VOL. 25 NO. 23

Electronic Design®

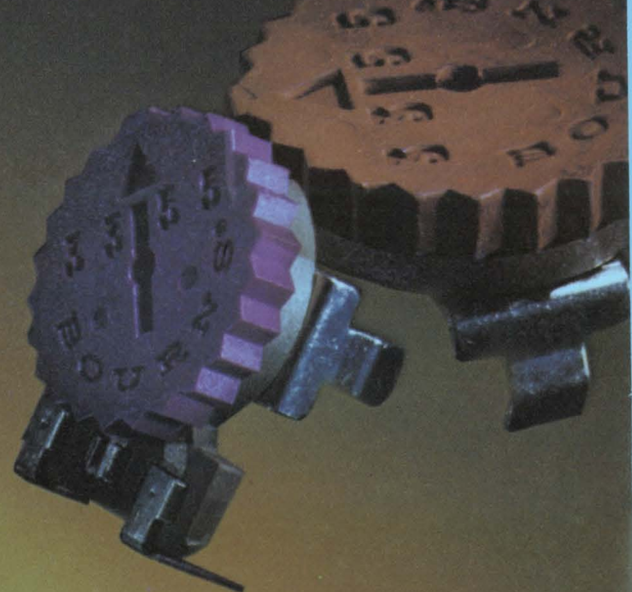
FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE

NOV. 8, 1977

Power transistors and thyristors depend heavily upon structural geometry to determine electrical properties. Yet manufacturers will use different configurations and make unannounced changes—but keep the same JEDEC number. Limit specs may not change, but altered spec details frequently upset circuit operation. See p. 52.

Another Colorful Innovation...

Conductive Plastic Trimmers at Carbon Prices.



Just when you thought "low cost" also meant "low performance", along comes the dazzling new Bourns® Model 3355. Compare it to the CTS 201, Mepco 46X or Piher PT15. Our revolutionary conductive plastic element vs. their carbon . . . fact is we outperform them all. To prove it, we spec important characteristics such as CRV at 1% and a TC of 500 PPM/°C . . . the others don't. And only the 3355 has board-wash capability, a UL-94V-1 flammability rating and an optional choice of nine rotor colors. The standard blue is priced at just 11¢ each (100,000 pieces). . . about what you'd expect to pay for the lower performance carbon types.

Send today for complete details on a colorful new way to design in superior performance for your cost effective needs — the Model 3355 Trimmer. Direct or through your local distributor.

TRIMPOT PRODUCTS DIVISION, BOURNS, INC., 1200 Columbia Ave., Riverside, CA 92507. Phone: 714 781-5050 — TWX: 910 332-1252.

CATALOG SHEET SPECIFICATION COMPARISONS

CHARACTERISTIC	BOURNS 3355	CTS 201*	MEPCO 46X*	PIHER PT15*
Element	Conductive Plastic	Carbon	Carbon	Carbon
Temperature Coefficient	500 PPM/°C	No Spec	No Spec	1000 PPM/°C
Contact Resistance Variation	1.0% max.	No Spec	No Spec	No Spec
Power Rating	.25 W at 70°C	.25 W at 55°C	.25 W at 55°C	.25 W at 40°C
Flammability	UL-94V-1	No Spec	No Spec	UL-94
Board Wash Capability	Yes	No Spec	No Spec	No Spec

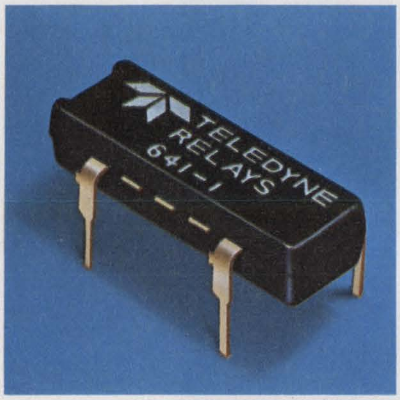
*Source: CTS Series 201 Data Sheet, Mepco Data Sheet ME1004, Piher Data Sheet F-2002 Rev 7/73

BOURNS®

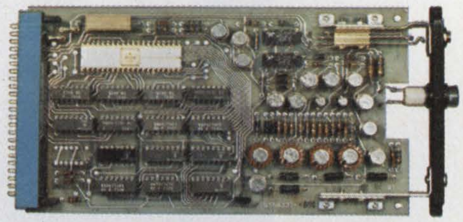
International Marketing Affiliates: European Headquarters — Switzerland 042/23 22 42 • Belgium 02/218 2005 • France 01/2039633 • Germany 0711/24 29 36 • Italy 02/32 56 88 • Netherlands 70/87 44 00 • United Kingdom 01/572 6531 • Norway 2/71 18 72 • Sweden 764/20 110 • Japan 075/921 9111 • Australia 02/55-0411 03/95-9566 • Israel 77 71 15/6/7

For Immediate Application — Circle 130
For Future Application — Circle 230

Did you get the message about our solid state SerenDIP relays?



International telex communication switching systems often are expected to run on a 24-hour, seven-day shift. Continuous duty like that calls for dependable, long-life component reliability — the kind RCA requires from Teledyne SerenDIP® relays used in their trunk terminator modules. These all-solid-state DIP relays provide wear-free and bounce-free switching — features you don't get with electro-mechanical or reed relays. What's more, our SerenDIP's offer high input/output isolation, low level logic input compatibility, and fast response time. And you get all of this in a low cost, low-profile TO-116 DIP package ready-made to replace any standard DIP reed relay. You also get your choice of output: bi-polar, AC (triac), or DC. There's lots more to a SerenDIP relay that you ought to know about. For detailed specs or applications assistance, contact your nearest Teledyne Relays sales office listed in EEM, Gold Book, or Electronic Buyers' Guide. You'll find we have the experience, products and technical support to meet all of your SSR needs.



RCA Trunk Terminator Module

RCA CCT-3 Series
Telex Switching System
(Courtesy of RCA/Camden, N.J.)

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CIRCLE NUMBER 3

VOL. 25 NO.

Electronic Design® 23

FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE

NOV. 8, 1977

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by Bruce Hull, courtesy of RCA Solid State Div.

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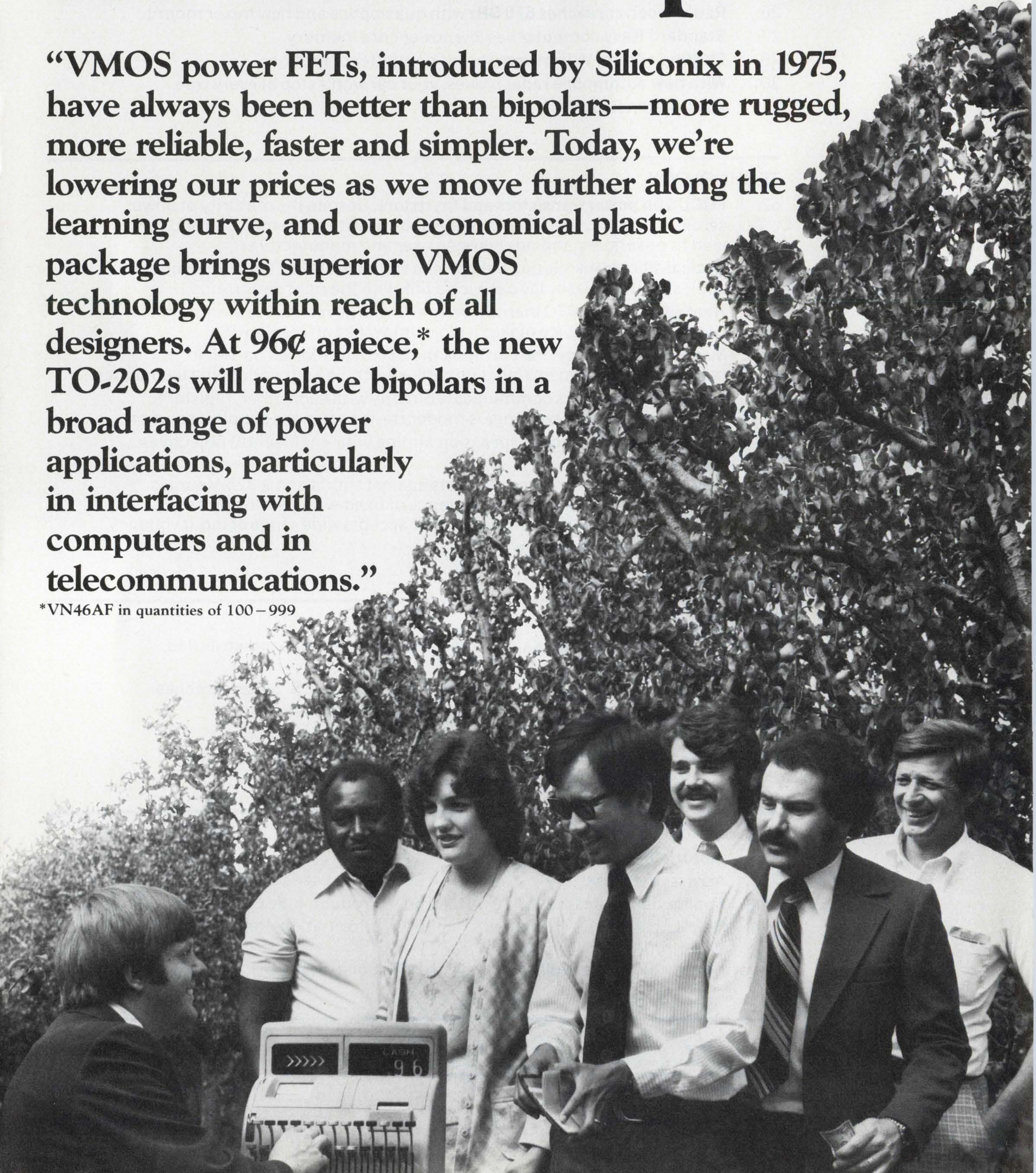
“Siliconix VMOS are down. Bipolars’

“VMOS power FETs, introduced by Siliconix in 1975, have always been better than bipolars—more rugged, more reliable, faster and simpler. Today, we’re lowering our prices as we move further along the learning curve, and our economical plastic package brings superior VMOS technology within reach of all designers. At 96¢ apiece,* the new TO-202s will replace bipolars in a broad range of power applications, particularly in interfacing with computers and in telecommunications.”

