.

Practical applications cited

- Ultrasonic cleaning baths: These products are experiencing tremendous growth directly de-



Ceramic transducers made from lead metaniobate come in various shapes and sizes.

pendent upon the development of ceramic piezoelectrics. Such baths are analogous to home washing machines, with the mechanical agitation taking place at 20 to 50 kHz rather than at 1 to 2 Hz. Under proper conditions, cavitation of the cleaning liquid occurs, producing a vigorous scrubbing action.

Ceramic piezoelectric properties important to this application are resistance to depoling under high driving fields, high electromagnetic coupling, high d constant and low dielectric dissipation factor. Lead zirconium titanates including PZT-4, HDT-31, LTZ-1, and EC-64 are well suited for such use.

- Nondestructive testing: This requires a piezoelectric probe acting as both an acoustic transmitter and receiver. Units of this type operate in the thickness resonance mode at frequencies from 1 MHz up to 20 MHz using piezoelectric ceramics only 0.003 inch thick. Ideally, the piezoelectric ceramic should generate a mechanical pulse identical to the applied electrical pulse and then convert the returning mechanical echo into a narrow voltage spike for display. These pulses should evolve from the thickness mode (d_{33}), with minimal interference from the radial mode (d_{31}).

For adequate sensitivity to returning (echo) signals, the g_{33} constant should be high. This constant is related to d_{33} by:

$$g_{33} = d_{33}/[(8.85 \times 10^{-12})\ (K_3T)].$$

K_3T is a free relative dielectric constant. The mechanical Q_m must be very low to eliminate ringing, which otherwise obscures returning echoes. Lead metaniobates such as LM302 and G-2000, with their low dielectric constant, Q_m, and low d_{31} values are well suited to such transducers.

- Medical diagnostic transducers: These are similar to nondestructive testing probes, except that the operating frequency can go to 30 MHz. High-frequency operation increases sonic beam directivity according to:

$$\sin\theta = 0.61\ \lambda/a$$

where θ is half angle of divergence; λ, wave length in media; and a, radius of source.

Diagnostic sonic equipment has been designed and built for biomedical cardiovascular, encephalographic and cardiographic research. Such equipment, using piezoelectric ceramic elements, greatly enhances operative techniques in eye surgery, brain mid-line determination, bloodclot and kidney-stone location. Development work is in progress toward locating tooth decay by ultrasonic means.

- Electromechanical filters: By use of special compositions and electroding, filters for many applications are produced. Typical properties are: center frequency, 455 kHz ± 2 kHz; bandwidth 8 kHz at 3 dB; and impedance at resonance 16 Ω or less.
- Flyback transformers: Small slabs (1-1/2 inches × 1/2 inch typical) are polarized in two directions, producing a high-voltage transformer operating at 15.75 kHz with a transformer ratio of 200.
- Memories: Timers for ordnance fusing are made from two pieces of piezoelectric glued together. The bottom layer flexes under an applied read signal and bends the top portion, which has been coded by polarizing pie sections in either a positive or negative direction.
- Automatic car identification: By arranging electromechanical filters with different resonant frequencies in parallel, a frequency codable system is evolved. Because such systems are interrogated by a repetitive sweep frequency, their Q_m should be an intermediate value (400-500). Several such systems are in operation today, and trial installations are being used to interrogate bridge and tunnel traffic.
- Ignition systems: Cam-applied mechanical force generates 20,000 volts.

Piezoelectric ceramics: lookng ahead

The largest quantity usage of a single ceramic composition is a cobalt oxide modification of the standard 95% $BaTiO_3$-5% CaO. At present, this material is used in all sonar equipment due to frozen designs and cost. New-generation sonar will probably use lead zirconium titanate compositions such as PZT-8, G-1408 or EC-69. These new ceramics are characterized by low dielectric losses at high electrical driving fields, high mechanical Q_m and low aging rates.

The advent of MOSFET high impedance amplifiers has been of great benefit to piezoelectric accelerometer applications. With MOSFET amplifiers mated to low impedance couplers, accelerometers can now drive recorders directly over long transmission lines. ■■

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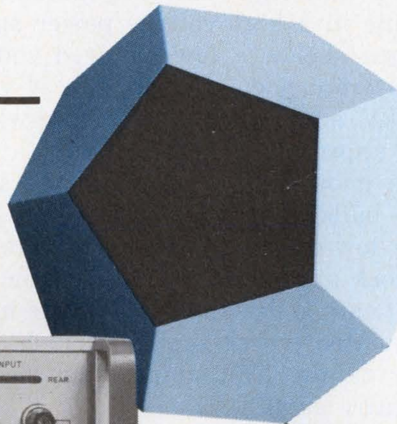

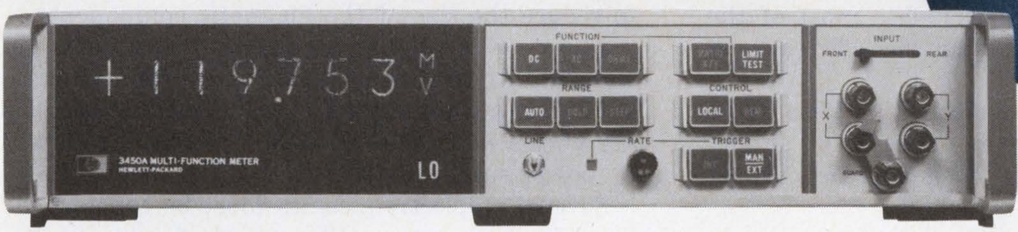

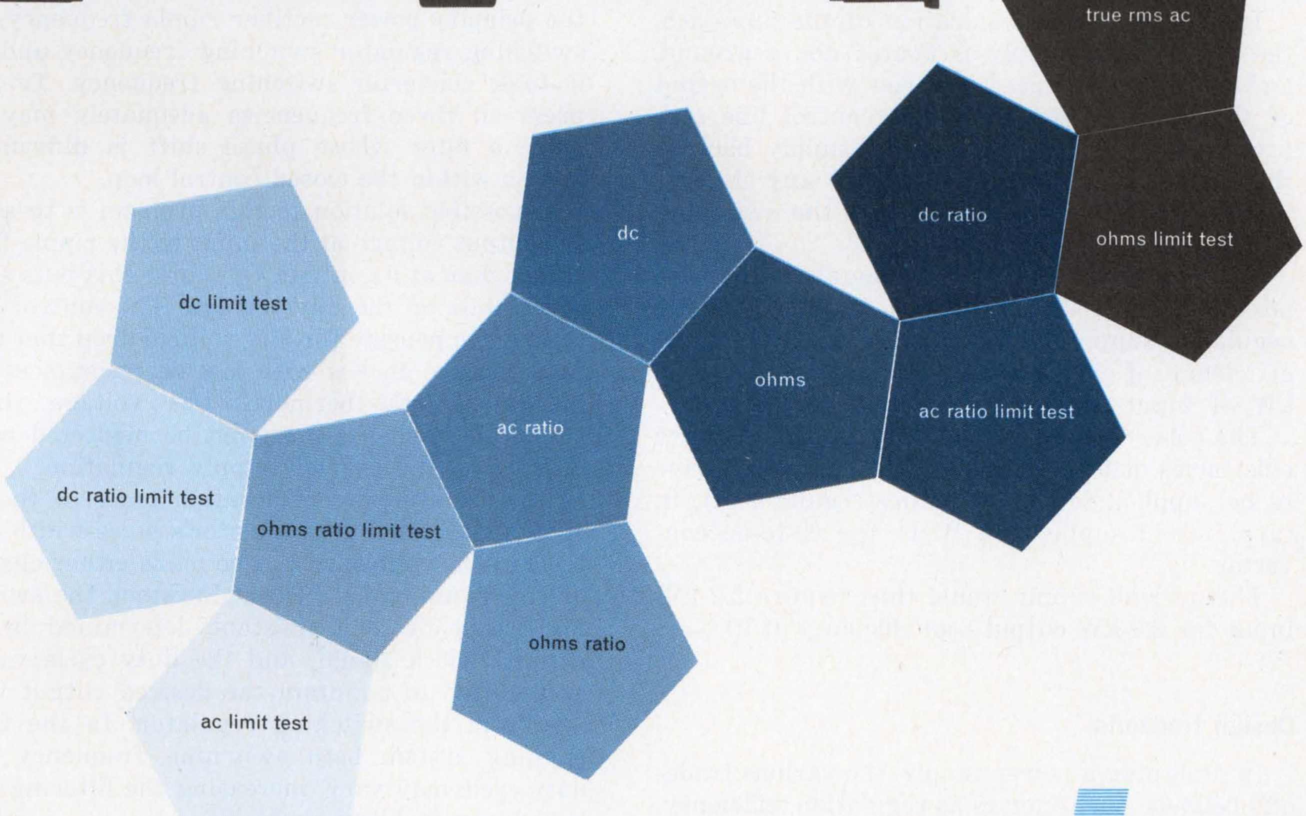

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DIGITAL VOLTMETERS

INFORMATION RETRIEVAL NUMBER 34

Step up power-supply efficiency

without sacrificing precision by combining a large, efficient unregulated supply with a smaller regulated one.

Good efficiency and regulation are hard to combine in a high-voltage power supply. At low voltages—below a few hundred volts—switching regulators can do the job. But if you need, say, a 15-kV supply for a traveling-wave tube, another approach must be found.

One good way is to make the supply out of three building blocks (Fig. 1) rather than a single low-efficiency series regulator. The building-block approach has two distinct advantages:

- It can be designed so that the highly efficient unregulated power supply furnishes most of the power to the load, improving the efficiency of the entire supply.
- It is a very reliable configuration because of the extreme simplicity of the unregulated supply and because the regulator need operate only at low power levels.

In a practical mechanization of the approach, the unregulated supply is floated above ground, and its output is placed in series with the output of the dc-to-dc converter. The control line connecting the output of the whole supply back to the switching regulator then senses any changes in the output voltage and adjusts the switching regulator to correct them.

To get a feel for the sort of numbers that are possible, let's consider a 2-kW supply. The unregulated supply might provide 1.5 kW at an efficiency of 95%. Thus it would require 1.58 kW of input power.

The other two blocks may be assumed to have efficiencies of 90% each. Thus 620 W would have to be supplied to the switching regulator. It, in turn, would supply 555 W to the dc-to-dc converter.

The over-all supply would thus require 2.2-kW input for 2.0-kW output—an efficiency of 91%.

Design tradeoffs

In designing a power supply, the various tradeoffs between such factors as regulation, efficiency, size, weight, ripple and regulator switching frequency must be considered. For example, highly efficient power transformers tend to be large and heavy. Since high-efficiency power supplies are often used in airborne applications, some efficiency may have to be sacrificed to save space and weight.

Similarly, the losses within the switching transistors in the switching regulator and dc-to-dc converter increase with the switching frequency. Yet it may be desirable to use high frequencies to reduce the size of the magnetic components.

Filtering is another important consideration, especially if the power supply is to be used with a TWT in a coherent radar system. Such systems are very sensitive to the phase variations caused by power-supply ripple.

Several ripple frequencies must be considered: the primary power rectifier ripple frequency, the switching regulator switching frequency and the dc-to-dc converter switching frequency. To suppress all three frequencies adequately may require a filter whose phase shift is difficult to handle within the closed control loop.

A possible solution to this problem is to sense the output voltage at the input to the ripple filter rather than at its output. Of course this puts some constraints on the filter chokes. The control loop cannot compensate for any voltage drop that they cause; hence chokes with low dc resistances are mandatory. Furthermore, the voltage drops across these chokes must not be neglected when calculating the over-all supply regulation.

Another system consideration concerns the design of the switching regulator's pulse-width controller. The controller can be made either clocked or free-running. In a clocked system, the switching frequency is a constant determined by an external clock signal, and the duty cycle varies as required to maintain the desired output voltage from the switching regulator. In the free-running system both switching frequency and duty cycle may vary, increasing the filtering and closed-loop stability problems.

An additional advantage of the clocked approach in radar systems is that it is possible to lock the switching frequency to the radar system

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PRF, which may be a benefit in interference considerations.

Designing a practical power supply

The preceding design considerations were all applied to the 15-kV 2-kW power supply of Fig. 2. The design goals for the unit were to maintain ±1.0% regulation for load variations from zero to full power and for ±10% line variations.

Typically for a 15-kV supply, the no-load output of the floating supply might be 13 kV. At full load this may drop to 12 kV. If the input power line should drop by 10%, the unregulated supply output voltage would then drop to 10.8 kV at full load. To maintain the full 15-kV output, the variable supply would have to furnish 4.2 kV at the full load current.

For a light load condition and an input line voltage 10% high, the output of the unregulated supply will be 14.3 kV. This condition will require 0.7 kV from the variable supply to maintain a 15-kV output voltage. The total dynamic range required of the variable supply to cover both line and load variations will thus be 0.7 to 4.2 kV.

The switching regulator

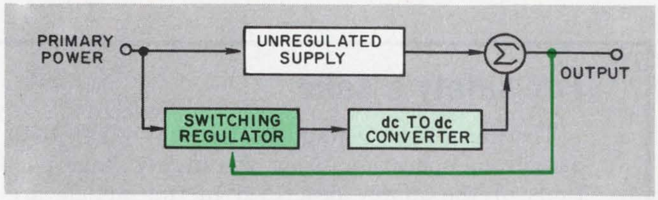
To meet these requirements, the switching regulator was designed to provide an output voltage variable between limits of approximately 50 and 175 V dc at currents up to 4 A.

Unregulated dc power from rectifier bridge D_1 is applied to the switch transistor, Q_1, which is driven by the switch driver and controlled by the pulse-width controller. An integrating network, L_1 and C_1, is connected to the switch output.

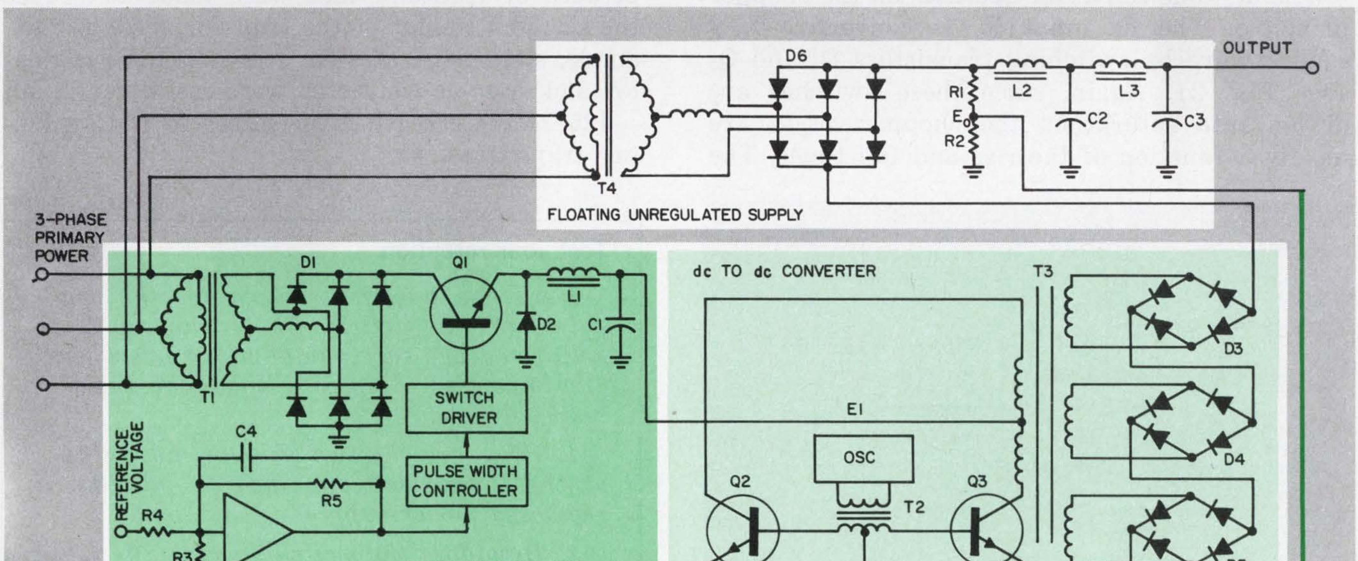
In operation, the switch, Q_1, is periodically closed, connecting the dc power source to the integrating network. The length of time that Q_1 remains closed will be what is required to maintain the specified output voltage under varying input and load conditions. When the switch is opened, a negative voltage is induced in L_1. The "free-wheeling" diode, D_2, acts to commutate this inductive current, maintaining current flow through the load and improving the efficiency of the system.

The pulse-width controller (Fig. 3) is a clocked system. The square-wave clock signal is integrated to form a triangular wave, e_1, which is superimposed on the dc level of the feedback signal, e_2. The composite signal, e_3, is applied to the input of a Schmitt trigger.

As the feedback signal e_2 decreases, the time interval over which e_3 is above the trigger level increases; hence the output pulse width increases. Conversely, when e_2 increases, the time interval that e_3 is above the trigger level will decrease,



1. **Very high efficiency** will be obtained with this configuration if the large unregulated supply is made to furnish most of the power. The regulator should handle only that fraction necessary to adjust for line and load variations.



2. **This practical realization** of the approach of Fig. 1 puts the floating unregulated supply in series with the dc-to-dc converter. The output is sampled before the ripple filter to prevent loop-stability problems.

For safety's sake

Testing a high-voltage power supply can be a dangerous operation. Since the high-voltage portions of the supply described in this article are simple and reliable, they should need little or no maintenance or adjustment. Thus it is desirable to develop a scheme for exercising the switching regulator portion without energizing the high-voltage circuitry.

The technique that has been used is the addition of a second servo loop to the system. This loop is closed around the switching regulator itself. The input to the dc-to-dc converter (E_1 in Fig. 2) is suitably weighted and then combined with the other inputs to the switching regulator.

Thus the input to the error-signal amplifier (Fig. 3) has three components: the reference voltage, E_R, the voltage fed back from the system output, E_o, and E_1. Actually, E_R and E_o are combined and passed through a weighting amplifier before being combined with E_1, which is weighted separately.

and it follows that the output pulse width decreases.

The efficiency of the switching regulator is largely a function of the design of the switch driver, which converts the output of the pulse-width controller to an appropriate base drive for the switching transistors. When switch Q_1 is closed, the transistor is driven into saturation and losses are very low. However, when the switch is in transition from one state to the other, it passes through a linear operating range where the transistor losses are high. It is necessary, therefore, to design the switch driver to minimize the rise and fall times of the current pulse through Q_1.

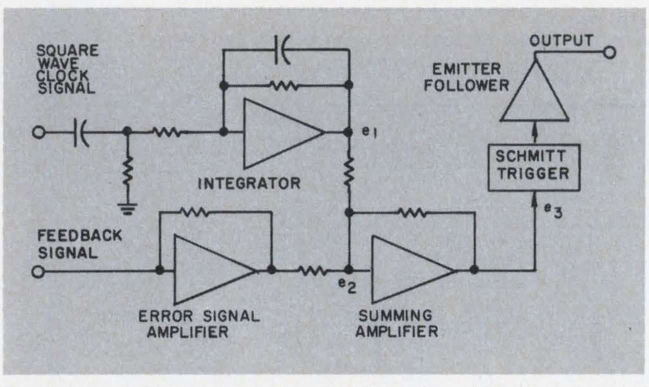
The dc-to-dc converter

The dc-to-dc converter operates on the chopper principle. The dc input E_1 is converted to a square wave by switching transistors Q_2 and Q_3 (see Fig. 2). Again, since these switches are driven into saturation, the chopper losses are mostly a function of the rise and fall times. The square-wave signal is fed into transformer T_3 and converted back to dc by the series diode bridges connected to the secondaries of T_3.

The number of secondaries required is a function of the desired step-up ratio and maximum diode voltage specifications. A practical system can be mechanized, using a unity turns ratio between the primary and each secondary, and a total of 32 secondaries. The resulting dc-to-dc converter is capable of a 6-kV dc output with less than 200 V dc input.

Experimental results

The power supply described has been built and successfully operated. The design goal of 1.0% regulation, including filter choke drop, was met. However, the operating efficiency was only 86% because of tradeoffs that were made to reduce the size and weight of the transformers. For example, switching rates for the switching regulator and dc-to-dc converter were made very high —125 kHz—increasing the losses in the switching transistors. ▪▪



3. **Pulse-width control** is provided by allowing the dc feedback signal to shift the dc level of triangle wave e_1. This varies the amount of time that e_3 is above the Schmitt trigger's firing level and hence varies the output pulse width.

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What are the two primary advantages of the three-block approach to building a regulated power supply?

2. How does the switching rate affect the efficiency and the size and weight of the power supply?

3. Why is it sometimes desirable to leave the ripple filters out of the control loop?

INFORMATION RETRIEVAL NUMBER 35

Check peak fm deviation the easy way

with this decibel plot of the Bessel function. It's designed expressly for low modulation indexes.

Using this graph of 20 $\log_{10} J_n(\beta)$ vs β can save engineers the time and trouble of converting Bessel functions into decibels when calculating fm spectra.

As is well known, in fm systems modulated by a single tone, the carrier and sideband amplitudes are described by Bessel functions of the first kind, $J_n(\beta)$. The subscript $_n$ corresponds to the sideband number (n=0 refers to the carrier), and $\beta = \Delta f/f_m$ is the modulation index—where Δf is the peak frequency deviation and f_m is the frequency of the modulating signal. The sidebands are separated by multiples of f_m above and below the carrier.

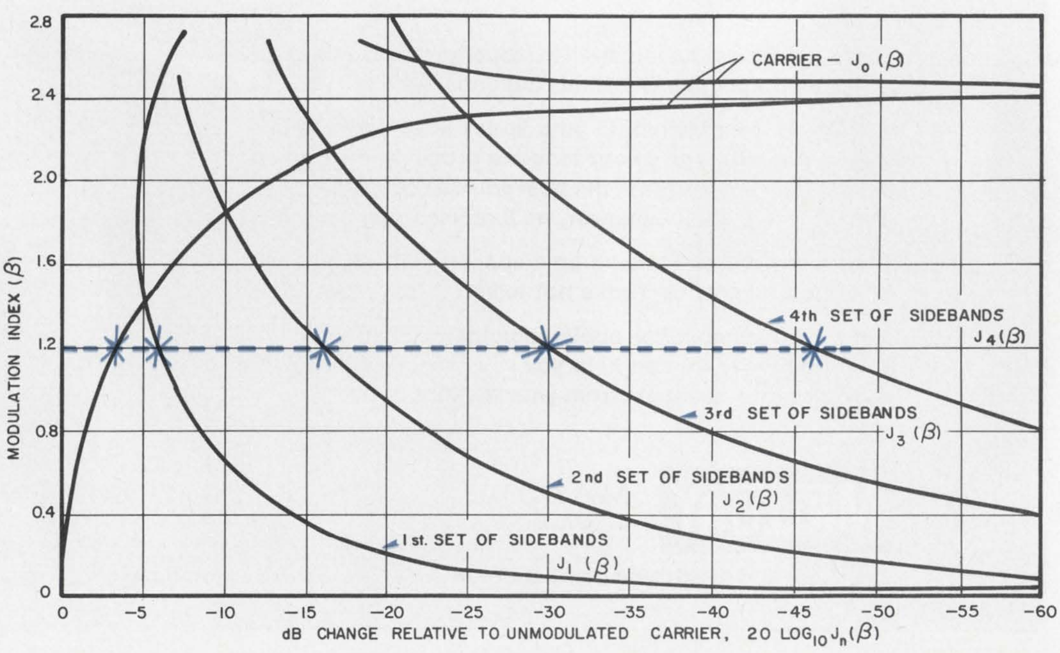
The quantity 20 $\log_{10} J_n(\beta)$ gives the number of decibels by which the unmodulated carrier exceeds the amplitudes of the various spectral components of the modulated signal. The graph is restricted to low modulation indexes because this is where the standard carrier-disappearance technique for the measurement of Δf gives unsatisfactory results.

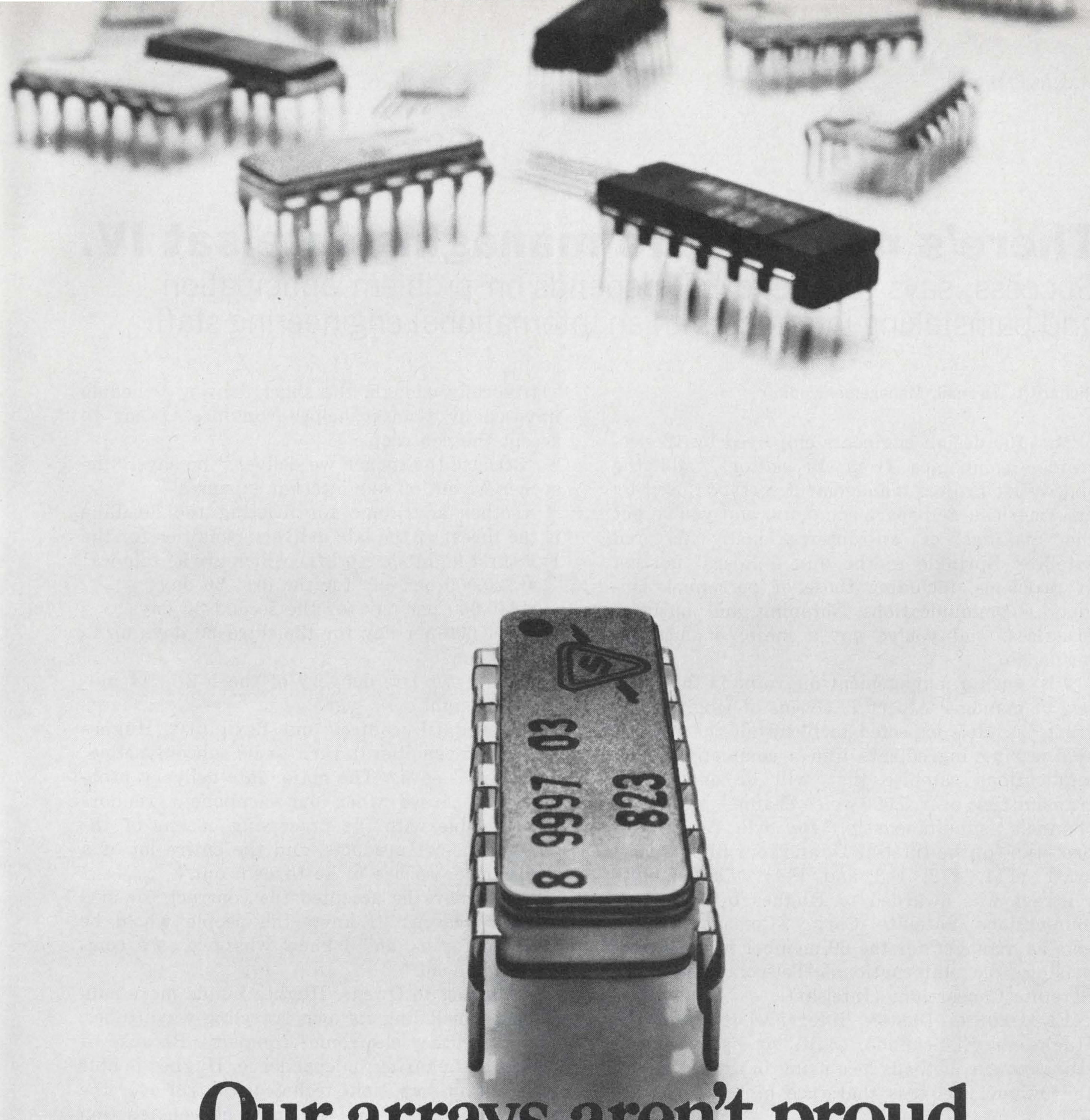
J. J. Tary and T. L. Livingston, Environmental Science Services Administration, Boulder, Colo.