*VN46AF in quantities of 100 – 999

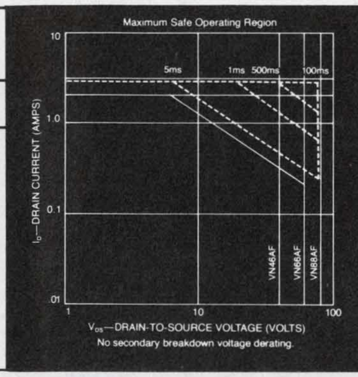


power FET prices time is up."

Siliconix VMOS power FETs in plastic: TO-202 package

Part #	BV_{DSS}	$V_{DS(on)}$ (I_D=1 Amp)	Price:1-29	31-99	100-999
VN46AF	40	3.0V	$1.33	$1.12	$0.96
VN66AF	60	3.0V	$1.39	$1.16	$1.00
VN88AF	80	4.0V	$1.54	$1.29	$1.10

All three devices are guaranteed over the temperature range of −55°C to 150°C; their maximum power dissipation is 12.5 watts, and their current rating is 2.0 amperes.



Other VMOS power FETs introduced by Siliconix are also available:

Part #	Package	P_{DISS}	BV_{DSS}	$V_{DS(on)}$ (I_D= 1.0 Amps)
2N6656	TO-3	25W	35	1.8V
2N6657	TO-3	25W	60	3.0V
2N6658	TO-3	25W	90	4.0V
2N6659	TO-39	6.25W	35	1.8V
2N6660	TO-39	6.25W	60	3.0V
2N6661	TO-39	6.25W	90	4.0V

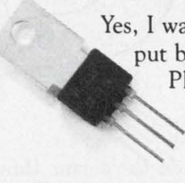
"Until 1975, MOS field-effect transistors (FETs) were restricted to small-signal, low-power applications. To control high currents, designers used bipolar devices. Then Siliconix, using Vertical MOS technology, introduced the VMOS power FET—combining the reliability of FETs with the power of bipolars.

"Today, Siliconix' new plastic TO-202 package means that VMOS power FETs are not only superior to bipolars in performance, but also competitive with them in price. They'll simplify designs and reduce component count in most systems because they eliminate pre-amplifiers, driver transistors, and external protective circuitry required for bipolars. And they can be inserted by machine, a time- and cost-saving advantage in high volume production.

"Anyone who has designed with bipolars knows the failures that can result from thermal runaway, secondary breakdown and current hogging. You don't have to worry about these problems with VMOS power FETs; their positive temperature coefficient eliminates hot-spotting and provides uniform current density, making them fail-safe. Consider how this inherent reliability will reduce your system interruptions and maintenance costs. And VMOS power FETs are faster than bipolars in switching operations—as much as 100 times faster. With all these advantages packed into the low-cost TO-202, you'll be able to eliminate bipolars' problems completely from many system designs.

"The high input impedance of VMOS and its threshold voltage range allow it to interface directly with CMOS, MOS and TTL logic families. And the VMOS power FET is the only interface device with a switching time comparable to that of ECL, so it will interface with a simple level shift—without losing speed. These features make the TO-202s ideal for data processing applications: computer peripherals, micro- and minicomputer systems, and process control equipment. They're also ideal for use in telecommunications: as telephone relay replacements, Touch-Tone muting switches, audio amplifiers, central office systems and analog switches.

"Our new line of VMOS power FETs in plastic may mean the end of the line for bipolars. We want you to discover for yourself how they can improve system design, so use the coupon to send for our detailed brochure. To order parts, contact any of our franchised distributors: Alliance, Century, Components Plus, Future, Hamilton/Avnet, Industrial Components Inc., Pioneer Standard, Pioneer Washington, Quality Components, Semiconductor Specialists, Wilshire, Wyle/Elmar, Wyle/Liberty, or RAE."



Yes, I want to find out for myself how Siliconix put bipolars on the list of endangered species. Please send me your brochure.

Name/title ____________________

Company ____________________

Address ____________________

City/State/Zip ____________________

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2201 Laurelwood Road, Santa Clara, CA 95054,
(408) 246-8000.

Siliconix

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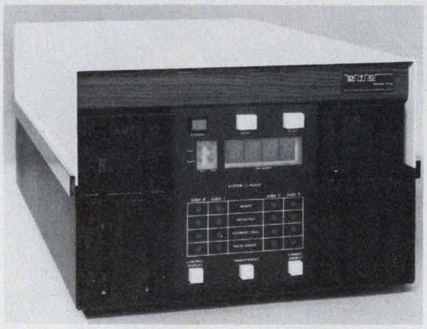
Across the desk

Me an editor?

If you'd like to be among the first to know (and write about) what's going on in the electronics industry, you might enjoy being an editor.

We have openings at our home office in Rochelle Park, NJ. Call Ralph Dobriner at (201) 843-0550.

Computer correction



We ran the wrong caption with the photo that appeared on p. 28 of ED No. 13, June 21, 1977. The product shown is *not* a 64-k dynamic memory board. It is the MICROFILE computer from Data Terminals and Communications, Campbell, CA. The unit includes an 8080A microprocessor, two or four flexible discs with storage of 300 k characters per disc, 7 k of ROM, and 8 k of RAM expandable in 16 k-increments to 56 k. The computer sells for $3650.

Burping circuit generates gas

The Idea for Design, "Timing Circuit Burps Battery" by John Okolowicz (ED No. 12, June 7, 1977, p. 116) was a very entertaining article. The positive attitude of its author is clear where he describes a momentary discharge of a battery as "....a negative charge is dumped into the battery."

However, since the intended polarity of C_2 and C_3 is unclear, I can't be sure just when these capacitors will explode. Is it before, or is it after the relay K_1, is activated by the 555 timer and the contacts of the former are fused permanently in the burp mode?

Perhaps, with a really run-down battery, the power transformer burns out first.

William A. Kinghorn
Senior Engineer

Auditory Devices
Telex Communications Inc.
9600 Aldrich Ave. South
Minneapolis, MN 55420

Mr. Okolowicz replies:

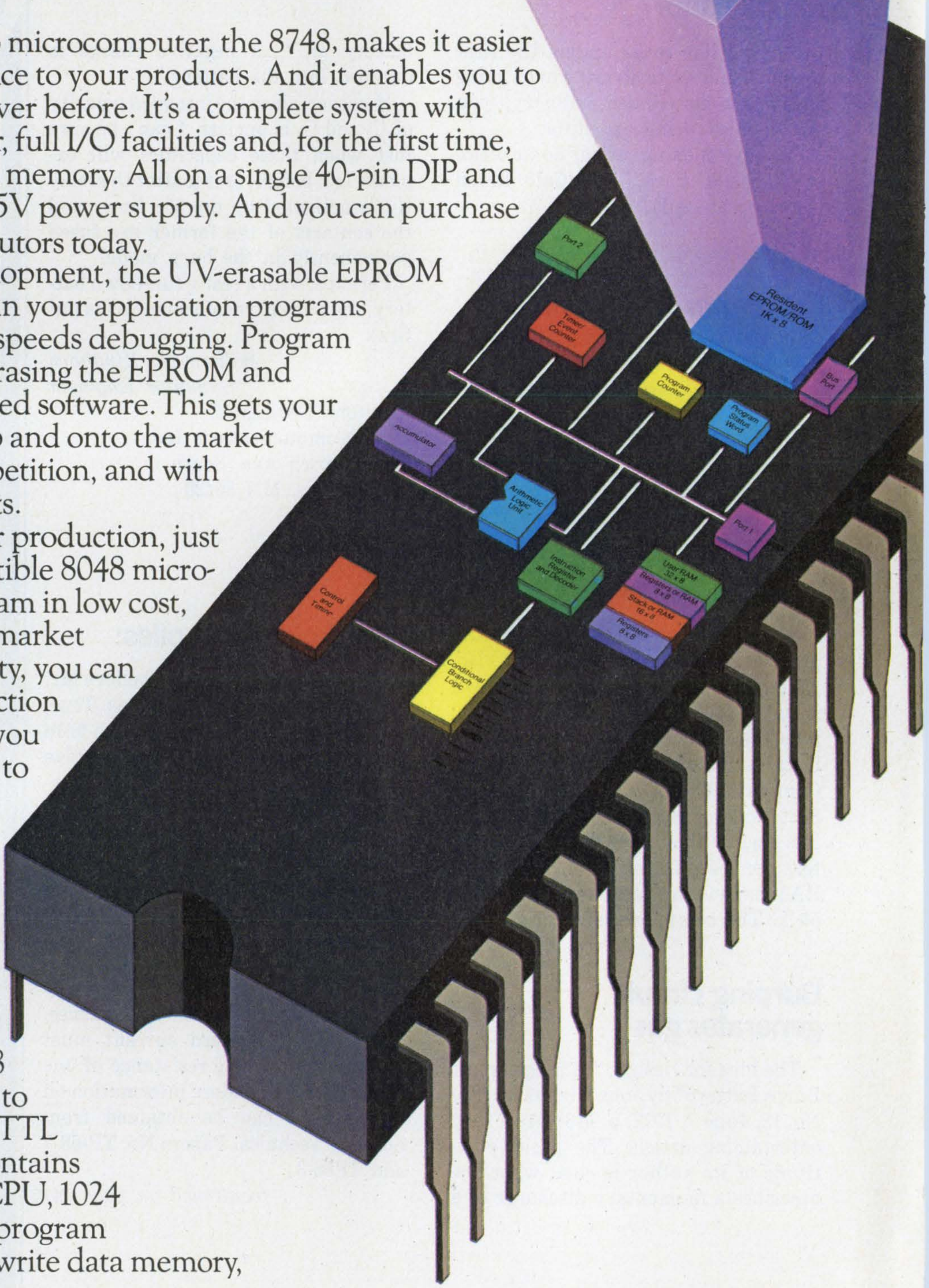
Like a burping battery, I believe Mr. Kinghorn is merely passing gas. True, capacitors C_2 and C_3 should have been shown back-to-back with their positive terminals tied together. This is Electronic Design's error, but one that should be readily recognized by anyone trained in the electronic arts. The circuit has worked well for me. It is self-limiting to a safe relay-contact current.