Measured spectrum data

Spectrum line	Change relative To unmodulated carrier (dB)
Unmodulated carrier	0.00
Modulated carrier	−3.60
First sideband	−6.05
Second sideband	−16.20
Third sideband	−29.85
Fourth sideband	−46.30

As an example of the use of the graph, assume that the data in the table has been gathered from an fm system modulated by a 20-kHz signal. (We assume that the upper and lower components of each sideband pair are close enough in amplitude to be considered identical.) The data points are plotted on the graph, and the modulation index is found to be 1.2. Thus, the peak deviation, $\Delta f = \beta f_m$, is found to be 24 kHz. ■■





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There's no magic to managing Intelsat IV.

Success, says this head EE, depends on problem anticipation and painstaking interface with an international engineering staff.

Richard L. Turmail, Management Editor

Mix 100 design engineers employed by 12 electronics companies from 10 nations, add the spacecraft project management methods used by an American aerospace company, and you've got the makings of an internationally flavored satellite. Sprinkle in the mix a liberal portion of problems, including those of personnel, language, communications, shipping and business practices, and you've got a major managerial headache.

Just such a management migraine is the problem of manager Albert T. Owens of Hughes Aircraft Co. He's expected to blend all the various engineering ingredients into a commercial communications satellite that will be capable of transmitting over 5,000 voice channels or 12 TV channels simultaneously. He will build one prototype of the Intelsat IV and four flight spacecraft (F-1, F-2, F-3 and F-4). The satellite contract was awarded to Hughes by the Communications Satellite Corp. (Comsat), which acts as manager for the 69 member nations comprising the International Telecommunications Satellite Consortium (Intelsat).

ELECTRONIC DESIGN interviewed Owens at Hughes in El Segundo, Calif., to discover what management methods he's using in order to solve the unique problems that face him.

Getting off the pad

"Actually," Owens says, "two of the most difficult management decisions had to be made before the Intelsat IV program was even launched. We had to agree to a 22-month delivery date of the first flight spacecraft to Comsat, and to determine the budget for the project."

Budget fixing was complicated by the international nature of the program because, as Owens says: "We'd never figured project costs on an international scale before. To fix a budget I had to draw on my experiences with the smaller programs, Intelsat I and II, and rely on input from our engineering personnel who had previous experience with spacecraft programs."

Ironically enough, the short delivery schedule imposed by Comsat helped convince Owens to accept the contract.

"Because the sooner we deliver," he says, "the sooner we cut off our internal expenses."

Another advantage for meeting the deadline is the threat of the late delivery penalties for the F-1 (first flight spacecraft) which are as follows:

- $20,000 per day for the first 30 days.
- $40,000 per day for the second 30 days.
- $70,000 per day for the third 30 days up to $7 million.

Penalty for late delivery of the F-2 is $1 million overnight.

To establish control and flexibility, Hughes levies stiff penalties in turn on its subcontractors. But, Owens says, "The major late delivery problems are caused when our component vendors have trouble with the processing of one of the state-of-the-art products, and the entire lot of a thousand or so has to be thrown out."

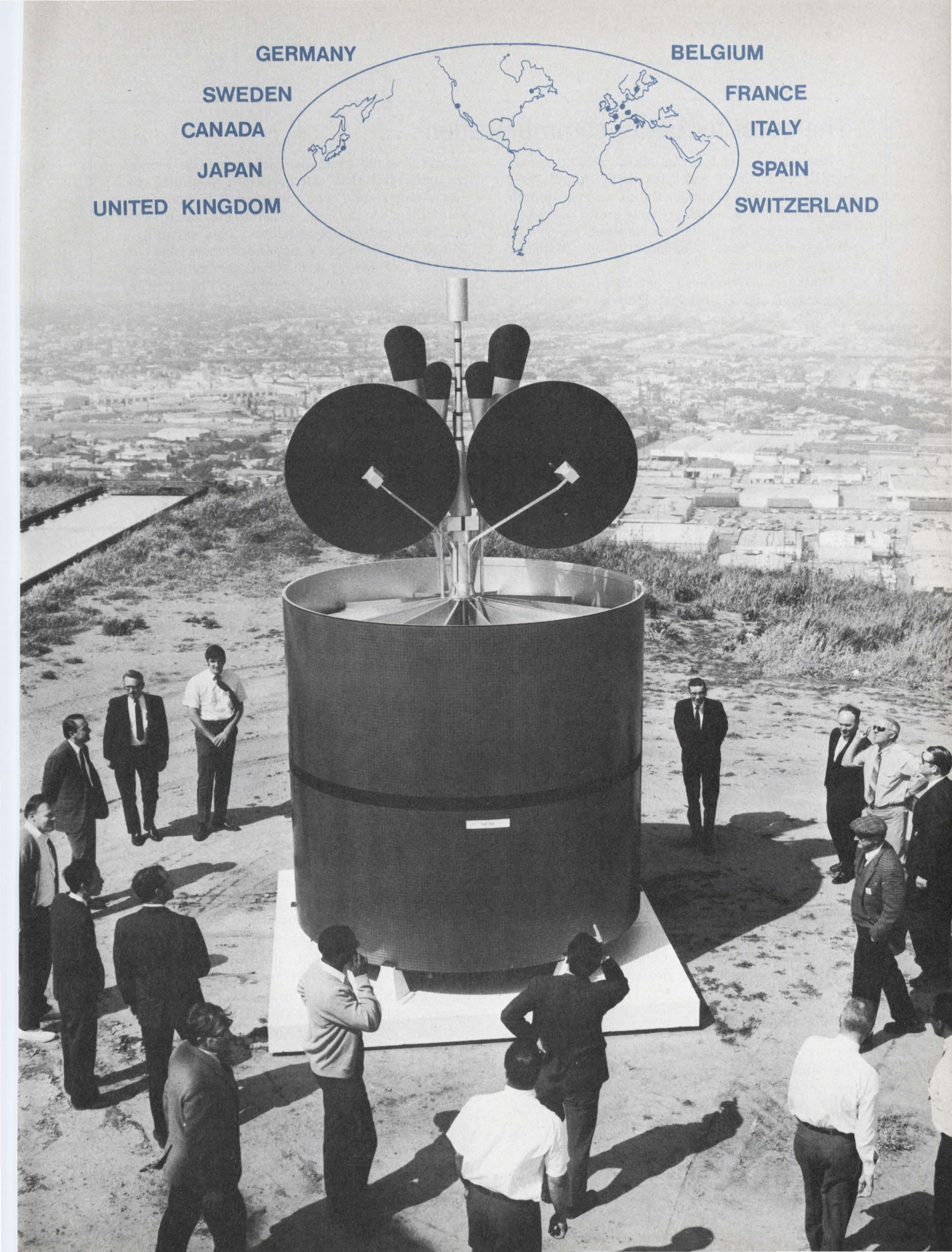
Owens says he accepted the contract for still another reason: "I knew the people who'd be working for us, and I knew what we as a company could do."

According to Owens, Hughes builds more subsystems, including its own traveling-wave tubes, than any other electronics company. Because of this manufacturing independence, Hughes is able to maintain very tight technical control over the many subsystems that go into the construction of a complete spacecraft.

Except for certain state-of-the-art components like Aerojet's (Calif.) apogee motor, and Hamilton Standard's (Conn.) valve thrusters, Owens says, "We're not dependent upon outside subcontractors to furnish a system to a given set of specifications only to find out six months downstream that if we'd had a little different spec the job would have been easier for all of us.

"We have great flexibility," he says, "because I can tell our traveling-wave-tube people, for example, 'Look, if you change this parameter

Engineers from ten nations "orbit" and inspect model of Intelsat IV they are helping to build.


GERMANY
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The quest for better communication . . .

Intelsat IV marks the sixth generation of synchronous orbit satellites built by Hughes Aircraft Co., El Segundo, Calif., and the fourth and largest of a series of commercial communications satellites to be constructed under the direction of the Communications Satellite Corp. (Comsat).

Hughes also designed, developed and tested Intelsats I and II. Intelsat III was constructed by TRW Inc.

Comsat was formed by the Satellite Communications Act of Congress in 1962 as a government-controlled national utility that serves as the carriers' carrier. It is the U.S. representative to the International Communications Satellite Consortium (Intelsat). The utility is equally owned by the public and by the Nation's Carriers, including RCA and Western Union Telegraph Co.

The new Intelsat IV will have 25 times more communications volume than any satellite in service and more capacity than all communications satellites now in combined operation. It will feature twin dish antennas (50 inches in diameter) that will provide capability to focus power into two "spotlight" beams and point them at any selected areas on earth that can be "seen" by the satellites. This capability will provide a stronger signal and more channel capacity for areas of heaviest communications traffic. These steerable antennas on the satellite can be controlled by signals from earth. Two horn antennas that will be carried aboard the satellite will provide communications coverage outside the areas covered by the spotlight beams. Two earth coverage horns (one provides redundancy) are used for reception.

The Intelsat IV spacecraft will also have 12-broadband (40-MHz bandwidths) communications channels that provide for about 500 communications circuits.

Scheduled for launching in January, 1971 from Cape Kennedy, Fla., Intelsat IV will be powered into a 22,300-mile synchronous orbit by an Atlas-Centaur rocket.

For reference the following table compares the specifications of the Intelsat series:

	INTELSAT I (Hughes)	INTELSAT II (Hughes)	INTELSAT III (TRW Inc)	INTELSAT IV (Hughes)
Diameter:	28.4 inches	56 inches	56 inches	93.5 inches
Height :	23.25 inches (solar drum only)	26 1/2 inches (solar drum only)	78 inches	210 inches
Weight :	150 pounds at liftoff 85 pounds in orbit	357 pounds at liftoff 192 pounds in orbit	632 pounds at liftoff 322 pounds in orbit	3058 pounds at liftoff 1400 pounds in orbit
Capacity :	240 voice channels or 1 TV channel	Same as Intelsat I, but triple the power	1200 voice channels or 4 TV channels	over 5,000 voice channels or 12 TV channels
Successful Launches:	April 6, 1965	January 11, 1967 March 22, 1967 September 27, 1967	December 18, 1968 February 5, 1969 May 21, 1969	simultaneously operational April 1971

so that it will more nearly match our receiver parameters, we'll end up with a better over-all system.' This gives us schedule and technical flexibility because we can warp the design as we go to fit a structure most compatible with fast delivery and good technical design."

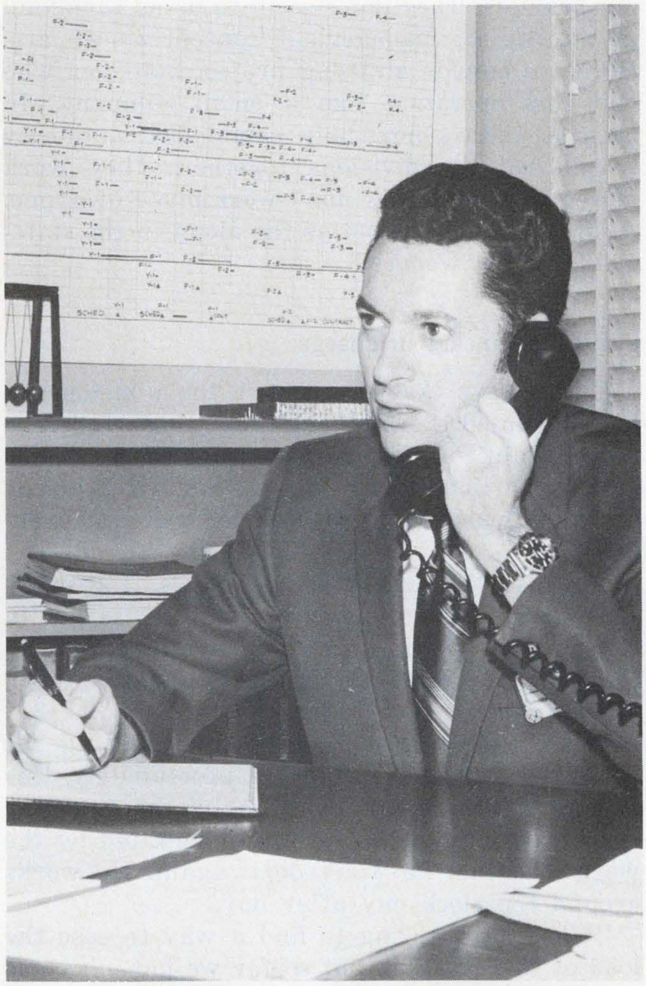
Profile of a project

As program manager, Owens is responsible for the financial, administrative and technical aspects of the Intelsat IV program. He is assisted by an associate program manager whose credentials include experience in engineering, personnel management, and company organization, and whose contacts are extensive without as well as within the company. His primary responsibility is to act in place of the program manager when necessary, and track down the major technical problems that crop up.

The program manager is also aided by an administrative type of assistant program manager. He is responsible for the organization of the program's finances, manpower, schedules, and charts, and he handles the general paper work.

Owens allocates program funds from a project office to all the participating divisions. In the case of Hughes aerospace these are the vehicle subsystem-space system; manufacturing; communications subsystems-R&D; and digital subsystems-data systems.

Supporting divisions are generally involved in getting materials in the house from the vendors, packaging those materials, and handling the con-



The top managerial spot for Intelsat IV was earned by Albert T. Owens, who served as assistant program manager of the Syncon and Early Bird communications satellite programs, and as manager of the systems engineering lab of Intelsat II. With Hughes since 1955, Owens' earlier responsibilities included the design, development, production, fabrication, and test of all experimental telemetering systems for Falcon missiles. He received his BSEE from MIT and his MSEE from USC.

tractual agreements with the subcontractors.

That is the way most Hughes' aerospace projects are set up.

"There are differences in the international setup," Owens understates.

Interface on a large scale

"You must understand," Owens says, "that our entire Intelsat IV operation has been set up in order to teach foreign personnel how to build our project item. It is technical interface on a large scale. If we didn't have to train these people, our operation would be more of a production-line process and our methods of management would change."

Before Owens supervised the turning of the first screw, he played host to about 100 engineers from 10 different Intelsat countries. They came to El Segundo to learn how to construct a satellite, and some of them stayed for a couple of weeks, while others lingered for over a year. The average visit was four months. No matter how long they stayed, most of them brought their families.

"We found it was necessary to set up a special office," Owens says, "to handle our visitors' personal needs, including housing, medical attention, schools and legal problems such as speeding tickets." (See Sidelights on p. 43.)

The language problem was held to a minimum because Owens stipulated that all foreign engineers participating in the program are required to speak English.

"This qualification wasn't difficult to fill," Owens says, "because most educated foreigners are schooled in English as well as their own language."

Putting it all together

"After all our Intelsat engineering partners were thoroughly briefed," Owens says, "to accommodate our international commitment and our late-delivery penalty, we elected to design and develop, with the cooperation of our subcontractors, the prototype and the first flight spacecraft entirely at Hughes in Calif. We wanted to make sure we got it out on time. So far the plan is working out quite well."

All the subsystems for the F-2 will be built overseas. The boxes will then be shipped to El Segundo, where they will be tested and assembled before being shipped to Cape Kennedy for launching. The last two spacecraft, F-3 and F-4, will be integrated and checked out by the British Aircraft Corp. in Bristol, England, then shipped to Hughes for testing before launch at the Cape.

"BAC is checking out the last two spacecraft," Owens says, "because they are the major sub with a good background in the systems approach."

Checks and balances

Approximately 30% of the Hughes program is involved with international subcontractors—10 in Europe, and one each in Canada and Japan. Owens says that this requires a fairly substantial staff overseas to help manage the project and handle the problems that are unique to an international undertaking. His answer was to set up a branch project office, located just outside London, and staff it with an assistant program manager who directs a staff of a dozen or so engineering, materiel, and product-effectiveness employees. These people are permanent residents who service European subcontractors.

"We also have half a dozen workers of similar talents who are residents in plants of our major subcontractors," Owens says.

"Materiel" people are non-engineering personnel who handle contract administration—that is, contractural changes that arise frequently due to changes in scope of the project; and the purchasing of additional components by subcontractors.

The "product-effectiveness" people are concerned with the quality-control aspects of the manufacturing itself.

Owens says, "During the manufacturing operation we must be assured that all of the subsystems are being fabricated to the same space standards that we use over here. Therefore, we have resident inspectors whom we call quality-control reps. They monitor the quality of subsystems and units as they are being fabricated by our European partners. They have engineering backgrounds, but they do not necessarily have an engineering degree.

"We can't afford to have all our technical people stationed overseas," Owens says. "If something goes wrong that requires personal explanation, we send the Hughes technical associate of the man in trouble to him and then bring him back."

He frowned. "These management techniques are new to us. We are generally prepared to accept European involvement as a way of life and feel that this is the way it's going to be."

To make any project function properly, one must anticipate problems. Owens says that to make sure that engineers in different areas know each other's problems, two-day meetings in Europe are established every four months with all of the subcontract people. These meetings are held on the upper management level between Hughes and the other companies to establish good communications, and to insure themselves and their top team members that they are very much interested in this program, and to solicit their cooperation through all the many problems that arise.

Each subcontractor makes a formal presentation of his company's accomplishments since the last meeting. Hughes reps advise the subs, and the meetings are topped off by a tour of the sub's plant. These meetings are followed up by more frequent get-togethers between members of Hughes resident staff in Europe and the individuals in the European companies.

"The main purpose of these meetings," Owens says, "is to establish personal contact at senior level. This is necessary because we should familiarize ourselves with our sub's ways of doing business. They don't seem to be as far along in the project management concept as we are. Here, we employ a strong project manager who runs his operation like a small company. In Europe, there's no firmly established authority to pull all the divisions together. They work more slowly, and they don't work much overtime. As a result, they're not as far along in the state-of-the-art as we are."

Putting engineers in charge

Owens says that in each of the divisions he has appointed a senior engineer whose full-time responsibility is to make sure that the problems of this particular division are known overseas and that his division knows the overseas problems.

As a further check on problems, for every spacecraft Hughes builds, an engineer is put in charge from the time the company starts putting the craft together to the time it is launched down at the Cape.

"He's really the mother of the thing all the way through," Owens says. "Unfortunately, this is such a demanding job that by the time the spacecraft is launched he is so enervated by the work load that he won't do it again. He works around the clock day after day.

"We've been trying to find a way to ease the load of this position, but so far we haven't come up with anything. We usually have to place a young energetic engineer who hasn't learned yet that he's not usually expected to work 80 hours a week, and get him phased in. Then he will be assigned to work with one of the people who has had the responsibility before, who is now in a more managerial position, and who can delegate some of the work load to younger subordinates. It works as long as we have the same basic group of people who worked on the project before."

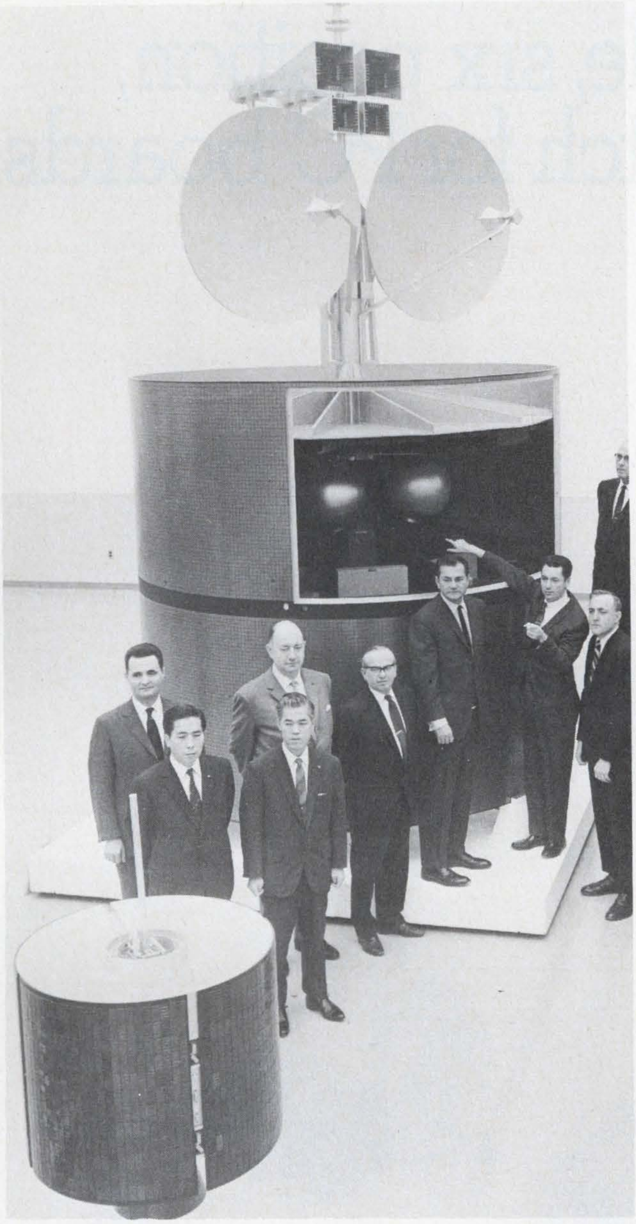
Extra inches can cost thousands

As a part of the over-all program plan, Hughes has agreements with its international subcontractors to provide them with kits of component parts on given dates so that the subs can start their fabrication on a given date for delivery of their subsystem back to Hughes.

Although the plan is simple, the shipping operation has been complex.

"There are so many tangibles involved," Owens says. "For one thing we've got to assume that everything we ship is going to receive rough handling, because we've had shipments of parts arrive in pieces.

"Another problem is in the determination of



Program manager Al Owens points out the size difference between models of Intelsat I (Early Bird) and the larger Intelsat IV to a few of the foreign engineers who are helping to construct the communications satellite.

the kit size. This can be a very costly decision. With the exception of the container that holds the entire spacecraft, which we ship on an L-100 freight aircraft, all components go on a 707 jet airliner. Early in the game we made the mistake of trying to ship items that were a fraction of an inch too large to ship in a 707, and we had to ship them in an L-100 at an extra expense of many thousands of dollars."

There are, of course, items like an antenna and receiver, that Owens prefers to ship in one piece. Such items are sensitive, and there is risk of damage if they are taken apart after once having been put together.

Some items have a limited shelf life. Epoxies and adhesives, for example, have to be packed in dry ice. Shipping them within the 72 hours required can be a risky game because an airline may change schedules at a moment's notice, or the shipment may be held up in customs. And every country has its own unique customs procedures. Hughes must document everything it ships overseas. The U.S. requires documentation on every item shipped in from outside. The accompanying paperwork creates time delays.

Communicating drawing changes

Owens says that one of the monumental headaches of the projects has been getting some 2000 Intelsat IV drawings on time and accommodating drawing changes. Engineers like to change things continually up to the last minute.

"We had two choices, Owens says: "You send a drawing out with the risk that you'll have to make changes on it later on—or you hold up the drawing until all the changes have been incorporated and then run the risk that the subs are not able to start their work on time.

"There's no clean answer to this. You make the best decision you can. What always results is that there are some engineering changes to be made after the drawings have been sent over. This is a real problem when you're dealing with subs, and it's particularly aggravating when you're dealing with international subs."

Owens remarked, "All of our drawings sent overseas are sent out in English. We do not attempt to make any translation here, which imposes a substantial burden on our subs.

"One of the problems that crops up is the translation of English units to metric units. Germany, for example, must translate inches into centimeters. Most of the translation is done abroad."

A longer stride

"There's no magical breakthrough on these problems," Owens says. "Some of them we may never solve completely. But each time we make a mistake we not only try harder, we anticipate potential problems, and that minimizes our troubles."

By January, 1971, if all goes well, Intelsat IV will be shot into orbit. Its presence around us provides a means to improve communications among the nations.

But perhaps the longer stride that man will have taken is not in the construction of the satellite itself, but rather in the international teamwork that was required to build it. ■■

Improved current source uses linear IC as a design element

An extremely useful circuit technique common to monolithic integrated circuits is the matched transconductance current source demonstrated by Widlar.[1] As shown in Fig. 1, Q_1 and Q_2 are a matched monolithic pair of transistors. Since the V_{be}s for a given collector current will be identical (matched transconductance) the collector current, I_o, of Q_2 will be equal to the reference current, I_R, flowing in Q_1.

Wilson[2] has shown how this simple but effective current source can be modified to raise the output impedance, thus refining a useful technique. The improved current source also has a lowered drift figure. The Wilson technique is shown in Fig. 2, and the pin connections are those of the CA3018 integrated circuit.

Tests run on a Tektronix 575 curve tracer using the base step generator to provide I_R while observing collector current I_o, bear out the claims made for the improved circuit. Compared to the simple regulator of Fig. 1 (made with another CA3018), the improved circuit has an extremely high output impedance. No output current change was detectable with 1-mA steps displayed on the oscilloscope (sensitivity = 1 mA/cm). The circuit of Fig. 1, by contrast, sloped approximately 1 mA/10 V at 5 mA I_o, equivalent to a 10-kΩ output impedance. Expanded scale measurements (0.1 mA/cm) of the improved circuit showed what appeared to be about 0.01 mA/10 V change. The limited resolution impaired a more accurate reading.

The improved circuit exhibited a higher current regulation knee; regulation occurred at 1 V with an I_o level of 5 mA. This is higher than the Fig. 1 circuit because of additive V_{be}s.

Disregarding the slight difference in threshold voltage, the improved circuit offers distinct advantages where a high output impedance is needed. Either circuit is readily implemented with the CA3018 unit, and the only additional component required to make a complete current regulator is a resistor to establish the reference current, I_R.

References:

1. Widlar, R. J. "Some Circuit Design Techniques for Linear Integrated Circuits," *IEEE Transactions on Circuit Theory*, January, 1966.

2. Wilson, G. R., "A Monolithic Junction FET—NPN Operational Amplifier," *Proceedings of International Solid State Circuits Conference*, Feb. 14, 1968.

Walter G. Jung, Maryland Center for Public Broadcasting, Owings Milk, Md.

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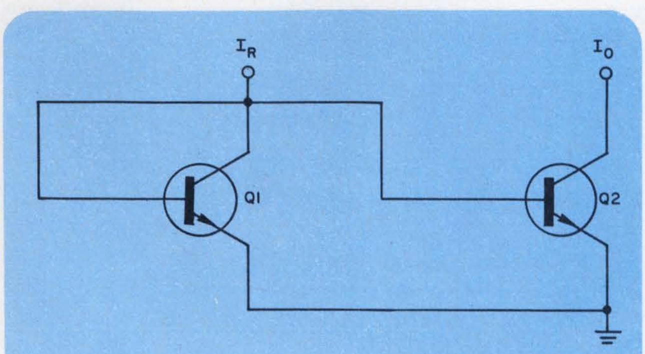
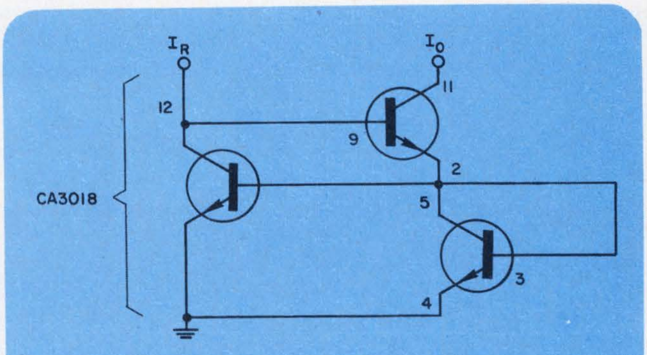


1. **Basic constant current source** uses a portion of an IC to achieve matched transconductances.



2. **Improved current source** has higher output resistance and lower drift.

Digitally Controlled Power Sources Include Added Systems-Oriented Functions

Digitally Controlled Power Sources (DCPS's) are complete digital-to-analog links between a computer (or other digital source) and any application requiring a fast, accurately settable source of dc or low frequency ac power. Such applications generally require more than a programmable power supply or D/A converter with a power amplifier — the DCPS's include these added functions in a single compact trouble-free package:

INTERFACE Customized plug-in interface cards match the Digitally Controlled Power Source to the computer (8421 BCD or Binary).

ISOLATION All digital inputs are floating and isolated from the floating analog output, thus avoiding troublesome loops between the output ground and computer ground.

STORAGE Inputs from all digital data lines are stored upon receipt of a gate signal from the computer. Output levels are maintained until a new gate signal is received — thus, the computer is free to perform other tasks in the interval between voltage level changes.

FUNCTION SELECTION Selects the output voltage range, and isolates the three input bits to the current limit D/A converter.

OUTPUT VOLTAGE D/A CONVERTER Converts one polarity bit plus 16 BCD voltage bits or 15 binary voltage bits to an analog voltage for input to the power amplifier. Thus, resolution is 0.5mV for straight binary and 1mV for BCD operation.

REFERENCES Provide voltage for the Output Voltage and Current D/A Converters.

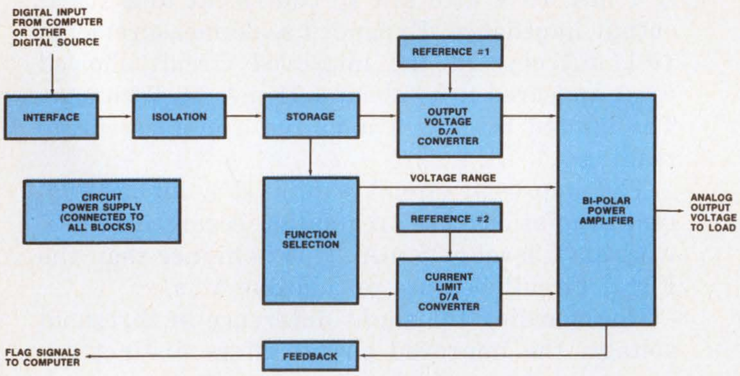
CURRENT LIMIT D/A CONVERTER Sets current limit of power amplifier to one of eight values.

CIRCUIT POWER SUPPLIES Provide all the necessary dc power — no external power supplies are required.

FEEDBACK Informs the computer when each programming operation is completed and when the output current is overloaded.

BIPOLAR POWER AMPLIFIER Programs either side of zero or through zero without output polarity switches or "notch" effects, with an accuracy of 1mV, 5mV, or 10mV depending on range and model. Outputs from —100V to +100V with currents up to 1A are available.

all this



in one compact package

Write for Digitally Controlled Power Brochure.

21904A

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COMPUTER INSTRUMENTATION

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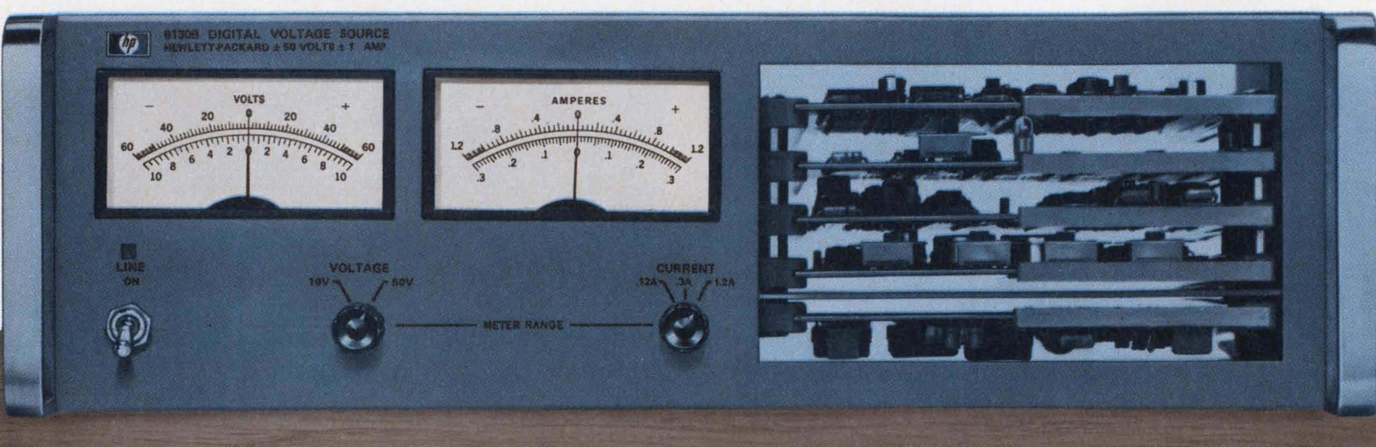


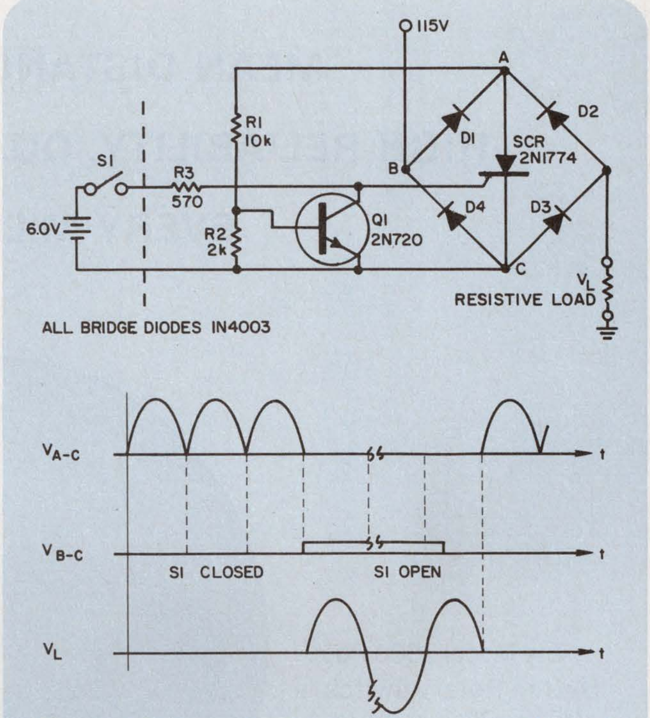
Simple zero crossing detector minimizes power-line RFI

Minimum RFI is generated when ac power is switched on and off to a load at the zero-voltage crossover point. This switching can be accomplished by a simple circuit consisting of four diodes, an SCR, a transistor and three resistors connected as shown in the figure.

With the positive output of the diode bridge ($V_{A\text{-}C}$) driving its base, transistor Q_1 is biased on during each half cycle of the supply voltage except when the voltage is at or near zero. The SCR can be triggered on only when Q_1 is biased off. This occurs at the zero voltage point. Closing of switch S_1 provides continuous voltage to the collector of Q_1, but a trigger pulse to the SCR gate is provided only at the zero crossing point ($V_{B\text{-}C}$). When switch S_1 is open, the SCR will commutate off at the zero voltage point (resistive load). The values of resistance for R_1 and R_2 are selected to provide the required trigger pulse width for the SCR being used.

A J. Marek, Engineer Specialist, LTV Aerospace Corp., Dallas, Tex.

VOTE FOR 312



Circuit initiates only at zero voltage regardless of when the switch is closed.

Three-transistor circuit functions as a one-shot SCR

A circuit using three transistors can switch a load voltage in the same manner as a one-shot multivibrator, while drawing negligible standby current. This arrangement matches the characteristics of an SCR.

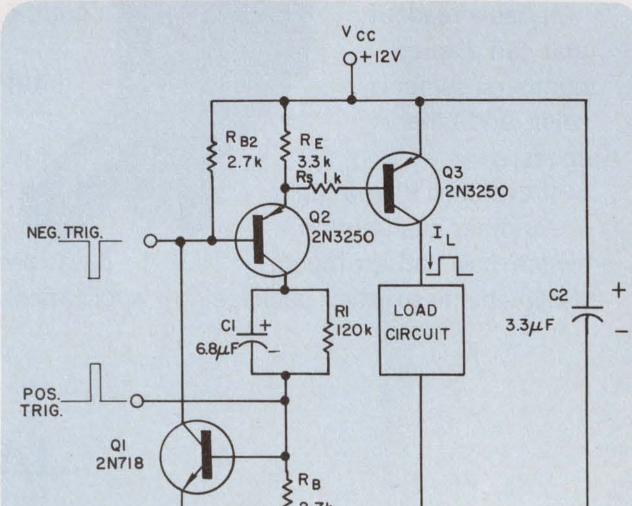
The three transistors work between two modes: cutoff and saturation. During the standby interval, the unit draws only the leakage currents of the transistors. This current is much lower than typical SCR leakage.

Q_1 and Q_2 are set in regenerative connection. If C_1 is shorted, they will act as an SCR. C_1 presents an ac short during the regenerative cycle and then limits the output after the desired time period has elapsed. R_1 discharges C_1 during the time interval following an input pulse. R_1 must be large enough to prevent bias from switching Q_1 ON when C_1 is charged; therefore:

$$V_{cc}\ R_B/(R_B+R_1) < V_{BE}$$

Q_3 is the load current switch.

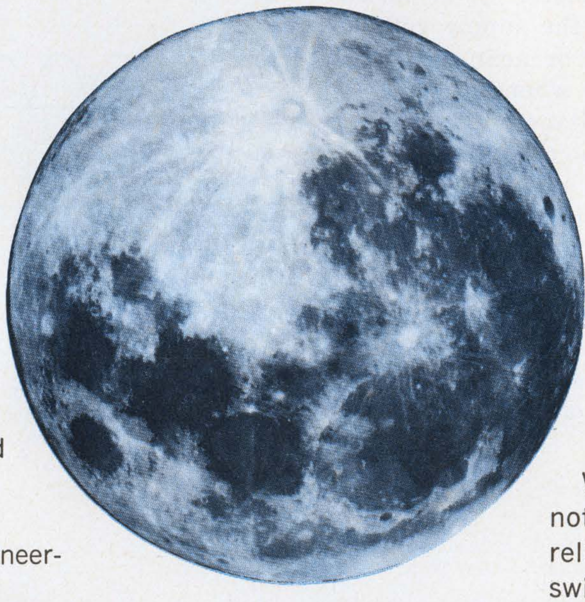
C_2 ensures that line transients do not premature-



Transistor equivalent of SCR can be triggered by either positive or negative pulses.

MEAN DISTANCE: 238,857 MILES.

HIGH-RELIABILITY, QUALITY PRODUCTS NEEDED EVERY MILE OF THE WAY



The Model 2600 Push-Button Rotary Switch is designed for only those applications requiring the highest of reliability and quality.

UNIQUE

Several interesting engineering accomplishments have made this push-button switch unique.

It is totally enclosed . . . and explosion proof.

It has a readout that can display numbers, symbols, color, and binary codes.

It even has its own light.

No other push-button switch has had so much designed into so little a package.

The Model 2600 is so small it has been nicknamed the "Space-Saver."

And a Space-Saver it is . . . Only .350 wide x 1.00 high. This adds up to panel space savings.

APPLICATIONS

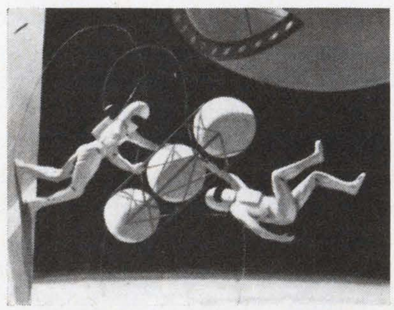
The Space-Saver represents tomorrow's push-button state of the art today.

It was designed for only those applications needing the finest quality push-button switch.

It was designed for applications where function and performance outweigh all other criteria.

When your project calls for nothing but the finest, high-reliability, push-button rotary switch manufactured, you can rest assured that it is available at Janco Corporation.

And we mean available . . . even for the mean distance and back!



JANCO
CORPORATION

3111 WINONA AVE., BURBANK, CALIFORNIA, 91504

INFORMATION RETRIEVAL NUMBER 39

ly trigger the unit.

The load current cuts off when current flow through C_1 and R_B drops below the level needed to bias Q_1 ON. Shot width time T is determined from the following equations:

$I_{C1}(t) \simeq [(V_{cc}-2V_{BE})/R_s]e^{-t/(R_sC_1)}$

$I_{C1}(T) \simeq V_{BE}/R_B$

$T \simeq R_s C_1 \ln\{[R_B/R_s]\ [(V_{cc}-2V_{BE})/V_{BE}]\}$

Transistor Q_3 must remain in saturation until Q_1 ctus off. Therefore the load current must obey:

$I_L < h_{FE3} V_{BE}/R_B$

If higher I_L is needed, another transistor(s) may be connected to the output.

Dan Bron, Electronic Engineer, Ministry of Defense, Tel-Aviv, Israel.

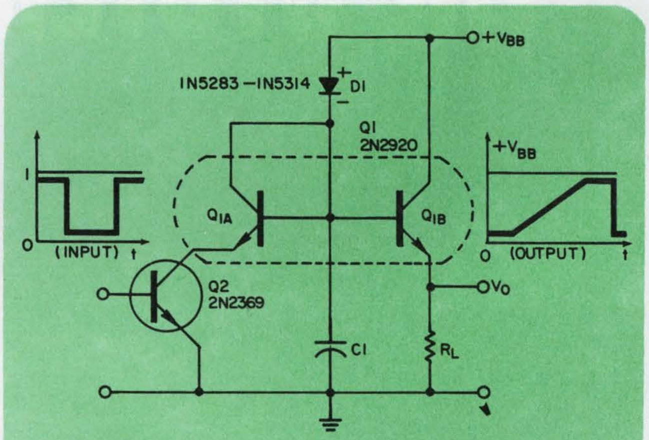
VOTE FOR 313

Simple ramp generator uses five components

An improved ramp generator that is linear and temperature stable can be constructed with very few components. As shown, the constant-current diode D_1 (1N5283—1N5314) is in series with a timing capacitor C_1. The diode has the unique characteristic of maintaining a constant current flow for voltage drops from several volts to approximately 100 volts. The capacitor voltage is simply iT/C where i is the diode current, T is time and C is the capacitance of C_1.

Q_{1B} is a current driver used to isolate the load impedance from the timing elements. Q_{1A} offsets the base-emitter drop of Q_{1B}. Thus V_o starts from V_{CEsat} of Q_2 for all temperatures. Q_2 is a saturated switch gating the ramp on and off.

The slope of the ramp is determined by the current value through D_1 and the capacitor C_1. As V_o approaches V_{bb}, some nonlinearity results as the diode turns off.



Ramp generator uses only five components to achieve linear, temperature-stable operation.

B. E. Dobratz, Group Head, Hughes Aircraft Co., Culver City, Calif.

VOTE FOR 314

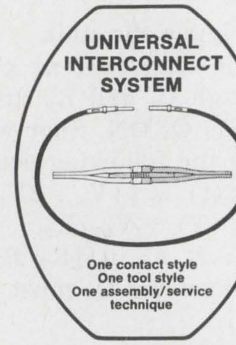
VOTE

Active filter design uses BASIC language

Common types of filters can be designed by means of BASIC program language to suit a wide variety of applications. Equations and step-by-step programs are outlined here for the design of active low-pass and band-pass filters.

Each filter described has a stable frequency response, which does not pass through the unstable zero dB gain, 180-degree phase shift point. They are designed to be overdamped (that is, damping ratio equals 1.41) so that the phase shift never exceeds 170 degrees. The relatively complex filter equations can be solved

OUR MIL-C-83723 CV's AND PV's PUT YOU ONTO THE SYSTEM:



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When you specify CANNON® CV or PV connectors, you're automatically part of Universal Interconnect. It's a system based on our original "LITTLE CAESAR®" rear release contact retention assembly—giving you one contact style, one tool for insertion and extraction, and one servicing procedure.

CV and PV connectors are the newest members of our universal system for MIL-SPEC connectors. They're qualified to MIL-C-83723, replacing MIL-C-5015's and 26482's in current aircraft, besides being approved as original equipment in advanced designs. And they are available now.

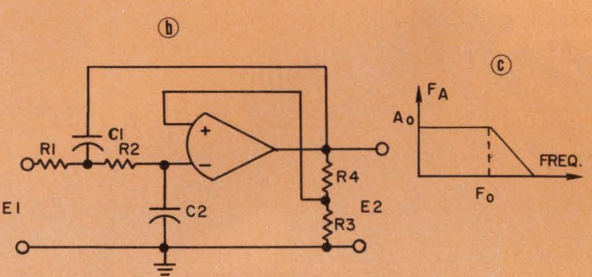
CV's intermate with all MIL-C-5015 types. PV's intermate with all MIL-C-26482 types and bayonet NAS1599 connectors. Both are the latest connectors developed for space environments. The insertion/extraction tools are free and disposable, a feature of all connectors in the CANNON Universal Interconnect System.

For full details on CV/PV connectors, contact your authorized ITT Cannon distributor or write ITT Cannon Electric, 3208 Humboldt Street, Los Angeles, California 90031. A division of International Telephone and Telegraph Corporation.

CANNON ITT

```
10  READ FO, AO
20  DATA 1000, 10
30  PRINT "ACTIVE LOW PASS FILTER DESIGN DATA"
40  PRINT "FO IS THE 3 DB ROLL OFF FREQUENCY IN HERTZ."
45  PRINT "RESISTANCE IN OHMS, CAPACITY IN FARADS."
50  PRINT "THE ABSOLUTE GAIN MAGNITUDE IN THE PASS REGION IS AO"
60  PRINT
70  PRINT "FO="FO;"AO="AO;
80  PRINT
90  PRINT "C1    ";"C2    ";"R1    ";"R2    ";"R3   ";"R4    "
100  DIM C[9]
105  READ C
110  DATA 1.E-09,1.E-08,2.2E-08,4.7E-08,1.E-07,4.7E-07,.000001
120  DATA .00001
130  LET K=C*6.28*FO
140  LET M=.5+(AO-1)
150  LET C2=M*C
160  LET R1=2/(1.41*K)
170  LET R2=1.41/(2*M*K)
180  LET R3=100000./AO
190  LET R4=R3*(AO-1)
200  PRINT C;C2;R1;R2;R3;R4
210  GOTO 105
220  END
```

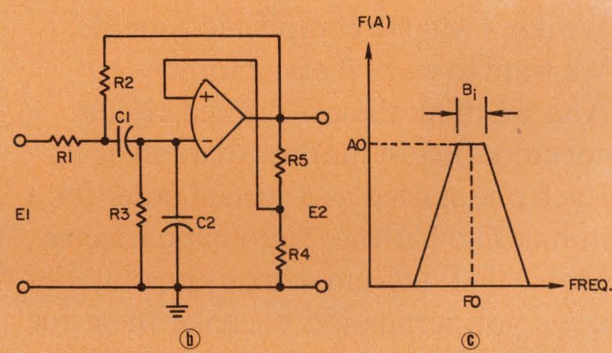
(a)



1. **This program designs low-pass filters.** The program listing is given in (a) for the circuit of (b). The approximate response is (c).

```
10  PRINT "ACTIVE BANDPASS FILTER DESIGN"
15  PRINT "FREQUENCY IN HERTZ, RESISTANCE IN OHMS, CAPACITY IN FARADS"
20  PRINT "AO IS THE ABSOLUTE GAIN MAGNITUDE IN THE PASS BAND"
25  PRINT
30  READ FO,B1
40  DATA 2400,100
50  LET Q=FO/B1
60  PRINT "BANDWIDTH IN HZ.= "B1;"CENTER FREQUENCY="FO;"Q="Q
70  PRINT
80  PRINT "C1  ";"C2   ";"R1   ";"R2   ";"R3  ";"R4   ";"R5  ";"AO  "
90  PRINT
100  DIM C[9]
110  READ C
120  DATA 1.E-09,1.E-08,2.2E-08,4.7E-08,1.E-07,2.2E-07,4.7E-07
140  DATA .000001,.00001
170  LET K=6.28*FO*C
180  LET R2=.666/K
190  LET R1=3*R2
200  LET R3=4/K
210  LET M=.333*(6.5-(1/Q))
220  LET AO=M*Q
230  LET C2=.5*C
240  LET R5=100000./M
250  LET R4=R5*(M-1)
260  PRINT C;C2;R1;R2;R3;R4;R5;AO
265  PRINT
270  GOTO 110
300  END
```

(a)



2. **This program designs band-pass filters.** The program listing is given in (a) for the circuit diagram of (b). The approximate response is (c).

quickly with the aid of a time-sharing computer.

The low-pass filter program accepts input data in program line 20 (Fig. 1a) for the 3-dB rolloff frequency FO and the absolute closed-loop gain the filter pass region, AO. Values for FO = 1000 Hz and AO = 10 were arbitrarily selected. The program printout furnishes nine different values for R_1, R_2, and C_2 for the nine standard values of C_1 supplied in program lines 110 and 120. The designer can then select the printout that offers him the most convenient set of components for any particular value of FO and AO. Resistors R_3 and R_4 are such that a 100-kΩ potentiometer can be used when set to the proper ratio.

The band-pass filter program accepts center-pass frequency FO, and band-pass region width B1, in program line 40. The closed-loop gain in the pass-band AO, is a function of Q and M (lines 50 and 210). Resistors R_4 and R_5 are a single 100-kΩ potentiometer as in the low-pass filter. The program operates basically the same as for the low-pass filter and provides nine different data printouts foreach set of FO and B1 placed into line 40.

Bibliography:

Handbook of Operational Amplifier Active RC Networks, Burr-Brown Research Corp., Tucson, Ariz., 1966.

Harold Minuskin, Senior Engineer, California Computer Products, Inc., Anaheim, Calif.

VOTE FOR 315

IFD Winner for October 25, 1969
Herbert Cohen, President, Electret Corp., New York, N.Y. His Idea "Triangular Waveform Generator is Simple Yet Effective" has been voted the Most Valuable of Issue Award.
Vote for the Best Idea in this Issue.

IFD Winner for November 8, 1969
Henry D. Olson, Research Engineer, Radio Physics Lab., Stanford Research Institute, Menlo Park, Calif. His Idea "Inexpensive Audio IC Serves As Regulator" has been voted the Most Valuable of Issue Award.
Vote for the Best Idea in this Issue.

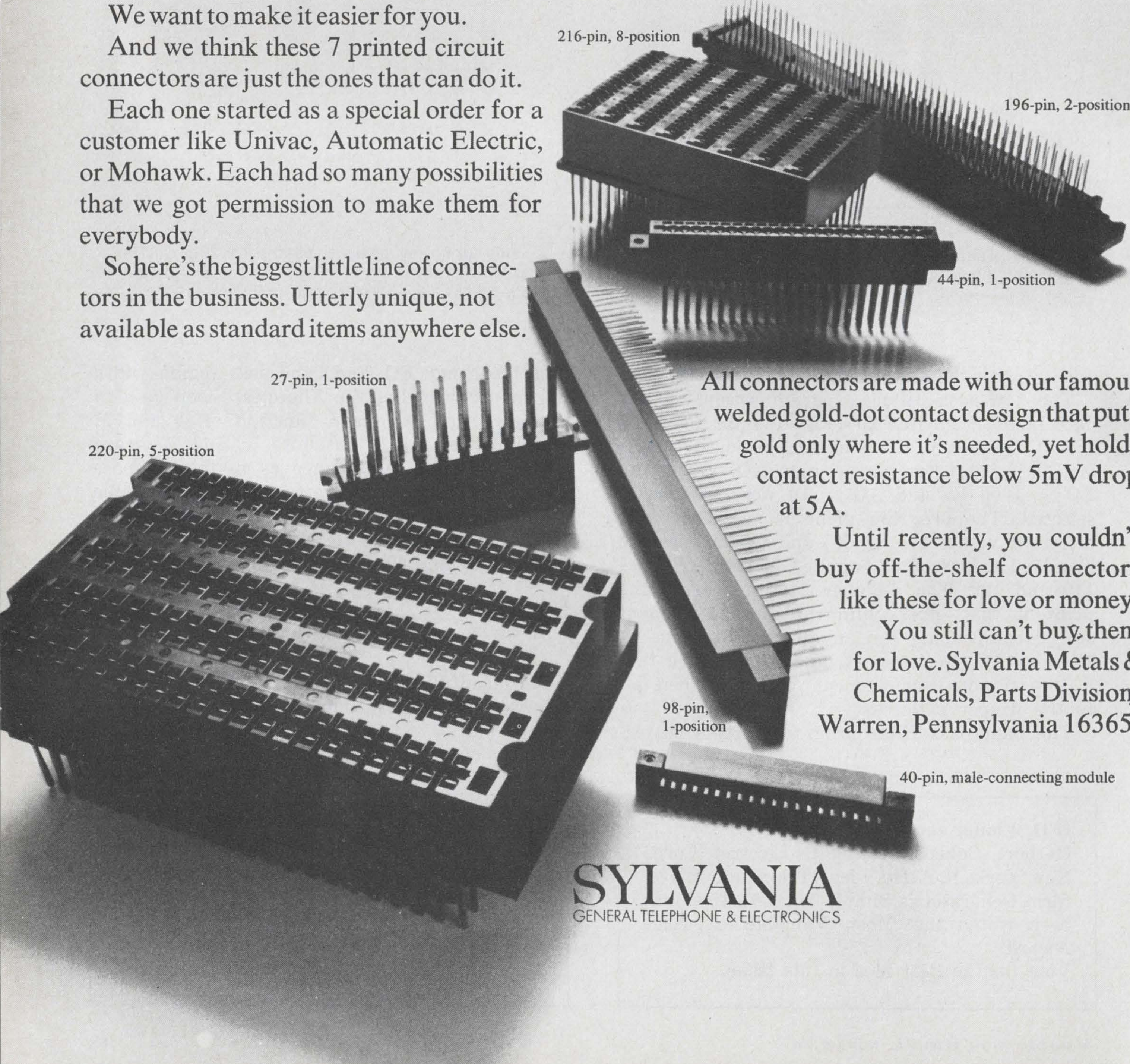
In a world that offers a million different connectors, who needs 7 more?