It must be remembered that electrolytic capacitors have relatively large equivalent series resistances. Furthermore, forward current must traverse the reverse resistance of one of the capacitors. More information on this subject can be obtained from Sprague Technical Papers No. TP-68-7 and TP68-3.

(continued on page 14)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St., Rochelle Park, NJ 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld upon request.

Intel delivers the first with resident EPROM.



Intel's new single chip microcomputer, the 8748, makes it easier than ever to add intelligence to your products. And it enables you to do it at a lower cost than ever before. It's a complete system with powerful central processor, full I/O facilities and, for the first time, resident EPROM program memory. All on a single 40-pin DIP and operating from a single +5V power supply. And you can purchase the 8748 from Intel distributors today.

During product development, the UV-erasable EPROM enables you to load and run your application programs in minutes. The 8748 also speeds debugging. Program changes can be made by erasing the EPROM and reloading with your updated software. This gets your new product out of the lab and onto the market months ahead of the competition, and with reduced development costs.

When you're ready for production, just substitute the fully compatible 8048 microcomputer with your program in low cost, resident masked ROM. If market entry timing has top priority, you can even ship your first production units with the 8748 while you gear up for the switchover to 8048. And by using the 8748 you can respond to non-standard customer requirements without waiting for ROM turnaround.

Intel's advanced MOS/LSI process technology allows a single 8748 or 8048 chip to replace up to 100 or more conventional TTL devices. The 8748/8048 contains an 8-bit general purpose CPU, 1024 bytes of EPROM or ROM program memory, 64 bytes of read/write data memory,

single chip microcomputer The 8748.

three programmable 8-bit I/O ports, 8 additional control/timing lines, programmable interval timer/event counter, priority interrupts, system clock generator and a full set of system controls. It's a single chip solution to a wide variety of applications, yet it's fully expandable by adding compatible MCS-80™/MCS-85™ I/O chips and Intel® standard memories.

There's also a new 8035 microcomputer that is exactly like the 8748/8048 but without resident program memory. It enables you to precisely match system memory size to your needs, using external ROM or EPROM.

Part No.	Description	Availability
	MCS-48 Components	
8748	Single chip μC with 1K bytes EPROM	NOW
8048	Single chip μC with 1K bytes masked ROM	NOW
8035	Single chip μC without resident program memory	NOW
8243	I/O Expander with 16 high current drive I/O lines	NOW
8355	ROM, 2K bytes, 16 I/O lines	NOW
8155	RAM, 256 bytes, 22 I/O lines and timer	NOW
	Compatible MCS-80/85 Components	
2316E	Standard ROM, 2K × 8, 450 ns	NOW
2708	Standard EPROM, 1K × 8, 450 ns, light erasable	NOW
2716	Standard EPROM, 2K × 8, 450 ns, light erasable	NOW
2111A-4	Standard RAM, 256 × 4, 450 ns, common I/O	NOW
2101A-4	Standard RAM, 256 × 4, 450 ns, standard I/O	NOW
5101	Standard RAM, 256 × 4, 650 ns CMOS	NOW
8255A	Programmable Peripheral Interface	NOW
8251	Programmable Communications Interface	NOW
8214	Priority Interrupt Controller	NOW
8253	Programmable Interval Timer	NOW
8259	Programmable Interrupt Controller	NOW
8279	Programmable Keyboard/Display Controller	NOW

The 8748 is the best supported single chip microcomputer you can buy. To speed development there's the Intellec® Microcomputer Development System with assembly language programming, symbolic debugging, and full EPROM programming capability. The ICE-48™ In-Circuit Emulation module simplifies hardware/software integration and debugging. And the Intel Prompt-48™ Design Aid is a low cost, stand alone alternative for 8748 programming, simulation and debugging. Intel supports you from prototype to production with development software, documentation, training and application assistance.

The new 8748 will give manufacturers of instruments, terminals, communications equipment, controllers, electronic games, automotive products, home appliances and hundreds of other products the competitive edge. It will help you get better products to market ahead of the competition at lower cost.

The 8748, 8035 and all compatible components can be purchased now from franchised Intel distributors: Almac/Stroum, Components Specialties, Cramer, Elmar, Hamilton/Avnet, Harvey Electronics, Industrial Components, Liberty, Pioneer, Sheridan, L.A. Varah, or Zentronics.

Or, for a copy of our single-chip microcomputer brochure write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051. Telephone: (408) 246-7501.

intel® delivers.

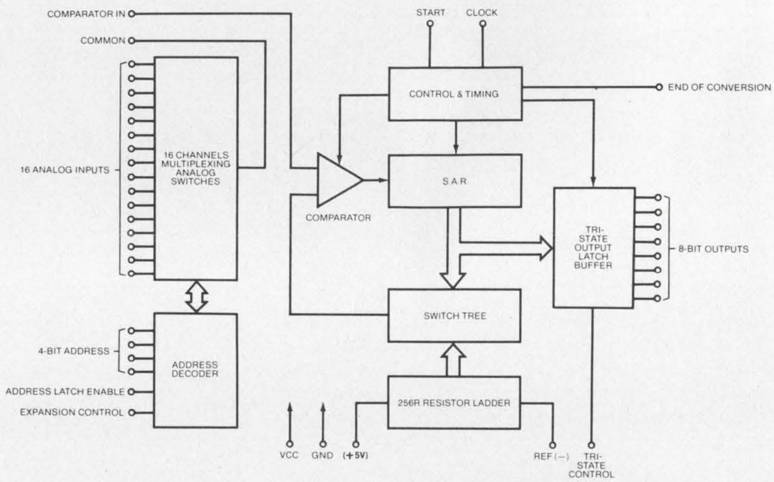
CIRCLE NUMBER 7

Complete instructions on how to assemble a data acquisition system:

Buy National Semiconductor's new ADC0816 and plug it in.
It's a complete data acquisition system on a chip. (Details on reverse.)

Complete details on the data acquisition system on a chip.

Introducing a revolutionary new product from National.
The first data acquisition system on a chip.
ADC0816.



8-bit analog-to-digital converter, 16-channel multiplexer, latched address inputs, and TRI-STATE® latched outputs.

In one ball of wax.

The converter provides absolute accuracy, so you can forget about error budget calculations. The total unadjusted error is $< \pm \frac{1}{2}$ LSB.

Nobody has ever offered accuracy like that.

And at $19.95 (100-piece price) this labor-saver will save you money, too. With 16 channels, it's only $1.25 a channel. (Single 5V power supply.)

So next time you start to build a data acquisition system, why not just buy one instead?