We don't want to complicate your life. We want to make it easier for you.

And we think these 7 printed circuit connectors are just the ones that can do it.

Each one started as a special order for a customer like Univac, Automatic Electric, or Mohawk. Each had so many possibilities that we got permission to make them for everybody.

So here's the biggest little line of connectors in the business. Utterly unique, not available as standard items anywhere else.



All connectors are made with our famous welded gold-dot contact design that puts gold only where it's needed, yet holds contact resistance below 5mV drop at 5A.

Until recently, you couldn't buy off-the-shelf connectors like these for love or money.

You still can't buy them for love. Sylvania Metals & Chemicals, Parts Division, Warren, Pennsylvania 16365.

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Frequency Meters

This Product Source Directory, covering Coaxial and Waveguide Frequency Meters, is the eighth in a continuing series of product selection data that will list comparative specifications and prices for products frequently purchased by design engineers. All categories will be arranged according to some primary parameter so that items having similar functional capabilities can be instantly compared.

How to use the table

The tables in this section list the specifications for coaxial and waveguide frequency meters.

The following abbreviations apply to all instruments listed

ina—information not available
n/a—not applicable
COC—Cross-over Counter

The parameter minimum dip is the transmission loss specification for frequency meters with transmission type circuits.

An index of models by manufacturer is included at the end of each table.

For each table, the instruments are listed in ascending order of one major parameter. The column containing this parameter is color-coded white. Manufacturers are identified by abbreviation. The complete name of each manufacturer can be found in the following Master Cross Index.

Abbrev.	Company	Reader Service No.
CDC	Control Data Corp. TRG Inc. 400 Border St. E. Boston, Mass. 02128 (617) 569-2110	460
Diamond	Diamond Antenna & Microwave Corp. 35 River St. Winchester, Mass. 01890 (617) 729-5500	461
Fel	Frequency Engineering Labs. P.O. Box 527 Farmingdale, N.J. 07727 (201) 938-9221	462
Microlab	FXR/Microlab 10 Microlab Road Livingston, N.J. 07039 (201) 992-7700	463
Gen Micro	General Microwave Corp. 155 Marine St. Farmingdale, N.Y. 11735 (516) MY 4-3600	464
GR	General Radio Co. 22 Baker Avenue W. Concord, Mass. 01781 (617) 369-4400	465
Gertsch	Gertsch Products Singer Instrumentation 3211 La Cienega Blvd. Los Angeles, Calif. (213) 870-2761	466
H-P	Hewlett Packard Co. 1501 Page Mill Road Palo Alto, Calif. 94304 (415) 326-7000	Contact Local Sales Office

Abbrev.	Company	Reader Service No.
Lampkins	Lampkin Labs. Inc. Perico Road Bradenton, Fla. 33505 (813) 746-4175	467
Marconi	Marconi Instruments 111 Cedar Lane Englewood, N.J. 07631 (201) 567-0607	468
Measure	Measurements Box 180 Boonton, N.J. 07005 (201) 334-2131	469
PRD	PRD Electronics, Inc. 6801 Jericho Tpke. Syosset, N.Y. 11791 (516) 364-0400	470
R-S	Rohde & Schwarz 111 Lexington Ave. Passaic, N.J. 07055 (201) 773-8010	471
Sell-Tronic	Sell-Tronic Products Co., Inc. 138-20 31st Road Flushing, N.Y. 11354 (212) 886-4763	472
Waveline	Waveline Inc. Box 718 W. Caldwell, N.J. 07006 (201) 226-9100	473
Weston-Lex	Weston-Lexington 17 Hartwell Ave. Lexington, Mass. 02173 (617) 861-9000	474

	Manufacturer	Model	FREQUENCY Minimum MHz	Maximum MHz	Bands No.	Accuracy %	Power Required to Operate	Circuit Type	Price Approx. $
FM 1	Weston/Lex	301C	0.5 Hz	0.2	5	0.01	115/230V	t	1350
	Weston/Lex	301	0.5 Hz	0.2	5	0.01	115/230V	t	1085
	Weston/Lex	300	5 Hz	0.2	4	0.01	115/230V	t	995
	Sell-Tronic	401A	10 Hz	1	9	2	Line	ina	249
	GR	1142-A	0.003	1.5	5f	±0.2	Line	COC	595
	Weston/Lex	302	0.5 Hz	2	6	0.01	115/230V	t	1245
	Measure	159LF	0.1	4.5	4	±2	Line	ina	235
	R-S	WEN	0.01	30	7	±0.5	115/230V	r	485
	Gertsch	FM9E	150	162	1	0.0001	115 Vac, 12 Vdc	p	2200
	Lampkin	103-B MFM	0.1	175	1	0.001	Line	p	240
FM 2	Lampkin	105-B MFM	0.1	175	1	0.001	Line	p	295
	Measure	159RF	2.2	420	7	±2	Line	ina	210
	Measure	760	25	475	3	±100 Hz	Line	ina	980
	R-S	WAM	30	500	8	±0.5	6V	q	500
	Gertsch	FM-10	0.1	500	1	0.0001	110 Vac, 12 Vdc	ina	3500
	Lampkin	107 DFM	0.01	500	1	0.0001	115 Vac, 12 Vdc	dp	2390
	Measure	159 UHF	420	940	1	±2	Line	ina	240
	Fel	WCF510-4N	500	1000	1	±0.01	None	c	960
	Fel	WC-510-1N	500	1000	1	±0.01	None	c	920
	PRD	587-A	250	1000	1	±0.2-0.5	None	bcd	435
FM 3	Fel	WC-912-3N	900	1200	1	±0.01	None	b	560
	Fel	WC-912-1N	900	1200	1	±0.01	None	c	560
	Fel	WCF912-4N	900	1200	1	±0.01	None	c	525
	Diamond	DIC2090	900	1450	1	1	None	coax	325
	Fel	WC1217-3N	1200	1700	1	±0.01	None	b	560
	Fel	WC-1217-1N	1200	1700	1	±0.01	None	c	560
	Fel	WCF1217-4N	1200	1700	1	±0.01	None	c	525
	Marconi	6050/3	1000	2000	1	±0.2	None	LC	255
	Fel	WDB1020-1N	1000	2000	1	±0.05	None	c	395
	Gen Micro	N607	950	2000	1	0.1	None	bc	395
FM 4	Diamond	DIC2091	1400	2300	1	1	None	coax	295
	R-S	WAL	470	2500	1	±0.08	115/230V	r	860
	Fel	WC-1628-3N	1600	2800	1	±0.01	None	b	560
	Fel	WC-1628-1N	1600	2800	1	±0.01	None	c	560
	Fel	WCF1628-4N	1600	2800	1	±0.01	None	c	525
	Fel	WCF2335-4N	2300	3500	1	±0.01	None	c	600
	Fel	WC-2335-1N	2300	3500	1	±0.01	None	c	560
	Fel	WC-2335-3N	2300	3500	1	±0.01	None	b	560
	Fel	WDB2040-1N	2000	4000	1	±0.01	None	c	395
	Gen Micro	N604	1900	4000	1	0.1	None	bc	395
FM 5	Microlab	N410A	1000	4000	1	0.1	None	c	525
	PRD	LS-518	960	4000	1	±0.17	None	ina	525
	R-S	WAT	1200	4200	2	0.1	6V	r	850
	Fel	WDA940	960	4200	1	0.17	None	c	525
	H-P	536A	960	4200	1	0.1	None	cn	550
	Fel	WDC-3645-1N	3600	4300	1	±0.01	None	c	1200
	Diamond	DIC2092	2200	4300	1	1	None	coax	270
	Fel	WC-3545-3N	3500	4500	1	±0.01	None	b	575
	Fel	WC-3545-1N	3500	4500	1	±0.01	None	c	575
	Fel	WCF3545-4N	3500	4500	1	±0.01	None	c	650
	Fel	WCF4458-4N	4400	5800	1	±0.01	None	c	650
FM 6	Diamond	DIC2093	3500	6500	1	1	None	coax	250
	Fel	WDB-4080-1N	4000	8000	1	±0.05	None	c	395
	Fel	WCF5882-4N	5800	8100	1	±0.01	None	c	575
	Gen Micro	N608A	3950	8200	1	0.15	None	bc	395
	Marconi	6049/1	2600	8200	1	±0.1	None	g	470
	Fel	WCF8211-4N	8200	11000	1	±0.01	None	c	975
	Microlab	N414A	3950	11000	1	0.1	None	c	525
	Marconi	6051	8200	12400	1	±0.2	None	g	175
	Gen Micro	N610	7000	12400	1	0.1	None	bc	395
	Fel	WDA3712	3700	12400	1	0.17	None	c	525
FM 7	PRD	CX-518	3700	12400	1	±0.17	None	cd	525
	H-P	537A	3700	12400	1	0.1	None	cn	525
	Marconi	6049/2	5300	18000	1	±0.1	None	g	500

Accuracy is our policy

In the Product Source Directory featuring Signal Generators (ED 2, Jan. 18, 1970) the Singer model SG-1000 specified on page 94, section SG5, and priced at $7790, should be $3790.

Signal Innovator

Singer has advanced the state-of-the-art with a signal generator so New it almost requires a new name.

The Model SG-1000 obsoletes every other signal generator within its frequency range . . . singly or in combination. Its performance is so superior that no other instrument available can equal or even approach it.

That's why we call it the Innovator.

Here's why you'll call it unbelievable . . .

■ Digital readout of frequency.

■ Broadband frequency coverage from 61kHz to 512MHz (to 1024MHz with a simple passive doubler) in a small 5¼″ high package.

■ Exceptional frequency accuracy and resolution . . . typically 0.005% . . . and no human readout errors.

■ Full modulation capability AM □ FM □ Pulse □ Video □ Internal 1,000Hz modulation □ . . . and combinations of the above.

■ Output levels from +20dBM to −146dBM.

■ An automatically leveled output . . . within ± 0.5dB over the entire frequency range.

■ Use it as a 2MHz counter for counting modulating signals or rep rates directly.

■ A spectrally pure output signal approaching that of a crystal . . . extremely low residual and incidental FM.

■ Total elimination of dial tracking errors.

■ The availability of BCD frequency output and a programmable attenuator to assure system integration.

This is only part of the SG-1000 story. A more complete technical description is available in Singer Application/Data Bulletin SG-10 upon request.

For additional information contact your local Singer Representative, or write or call —

The Singer Company
Instrumentation Division
915 Pembroke Street
Bridgeport, Conn. 06608.
203-366-3201.
In Europe contact: Singer Sewing Machine Company, Instrumentation Division, P.O. Box 301, 8034 Zurich, Switzerland, Telephone: (051) 47 25 10
TWX 710-453-3483

SINGER
INSTRUMENTATION

INFORMATION RETRIEVAL NUMBER 42

Waveguide Frequency Meters

	Mfr	Model	FREQUENCY Minimum GHz	FREQUENCY Maximum GHz	FREQUENCY Accuracy %	Circuit Type	Q Loaded k	Minimum Dip dB	Connector Type	Price $
FM 8	Fel	WDC-3645-1W	3.6	4.3	±0.01	c	3	1	CMR-229	1200
	Fel	WC-3545-1W	3.5	4.5	±0.01	c	3	1.5	UG-149	575
	Diamond	DIC590-1	3.95	4.85	0.1	a	ina	1.0	UG	375
	Diamond	DIC592-1	3.95	4.85	0.1	b	ina	1.0	UG	375
	Diamond	DIC591-1	3.95	4.85	0.1	top wall	ina	1.0	UG	375
	Fel	WC-4458-1W	4.4	5.8	±0.01	c	3	1.5	UG-149	575
	Fel	WC-4458-3W	4.4	5.8	±0.01	b	3	9	UG-149	575
	Diamond	DIC592-2	4.85	5.85	0.1	b	ina	1.0	UG	375
	Diamond	DIC590-2	4.85	5.85	0.1	a	ina	1.0	UG	375
	Diamond	DIC591-2	4.85	5.85	0.1	top wall	ina	1.0	UG	375
FM 9	PRD	532	3.95	5.85	±0.08	cd	ina	ina	UG-149	440
	Microlab	H410A	3.95	5.85	0.08	cd	8	20%	UG-149A	380
	H-P	G532A	3.95	5.85	0.033	ch	10	1	UG-407	500
	Waveline	398-DR	3.95	5.85	0.07	ce	ina	1	UG-149A	reg
	Fel	WDC5459-3W	5.4	5.9	±0.01	b	7	10	UG-344	1200
	Fel	WDC5459-1W	5.4	5.9	±0.01	c	7	1	UG-344	1100
	Fel	WC-5264-1W	5.2	6.4	±0.01	c	4	1.5	UG-344	575
	Fel	WC-5264-3W	5.2	6.4	±0.01	b	4	9	UG-344	575
	Fel	WDC-5965-3W	5.85	6.5	±0.01	b	7	10	UG-344	1200
	Fel	WDC-5965-1W	5.85	6.5	±0.01	c	7	1	UG-344	1100
FM 10	Fel	WDC-5465-3W	5.4	6.5	±0.01	b	7	10	UG-344	1250
	Fel	WDC-5465-1W	5.4	6.5	±0.01	c	7	1	UG-344	1200
	Diamond	DIC690-1	5.85	7.05	0.1	a	ina	1.0	UG	350
	Diamond	DIC691-1	5.85	7.05	0.1	top wall	ina	1.0	UG	350
	Diamond	DIC692-1	5.85	7.05	0.1	b	ina	1.0	UG	350
	Fel	WC-5882-3W	5.8	8.1	±0.01	b	3	9	UG-344	575
	Fel	WC-5882-1W	5.8	8.1	±0.01	c	3	1.5	UG-344	575
	Diamond	DIC791-1	7.05	8.2	0.1	top wall	ina	1.0	UG	325
	Diamond	DIC692-2	7.05	8.2	0.1	b	ina	1.0	UG	350
	Diamond	DIC690-2	7.05	8.2	0.1	a	ina	1.0	UG	350
FM 11	Diamond	DIC792-1	7.05	8.2	0.1	b	ina	1.0	UG	325
	Diamond	DIC790-1	7.05	8.2	0.1	a	ina	1.0	UG	325
	Diamond	DIC691-2	7.05	8.2	0.1	top wall	ina	1.0	UG	350
	PRD	533	5.85	8.2	±0.08	cd	ina	ina	UG-344	425
	Waveline	498-DR	5.85	8.2	0.07	ce	ina	1	UG-344	reg
	Microlab	C410B	5.85	8.2	0.08	cd	8	20%	UG-344	360
	H-P	J532A	5.3	8.2	0.033	ch	10	1	UG-441	550
	Fel	WDC-7585-1W	7.5	8.5	±0.01	c	7	1	UG-51	1200
	Fel	WDC-7585-3W	7.5	8.5	±0.01	b	7	10	UG-51	1300
	Fel	WDC-9095-1W	9	9.5	±0.01	c	7	1	UG-39	1070
FM 12	Fel	WDC-8596-1W	8.5	9.6	±0.01	c	7	1	UG-39	1200
	Fel	WDC-9197-1W	9.1	9.7	±0.01	c	7	1	UG-39	1070
	Fel	WC-8397-3W	8.3	9.7	±0.01	b	7	9	UG-39	575
	Fel	WC-8397-1W	8.3	9.7	±0.01	c	7	1.5	UG-39	575
	Diamond	DIC792-2	8.2	10	0.1	b	ina	1.0	UG	325
	Diamond	DIC790-2	8.2	10	0.1	a	ina	1.0	UG	325
	Diamond	DIC890-1	8.2	10	0.1	a	ina	1.0	UG	300
	Diamond	DIC891-1	8.2	10	0.1	top wall	ina	1.0	UG	300
	Diamond	DIC892-1	8.2	10	0.1	b	ina	1.0	UG	300
	Diamond	DIC791-2	8.2	10	0.1	top wall	ina	1.0	UG	325
FM 13	Waveline	598-DR	7.05	10	0.08	ce	ina	1	UG-51	reg
	H-P	H532A	7.05	10	0.04	ci	10	1	UG-138	600
	Microlab	W410B	7.05	10	0.08	cd	8	20%	UG-51	320
	Fel	WC-7010-1W	7	10	±0.01	c	3	1.5	UG-51	575
	Fel	WC-7010-3W	7	10	±0.01	b	3	9	UG-51	575
	PRD	534	7	10	±0.08	cd	ina	ina	UG-51	385
	Fel	WCF9611-4W	9.6	11	±0.01	c	5	ina	UG-39	975
	Fel	WC-9611-3W	9.6	11	±0.01	b	6	9	UG-39	575
	Fel	WC-9611-1W	9.6	11	±0.01	c	6	1.5	UG-39	575
	Fel	WC-8211-3W	8.2	11	±0.01	b	3	9	UG-39	575
FM 14	Fel	WC-8211-1W	8.2	11	±0.01	c	3	1.5	UG-39	575
	Diamond	DIC890-2	8	11	0.1	a	ina	1.0	UG	300
	Diamond	DIC891-2	8	11	0.1	top wall	ina	1.0	UG	300
	Diamond	DIC892-2	8	11	0.1	b	ina	1.0	UG	300
	Fel	WDC-8011-1W	8	11	±0.01	c	4	1	UG-39	1295
	Fel	WDC-10110-3W	10	11.5	±0.01	b	5	10	UG-39	1300
	Fel	WDC-10110-1W	10	11.5	±0.01	c	5	1	UG-39	1200
	Microlab	X411A	8.2	11.5	0.1	bd	5	20%	UG-39	300
	Fel	WCF10711-4W	10.7	11.7	±0.01	c	5	ina	UG-39	975
	Fel	WC-11120-3W	11	12	±0.01	b	6	10	UG-39	575
FM 15	Fel	WC-11120-1W	11	12	±0.01	c	6	1.5	UG-39	575
	Fel	WCF11120-4W	11	12	±0.01	c	6	ina	UG-39	975
	Diamond	DIC892-3	10	12.4	0.1	b	ina	1.0	UG	300
	Diamond	DIC891-3	10	12.4	0.1	top wall	ina	1.0	UG	300
	Diamond	DIC890-3	10	12.4	0.1	a	ina	1.0	UG	300

Mfr		Model	FREQUENCY Minimum GHz	Maximum GHz	Accuracy %	Circuit Type	Q Loaded k	Minimum Dip dB	Connector Type	Price $
FM 16	Microlab	X410B	8.2	12.4	0.08	cd	8	20%	UG-39	220
	H-P	X532B	8.2	12.4	0.05	cj	10	1	UG-39	300
	Waveline	698-DR	8.2	12.4	0.08	ce	ina	1	UG-39	reg
	PRD	535	8.2	12.4	±0.08	cd	ina	ina	UG-39	240
	Fel	WDB8212-1W	8.2	12.4	±0.05	c	5	1	UG-39	395
	Diamond	DIC990-1	12.4	15	0.1	a	ina	1.0	UG	300
	Diamond	DIC992-1	12.4	15	0.1	b	ina	1.0	UG	300
	Diamond	DIC991-1	12.4	15	0.1	top wall	ina	1.0	UG	300
	Fel	WCF12150-4W	12	15	±0.01	c	4	ina	UG-419	975
	Fel	WC-12150-1W	12	15	±0.01	c	4	1.5	UG-419	575
FM 17	Fel	WC-12150-3W	12	15	±0.01	b	4	10	UG-419	575
	Fel	WDC-16170-1W	15.8	17.2	±0.01	c	5	1	UG-419	1250
	Fel	WDC-15180-4W	15	18	±0.01	c	3	ina	UG-419	975
	Fel	WC-15180-1W	15	18	±0.01	c	3	1.5	UG-419	575
	Fel	WC-15180-3W	15	18	±0.01	b	3	10	UG-419	575
	Fel	WDC-15180-1W	15	18	±0.01	c	5	1	UG-419	1250
	PRD	536	12.4	18	±0.1	cd	ina	ina	UG-419	340
	Waveline	798-DR	12.4	18	0.1	ce	ina	1	UG-419	reg
	CDC	KU551	12.4	18	0.1	cd	ina	0.5-1	UG-419	350
	H-P	P532A	12.4	18	0.068	ck	10	1	UG-419	350
FM 18	Microlab	Y410B	12.4	18	0.1	cd	4.5	20%	UG-419	260
	Fel	WDB12180-1W	12	18	±0.05	c	3	1	UG-419	395
	Diamond	DIC992-2	15	18.7	0.1	b	ina	1.0	UG	300
	Diamond	DIC990-2	15	18.7	0.1	a	ina	1.0	UG	300
	Diamond	DIC991-2	15	18.7	0.1	top wall	ina	1.0	UG	300
	Fel	WDB18260-1W	18	26.5	±0.05	c	2	1	UG-595	550
	PRD	537-F1	18	26.5	±0.1	cd	ina	ina	UG-595	360
	Waveline	898-DR	18	26.5	0.11	ce	ina	1	UG-595	reg
	CDC	K551	18	26.5	0.11	cd	ina	0.5-1	UG-595	400
	Microlab	K410B	18	26.5	0.1	cd	4	20%	UG-425	370
FM 19	Microlab	K410AF	18	26.5	0.1	cd	4	20%	UG-595	340
	Fel	WDB-26400-1W	26.5	40	±0.05	c	2	1	UG-599	700
	PRD	538-F1	26.5	40	±0.2	cd	ina	ina	UG-599	380
	Waveline	1098-DR	26.5	40	0.3	ce	ina	1	UG-599	reg
	CDC	A551	26.5	40	0.12	cd	ina	0.5-1	UG-599	375
	H-P	R532A	26.5	40	0.083	cm	10	1	UG-599	525
	Microlab	U410AF	26.5	40	0.1	cd	3	20%	UG-599	380
	Microlab	Q410X	33	50	0.15	cd	1.5	15%	UG-383	400
	CDC	B550	33	50	0.2	ce	ina	0.5-1	UG-383	480
	CDC	B551	33	50	0.12	cd	ina	0.5-1	UG-383	600
FM 20	CDC	U550	40	60	0.2	ce	ina	0.5-1	UG-383	460
	CDC	U551	40	60	0.2	cd	ina	0.5-1	UG-383	750
	CDC	V551	50	75	0.2	cd	ina	0.5-1	UG-385	800
	CDC	V550	50	75	0.2	ce	ina	0.5-1	UG-385	450
	Microlab	M410X	50	75	0.2	ce	1.5	15%	UG-385	400
	CDC	E551	60	90	0.2	cd	ina	0.5-1	UG-387	1000
	CDC	E550	60	90	0.25	ce	ina	0.5-1	UG-387	500
	Microlab	E410X	60	90	0.25	ce	1.5	15%	UG-387	480
	CDC	W551	75	110	0.2	cd	ina	0.5-1	UG-387	1200
	CDC	W550	75	110	0.3	ce	ina	0.5-1	UG-387	600
FM 21	CDC	F550	90	140	0.5	ce	ina	0.5-1	TRG-714	650
	Microlab	F412A	90	140	0.5	ce	0.5	15%	special	600
	CDC	D550	110	170	0.5	ce	ina	0.5-1	TRG-716	700
	Microlab	G413A	180	220	0.5	ce	1	20%	special	680
	CDC	G550	140	220	0.7	ce	ina	0.5-1	TRG-715	750
	Microlab	G412A	140	220	0.5	ce	0.5	15%	special	720

a. Circuit type: single ended.
b. Circuit type: transmission.
c. Circuit type: absorption.
d. Direct reading.
e. Micrometer.
f. Also used as fm discriminator.
g. Circuit type: cavity
h. Accuracy: Dial accuracy only. Overall accuracy which includes dial accruacy, 20°C temperature variation and 0-100% humidity variation is 0.065%.
i. Same as note h except overall accuracy 0.075%.
j. Same as note h except overall accuracy 0.08%.
k. Same as note h except overall accuracy 0.1%.
m. Same as note h except overall accuracy 0.12%.
n. Same as note h except overall accuracy 0.17%, type N connectors.
p. Circuit type: Heterodyne.
q. Circuit type: Resonent transistor amplifier.
r. Circuit type: Resonance.
s. Accuracy: From 600-2000 MHz, ±0.15% from 470-600 MHz and 2000-2500 MHz. Sensitivity to 800 MHz 60 mV above 800 MHz.
t. Circuit type: IC.

Index by Model Number

Name	Model	Code
CDC	A551	FM19
Control Data	B550	FM19
Corp., TRG	B551	FM19
Inc.	D550	FM21
	E550	FM20
	E551	FM20
	F550	FM21
	G550	FM21
	K551	FM18
	KU551	FM17
	U550	FM20
	U551	FM20
	V550	FM20
	V551	FM20
	W550	FM20
	W551	FM20
Diamond	DIC590-1	FM8
Diamond	DIC590-2	FM8
Antenna &	DIC591-1	FM8
Microwave	DIC591-2	FM8
Corp.	DIC592-1	FM8
	DIC592-2	FM8
	DIC690-1	FM10
	DIC690-2	FM10
	DIC691-1	FM10
	DIC691-2	FM11
	DIC692-1	FM10
	DIC692-2	FM10
	DIC790-1	FM11
	DIC790-2	FM12
	DIC791-1	FM10
	DIC791-2	FM12
	DIC792-1	FM11
	DIC792-2	FM12
	DIC890-1	FM12
	DIC890-2	FM14
	DIC890-3	FM15
	DIC891-1	FM12
	DIC891-2	FM14
	DIC891-3	FM15
	DIC892-1	FM12
	DIC892-2	FM14
	DIC892-3	FM15
	DIC990-1	FM16
	DIC990-2	FM18
	DIC991-1	FM16
	DIC991-2	FM18
	DIC992-1	FM16
	DIC992-2	FM18
	DIC2090	FM3
	DIC2091	FM4
	DIC2092	FM5
	DIC2093	FM6
Fel	WC-510-1N	FM2
Frequency	WC-912-1N	FM3
Engineering	WC-912-3N	FM3
Labs.	WC-1217-1N	FM3
	WC-1217-3N	FM3
	WC-1628-1N	FM4
	WC-1628-3N	FM4
	WC-2335-1N	FM4
	WC-2335-3N	FM4
	WC-3545-1N	FM5
	WC-3545-3N	FM5
	WC-3545-1W	FM8
	WC-4458-1W	FM8
	WC-4458-3W	FM8

Name	Model	Code
	WC-5264-1W	FM9
	WC-5264-3W	FM9
	WC-5882-1W	FM10
	WC-5882-3W	FM10
	WC-7010-1W	FM13
	WC-7010-3W	FM13
	WC-8211-1W	FM14
	WC-8211-3W	FM13
	WC-8397-1W	FM12
	WC-8397-3W	FM12
	WC-9611-1W	FM13
	WC-9611-3W	FM13
	WC-11120-1W	FM15
	WC-11120-3W	FM14
	WC-12150-1W	FM16
	WC-12150-3W	FM17
	WC-15180-1W	FM17
	WC-15180-3W	FM17
	WCF-510-4N	FM2
	WCF-912-4N	FM3
	WCF-1217-4N	FM3
	WCF-1628-4N	FM4
	WCF-2335-4N	FM4
	WCF-3545-4N	FM5
	WCF-4458-4N	FM5
	WCF-5882-4N	FM6
	WCF-8211-4N	FM6
	WCF-9611-4W	FM13
	WCF-10711-4W	FM14
	WCF-11120-4W	FM15
	WCF-12150-4W	FM16
	WDA-940	FM5
	WDA-3712	FM6
	WDB-1020-1N	FM3
	WDB-4080-1N	FM6
	WDB-8212-1W	FM16
	WDB-12180-1W	FM18
	WDB-18260-1W	FM18
	WDB-26400-1W	FM19
	WDC-3645-1N	FM5
	WDC-3645-1W	FM8
	WDC-5459-1W	FM9
	WDC-5459-3W	FM9
	WDC-5465-1W	FM10
	WDC-5464-3W	FM10
	WDC-5965-1W	FM9
	WDC-5965-3W	FM9
	WDC-7585-1W	FM11
	WDC-7585-3W	FM11
	WDC-8011-1W	FM14
	WDC-8596-1W	FM12
	WDC-9095-1W	FM11
	WDC-9197-1W	FM12
	WDC-10110-1W	FM14
	WDC-10110-3W	FM14
	WDC-15180-1W	FM17
	WDC-15180-4W	FM17
	WDC-16170-1W	FM17
Gen Micro	N604	FM4
General	N607	FM3
Microwave	N608A	FM6
Corp.	N610	FM6
Gertsch	FM9E	FM1
Gertsch	FM10	FM2
Products		
Singer		
Instrumen-		
tation		

Name	Model	Code
GR	1142-A	FM1
General		
Radio Co.		
H-P	536A	FM5
Hewlett	537A	FM7
Packard Co.	G532A	FM9
	J532A	FM11
	H532A	FM13
	P532A	FM17
	R532A	FM19
	X532B	FM16
Lampkin	103-B MFM	FM1
Lampkin	105-B MFM	FM2
Labs.		
Marconi	6049/1	FM6
Marconi	6049/2	FM7
Instru-	6050/3	FM3
ments	6051	FM6
Measure	159LF	FM1
Measure-	159RF	FM2
ments	159UHF	FM2
	760	FM2
Microlab	C410B	FM11
FXR/Micro-	E410X	FM20
lab	F412A	FM21
	G412A	FM21
	G413A	FM21
	H410A	FM9
	K410AF	FM19
	K410B	FM18
	M410X	FM20
	Q410X	FM19
	U410AF	FM19
	W410B	FM13
	X410B	FM16
	X411A	FM14
	Y410B	FM18
PRD	CX-518	FM7
PRD Elec-	LS-518	FM5
tronics	532	FM9
	533	FM11
	534	FM13
	535	FM16
	536	FM17
	537-F1	FM18
	538-F1	FM19
	587-A	FM2
R-S	WAL	FM4
Rohde &	WAM	FM2
Schwarz	WAT	FM5
	WEN	FM1
Sell-Tronic	401A	FM1
Sell-Tronic		
Products		
Co.		
Waveline	398-DR	FM9
Waveline,	498-DR	FM11
Inc.	598-DR	FM13
	698-DR	FM16
	798-DR	FM17
	898-DR	FM18
	1098-DR	FM19
Weston/Lex	300	FM1
Weston-	301	FM1
Lexington	301C	FM1
	302	FM1

Infinite VSWR...improved gain...Ultraceramic package

TRW was first to break the Gigahertz barrier in RF Power Transistors. Now our technology has produced new state of the art ruggedized power at 1 GHz. The new 3 watt 2N5764 and 5 watt 2N5765 offer significant performance advantages over the older 2N4430 and 2N4431.

They will withstand severe mismatch – any load, any phase. Gain is increased to 6 dB and efficiency to 40%. Both operate from a 28 volt source. Both are in advanced ultraceramic stripline packages.

Contact any TRW distributor or TRW Semiconductors Inc., 14520 Aviation Blvd., Lawndale, California 90260. Phone: (213) 679-4561. TWX: 910-325-6206.

TRW Semiconductors Inc., is a subsidiary of TRW Inc.

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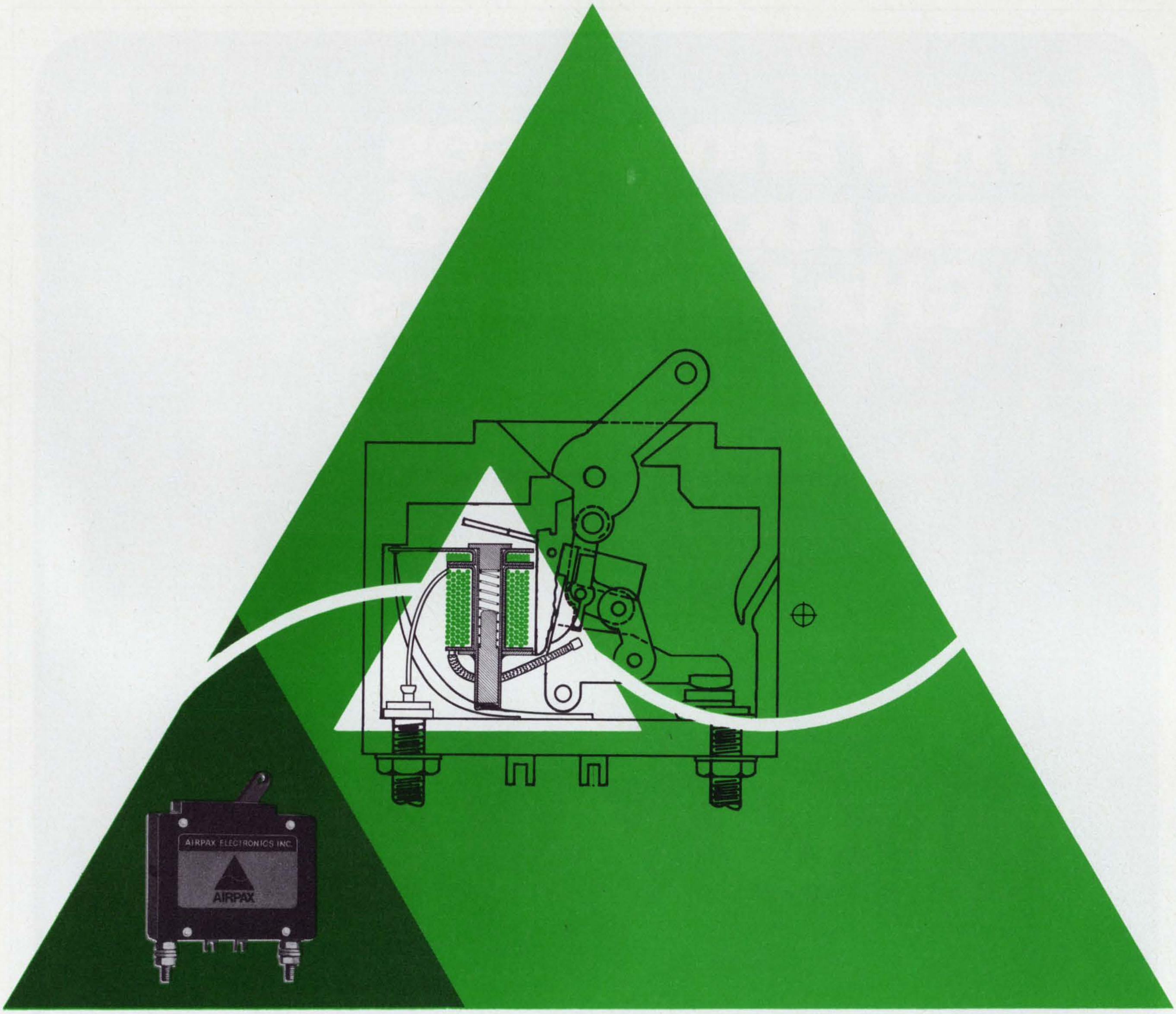
INFORMATION RETRIEVAL NUMBER 43


AIRPAX

New Products

High-speed plated-wire read-only memories can electronically alter stored-program data

Memory Systems, Inc., 3341 El Segundo Blvd., Hawthorne, Calif. Phone: (213) 772-4220. P&A: 5¢ to 10¢/bit; from 60 days.

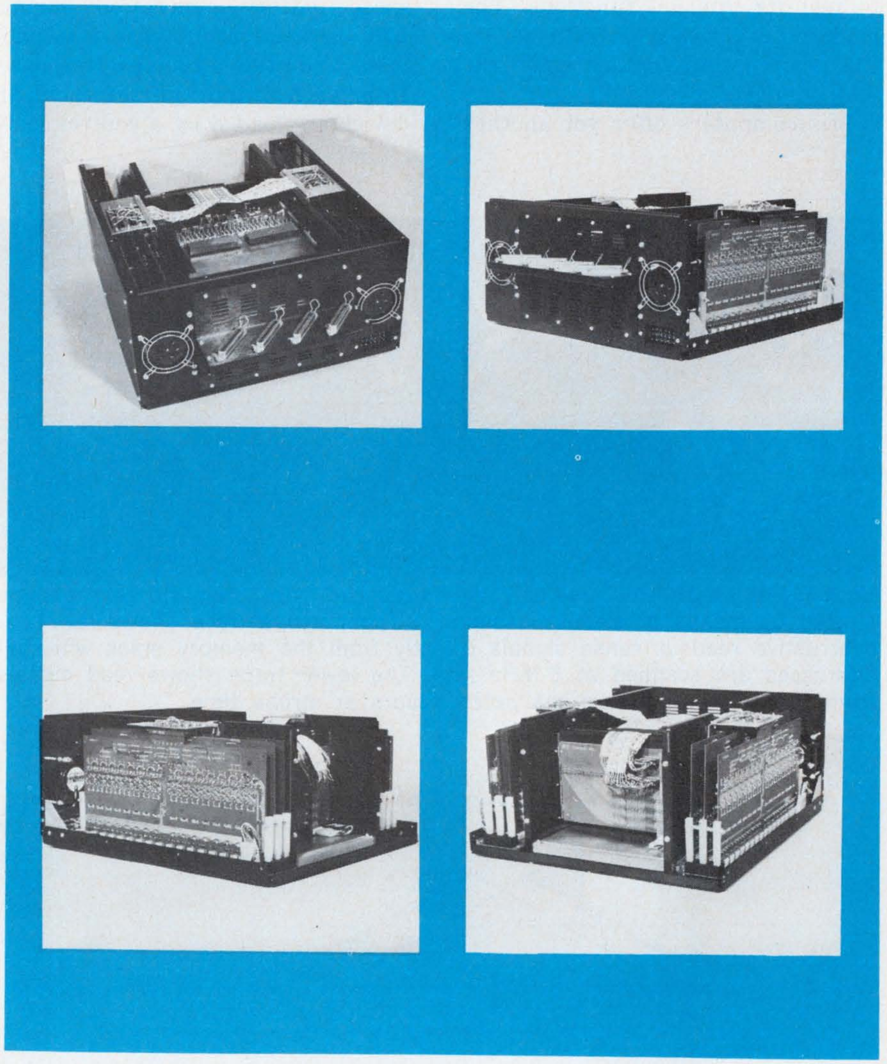
Electrically alterable read-only memories may be a new phrase for the seventies and, perhaps, will mean a new era in memory technology. From Memory Systems, Inc. comes a new family of plated-wire memories that can read at speeds as fast as 125 ns, and yet can be written into at the not-so-moderate rate of 1 μs.

What does all this mean to you, the engineer who designs, specifies or uses memories? Now, instead of returning the memory to the manufacturer for mechanical alteration of its stored program, you can change this stored data with electronic signals.

Simply and directly, control sequences generated by the memory can be changed at will, through standard interfacing already existing in a system. In addition, minor program changes, often the undoing of many computer operations, can be easily corrected without removing the memory and mechanically changing its contents.

Immediate applications for the new electrically alterable read-only memory include variable control

(continued on next page)



Also in this section:

(continued from page 95)

storage for central processing units, and character generation and display format control for CRT terminals.

Automatic system testing is another possibility. A machine's internal control sequence could be changed to execute different operations, thereby allowing the machine to test its internal functions. The machine could then be returned to the desired architecture after the test sequence.

Minicomputers offer yet another fertile field. Far more computing power could be made available from an already low-cost minicomputer system—for example, under software control in real time, a machine can be structured to efficiently run FORTRAN, COBOL or special languages for command, control or simulation applications.

The new memory could also be used as a control storage for high-speed pattern generation during LSI circuit testing. The test pattern and the expected response from each output pin of the LSI device are loaded by a control computer, paper tape, or even by hand switches. Then, the memory is set to its high-speed read mode, and the pattern is emitted at rates as fast as 10 MHz. The 1-μs write speed is acceptable since the pattern is assembled by a computer and usually loaded by an I/O line.

A typical plated-wire memory system is organized around a matrix of, for instance, 256 word straps with a diode or transistor word-selection array and 32 plated-wire bit lines (as shown in the block diagram). This factoring is typical and others are easily obtained.

With the selection of one word strap, 32 nondestructive readout signals are generated, converted to logic levels by IC sense amplifiers, and presented for interfacing. This output signal is now the control micro-instruction.

Writing can be accomplished through low-cost IC logic gates, which operate as digit drivers and are loaded from conventional logic interface. The low writing speed eliminates the need for critical timing and costly arrangements for fast recovery from write transients. The latter is often a problem in high-speed read/write memories.

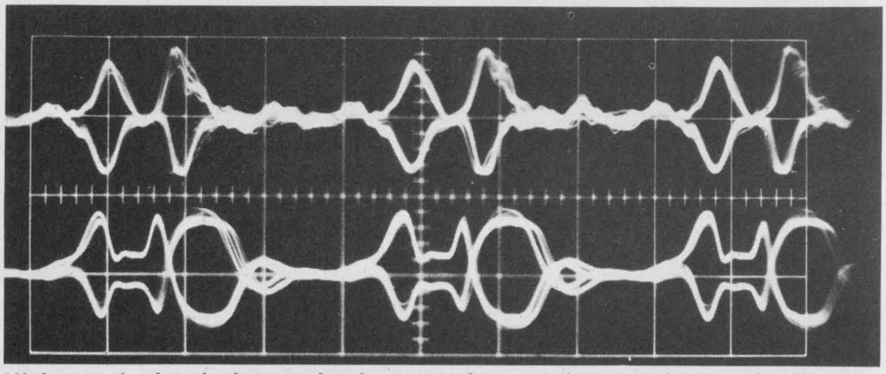
The writing circuits may be placed under an interlock so that only authorized personnel or software instruction can have access. It is even possible to physically remove the write circuits when they are packaged on a plug-in module for total stored-program control.

The new memories form a complete family of devices offering a wide choice of speeds, sizes and packages. The first systems will stress speed, providing read cycle times of 125 ns and access times of 70 ns. Economy systems will operate with 300-ns read times and 100-ns access time. Write time will be 1 μs for all standard systems.

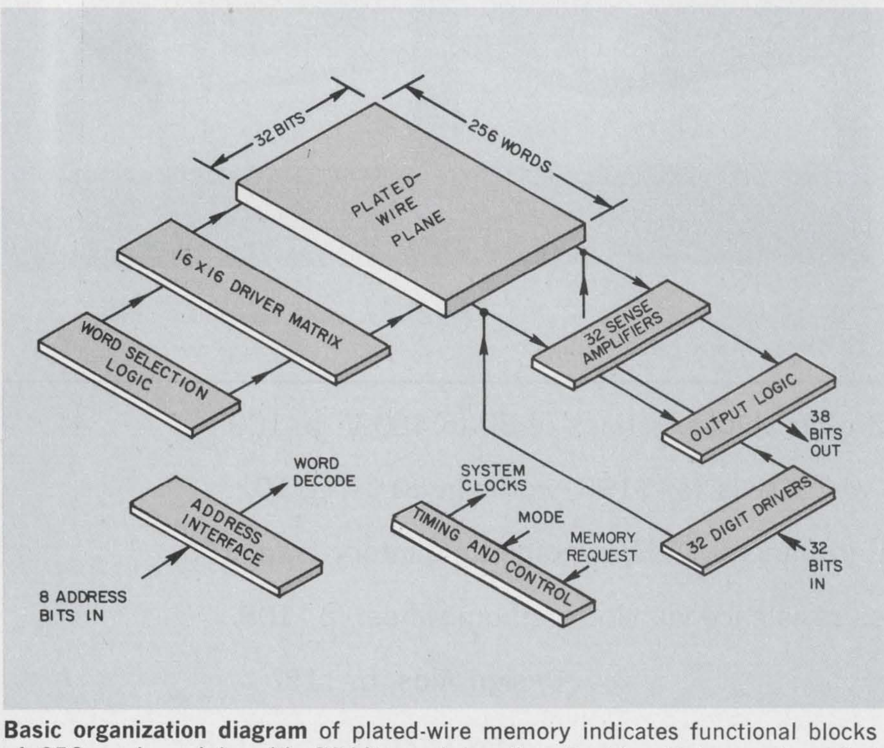
Initially, the systems will be packaged in a relay rack for use as peripheral equipment. Smaller systems, which will be available by mid-year, will be on large plug-in cards for use in minicomputer cabinets.

Sizes, which are based on a 256-word module, run from 8 to 160 bits. Modules can be easily stacked for larger-size systems.

CIRCLE NO. 250

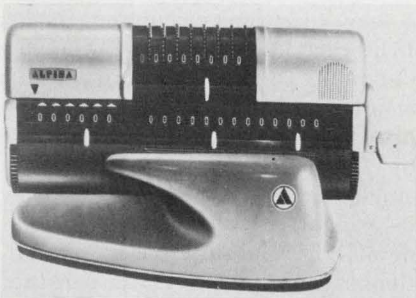


High-speed plated-wire read-only memories can have their stored programs altered by means of electronic signals. Upper scope trace shows raw nondestructive readout sense signals directly from the memory stack while all addresses are scanned at 5-MHz rate. The lower trace shows read signals from the sense amplifier; the notch occurs at strobe time.



Basic organization diagram of plated-wire memory indicates functional blocks of 256-word module with 32-bit word lengths. Besides high speed, plated wire offers non-destructive non-volatile readout and high density.

Portable calculator is size of billfold

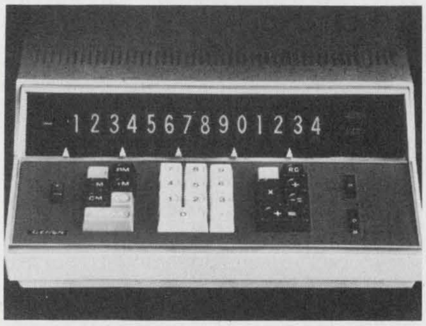


Alpina of West Germany (manufacturer), Raymond Packer Co. (distributor), 66 Myron St., West Springfield, Mass. Phone: (413) 739-9220. Price: $148.

Designed for desk and field use, a portable universal calculator is only the size of a billfold and weighs but 19-1/2 oz. The unit has a capacity of 8 by 6 by 13 digits, and can add, subtract, multiply or divide. Simple slide movements allow uncomplicated decimal point settings, and end-to-end tens transfer permits short-cut multiplication.

CIRCLE NO. 251

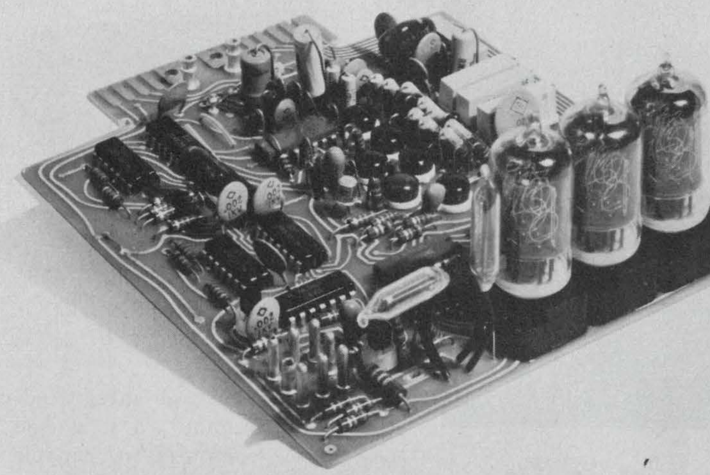
Low-cost calculator totals automatically



Nippon Columbia Corp. of America, 6 E. 43rd St., New York, N.Y. Phone: (212) 661-5530. Price: $895.

The Denon 621 electronic calculator, which retails for only $895, features a sophisticated memory system with automatic accumulation of grand totals and individual extensions. Other performance advantages include automatic chain discounting, automatic decimal positioning, and floating and raise functions. The display uses 14 Nixie tubes. This new calculator can also handle constants automatically.

CIRCLE NO. 252



INFORMATION RETRIEVAL NUMBER 45

Desktop calculator incorporates memory

Canon U.S.A., Inc., 64-10 Queens Blvd., Woodside, N.Y.

With its built-in memory system, a new desktop calculator, model 141, can perform many complex calculations. The unit, which weighs just over 13 pounds, measures 6-in. high by 12-1/2-in. wide by 15-1/2-in. deep. It features a single back-spacer, a reverse key to exchange factors, and an overflow light and interlock. In addition, it has an automatic constant for multiplication and division.

CIRCLE NO. 253

Calculator/computer programs 128 steps

Eugene Dietzgen Co., 2425 N. Sheffield, Chicago, Ill. Phone: (312) 549-3300.

Using large-scale integrated circuitry throughout, a new desktop calculator/computer is capable of accepting up to 128 programming steps by means of its self-contained Learn-Mode programming module. This programmer carries all the logic necessary to develop programs; no special computer language is necessary. There are 10 recallable memory storage registers.

CIRCLE NO. 254

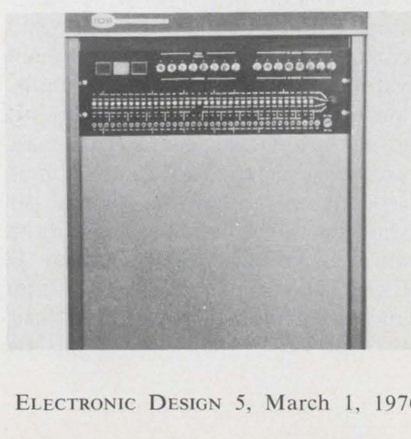
Computer for $1800 stores 512 bytes

Unicom, Inc., Fairfield, N.J. Price: $1800.

Said to be the lowest price computer available, the CP-8A general-purpose $1800 computer features a 1.5-μs cycle time, 512 bytes of read-only memory, four hardware scratchpad registers, and a set of 40 byte-oriented instructions. In addition, a powerful set of I/O instructions allow the unit to address up to 1024 external devices. Two I/O operation modes permit use as a peripheral device or a computer.

CIRCLE NO. 255

Disc drive controller frees computer functions

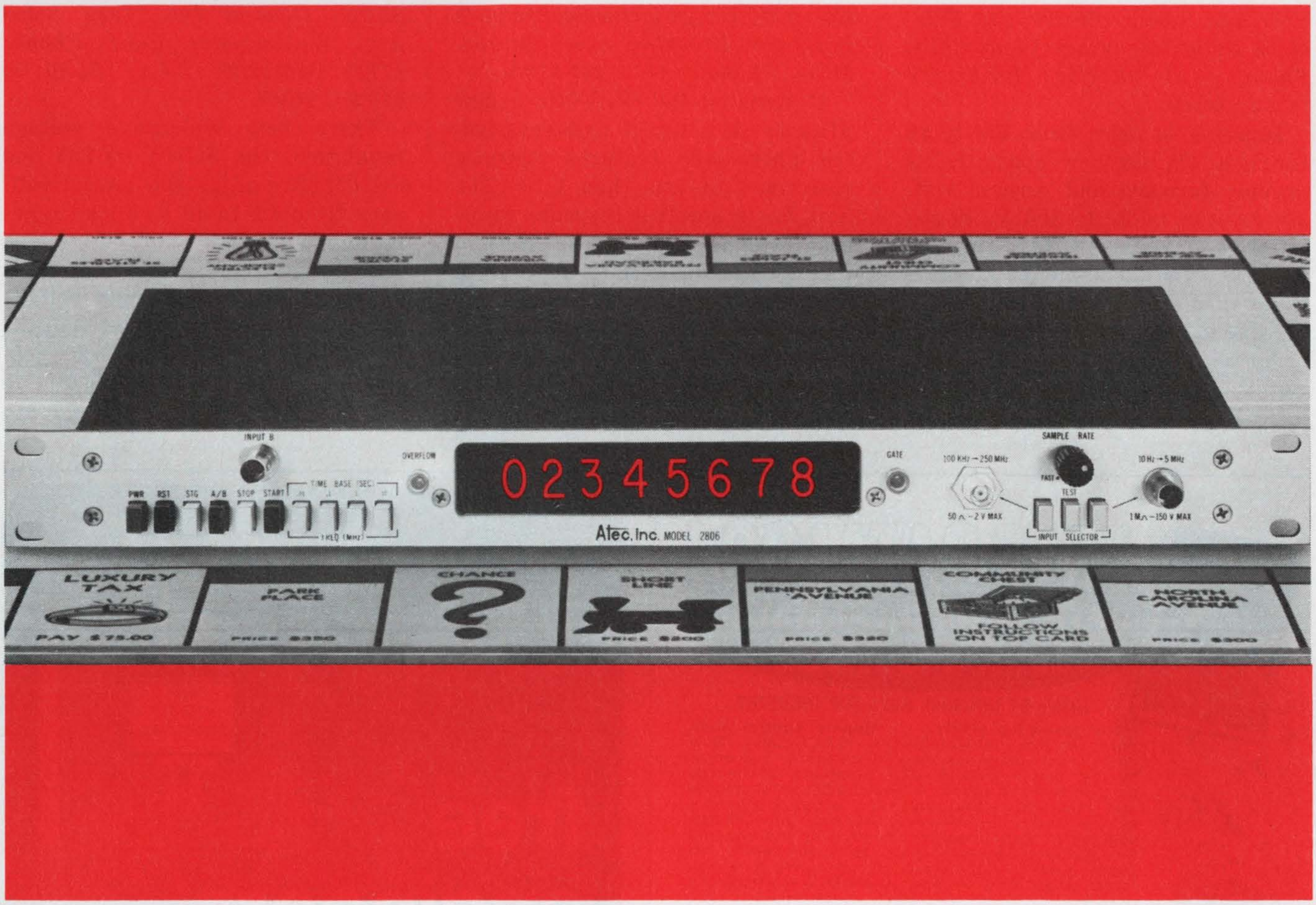


KDI Interactive Data Systems, Inc., 17785 Sky Park Circle, Irvine, Calif. Phone: (714) 549-3329. P&A: from $6000; 30 to 60 days.