National Semiconductor, 2900 Semiconductor Drive, Santa Clara, CA 85051

Gentlemen:
Please send data sheets on your:
☐ data acquisition system ☐ references ☐ microprocessors

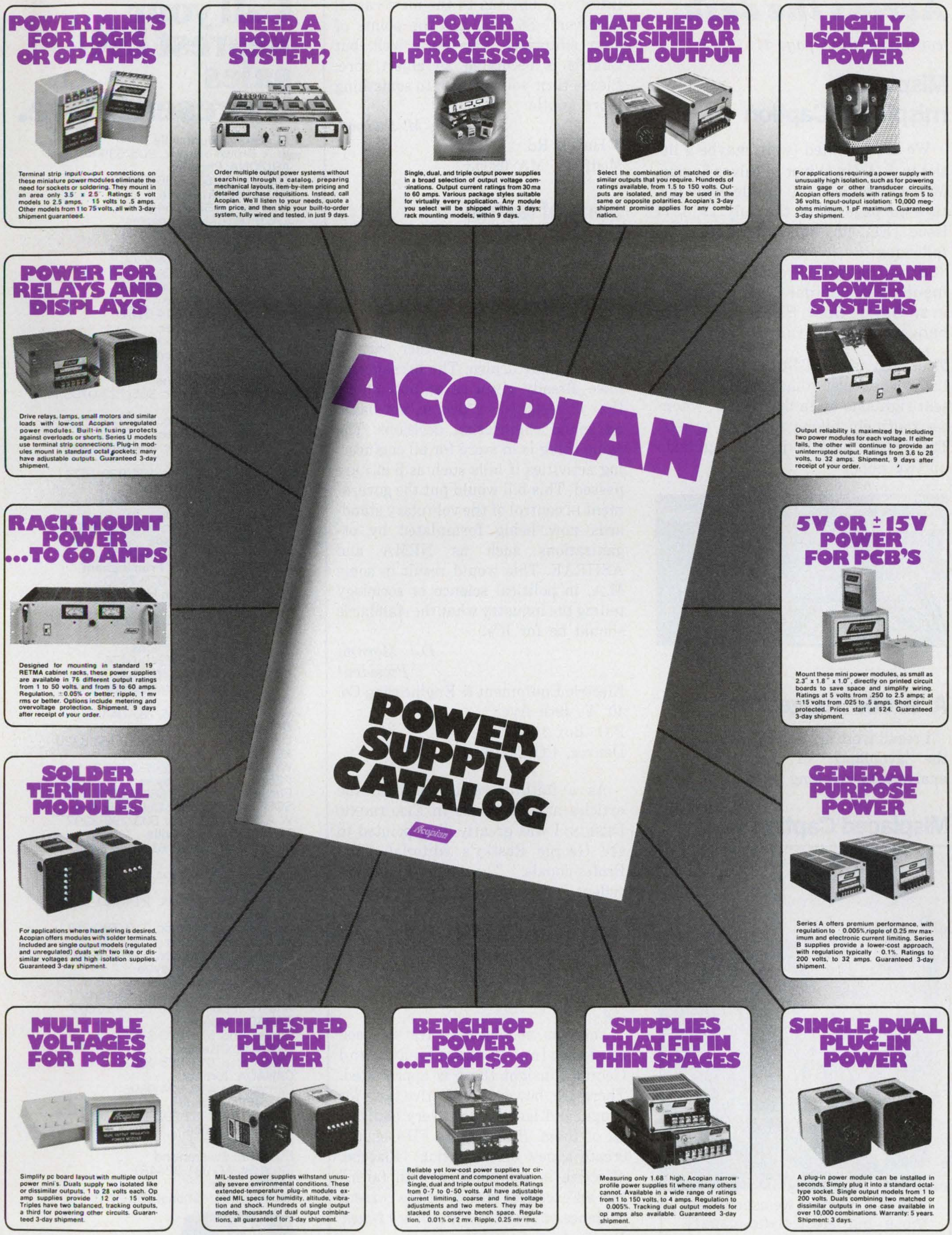
Name ______________________________

Company ____________________ Address ____________________

City ______________ State __________ Zip ______________

ED 11/8

National Semiconductor


POWER MINI'S FOR LOGIC OR OP AMPS
Terminal strip input/output connections on these miniature power modules eliminate the need for sockets or soldering. They mount in an area only 3.5" x 2.5". Ratings: 5 volt models to 2.5 amps, ±15 volts to .5 amps. Other models from 1 to 75 volts, all with 3-day shipment guaranteed.
NEED A POWER SYSTEM?
Order multiple output power systems without searching through a catalog, preparing mechanical layouts, item-by-item pricing and detailed purchase requisitions. Instead, call Acopian. We'll listen to your needs, quote a firm price, and then ship your built-to-order system, fully wired and tested, in just 9 days.
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Single, dual, and triple output power supplies in a broad selection of output voltage combinations. Output current ratings from 30 ma to 60 amps. Various package styles suitable for virtually every application. Any module you select will be shipped within 3 days; rack mounting models, within 9 days.
MATCHED OR DISSIMILAR DUAL OUTPUT
Select the combination of matched or dissimilar outputs that you require. Hundreds of ratings available, from 1.5 to 150 volts. Outputs are isolated, and may be used in the same or opposite polarities. Acopian's 3-day shipment promise applies for any combination.
HIGHLY ISOLATED POWER
For applications requiring a power supply with unusually high isolation, such as for powering strain gage or other transducer circuits, Acopian offers models with ratings from 5 to 36 volts. Input-output isolation: 10,000 megohms minimum, 1 pF maximum. Guaranteed 3-day shipment.
POWER FOR RELAYS AND DISPLAYS
Drive relays, lamps, small motors and similar loads with low-cost Acopian unregulated power modules. Built-in fusing protects against overloads or shorts. Series U models use terminal strip connections. Plug-in modules mount in standard octal sockets; many have adjustable outputs. Guaranteed 3-day shipment.
REDUNDANT POWER SYSTEMS
Output reliability is maximized by including two power modules for each voltage. If either fails, the other will continue to provide an uninterrupted output. Ratings from 3.6 to 28 volts, to 32 amps. Shipment, 9 days after receipt of your order.
ACOPIAN
POWER SUPPLY CATALOG
Acopian
RACK MOUNT POWER ...TO 60 AMPS
Designed for mounting in standard 19" RETMA cabinet racks, these power supplies are available in 76 different output ratings from 1 to 50 volts, and from 5 to 60 amps. Regulation, ±0.05% or better; ripple, 1 mv rms or better. Options include metering and overvoltage protection. Shipment, 9 days after receipt of your order.
5V OR ±15V POWER FOR PCB'S
Mount these mini power modules, as small as 2.3" x 1.8" x 1.0", directly on printed circuit boards to save space and simplify wiring. Ratings at 5 volts from .250 to 2.5 amps; at ±15 volts from .025 to .5 amps. Short circuit protected. Prices start at $24. Guaranteed 3-day shipment.
SOLDER TERMINAL MODULES
For applications where hard wiring is desired, Acopian offers modules with solder terminals. Included are single output models (regulated and unregulated) duals with two like or dissimilar voltages and high isolation supplies. Guaranteed 3-day shipment.
GENERAL PURPOSE POWER
Series A offers premium performance, with regulation to ±0.005%, ripple of 0.25 mv maximum and electronic current limiting. Series B supplies provide a lower-cost approach, with regulation typically ±0.1%. Ratings to 200 volts, to 32 amps. Guaranteed 3-day shipment.
MULTIPLE VOLTAGES FOR PCB'S
Simplify pc board layout with multiple output power mini's. Duals supply two isolated like or dissimilar outputs, 1 to 28 volts each. Op amp supplies provide ±12 or ±15 volts. Triples have two balanced, tracking outputs, a third for powering other circuits. Guaranteed 3-day shipment.
MIL-TESTED PLUG-IN POWER
MIL-tested power supplies withstand unusually severe environmental conditions. These extended-temperature plug-in modules exceed MIL specs for humidity, altitude, vibration and shock. Hundreds of single output models, thousands of dual output combinations, all guaranteed for 3-day shipment.
BENCHTOP POWER ...FROM $99
Reliable yet low-cost power supplies for circuit development and component evaluation. Single, dual and triple output models. Ratings from 0-7 to 0-50 volts. All have adjustable current limiting, coarse and fine voltage adjustments and two meters. They may be stacked to conserve bench space. Regulation, ±0.01% or 2 mv. Ripple, 0.25 mv rms.
SUPPLIES THAT FIT IN THIN SPACES
Measuring only 1.68" high, Acopian narrow-profile power supplies fit where many others cannot. Available in a wide range of ratings from 1 to 150 volts, to 4 amps. Regulation to ±0.005%. Tracking dual output models for op amps also available. Guaranteed 3-day shipment.
SINGLE, DUAL PLUG-IN POWER
A plug-in power module can be installed in seconds. Simply plug it into a standard octal-type socket. Single output models from 1 to 200 volts. Duals combining two matched or dissimilar outputs in one case available in over 10,000 combinations. Warranty: 5 years. Shipment: 3 days.

Across the desk

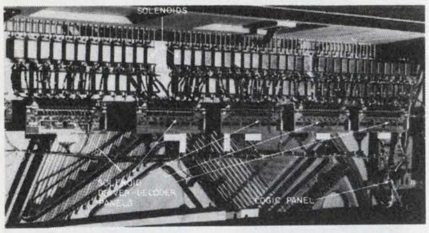
(continued from page 7)

Misplaced misplaced Caption

We are indebted (well, maybe a little) to J. Allen Oliver of Silver Spring, MD, who noticed the upside-down picture on page 21 of the July 19, 1977 issue (ED No. 15) and offered the following:

"Sorry. That's the Production Department's 'Pianocorder System Installed in an Upside Down Piano,' which now hangs above Ms. Duffy's desk."

Ms. Duffy is our Editorial Production Lady. She insists that the picture was sent rightside up to the printer, whom we routinely blame for such upsets. The picture here is, in fact, rightside up (we hope).



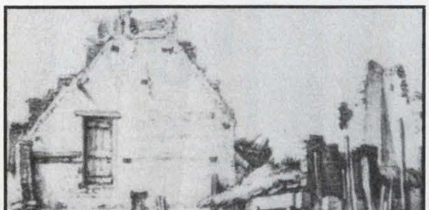
A 'subtle' suggestion

I recall from my undergraduate days the avoidance of many detailed analyses by invoking the maxim: "It is intuitively obvious to the most casual observer." So, too, are the points of your editorials. You write well, but Charlie is becoming an abject bore. Please turn your talents to something more subtle.

Steven M. Rudnick

3 Haven Rd.
Medfield, MA 02052

Misplaced Caption Dept.



And this is where we used to test those big electrolytic capacitors.

Sorry. That's Herman Saftleven's "Ruins," which hangs in the National Gallery of Ireland in Dublin.

Sons of laetrile

Your July 19 editorial on "The Professionals" (ED No. 15, p. 51) was excellent. Although you specifically mentioned the FDA in the case of laetrile, the bureaucracy's role in engineering decisions is another parallel that could be drawn. The bureaucrats have already given us an automobile that is designed by decree, not based on sound engineering decisions. The same thing is in store for all engineering activities if bills such as S 825 are passed. This bill would put the government in control of the voluntary standards now being formulated by organizations such as NEMA and ASHRAE. This would result in some M.A. in political science or sociology telling the industry what the standards should be for ICs.

D.J. Morroni
President

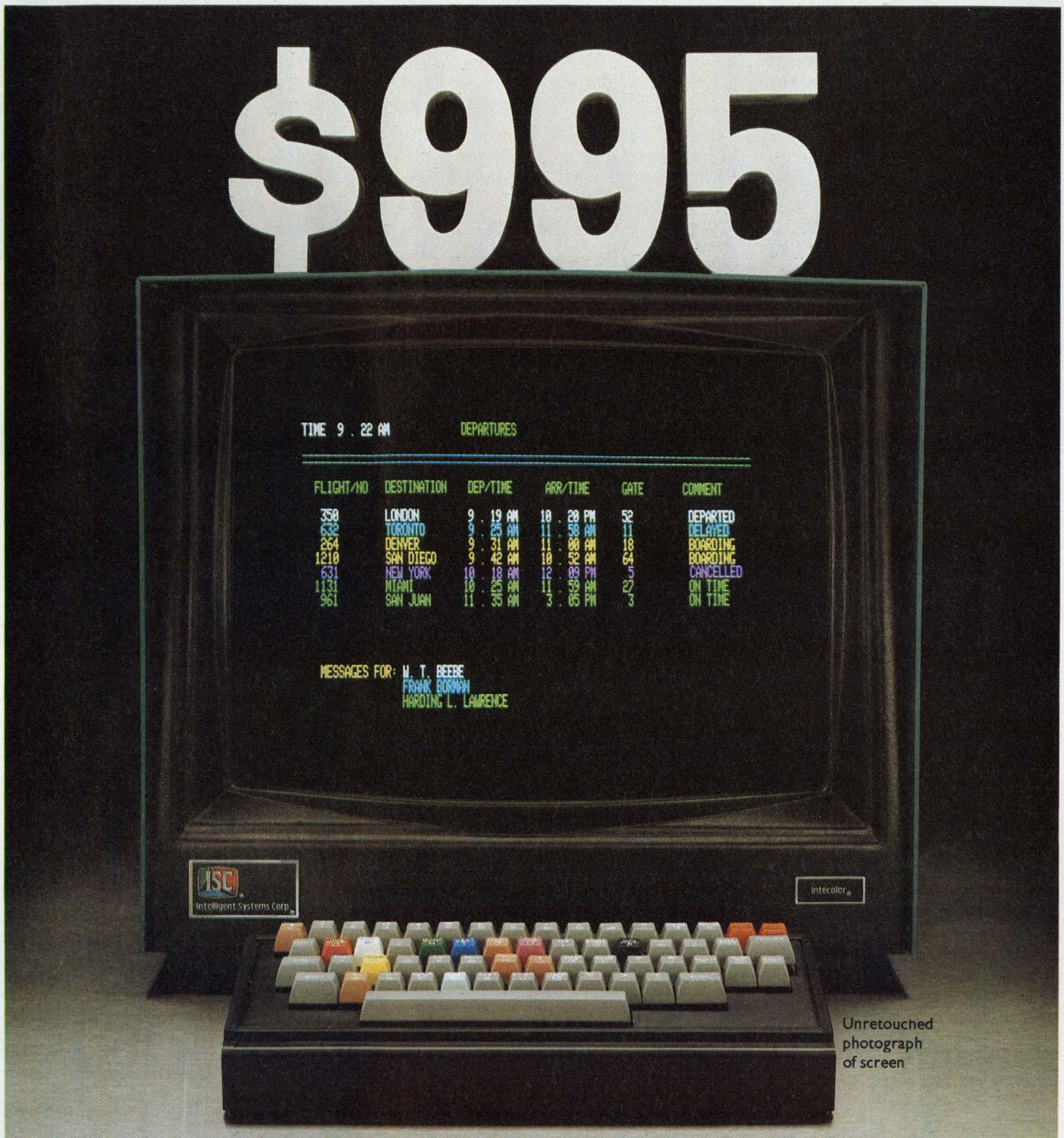
Electric Equipment & Engineering Co.
40 W. 49th Ave.
P.O. Box 16383
Denver, CO 80216

As a faithful reader of both the articles and editorials in ELECTRONIC DESIGN, I was greatly disappointed to see George Rostky's editorial, "The Professionals." The pages of an excellent electronics magazine are no place to endorse a highly controversial compound (allegedly a vitamin). ELECTRONIC DESIGN usually does not accept either manufacturers' claims or glowing testimonials without further testing.

There is no objective test of good engineering management, and George's insight there is appreciated. There are, however, objective tests for drugs, and laetrile does very badly in all of them. Perhaps the FDA should create a new classification: "Placebo, effective in combination with faith." For an excellent review of the current evidence on laetrile, see *Science News*, No. 6, Aug. 6, 1977.

David Griesinger

David Griesinger Recordings
86 Washington Ave.
Cambridge, MA 02140



Unretouched photograph of screen

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CIRCLE NUMBER 11

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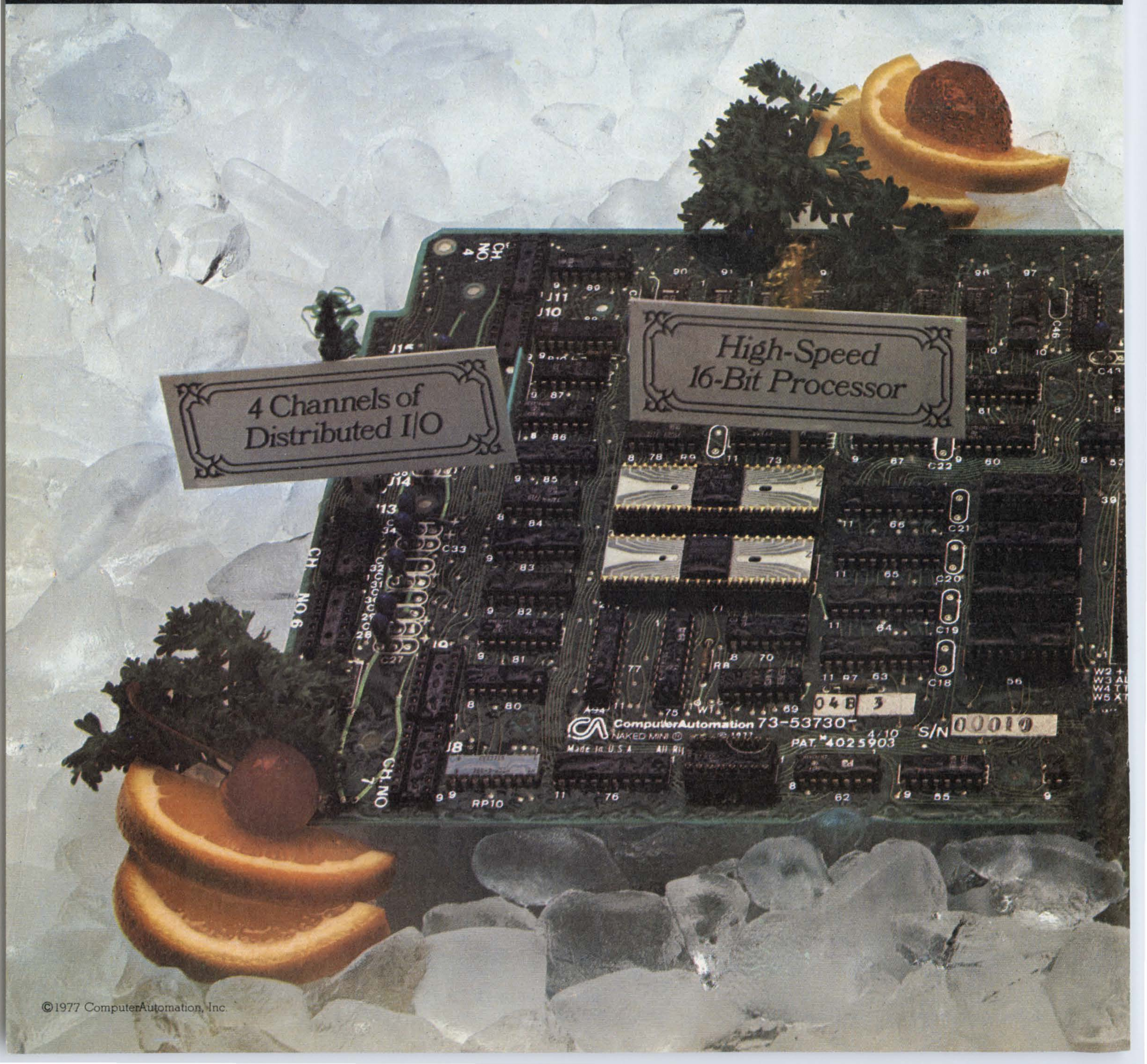
SMORGA