A new disc drive controller that enables mini-computers to provide expanded data bases is now available. Called the DC-16, the unit interfaces with all available minicomputers and from one to eight IBM 2311 or 2312 disc drives. The controller can take over software functions and also provides for simultaneous seek operations.

CIRCLE NO. 256

COUNT DIRECTLY TO 250 MHZ. DO NOT PRESCALE. DO NOT PAY MORE THAN $1395.



■ This 1¾-inch-high Atec 2806 Frequency Counter has a monopoly in the range from 10 Hz to 250 MHz. It operates without prescaling or additional computation, it also measures ratio and totalizes, and its input sensitivity is 50 mV over the entire range. It costs $1395.

■ Eight-digit readout, readout storage (for both the display and the BCD 1-2-4-8 digital output), remote programming, and a register overflow indicator are included at no extra cost. The optional oven-stabilized crystal adds $75.

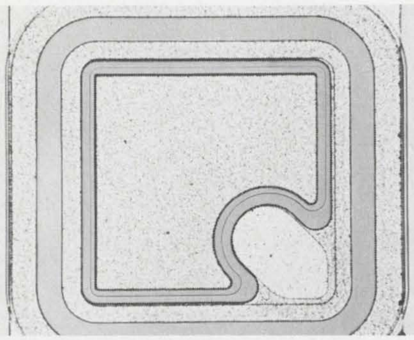
■ Circle the reader service number below and we'll send you a complete data sheet **plus** a reprint of Electronic Design's recent Product Source Directory which compares the Atec 2806 with every other counter in its class. It will be quite clear that no one but Atec can get you anywhere near 250 MHz for $1395 . . . a simple case of getting Boardwalk quality for Marvin Gardens prices.

Atec, Inc.

1125 LUMPKIN STREET, HOUSTON, TEXAS • PHONE (713) 468-7971
MAILING ADDRESS: P.O. BOX 19426 • HOUSTON, TEXAS 77024

INFORMATION RETRIEVAL NUMBER 47

Epoxy SCRs for 77¢ handle 30 to 400 V

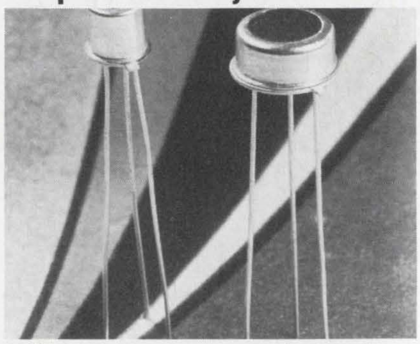


Fairchild Semiconductor, 313 Fairchild Drive, Mountain View, Calif. Phone: (415) 962-3563. P&A: 77¢ to $2; stock.

Ranging in price from 77¢ to $2 for 1 to 99, six new epoxy SCRs provide forward and reverse voltage ratings of 30 to 400 V. Registered as types 2N5787 through 2N5792, the lead-mount devices come in a TO-106 package, which has the same circular pin configuration as the popular TO-19 metal can.

CIRCLE NO. 257

Widerange photodiode responds in just 1 ns

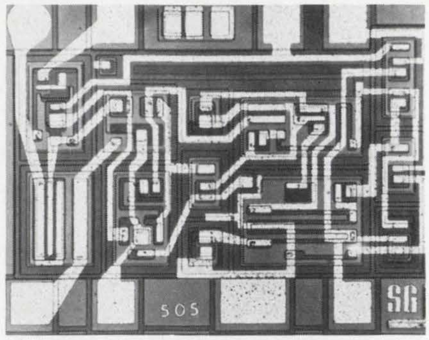


EG & G, Inc., Electronic Products Div., 160 Brookline Ave., Boston, Mass. Phone: (617) 267-9700.

Designated the SGD-040, a new planar-diffused oxide-passivated photodiode features response rise times of less than 1 ns. The unit has a spectral response range that extends from 0.35 microns in the UV region to 1.13 microns in the near-IR region. Its sensitivity is 0.5 amperes per watt at 0.9 microns, and its dark leakage current is less than 1 nA.

CIRCLE NO. 258

Monolithic regulators hold 0.06%/V at 40 V

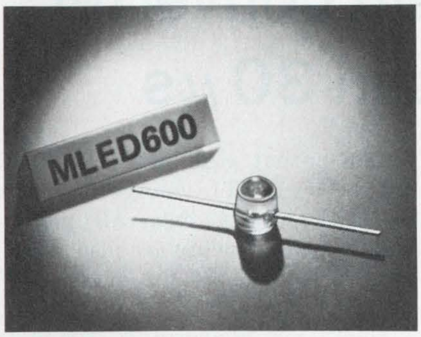


Silicon General Inc., 7382 Bolsa Ave., Westminster, Calif. Phone: (714) 839-6200. P&A: $4.80 to $16.90; stock.

Three new widerange voltage regulators, the SG105, SG205 and SG305, offer adjustable output voltages from 4.5 to 40 V, a load regulation of better than 0.01%/mA and a line regulation of at least 0.06%/V. With their input voltage rating of 50 V, the devices will deliver load currents up to 20 mA. Two packages are available.

CIRCLE NO. 259

Plastic red LED retails for $2.05

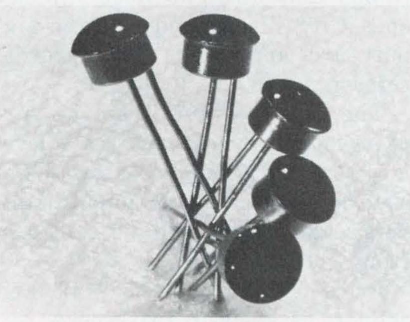


Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Ariz. Phone: (602) 273-6900. P&A: $1.45 to $2.05; stock.

Housed in a plastic package, the type MLED600 light-emitting diode sells for $2.05 in 100-up quantities and $1.45 in 1000-up quantities. The new device emits in the visible red wave band with typical peak emission at 660 nm. Minimum brightness is 50 foot-lamberts at 10 mA; typical brightness is 700 foot-lamberts at currents above 40 mA.

CIRCLE NO. 260

Phototransistors sense 0.4 to 10 mA

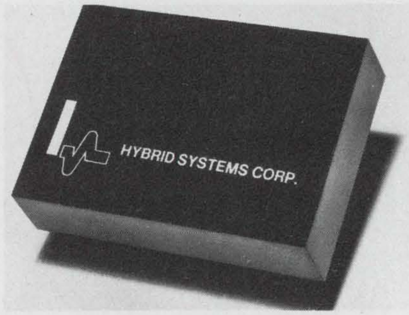


Texas Instruments Inc., Components Group, P.O. Box 5012, Dallas, Tex. Phone: (214) 238-2011. P&A: 67¢ to $1; 2 wks.

Supplied in a two-lead sealed package, a new line of low-cost npn planar silicon phototransistors features a minimum light current sensitivity of 0.4 to 10 mA. Specifically types TIL-63, -64, -65, -66 and -67 have a minimum light current sensitivity range of 0.4 mA, 0.4 to 1.6 mA, 1 to 4 mA, 2.5 to 10 mA, and 6 mA, respectively.

CIRCLE NO. 261

Modular $195 a/d converter handles 10 bits in 30 μs



Hybrid Systems Corp., 95 Terrace Hall, Burlington, Mass. Phone: (617) 272-1522. P&A: $195; stock to 4 wks.

Costing only $195 in quantities from one to nine, a new analog-to-digital converter can translate a full 10 bits in less than 30 μs. Model 501 is a fully encapsulated module that is suitable for printed-circuit mounting with its dimensions of 2.8 × 4.1 × 0.625 in.

The unit employs a very fast-settling digital-to-analog converter to internally generate a ramp. When the voltage level of this ramp equals that of the input signal, the ramp no longer increases. The signal level contained in the d/a converter at this time corresponds to the signal being converted.

Input signals can range from 0 to +10 V. By using an external trimming resistor, however, the input can be adjusted over the range of ±5 V.

Model 501 is completely self-sufficient. It contains its own reference sources, its own clock signal, and all the digital logic necessary for operation.

The output code, which is compatible with TTL voltage levels, is a 10-bit binary one. All power-supply requirements are also standard—±15 V at 30 mA and +5 V at 300 mA.

Operating temperature range is −25 to +75°C, and accuracy-versus-temperature drift is 25 ppm/°C. Device input impedance is 10 kΩ.

Also being released at this time is a fast-settling digital-to-analog converter with a novel feature. This feature is a variable reference voltage that may be externally applied over the range of 0 to +10 V.

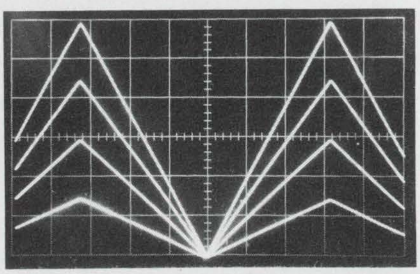
Of particular importance to CRT display applications, the 340E offers a settling time of 200 ns to 0.05% with a digital input. Settling time to 0.05% increases to 2 μs when the reference varies from 0 to +10 V.

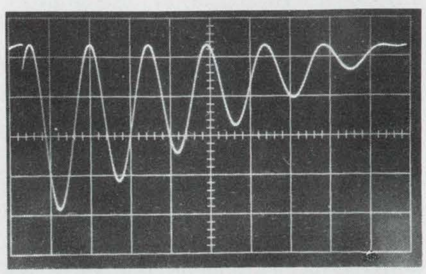
In effect, the 340E d/a converter multiplies its reference by the digital input signal. This means that it can be used to position ramps and straight lines directly on a CRT display, when these signals are applied as the external reference.

The unit's output is a true current source, whose full-scale level is 10 mA. By using external resistors (without operational amplifiers), the output voltage can vary from −10 to +2 V.

Price for the 340E is $149, and delivery is stock to two weeks.

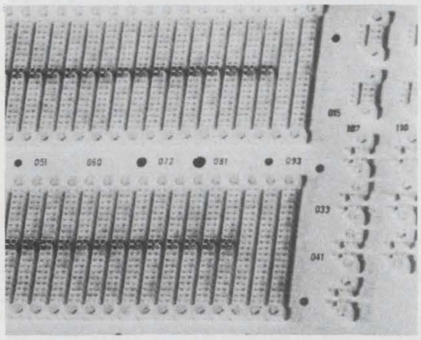
CIRCLE NO. 262





High-speed a/d converter for $195 and d/a converter for $149 handle 10-bit binary data. Scope traces show resulting output when triangular wave (left) or sinusoid (right) is applied as the variable reference to the d/a converter.

Tiny 5-W PC-card supply powers 1000 logic gates

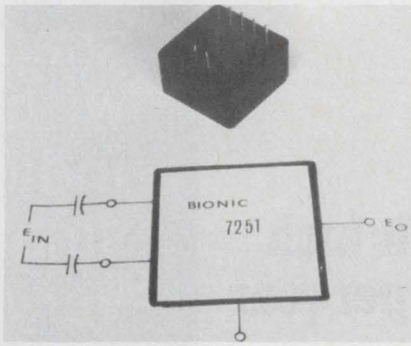


Semiconductor Circuits, Inc., 163 Merrimac St., Woburn, Mass. Phone: (617) 935-5200. P&A: $35; stock.

Measuring 4.5 × 3 × 2 in., the model 1.5-1000 PC-card power supply can drive 1000 logic gates with 5 watts of output power. Its output of 5 V dc at 1 A is regulated to 0.1% with ripple and noise at 2 mV rms. Input requirements are 105 to 125 V ac, 50 to 400 Hz, and temperature coefficient is 0.02%. It is short-circuit proof and is mated for a 10-pin PC connector.

CIRCLE NO. 263

Wideband amplifier holds noise to 1 μV

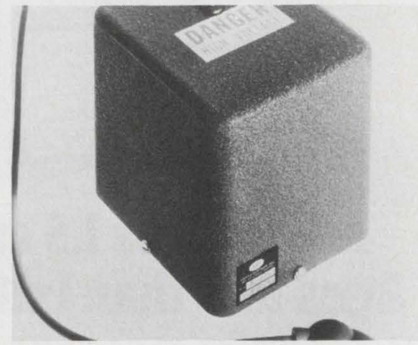


Bionic Instruments, Inc., 221 Rock Hill Rd., Bala Cynwyd, Pa. Phone: (215) 839-3250. P&A: $30; 2 to 4 wks.

Providing 100 dB of common-mode rejection ratio without external compensation, a new amplifier offers an equivalent input noise of less than 1 μV rms. Model 7251 responds from 0.1 Hz to 15 MHz, has internal biasing and its input impedance is 3 MΩ. Differential-input signals can be capacitively coupled where dc-isolation applications are required.

CIRCLE NO. 264

Regulated CRT supply boasts a cost of $89.50

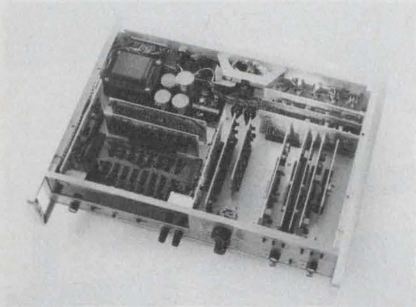


Sierra Systems, Inc., 2255 Old Middlefield Way, Mountain View, Calif. Phone: (415) 969-3056. P&A: $89.50; stock.

Providing 0.1% ripple and regulation for computer display applications, a new CRT power supply costs only $89.50. The model 725 delivers 12000 V at 250 μA, with extra outputs of +400 and −100 V at 1 mA each for focus and intensity controls. It uses push-pull dc-to-dc conversion, and operates from ±25 to 30 V or ±12 to 18 V. It is also short-circuit proof.

CIRCLE NO. 265

Timer/counters + DVM are systems instruments



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $1195 or $1550; 4 wks.

Recognize this feature? Even ELECTRONIC DESIGN can occasionally err, and we like to make amends as soon as possible.

Two instruments (ED 2, January 18, p. 106, circle no. 263) currently make up Hewlett-Packard's new series 5326 family of timer/counters; the 5326A is a timer/counter alone, while the 5326B is a timer/counter/DVM in a single package.

Besides extending frequency performance out to 50 MHz, both instruments feature a measurement technique called time-interval averaging. This allows a reduction in the significance of the plus-and-minus-one-count error. For example, a resolution of 10 ps can now be achieved by averaging 10^8 repetitive intervals.

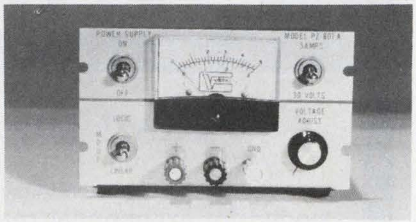
The 5326B incorporates a two-to-six-digit voltmeter (not seven digits as reported earlier), depending on measurement gate time, which ranges from 1 ms to 10 s. Unlike previous counter/DVMs, the new instrument does not completely separate the frequency and voltage measuring functions.

With its internal DVM, the 5326B can read the dc level of its own trigger level settings. When making time-interval measurements, the user can now precisely know the dc level of the start and stop trigger points, and the time between them. In addition, measurement of 10-to-90% rise times can be made with DVM certainty of the voltage levels. Other voltage-dependent time-interval measurements can also be made simply.

Our earlier story carries more detailed specifications.

CIRCLE NO. 266

Regulated power supply drives down cost to $78

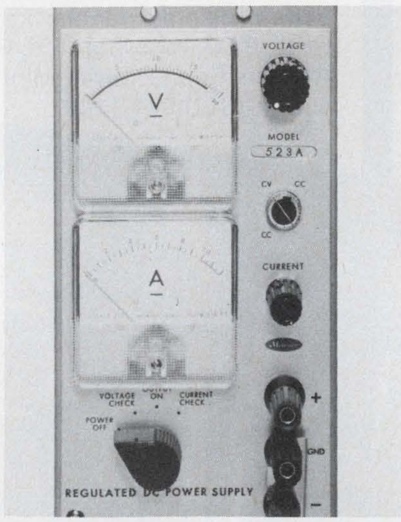


Viking Electronics Inc., 721 St. Croix, Hudson, Wis. Phone: (612) 436-7204. P&A: $78; stock.

Providing two outputs, each in a different regulation mode, a new power supply retails at only $78. The PZ-801-A provides 0 to 25 V at 5 A at 0.2% regulation and 10 mV of ripple. By flipping a switch, the output becomes 0 to 25 V at 1 A at 0.1% regulation and 1 mV of ripple. Remote sensing and programming, a floating output and current limiting are also included.

CIRCLE NO. 267

Metered power supply retails at only $119

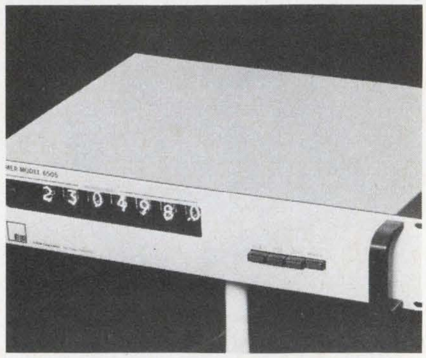


Metronix Inc., Box 1316, Danbury, Conn. Phone: (203) 744-7272. P&A: $119; stock.

With separate meters monitoring voltage and current, a new constant-voltage constant-current power supply costs only $119. The model 523A has an output of 0 to 18 V dc at 1 A and features automatic crossover. An indicator shows the voltage or current mode and also acts as a pilot light. The supply has remote sensing terminals and is available in a 0-to-35 V dc model at 0.5 A.

CIRCLE NO. 268

Time-interval counter resolves time to 0.1 μs

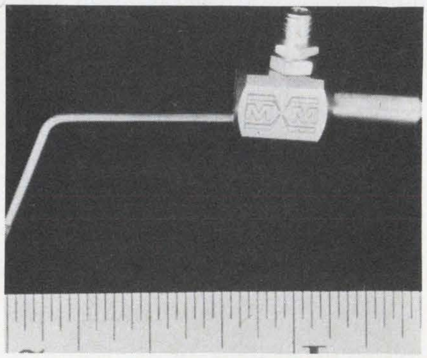


Itron Corp., 11675 Sorrento Valley Rd., San Diego, Calif. P&A: $650; 30 days.

Designed for precise, timing applications, a new seven-decade time-interval counter resolves time to 0.1 μs. Used with a 10-MHz clock-oscillator, the model 6505 begins counting upon receipt of a positive-going "A" input. It stops upon receipt of a positive-going "B" input. The displayed count is held, and restarting is prevented until a "Restart" command is given.

CIRCLE NO. 269

High-frequency probe tests large-scale ICs



The Micromanipulator Co., 1120 Industrial Ave., Escondido, Calif. Phone: (714) 746-5600. Availability: stock.

Containing a 30-in. coaxial cable and a BMC adaptor, a new LSI probe tests large-scale integrated circuits wherever high-frequency or low-level testing is needed. It is the only coaxial probe specifically designed for testing LSI. It has a 50-Ω impedance, and an insulation resistance greater than 10,000 MΩ at 500 V dc. The probe point has a radius that is less than 0.0001 in.

CIRCLE NO. 270

80 MHz WIDEBAND RF POWER AMPLIFIER

MODEL RF-805

- 10 Watts Output into 50Ω
- 0.1 Volts In — 22.5 Volts Out
- .05 MHz to 80 MHz Broadband
- Low Distortion
- Solid State
- Flat 47 db Gain

The RF-805 is a solid state amplifier, broadband from .05 to 80 megahertz, which produces ten watts with −30 db harmonic and intermodulation distortion. Lower distortion is available at lower output levels. Gain is 47 db minimum, constant within 1 db, so that full output is developed with less than 0.1 volt at the 50 ohm input. Accurate output metering and overload protection is provided.

The RF-805 will raise the power of most manual and swept tuned signal generators and thus extend the usefulness and versatility of available signal generators. Receiver testing, wattmeter calibration, antenna testing, RFI testing, attenuator measurements, and filter and component testing will be aided with the use of this equipment.

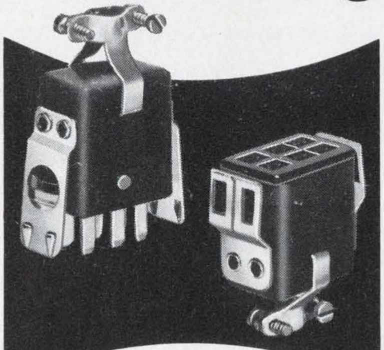
rf R F COMMUNICATIONS, INC.
1680 University Avenue • Rochester, N. Y. 14610

INFORMATION RETRIEVAL NUMBER 59

Set an improved *PDQ standard by comparing with

BEAU

Connectors



Series 3300

***PDQ:**

Price — right
Delivery — dependable
Quality — proved

BEAUPLUG® Series 3300 electrical connectors, for instance, have been developed to provide a reasonably priced, reliable, versatile connector for chassis, cable and modular use where space is not a prime consideration.

Visit Booth No. 26
NEPCON CENTRAL, Chicago
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Vernitron Electrical Components
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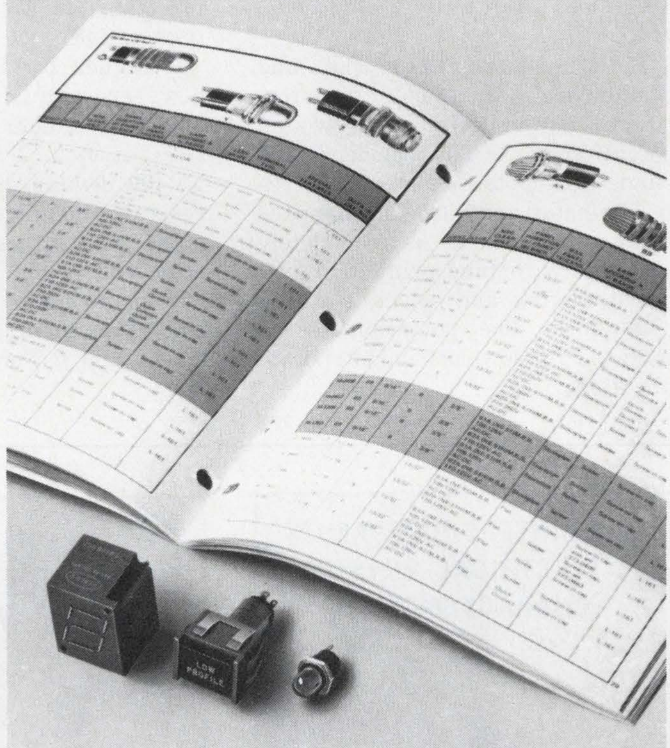
Tel: (603) 524-5101 TWX: 710-364-1843

INFORMATION RETRIEVAL NUMBER 60

The newest, fastest and easiest way to specify indicator lights, push button switches and readouts.



Dialco's new 56-page product selector guide helps you select from over 1,500,000 visual indicators

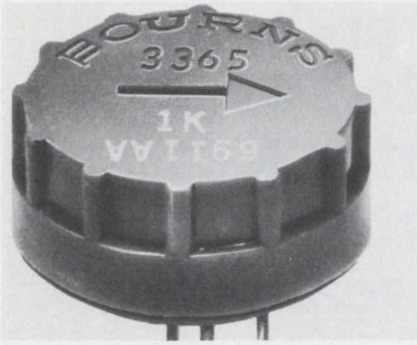
This book is the result of an all-out effort to provide you with fingertip data on all Dialight components and to make it very easy for you to locate the detailed specs and information you desire. Designers and engineers will find the "Product Selector Guide" invaluable in their work. Send for your copy today. Dialight Corp. 60 Stewart Ave., Brooklyn, N.Y.11237.

DIALCO

DIALIGHT
A North American Philips Company

INFORMATION RETRIEVAL NUMBER 61

Single-turn pot adjusts 2 ways

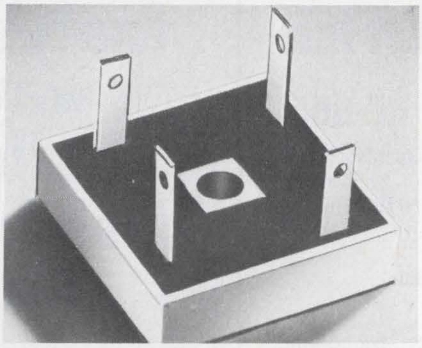


Bourns, Inc., 1200 Columbia Ave., Riverside, Calif. Phone: (714) 684-1700.

Both screwdriver slot and thumbwheel adjustments are offered on a new redesigned wirewound potentiometer. The model 3365 single-turn potentiometer has 1/2-in. diameter and 0.020-in. diameter terminal pins. It is completely sealed to withstand printed circuit-board fluxing and solvent bathing techniques. The potentiometer is intended for low-cost industrial applications.

CIRCLE NO. 271

Tiny bridge rectifiers measure 1 × 1 × 1/4 in.