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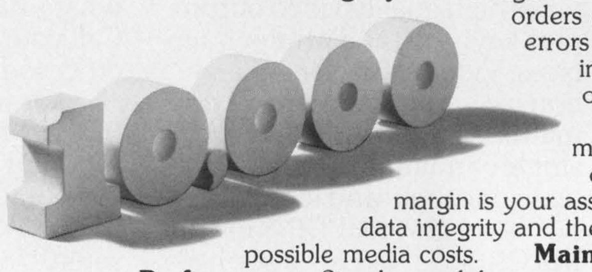

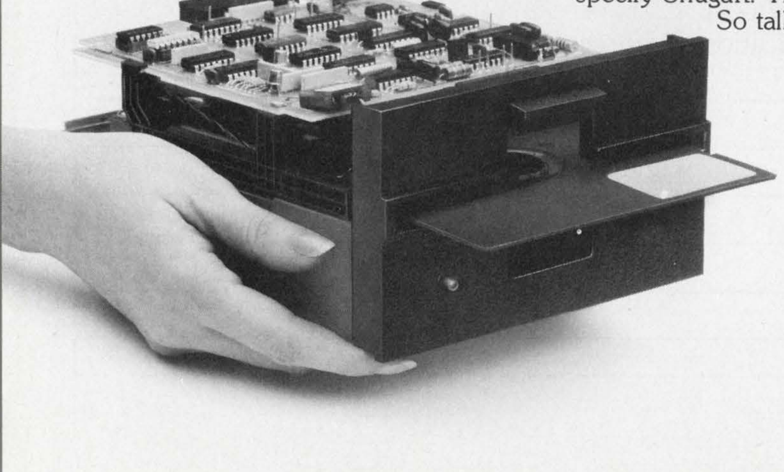

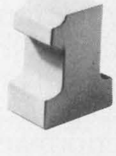

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CIRCLE NUMBER 14

Two DPM makers earn Underwriters' recognition

Two lines of 3 1/2-digit, ac line-powered digital panel meters have gained acceptance by Underwriters' Laboratories as recognized components, and will be easier to incorporate into equipment that must be rated by UL.

Models in the 2460 series from Weston Instruments and the Model 4424 from LFE Corp. will, in most cases, no longer have to be tested as if they were just another part of the circuitry in order for an end product to be granted UL listing. This recognition applies to commercial and industrial applications as well as medical applications that don't involve direct connection to a patient.

When the final product is a patient-connected medical instrument such as a heartbeat or respiration monitor, Underwriters' will still examine all DPMs. But the tests for the recognized ones will most likely be limited to current leakage and dielectric withstand.

Most other tests on the DPMs, like flammability and face-plate resistance to shattering, have been performed to gain component recognition—a process that takes about six months, says Mark Rehnborg, product marketing manager at Weston Instruments in Newark, NJ. Aside from the time, "there's quite an expense involved," says Mike Ryan, digital instrument product specialist at LFE in Waltham, MA. Recognition cost his firm about $20,000.

The LFE 4424 costs $135. Weston's recognized 2460 series meters go for $139 and nonrecognized versions for $127.50. The accepted versions have a thermal fuse in the power transformer, and a new PC board layout to increase clearances between current-carrying lines.

Double memory catches hidden logic glitches

With two memories—one to store logic transitions and one to store glitches—a logic analyzer can capture and display glitches even when they occur in the same sample period as a normal logic transition. Transients as short as 5 ns can be uncovered.

Most logic analyzers have "pulse stretching" circuitry that stores a transient and displays it at the next system-clock transition. But should a glitch occur just before or just after a normal transition in the signal line—ringing, for example—it will be masked in the resulting display, which shows only the transition.

By storing transition and glitch data in its own 256 × 8-bit memories, the Model 1615A logic analyzer from Hewlett-Packard Co., Palo Alto, CA, can be set to begin storing or displaying the activity in digital systems when a glitch *or* a particular logic pattern—or both—ocurs. Glitches during data transitions are displayed as brightened edges on the transition.

In the timing-analyzer mode, the 1615A samples at 2 Hz to 20 MHz, and displays 249 of the 256 stored data transactions. Up to eight data lines can be accommodated.

In the state-analyzer mode, the 1615A handles 24 lines at up to 20 MHz. A 6-bit clock qualifier allows the analyzer to display specific data such as read and write commands, and input/output transactions.

The HP analyzer can also be configured to display 16 bits of state information and eight bits of timing information simultaneously. And when a specific state or timing sequence—or both—has occurred, the analyzer can be triggered to operate, then display either or both sets of information.

Input threshold levels are either TTL-compatible or adjustable from −10 to +10 V.

CIRCLE NO. 315

Photocell tells if army weapons are on-target

A specially designed photocell that is sensitive to the light of a particular frequency is helping the Army check the effectiveness of its weapons during training exercises. For this application, the silicon light detector produced by International Rectifier is tuned during fabrication to react to pulsed infrared light at a wavelength of 900 nm.

During an exercise, quarter-sized photocells are worn by troops and placed on vehicles, installations and weapons. When the weapons are fired, 900-nm light sources on them are triggered in place of live ammunition. "Hits" are registered on the detectors.

The precision needed for the Army application requires a photocell with a capacitance of just 4.5 nf, and a variation of ±0.4 nf. This highly specialized cell, which ordinarily would be too expensive to buy, is picked out from among the conventional wafers that the company uses in making other products, notes Harold Weinstein, project manager of International Rectifier, El Segundo, CA.

The photocell is immune to stray electromagnetic radiation because its opening is covered by an electrically grounded, chemically milled, stainless steel screen, says Weinstein. This screen permits a high level of shielding from interference while letting the infrared signal get through easily.

Since its sensitivity to light can be tuned, this photocell can be made to respond only to certain weapons. For example, tanks equipped with a modified cell might register hits from artillery but not small arms.

Computer locates objects on production line

A new worker has joined the production line at General Motor's Delco Electronics Div.—a computer system that sees.

Right now the computer, called Sight-1, is used to locate transistor chips and calculates their positions as they are being processed for use in GM's high-energy automotive ignition systems. Sight-1 also verifies a chip's structural integrity and rejects those that are defective. But the system can also be used to find and calculate the position of any object on a production line.

Both overlapping and nonoverlapping objects can be recognized by the computer, says GM's Dr. Michael L. Baird, co-developer of the system. For both types, an image is sensed by a TV camera, digitized, then sent to the computer. At that point, if the object isn't overlapping other objects, a program can help the computer find it rapidly and reliably by "sharpening" the computer's sight.

Using the digitized data, the computer works through a series of image enhancements to produce a silhouette that emphasizes the outline of the nonoverlapping object.

Squares of the digitized picture are intensified, along the object's edges, Baird explains. Next, the program helps get rid of the rough edges by smoothing the data.

This approach doesn't call for specific mathematical formulas. In fact, the computer doesn't even have to know what it is looking for, since it just locates and emphasizes the edges.

However, specific mathematical models are used to help the computer detect overlapping and partially obscured chips. When such objects are shown to the computer, it analyzes them and stores the data needed to identify the objects in memory.

Dr. Michael Baird (adjusting camera) and Dr. Walton Perkins have developed a system that helps computers locate and calculate the position of parts on an assembly line.

Audio compass tells you when you're out-of-line

A belt-worn audio compass system warns its user when he isn't walking in the right direction. The 5-oz unit contains an unusual magnetic field sensor—a sensitive magnetic reed relay. The reed relay is the active element of a subaudio frequency oscillator that produces the warning sound, a series of sharp clicks.

The compass can be very useful to the blind as well as to hikers and search parties in remote areas. The wearer turns a compass dial to the bearing he wishes to track. So long as he maintains his course within 4° of this bearing, the compass is silent. But at the 4° limit, a warning of 2 to 4-Hz clicks sounds. As the user goes farther off course, the clicks, which are produced by a barium-titanate ceramic unit, come more quickly.

The reed-relay sensor in the compass system is highly sensitive when biased with magnets, notes inventor Ray W. Hoeppel of Oak View, CA. It responds to a change in the field of about 1 milligauss, or better than 1/500 of the earth's magnetic field.

The reed relay acts like a single-pole, double-throw unit. When it is aligned with the magnetic North, the reed remains in a neutral position between its two contacts. As the compass and reed relay turn away from North, the flexible reed attempts to remain aligned with the field, closing a circuit through one of the two contacts at about ±4°. Once contact is made, a transistor amplifier energizes the reed-relay coil, pulls the reed away and breaks the contact. It also applies a sharp pulse to the ceramic unit. This allows the reed to spring back and make contact again. Oscillations continue unitl the reed and compass are again pointed to North, within the 4° limit.

Maximum sensitivity of the reed system is achieved with the oscillator period of 2 to 4 Hz. The oscillator's long time constant is obtained with high capacitance in the transistor circuit. The compass is powered by two mercury cells.

Moreover, should the compass system's magnetic bearing deviate from true North, a provision in the compass will bring it back.

Earphones can be plugged in for use in noisy environments, and a neon lamp for night use. The lamp operates off a dc-to-dc converter.

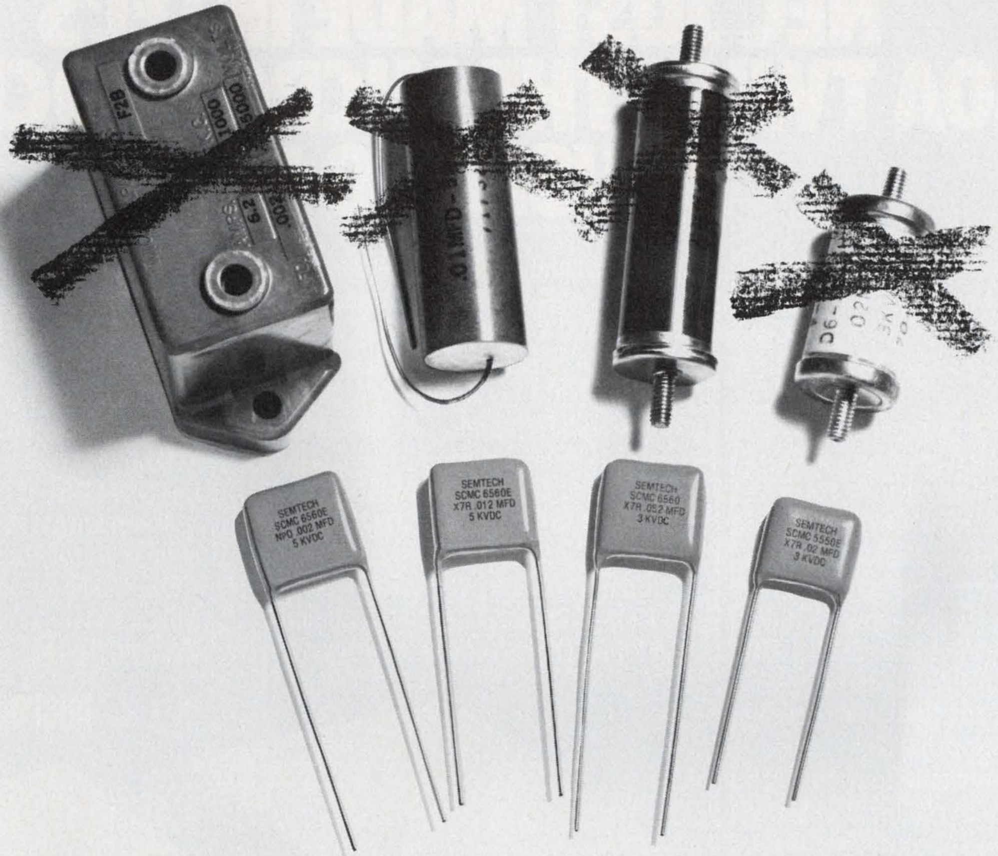
The principle upon which the compass works is being applied to developing position, or distance-measuring, transducers. Here, a change in oscillator frequency—as the reed sensor moves to or from a magnet—is calibrated as distance.

PLL IC for televisions eliminates H and V knobs

Working with a ceramic-resonator frequency reference, a phase-locked-loop integrated circuit that costs less than $1 in large quantities eliminates the need for horizontal and vertical-hold controls in television sets.

Most television receivers use an LC or RC voltage-controlled oscillator, operating at about 15 kHz, as a frequency reference. And "because of the inherent inaccuracies in most LC or RC-based oscillators, the pull-in range is seldom sufficient for accurate operation without hold controls of some sort," says Matt Wilcox, design engineer at National Semiconductor Corp., Santa Clara, CA, which makes the PLL chip. With the LM1880 and a 503.5-kHz ceramic resonator made by MuRata Corp. of America, Rockmart, GA, the horizontal-oscillator frequency does not have to be adjusted to ensure lock-up to a sync signal applied to the PLL. And vertical lock-up is guaranteed, since the vertical signal is derived from the same source.

The LM1880, fabricated with an 8-μ epitaxial-layer, mixed-linear and integrated-injection-logic digital process, has a 32-times horizontal-frequency VCO accurate to within 2 kHz of a 503.5-kHz center frequency. The VCO signal is divided to produce a predriver output that is locked into negative sync by an on-chip phase detector. The vertical-output ramp is injection-locked by a vertical sync, which is subject to a sync window derived from a 546-element countdown section. If no sync pulse arrives following the 514th count, the counter continues to 546, when an automatic reset occurs. If the horizontal output is locked to 15.734 kHz, the vertical output can be injection-locked from 57.63 to 61.22 Hz.



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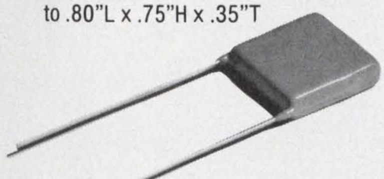

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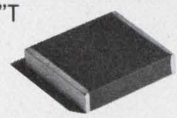

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Insulation Resistance (I.R.)	100K megΩ or 1000 megΩ microfarads, whichever is less (25°C, 500VDC)	100 K megΩ or 1000 megΩ microfarads, whichever is less (25°C, 500 VDC)
Aging	0	1% per decade
Dielectric Withstanding Voltage	1.2 Times Rated Voltage*, at 25°C	1.2 Times Rated Voltage*, at 25°C
Dimensional Tolerance	±.010 or±5%, whichever is greater	±.010 or±5%, whichever is greater

*Dielectric Withstanding Voltage Tests are conducted with charging current limited to 10 mA and the discharge current limited to 5 A.

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CIRCLE NUMBER 15

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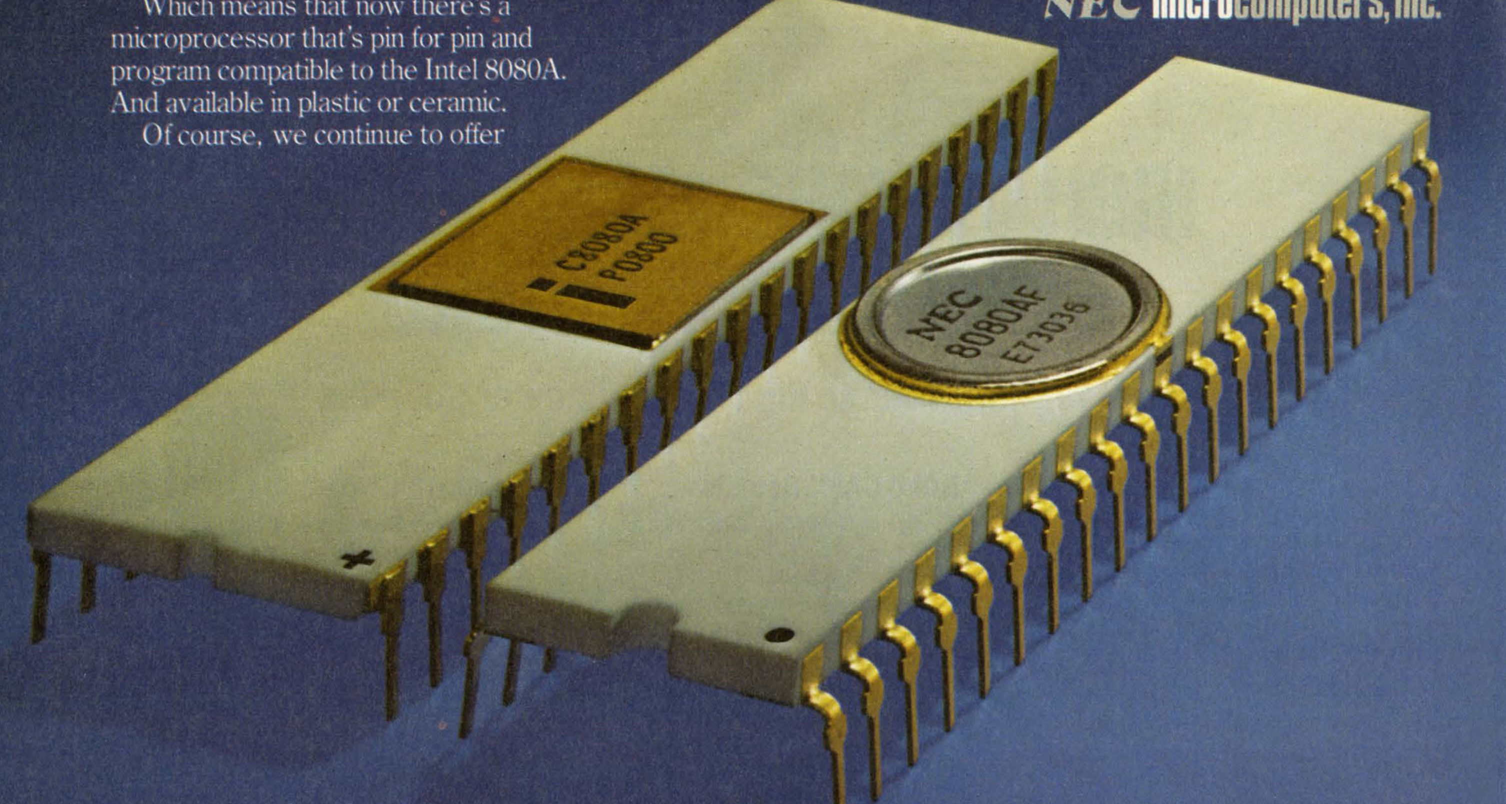

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Radio receiver reaches 670 GHz with 'quasioptics' and new mixer mount

A submillimeter radio receiver, or radiometer, will put the unused electromagnetic region between microwaves and infrared to some practical uses, including anti-terrorist technology. A combination of "quasioptics"—lenses made of Teflon—and a new mounting technique for the conventional Schottky-barrier diode mixer extends the receiver's range to 670 GHz.