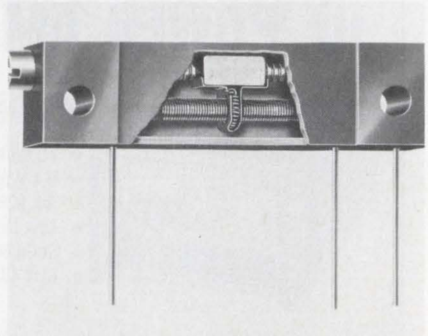


Sarkes Tarzian, Inc., Semiconductor Div., 415 College Ave., Bloomington, Ind.

Designed for PC applications, a new series of single-phase silicon bridge rectifiers feature reduced sizes of 1 × 1 × 1/4 in. Model XP409 devices are rated for 15-A resistive-inductive loads. They have eight peak inverse voltage ratings from 100 to 800 V at 60 Hz with maximum inputs from 70 to 560 V rms. Maximum surge current is 240 A and power dissipation is 33 W.

CIRCLE NO. 272

High-resolution trimmer is virtually noiseless

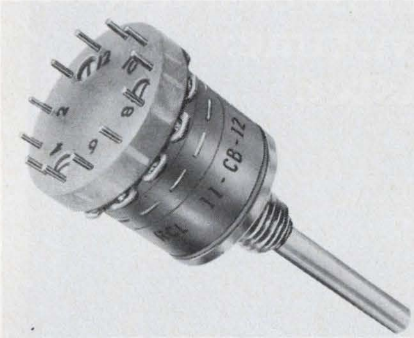


Republic Corp., Components Div., 950 Sepulveda Blvd., El Segundo, Calif.

A rectilinear trimming potentiometer that is virtually noiseless and gives twice the resolution of conventional units is now available. The Quiet-Trim unit has a patented coil-spring ring wiper which wraps completely around the resistance element. Because the wiper has light constant contact pressure and covers 360° of the resistance element, any resistance change is reliably detected.

CIRCLE NO. 273

Rotary PC-board switch includes several decks

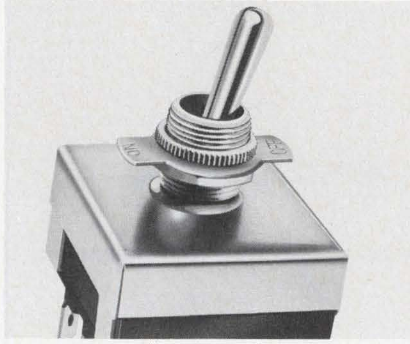


RCL Electronics Inc., 700 S. 21 St. Irvington, N.J. Availability: stock.

True PC-board mounting for multi-deck switches is now possible with a new multi-deck switch. It plugs directly into a rear-mounted PC board since all its terminals are at the rear and are axial. The switch has a diameter of 0.9 in., and has on any one deck 1 pole 12 positions through 6 poles 2 positions, with the first position "off." Shorting and non-shorting poles may be grouped on one deck in any combination.

CIRCLE NO. 274

Toggle switches multiply poles

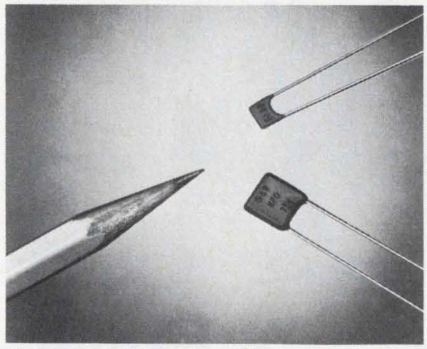


McGill Manufacturing Co., Inc., Electrical Div., 909 N. Lafayette, Valparaiso, Ind. Phone: (219) 462-2161.

Series 0140 three and four-pole toggle switches are available in single-throw and double-throw, and momentary-contact and maintained-contact models. Electrical ratings are 17 A at 277 V ac, 6 A at 600 V ac, 1 hp at 125 V ac, 2 hp at 250, 480, or 600 V ac—for one, two or three-phase circuits. Features include silver-cadmium-oxide contacts.

CIRCLE NO. 275

Ceramic capacitors boast small sizes

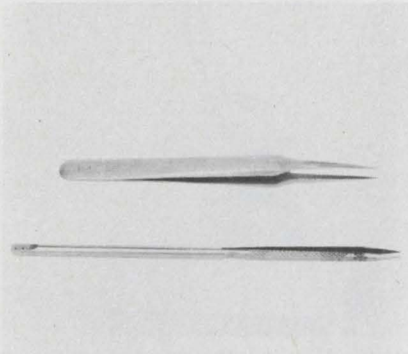


Gulton Industries, Inc., Metuchen, N.J. Phone: (201) 548-2800.

A new line of NPO ceramic capacitors with double the dielectric constant of previous types and the same performance characteristics reduces their over-all size. Sizes range from 0.12 in.^{2} × 0.03-in. thick to 0.455 in.^{2} × 0.125-in. thick. The ultra-stable DR series is available with a capacitance range of 1 to 470 pF in dipped radial-lead construction. They meet or exceed the requirements of MIL-C-20.

CIRCLE NO. 276

Easy-to-use tweezers increase versatility

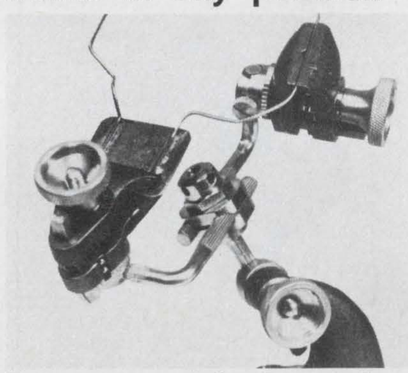


D. G. Mountz Associates, Inc., 1080 N. 11th St., San Jose, Calif.

Two new round tweezers give amazingly great operator dexterity and cut down fatigue and handling time when positioning miniature components. They are tungsten-carbide tipped and are available in all standard point styles. A choice of carbon, inox stainless, and anti-magnetic stainless tweezers is possible. They are ideal for high-temperature applications and use a guide pin to keep the points parallel.

CIRCLE NO. 277

Two-jawed 360° vise works in any position



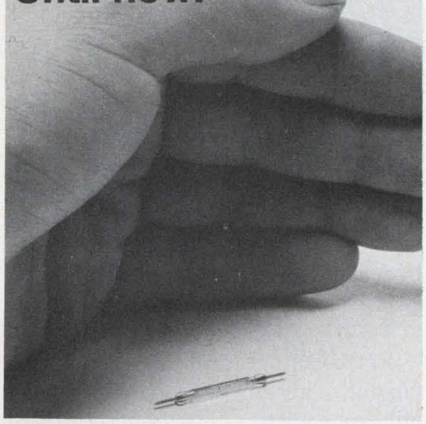
Montgomery and Co., Inc., 12 Commerce St., Chatham, N.J. Phone: (201) 635-7786. Price: $29.50.

Containing two jaws, a new two-fisted vise holds any two working pieces in any position relative to each other. Both jaws rotate 360° in every plane, independent of each other, for any compound angle between them. They rotate on a rachet with angle steps of 9°. The jaws are lined with neoprene rubber and a knurled nut provides adjustments and locking.

CIRCLE NO. 278

Isolation was the only thing preventing a high-frequency Reed Switch Matrix

Until now.



The Cunningham Reed Switch Matrix reduces high-frequency crosstalk and interference to a new low. Unique "sandwich" design seals, shields and separates matrix-mounted reed switches from their controls.

Offers:

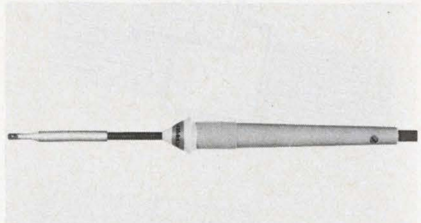
- **Excellent signal characteristics:** 50-ohm distributed. Broadband handling with top isolation. Low thermal noise.
- **100% Random access:** Any number or combination of crosspoints can be set, any place, any direction without affecting other crosspoints.
- **Computer compatibility:** Can be directly addressed by all computers using +5 volt logic. No added interfacing needed.
- **Proven reliability:** Up to 100 million operations.
- **Easy inspection and maintenance:** Control and signal sections can be separated for easy access.
- **Applications:** Interconnecting video channels; broadband data switching; test systems for nanosecond digital pulses; telemetry equipment for multiple data channels; antenna switching; medical data monitoring.

Write or call for Data Sheet No. 603, Cunningham Corporation, 10 Carriage St., Honeoye Falls, New York 14472. Phone: (716) 624-2000.

Cunningham Corporation

SUBSIDIARY OF GLEASON WORKS

Lightweight solder iron warms up in 60 seconds



Edsyn, Inc., 15954 Arminta St., Van Nuys, Calif. Phone: (213) 989-2324. Price: $6.50.

Easy to hold and lightweight, a new pencil-type soldering tool warms up in 60 s. The Ersa TIP 16 weighs only 3-1/4 oz (including line cord) and has a tip that needs no filing or shaping during its lifetime. Its streamlined shape allows the operator to reach those hard-to-get-at tight spots in integrated circuits or on discrete components.

CIRCLE NO. 279

Disposable flashlights seal in batteries/lamps

Bridgeport Metal Goods Mfg. Co., Bridgeport, Conn. Price: 79¢, 99¢, $1.39, $1.59.

Filling the wide needs in flashlights are four sealed disposable flashlights. They are a 3-1/2-in. Key Chain Lite, a full-sized Penlight, a Compact Spotlite and a full-sized Spotlite. They never need battery or bulb replacements. Simply use them until they fail, then throw them away. Each has a bright light output and is guaranteed for one year.

CIRCLE NO. 280

Test Power Transistors

FAST · ACCURATE · AUTOMATIC

The Lorlin Automatic Transistor Tester Model TB is programmable over a range of 0.1 nanoamps to 10 amps and 10 mV to 600 V. All types of transistors from small signal to high power can be tested for breakdown voltages, leakage, gain and saturation voltages with 1% accuracy.

A complete test sequence can be programmed by the operator in minutes. Since a standard test takes just 16 milliseconds, high daily thruput is possible.

Models are available with up to 24 test positions and 18 sorting classifications. Remote test stations with the same range and accuracy are available to permit several operators to share one tester. All Lorlin testers will interface with automatic probing, handling and classifying equipment.

Lorlin testers are designed for maximum reliability, ease of service, convenience of programming, and simplicity of operation. Their speed, accuracy and reasonable price provide users a substantial return on their capital investment. Write or call for more information and a demonstration in your plant.

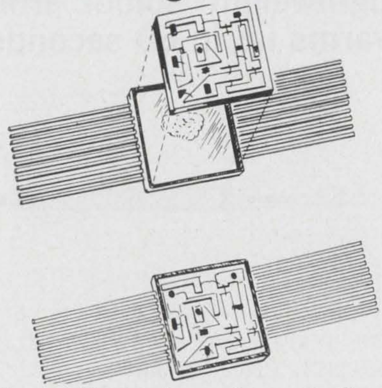
SEE THE MODEL TB AT BOOTH 2K37 IEEE

LORLIN industries inc.

Precision Road, Danbury, Connecticut 06810
Tel: 203-744-0096

For Literature circle 71
For Demonstration circle 72

Epoxy for hybrid units bonds large substrates

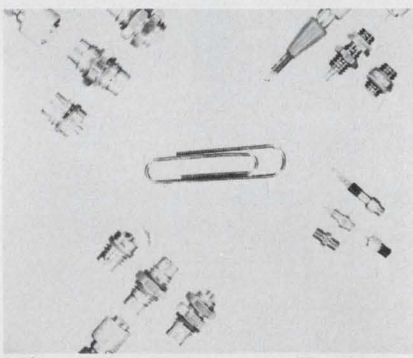


Epoxy Technology, Inc., 65 Grove St., Watertown, Mass. Price: $15 per 1-oz trial kit.

Developed for bonding large substrates in hybrid circuit packages is a new two-component 100%-solids silver-filled epoxy. The mixed components form a low-viscosity and smooth-flowing paste. Epo-Tek H24 cures from 20 minutes to 1 hour at a lap shear strength of 1000 psi. It is used for intermittent operations from 300 to 400°C and withstands continuous exposure to 250°C.

CIRCLE NO. 281

Cable-connector pairs reduce OD to 0.06 in.

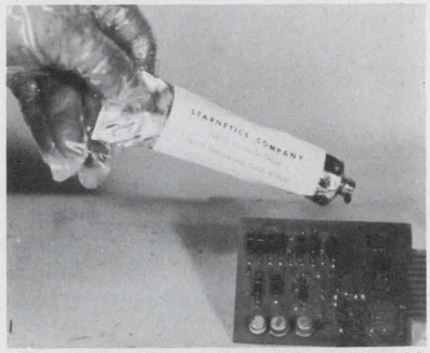


Microtech, Inc., 777 Henderson Blvd., Folcroft, Pa. Phone: (215) 532-3388. P&A: from 75¢; stock.

Closing the gap for high-density packaging and extreme miniaturization are two coaxial-cable-connector combinations with outer cable diameters of 0.08 and 0.06 in. The units are factory pre-assembled, and the operator need only trim the cable to the proper length and screw it into the connector in a matter of seconds. Cables are of AWG #30 wire and connectors mate with A and C series connectors.

CIRCLE NO. 282

Conductive epoxy bonds to 6000 psi

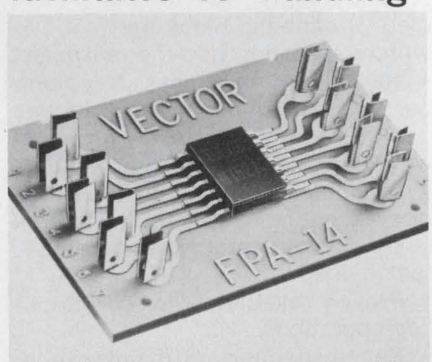


Starnetics Co., 10639 Riverside, N. Hollywood, Calif. Phone: (213) 769-8437. Price: 60¢ per oz.

Fritz-Copper 150 is a two-component air-drying copper-epoxy adhesive with a tensile strength of 5000 to 6000 psi. The adhesive combines the conductivity of copper and the strength of epoxy at a low cost. It has excellent adherence to ceramic parts used in microelectronics and is used to attach active devices to passive metallized alumina substrates.

CIRCLE NO. 283

Adapter for flat-packs facilitates IC handling

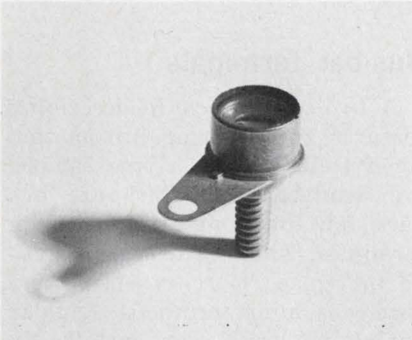


Vector Electronics Co., Inc., 12460 Gladstone Ave., Sylmar, Calif. Phone: (213) 365-9661. P&A: 53¢; stock.

Accepting 14-lead integrated circuits, a new flat-pack adapter makes it easier to mount, solder and handle flat-pack ICs in prototype breadboarding applications. The FPA-14 is a 1/16-in. thick epoxy paper wafer with a 2-oz copper-etched pattern that matches the 0.05-in. spaced lead pattern on flat packs. The leads are fanned out to alternate at 0.1-in. spacings at each wafer end.

CIRCLE NO. 284

Infrared Ga-As emitters beam energy at 935 nm

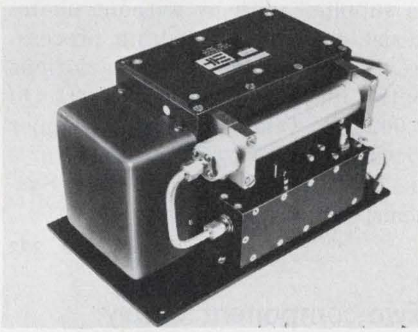


Spectronics, Inc., 541 Sterling Dr., Richardson, Tex. Phone: (214) 231-9381.

Four new semiconductor emitters, which are made from amphoterically doped solution-grown gallium arsenide, radiate infrared energy at 935 nm. Three different headers offer a variety of outputs and beam patterns. These range from an optical power output of 0.36 mW into a 16-degree optical beam to an optical power output of 150 mW into a 150-degree beam.

CIRCLE NO. 285

Stable 10-GHz source varies only ±350 kHz

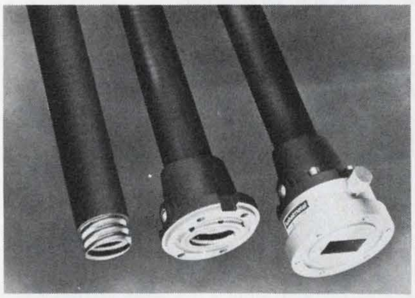


Elpac, Inc., 18651 Von Karman Ave., Irvine, Calif. Phone: (714) 833-1717.

Supplying 100 mW at 10 GHz, a new X-band source provides an output power variation of ±350 kHz and a stability of 1 ppm/hour. The model G1025 generates a 107-MHz fundamental frequency by an oven-stabilized voltage-controlled crystal oscillator for a phase-stable output. Spurious levels are 40 dB below the carrier and an isolated output of 100 mW is provided.

CIRCLE NO. 286

Waveguide attachments simplify terminations

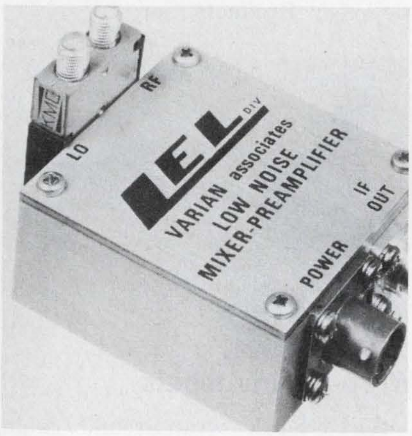


Eltek Corp., 7 Woodland Ave., Larchmont, N. Y. Phone: (914) 834-8865.

A line of two-piece flexible elliptical waveguide terminations simplifies their interconnection and they also require no tuning. Except for a flanging tool, they can be field-assembled with ordinary hand tools. They consist of a chromium-plated aluminum alloy section that attaches to the waveguide, plus a bolted-on chromium-plated brass adaptor for hooking up to standard waveguides.

CIRCLE NO. 287

Mixer-preamplifiers cover 1 to 12.5 GHz

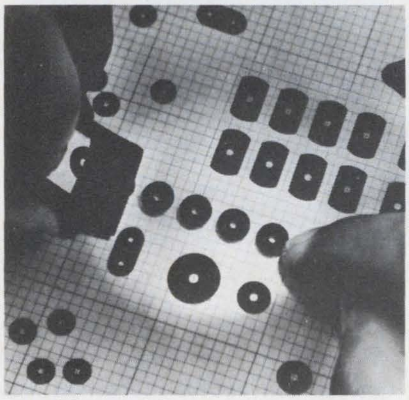


Varian Solid State Div., Akron St., Copiague, N.Y. Phone: (516) 598-2240.

Designated 7A, a new series of low-noise solid-state mixer-preamplifiers covers 1 to 12.5 GHz in four models. With noise figures from 7 to 7.5 dB and output power of +10 dBm (1-dB compression), they demand a low dc power requirement of −20 V at 10 mA. The local-oscillator input power requirement is 2 to 4 mW. I-f output VSWR is a maximum of 3:1.

CIRCLE NO. 288

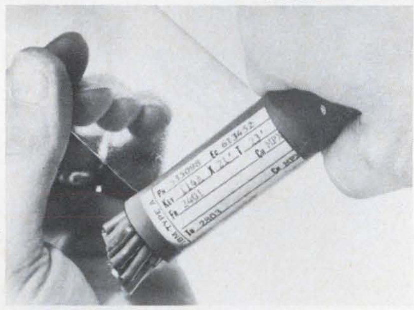
Evaluation Samples



Drafting aids

An informative 40-page catalog describes an extensive line of pressure-sensitive electronic-circuitry drafting aids. A wide spectrum of products is included such as a large variety of single and multi-pad configurations. Also included are tapes, sequential reference designations, letters, symbols and several accessory items. A special section on the preparation of two-sided master artwork is also included. A copy of the catalog and samples are available free. Chartpak Rotex, div. of Avery Products Corp.

CIRCLE NO. 289



Wrap-around labels

Able-Stik wrap-around cable markers are new pressure-sensitive labels. They provide positive electrical cable identification with built-in heat-resistant and transparent vinyl. Specially treated opaque black-and-white sections can be imprinted, either manually or mechanically, with appropriate identifying data. Once the data is entered the vinyl strip is peeled from its protective-backing sheet and affixed to the cable. Samples are available. Allen Hollander, div. of Litton Industries.

CIRCLE NO. 290

Bus-bar terminals

A two-color brochure describing features and ordering information for Pin Bars, plus a free sample, are available. Pin Bars are bus bars for interconnecting common terminals. They have been designed to replace more expensive and time-consuming terminals. Regular wiring personnel can install Pin Bars by simply lining them up on the terminal posts and tapping them lightly into place. They can be manufactured in any length and spacing, and cut to length with ordinary shop tools. Two standard finishes of gold and tin are available on request. Lear Siegler Inc., Electronic Instruments Div.

CIRCLE NO. 291

Fused base material

A new fused base material sample for manufacturing flat and flexible cables and circuits is available free of charge. The base material consists of polyamide-polyimide insulation that is multipass-coated on one side of rolled and annealed copper foil. The material is supplied with or without photoresist coating for etching processes. It is available in six variations with insulations from 0.001 to 0.0022-in. thick and rolled copper from 0.0014 (1 oz) to 0.098 (7 oz)-in. thick. Electro Connective Systems, Inc.

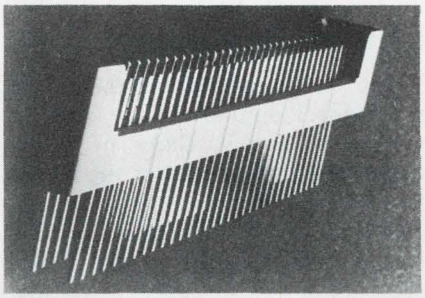
CIRCLE NO. 292

Two-component epoxy

EPOMARINE 3534 is the first of a series of maintenance materials for use on wet or submerged surfaces. It is a two-component epoxy coating with good adhesion to wet ferrous metals and concrete. Coatings of 20 to 30 mils of thickness may be obtained. This material is unique in that a mortar-like consistency can be made by mixing in silica flour. The addition of clean sand yields a material with the consistency of grout. Samples and literature are available on request. Hardman Inc.

CIRCLE NO. 293

Design Aids



Connector chart

A comprehensive visual guide for purchasing agents and engineers has a selector chart for various connectors. It includes printed-circuit edge, inter, combination and high-density connectors. Also included are varieties of body and contact material, contact and termination styles, contact spacing, number of connections and the shape of contact springs. Mepco, Inc.

CIRCLE NO. 294

Motors and generators

Electrical and mechanical properties of servomotors, generators and motor generators are conveniently listed on a wall-chart selection guide that is available free on request. The guide shows such information as motor sizes, type, frequency, poles, stall torque and free speed. It also indicates motor voltage, input power, inertia, time-constant, weight and length. Applications and temperature-effects information are also included. Berg Electronics Inc.

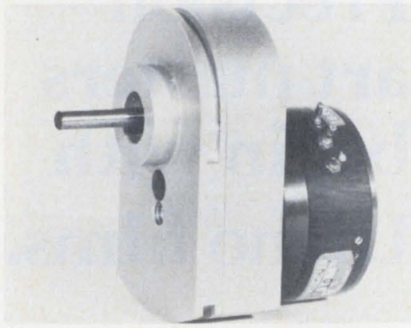
CIRCLE NO. 295

Conversions

Available free of charge to electronic design engineers is a 20-page booklet with many conversion factors and formulae. It contains, in alphabetical order, conversions of abcoulombs to statcoulombs ending up at yards to millimeters. All conversions include the necessary multiplication factors. Included are both the metric and English systems of measurement. The booklet also includes common electronic formulae for series and parallel circuits. Centralab Electronics Div. of Globe-Union Inc.

CIRCLE NO. 296

Application Notes



Gears for math functions

A six-page brochure discusses the design and use of noncircular gears to generate mathematical functions. The gears are mounted in a compact unit along with a linear potentiometer or a transducer to provide mathematical functions at a high-degree of accuracy. It is shown that gears, which have a function accuracy of 0.05%, are more accurate than other means, since the accuracy of most functions is limited by the output device. Cunningham Industries, Inc.

CIRCLE NO. 340

Fine-depth measurement

An inexpensive interferometer technique for the measurement of diffused layers in materials and instrumentation is outlined and discussed in a two-page article. These fine-depth measurements are for analyzing polished surfaces and for measuring thin films. The article discusses basic interferometry, established techniques, a modified Michelson device, flat specimens and film measurement. Hacker Instruments Inc.

CIRCLE NO. 341

Path-loss testing

A discussion of path-loss testing in microwave systems is contained in a new booklet. It leads off with information on the use of path-loss testing for system quality assurance. This is followed by an outlined and step-by-step consideration of path-loss procedures. The last page contains graphical information on losses from grazing and reflected zones of energy that are plotted for path-clearance analysis. Microwave Systems Co.

CIRCLE NO. 342

Light-emitting diodes

The technical requirements of some novel opto-electronic circuits which use a new GaAs negative-resistance light-emitting diode are the subject of a new brochure. It discusses the basic considerations in using light-sensitive and light-emitting devices. Current, voltage and resistance curves are provided. Also shown are several circuit applications that use light-emitting diodes. These are shown with schematic representations. Hayakawa Electric Co., Ltd., U.S. Subsidiary: Sharp Electronics Corp.

CIRCLE NO. 343

Motor transducers

Considerations in the use of Bimorphs as motor transducers is the subject of a new technical paper. Bimorph is a trade name for a flexure-responsive element featuring sandwich-construction of two piezoelectric ceramic wafers bonded to an interleaved-copper shim. The paper includes discussions of optimum mountings, inter-parameter relationships, limitations and design charts and curves. A table of properties of several ceramic materials, problem examples and solutions, and a list of related terms and symbols is included. Gould Inc., Piezoelectric Div.

CIRCLE NO. 344

Metal powders

The many uses of metals in the form of powder are described in a 19-page brochure. Both industrial and consumer applications are covered. A five-page fold-out chart lists hundreds of the more important metal powder applications and the types of powders used, with particular emphasis on non-structural uses. Descriptions of the special chemical, metallurgical and physical properties that characterize metal powders are included. The brochure will be helpful to those interested in learning about ferrous and nonferrous metal powders, and how they can be utilized in product applications. Metal Powder Producers Association.

CIRCLE NO. 345

New Literature

Computer-aided design

DART—Design Analysis and Review Techniques—is described in a new 16-page brochure. It is a new free field computer program developed under the technical supervision of Stanford Research Institute to optimize the effectiveness of engineering talent while conserving time and expense from product inception to production. System analysis, including error detection and correction, documentation and the production of punched paper tape for numerically controlled wiring are all procedures within the capability of DART. Data Technology Corp.

CIRCLE NO. 346

Panel instruments

Over 1500 stock ranges, sizes and types of panel instruments are described in a 32-page catalog. It shows a new series that combines the advantages of a modern design with rugged construction. Another series shown features non-blinking readouts that change only when the measured value changes. Other products shown are three-hole-mounting instruments, contactless controllers and illuminated VU meters. A quick-reference index on the cover, characteristics charts and a glossary of useful terms are included. Simpson Electric Co. Div. of American Gage & Machine Co.

CIRCLE NO. 347

Microwaves

For those who are working in vhf, uhf, microwave and light frequencies the new microwaves and optoelectronics short-form catalog is now available. It contains information on hybrid integrated circuits and solid-state sources for the communications-field designers. Transistor and chip information is also available for high-frequency instrument and component designers. Computer and card-reader designers can also benefit from the included information on optical devices and arrays. Fairchild Microwaves & Optoelectronics Div.

CIRCLE NO. 348

Information services

A list of expanded services, books and programs for business and education in the information processing, office products and environment-planning and design fields is offered in a new catalog. In addition, information on a tape-cassette learning course on electronic data processing terminology and a tape-cassette series on socio-physical design are included. Other offerings include monthly updated looseleaf handbooks for software and data equipment and data processing textbooks. Business Press International Inc.

CIRCLE NO. 349

Semiconductors

Semiconductor discrete components and integrated circuits are conveniently outlined with typical operating characteristics and applications in a short form catalog. Included are junction, MOS and dual field-effect transistors and multichannel field-effect transistor switches. Also listed are current limiters, voltage-controlled resistors and digital and linear integrated circuits. The catalog also covers integrated drivers and driver/switch combinations. Siliconix Inc.

CIRCLE NO. 350

Power supplies

A new 16-page new product catalog supplements a previous power supply handbook. The supplement details new modular and rack-adaptable power supplies for systems, test equipment and OEM applications. It includes detailed specifications on standard bench models as well as descriptions of standard and custom rack-mounting power supplies capable of supplying dc voltages from 0 to 180 V dc and currents up to 70 A. Trygon Electronics, Inc.

CIRCLE NO. 351

Switches

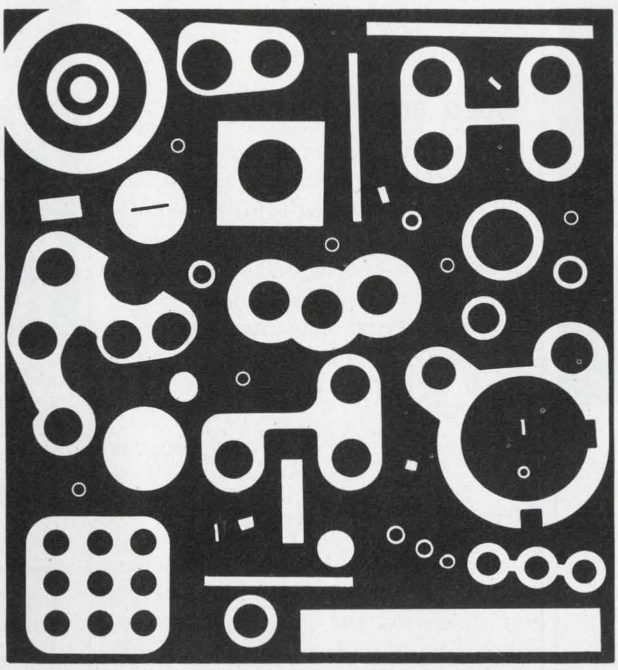
Snap-action, rocker-actuated, paddle, toggle and push-button switches make up a new catalog. It contains data on several new switch series, including lighted miniature rocker and four-pole toggle switches. Rocker switches and a sealed splash-proof switch are also shown. Most types are available in a variety of ratings, circuitry, actuator styles, colors and mounting arrangements. McGill Manufacturing Co., Inc.

CIRCLE NO. 352

Operational amplifier

A complete listing of four new model operational amplifiers is in a new four-page brochure. It shows the specifications and a general description of the amplifiers in a tabular form. Also included in the catalog is a listing of four different power supply models needed to operate the operational amplifiers. Their specifications and characteristics are also discussed. Optical Electroncis Inc.

CIRCLE NO. 353



Tin-novation

Solder preforms . . . a new way to use tin solder

Automation and miniaturization have made it necessary to change the physical structure and dimensions of many components and products. Solder is no exception.

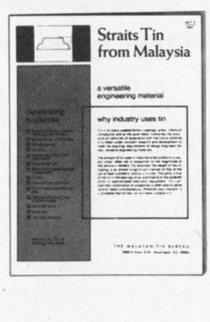
Solder preforms are available from most of the large solder manufacturers — in either flux cored or solid forms — in an almost limitless variety of shapes, sizes, designs, and configurations: washers, discs, rectangles, ovals, pellets, rings, coils, stampings, wire, sleeves, tubes, spheres, etc.

Just the right amount of flux and solder of a predetermined tin alloy is placed exactly where it is required. Waste is eliminated, production increased, joints uniform, and rejects reduced. Many soldering operations can be made part of an automatic operation, eliminating the need for skilled soldering help. Solder preforms are especially adaptable for soldering inaccessible points — and where previous bonds should not be disturbed. Further operating cost reductions are realized with mass production heating techniques.

Solder is the second largest user of tin in the world, tinplate being first. About 20% of the world's consumption of tin goes into solder. Tin's unusually advantageous combination of properties makes it an ideal metal for use in solder alloys. Tin has a low melting temperature, malleability, corrosion resistance, and an attractive lustrous appearance.

Think Tin

Just as tin works so well in solder and solder preforms, it may also hold the answer to one of your current or future metal problems — as an additive, an alloy, or coating. Straits Tin from Malaysia, the sterling of tin . . . world standard for uniformity.



Send for new engineering bulletin on Straits Tin.

Contains thorough descriptions of major applications and useful technical data on general, thermal, electrical, and mechanical properties. Send for your free copy today.

THE MALAYAN TIN BUREAU

Dept. S19-C, 2000 K St., N.W., Washington, D.C. 20006

INFORMATION RETRIEVAL NUMBER 83

Video amplifiers

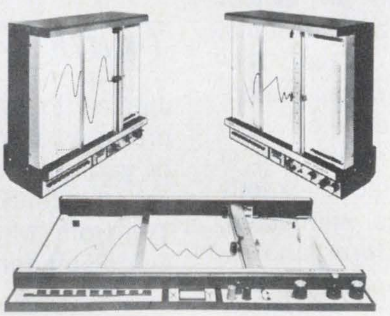
Bulletin 1401 is a six-page brochure that describes a new series of integrated-circuit high-frequency video amplifiers. In addition to a complete characterization, it has two pages of application notes for the amplifiers. The amplifiers can be used in the frequency range from dc to 200 MHz. Silicon General Inc.

CIRCLE NO. 354

Intruder detection

A four-page brochure describes a new microwave intruder detector. It discusses the relative effectiveness of microwave, ultrasonic, and radar intruder detection systems. It also explains why the microwave detector provides significant freedom from false alarms. Included are diagrams showing how the microwave intruder detector system may be used to provide trap and broad-area surveillance patterns. Advanced Devices Laboratory, Inc.

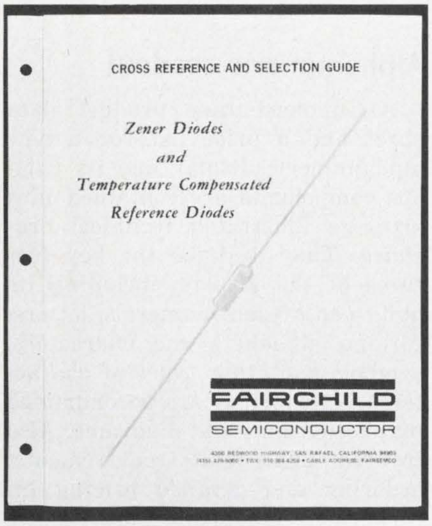
CIRCLE NO. 355



Strip chart recorders

A new line of strip chart recorders is completely described in a 12-page bulletin. It details recorder models that use paper that is 10-in. wide and 100-ft long. The recorders use push-button controls to select speeds from 20 to 0.05 in per minute. English/metric scaling, low profile, and bench or rack mounting are some of their other features. Also shown are nine selectable plug-ins for the Y axis of the recorders. Houston Instrument, div. of Bausch & Lomb.

CIRCLE NO. 356


CROSS REFERENCE AND SELECTION GUIDE

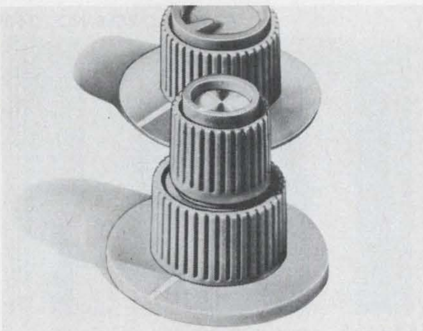
Zener Diodes
and
Temperature Compensated
Reference Diodes

FAIRCHILD
SEMICONDUCTOR

Zener/reference diodes

A cross-reference and selection guide for an extensive line of zener and temperature-compensated reference diodes is available. It describes approximately 800 diode devices, including a series of new 1-W zeners. Each device listed is identified by its voltage, current, and impedance capabilities. Package information is also provided, together with diagram illustrations. Included in the listing are voltage reference diodes. The six-page guide is designed for use with spiral ring binders. Fairchild Semiconductor.

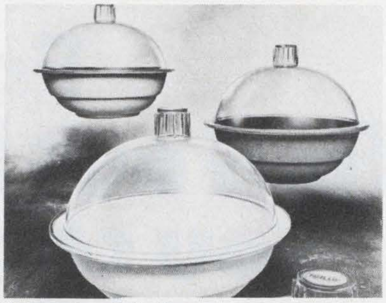
CIRCLE NO. 357



Instrument knobs

A unique approach to knob selection for designers, engineers, and purchasing personnel is contained in a catalog for a series of instrument knobs. The new knobs are of the most popular functional types —round, dial, pointer, single and double bar, spinner and a wide combination of concentric types. The catalog is complete with knob illustrations, specifications, dimensions and descriptions. Control Knobs Div. of Electronic Hardware Corp.

CIRCLE NO. 358



Chemical labware

Six new plastics labware products, along with a number of product improvements, are featured in a 1970 labware catalog. Included among the new products are a 150-mm unbreakable desiccator and two dropping bottles of new design. Also included are a space-saving rectangular bottle, a polycarbonate Fernbach flask and an evaporating and titrating dish. Other items include a new quick-action spigot and new sizes of Erlenmeyer flasks and centrifuge tubes. Nalge Co., Nalgene Labware Div.

CIRCLE NO. 359

High-voltage rectifiers

High-voltage rectifier columns are the subject of a 24-page engineering bulletin. The columns are built in 14 basic series with peak reverse voltages ranging up to 300,000 V. Their continuous current ratings range from 1 to over 220 A. Shown are standard rectifier circuits in single and three-phase bridge configurations. Power capacities above 20 MW are discussed. Several pages are devoted to tabular and graphical data. International Rectifier Semiconductor Div.

CIRCLE NO. 360

Computer diagnosis

How to identify circuit faults you cannot afford at a price you can afford is the subject of a new product brochure. The product is a diagnostic computer for functional testing of logic devices. It identifies and isolates defects and enables even unskilled personnel to cut check-out time, thus minimizing both production down-time and field service effort. Discussed are the computer's applications, principles of operation and technical specifications. Digital/General Corp.

CIRCLE NO. 361

Alphanumeric readout

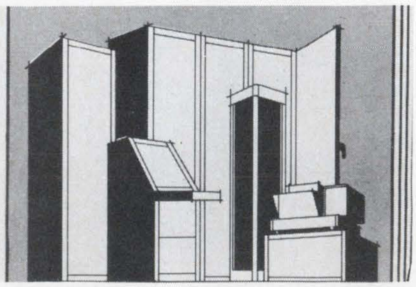
A supplementary product data sheet and a price list for a new alphanumeric display and its various components are contained in a six-page illustrated technical brochure. They describe the key features of the display, including its ability to present numerals, letters, foreign alphabets and characters, symbols and other types of characters. Descriptions are accompanied by photographs and diagrams. Also covered are input requirements, ordering and detailed pricing information. Madatron Corp.

CIRCLE NO. 362

Digital converters

A dozen applications for conversions from digital inputs to analog or other outputs are available in a six-page design manual. It shows engineers how to use solid-state converter modules to interface digital systems design with the widely prevalent synchro resolver and dc analog systems. Among the applications covered are digital angle to sine-cosine dc, or to three-wire synchro, or to resolver or to digital sine-cosine. Also covered are digital sine-cosine to synchro or to digital angle or to linear dc. Transmagnetics, Inc.

CIRCLE NO. 363



Metal enclosures

Catalog No. 70 features a complete line of standard metal enclosures for the electronics industry. The new 56-page booklet shows complete modular systems, as well as smaller cabinets. Panels, cases, chassis, accessories and hardware in a wide range of sizes are also included. Flexibility and adaptability in designing packaged systems is emphasized. An entire section is devoted to detailed mechanical drawings. Premier Metal Products Co., a Sub. of Sunshine Mining Co.

CIRCLE NO. 364

Brass wire

Specifications, details of manufacture, description and uses of brass wire are presented in a new eight-page brochure. It includes data on alloyed, hot-extruded, annealed and drawn brass. Also included is a discussion of alloys, wire diameters, temper, tolerances, shipping alternatives, and other data. Brass wire offered is in diameters of 0.0089 to 0.750 in. round style and 0.03 to 0.75 in. hexagon and octagon styles. Cerro Copper & Brass Co.

CIRCLE NO. 365

Hybrid thick-films

A custom hybrid thick-film process, and materials used for producing modules to the customer's design specifications are described in a new 12-page brochure. Illustrated are typical package designs. Resistor characteristics are presented in chart form for simplified understanding. Also included is a description of the facilities used for production as well as details of a research and development program. Columbia Components Corp.

CIRCLE NO. 366

Nickel

Nickel and nickel-base alloy tubing is described in a revised 40-page catalog. It contains updated information on cobalt alloys, nickel-iron alloys, and other highly alloyed materials, as well as nickel and nickel-base alloy tubing. Specific sections are included on chemical, mechanical and physical properties of various analyses, tempers, heat treatment, surface finishes and available tubing lengths. Superior Tube Co.

CIRCLE NO. 367

Knobs

A high-quality line of control knobs designed for industrial and instrumentation uses is featured in a new catalog. The line includes four round sizes with matching pointers and concentric configurations. Shown are round, pointer and concentric models, with or without rings or dial skirts. Also shown are custom-appearance knobs in a choice of spun aluminum cupped caps or with flat unlaid discs. Raytheon Co., Industrial Components Operation.

CIRCLE NO. 368

Electronic Design

ELECTRONIC DESIGN'S function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
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- To provide a central source of timely electronics information.
- To promote two-way communication between manufacturer and engineer.

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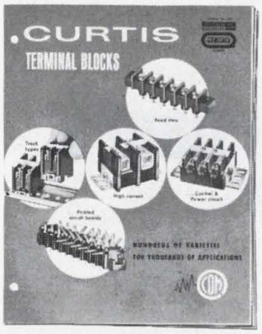
Terminal Block Selector



A new 24-page, completely illustrated catalog contains photos, descriptions, ratings, engineering drawings, and prices of the complete line of Curtis terminal blocks. Included are printed circuit, insulated feed-thru, quick disconnect, track type, and high current terminal blocks. Handy selection chart quickly locates the perfect block for your particular requirements. Send today for your free copy.

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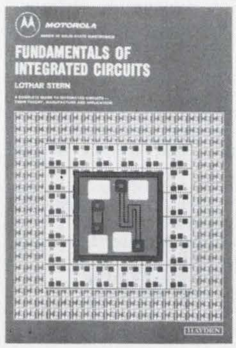
FUNDAMENTALS OF INTEGRATED CIRCUITS



A practical guide to integrated circuits, their theory, manufacture, and applications. This new guide by Lothar Stern offers compete, highly readable coverage of the various techniques of circuit fabrication, and their effect on circuit design and performance. As to marketing considerations, it compares the characteristics of the numerous IC structures devised to date in terms of economics and logistics. A volume in the **Motorola Series in Solid-State Electronics.** 198 pages, 7 x 10, illustrated. $8.95, clothbound. Circle the reader-service number below for 15-day examination copies.

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Send today for the By-Buk Printed Circuit Drafting Aids P-45 Catalog featuring the most comprehensive listings of basic pressure sensitive printed circuit drafting shapes, tapes and aids. Contains thousands of pads, tees, elbows, corners, donuts, connectors, fillets, colored tapes, multi-pads for dual in-lines, flat packs, TO cans and more. Here is your guide to better printed circuit drafting. Scores of ideas to speed master art-work preparation time and reduce drafting costs. Send for your free catalog and samples.

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Advertisers' Index

To the Businessmen of the Nation:

Each of us will be asked to take an active part in the 1970 census, the 19th time at 10-year intervals that our Nation has taken stock of its greatest asset, its people. Census Day will be April 1, 1970.

You will be asked to be your own census taker. Your census form will be delivered by mail, and you are asked to answer the questions about your household. Most of us, those who live in the larger metropolitan areas, will be asked to return the form, with all questions answered, by mail. In other areas census enumerators will call at your home to collect the form.

I ask you to use your position of leadership in your firm and your community to urge your associates also to fill out their census forms, and to follow instructions which tell each head of household whether to return the form by mail or hold it until a census enumerator calls to pick it up.

IT'S EASY

Most households, four out of five, will have a maximum of 23 questions, requiring about 15 minutes for an average family. Simply use a pencil to fill in the circle which indicates the correct answer for each question. If you don't know the precise answer, your best estimate will be accepted.

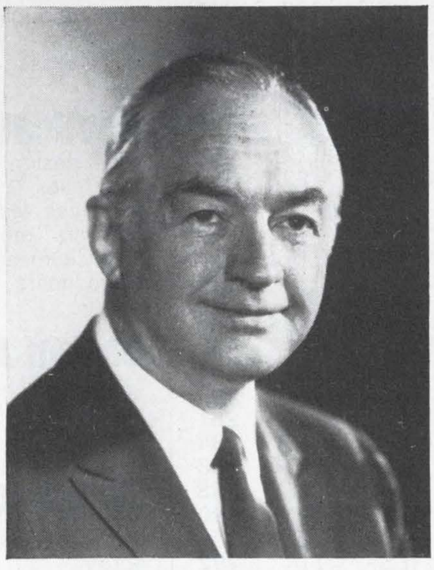
IT'S SECRET

No one but census employees ever will see your answers on a questionnaire and every census worker takes an oath of confidentiality. The information will be used only for statistical purposes. It will never be made available to tax collecting agencies, police or regulatory agencies. This is assured by the Federal Census Law and backed by long tradition of the Census Bureau.

IT'S IMPORTANT

The statistics produced by a census tell all of us not only how many of us there are in the Nation and each of its parts, but also how we are living: whether we are gaining or losing in our efforts to provide adequate jobs, education, housing, and other elements that we have established as our goals and which segments of our population are being left behind in the attainment of those goals. The information provided by the census will be used to guide governments and businesses in major decisions during the coming years.

In the United States, everyone counts, and the census counts everyone!



Maurice H. Stans

MAURICE H. STANS
Secretary of Commerce

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New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

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Here is the sinewave source of the future ... all the accuracy, stability and resettability that only a frequency synthesizer can give you, plus such signal generator advantages as accurately calibrated output level, AM or FM modulation capability (or both), and built-in sweeps with provision for sweeping externally.

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The Model 3100A-016 Programmable Frequency Synthesizer is $4950. Our non-programmable version, Model 3100A, is $4250. An 8-page Technical Bulletin fills out the story. For your copy write: Monsanto Company, Electronic Instruments, West Caldwell, N. J. 07006.

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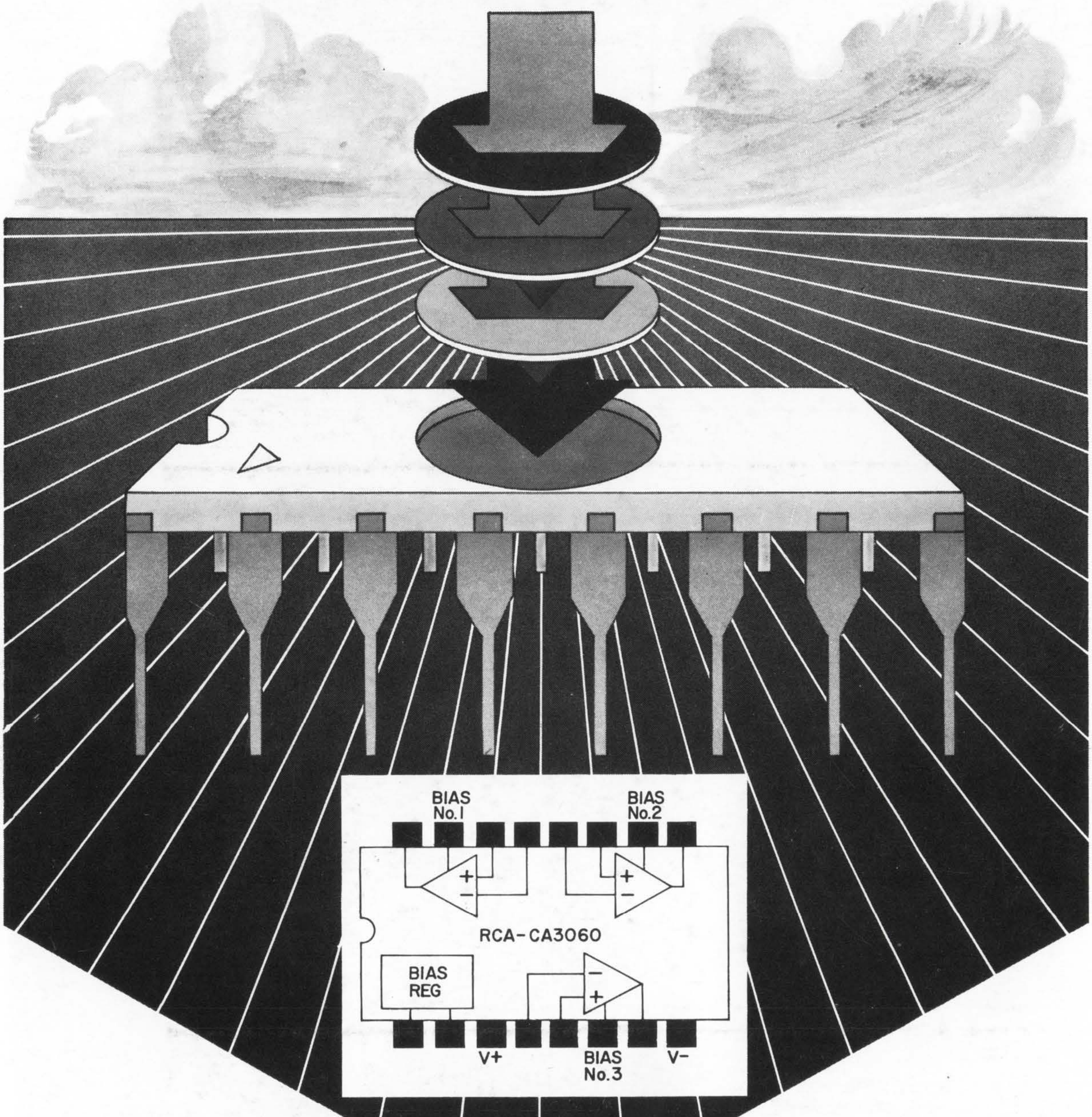
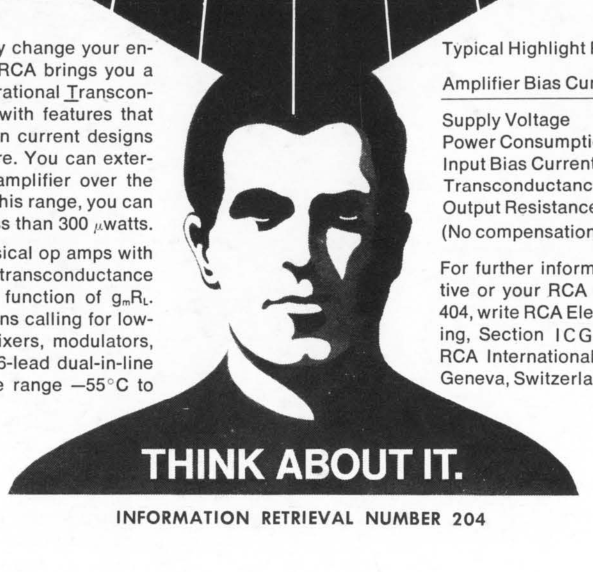
OTA–NEW DIMENSION IN OP AMPS FOR THE CREATIVE DESIGNER



Here's the IC design breakthrough that may change your entire approach to op amps. In the CA3060, RCA brings you a monolithic array of three independent Operational Transconductance Amplifiers and a bias regulator with features that will send you back to the drawing board on current designs and start a new chain of ideas for the future. You can externally adjust the supply current for each amplifier over the range from 10 μA to 1 mA. At the low end of this range, you can have three amplifiers working for you on less than 300 μwatts.

The CA3060 has the characteristics of classical op amps with the added feature of externally variable transconductance (g_m). Hence, open-loop voltage gain is a function of $g_m R_L$. Think about it and look into it for applications calling for low-power op amps, active filters, gyrators, mixers, modulators, or multipliers. Price $5.95 (1000 units) in 16-lead dual-in-line ceramic package (full military temperature range −55°C to +125°C).



Typical Highlight Parameters (Per Amplifier)

Amplifier Bias Current	1 μA	100 μA
Supply Voltage	±2 to ±6 V	±2 to ±6 V
Power Consumption	≦ 100 μW	≦ 10 mW
Input Bias Current	33 nA	2500 nA
Transconductance (g_m)	380 μmho	35 mmho
Output Resistance	200 MΩ	2 MΩ

(No compensation required in many applications)

For further information, contact your local RCA Representative or your RCA Distributor. For technical bulletin, File No. 404, write RCA Electronic Components, Commercial Engineering, Section ICG3, Harrison, N. J., 07029. In Europe: RCA International Marketing, S. A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

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