Schottky-barrier diodes by themselves can detect radio signals at terahertz (10^{12} Hz). But the mechanical "plumbing" needed has long been a stumbling block to pushing the limit beyond 100 GHz or so.

For example, a conventional microwave receiver, scaled to operate at 600 GHz (1/2-mm wavelength) would need a rectangular input waveguide of truly hair-breadth dimensions—0.008 × 0.014 in. A tiny hole would have to be drilled through one of the waveguide's 8-mil walls and a whisker antenna positioned across the waveguide, to contact a Schottky diode chip on the other 8-mil wall. Then a lilliputian tuning slug (back-short) would be needed inside the waveguide to reflect the incident rf energy. A tiny micrometer adjustment would be necessary for the slug to create a standing wave of incident and reflected energy just at the point of the whisker antenna.

Dick Hackmeister
Western Editor

Enter quasioptics

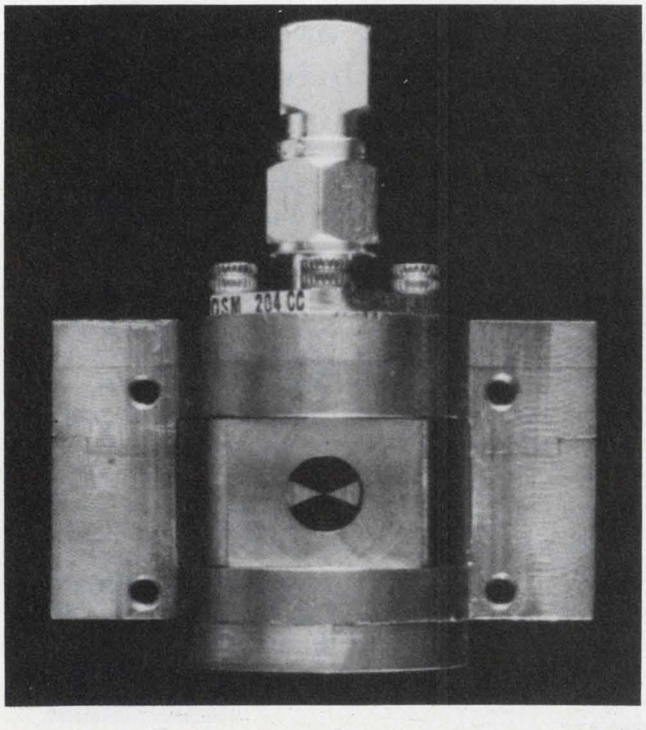
To sidestep these problems, when building the submillimeter receiver, a team of four scientists at University of California (Los Angeles) abandoned many of the conventionally sized receiver components—only fractions of a wavelength—for much larger components—10 to 100 wavelengths. Since pure optics calls for huge parts—10,000 wavelengths or so—the UCLA team calls its technique "quasioptics."

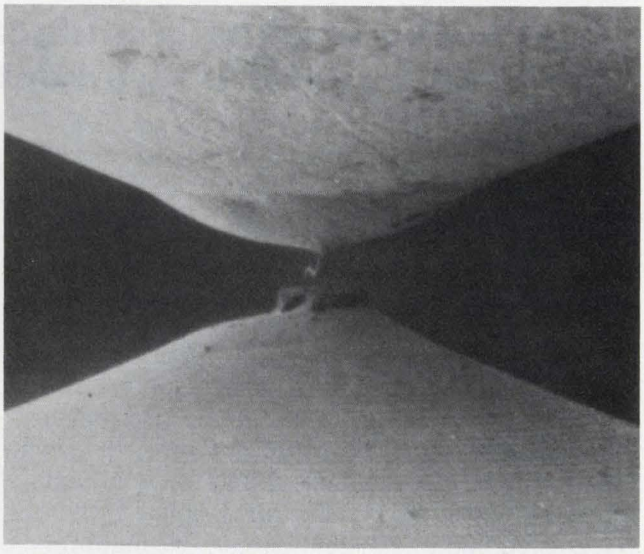
A Teflon lens in the receiver focuses the submillimeter wavelength energy into a spherical resonant cavity. Micrometer tunable (see photo), the cavity contains a pair of cones that act both as an antenna and as a mount to hold the whisker antenna/Schottky diode assembly in the standing rf wave.

The Schottky-diode chip used is actually an array of several thousand diodes, each about 1000 angstroms in diameter. The contacting whisker is etched to a point finer than the diodes' diameters so that it can contact one and only one diode at a time. This minimizes signal-attenuating capacitance.

With the cavity properly tuned, rf energy is coupled into the whisker. A diode touching the whisker is ohmically mounted to one apex of the biconical antenna, and the rectified (detected) rf energy is passed into the cone.

Grooves cut into the diameter of the cone's shaft act as a low-pass filter, allowing only the intermediate frequency of 1.42 GHz to pass into the





Quasioptical radiometer mixer (left) uses a biconical antenna for the Schottky-diode/Whisker-antenna mount. It detects microwave signals approaching a THz. Built by Aerospace Corp., the radiometer is expected to find use in thermonuclear plasma and security applications.

next stage. All other parts of the radiometer are conventional.

New signatures, new uses

The number of applications for submillimeter radiometric imaging is growing, according to Dr. Dean Hodges, staff scientist at Aerospace Corp., El Segundo, CA, and a member of the developing team. Beyond monitoring the goings-on within a magnetically contained thermonuclear plasma, quasioptical radiometers are expected to be pressed into service as anti-terrorist security monitors.

"The clothes we wear are opaque in visible light," explains Hodges. "But passive radiometric monitoring at submillimeter wavelengths can detect weapons, explosives and other contraband items without X-rays."

Already, radioastronomers looking for life in deep space have used a radiometer to find water vapor in the Orion constellation (water has strong spectral lines at 180 and 320 GHz, notes Hodges). A quasioptic radio receiver can also help keep tabs on air pollution and the earth's ozone layer by monitoring the signatures of gases in the earth's atmosphere between 100 and 1000 GHz according to Hodges. ■■

Standard Navy computer has low-power core memory

A core memory system that is twice as dense and uses 40% less power than earlier military core memories, yet costs only 15% more, is being built by two suppliers as part of the Navy's program to standardize on the AYK-14 avionics computer.

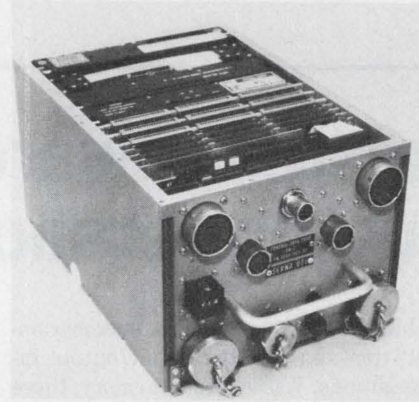
The AYK-14 is already scheduled to go into the F-18 fighter being developed for the Navy by McDonnell Douglas Corp. in St. Louis. It is being considered for the Navy's Lamps helicopter, EP-3 intelligence aircraft, and for updates of the P-3 patrol aircraft.

Control Data Corp. of Minneapolis is building the AYK-14 for the Navy, which required that CDC find a second source for the memory and power supply systems. Electronic Memories & Magnetics Corp.'s Severe Environment Products division, Chatsworth, CA, has signed an agreement with CDC to build identical core memory systems.

Each bit in the memory system is a toroid of iron oxide to which lithium, cobalt and copper trace quantities have been added. The additives change the core's temperature-response curve so that, with the proper mixture, the core operates over the military temperature range (−55 C to 125 C) with little variation in performance.

In the AYK-14 core memory, the response curve is a straight line, but tilted to compensate for the variation in resistance with temperature of the copper stringing wire that feeds current through the toroids.

The cores are 13 mils in diameter, the smallest used in military systems. This core size has been used by Ampex Corp., Redwood City, CA, but in commercial systems not designed to operate over the military temperature range. Most standard military and commercial cores are 18 mils in diameter.



The standard computer for future Navy avionics programs, the AYK-14 is being developed by Control Data Corp. and, it is hoped, will be available from other vendors as well. The first application is in the F-18 fighter.

Cutting current drain

Drive current through the cores is 300 mA, less than half that of conventional memory cells, which use lithium alone as an additive. As a result of the lower drive current, power consumption is cut from between 105 and 110 W to less than 65 W under worst-case conditions: an operating temperature of −55 C and a stored pattern of all zeros.

The major benefit of lower power consumption is higher reliability. Temperatures at the semiconductor junctions in the sense amplifiers that drive and read the memory elements have been cut from 125 to 110 C, even when, as in the AYK-14, the core memory system is cooled only by conduction—without fans. The surface on which the memory card is mounted is specified at 85 C, so the temperature rise in the system can be no more than 25 C.

At the same time the AYK-14 memory consumes less power than its predecessor, it can store twice as much data. The AYK-14 core system stores 32 kwords of data, each word 18 bits wide. The earlier unit stores 16 kwords of data.

With all these advances, "you don't give up anything," says Don Ballantyne, engineering manager at EMM Severe Environment Products. The price of the newer memory, which EMM calls the SEMS-16, is only about 15% higher than that of the 16-k SEMS-9PI, he adds.

The lower cost-per-bit is the result of smaller cores—13 vs. 18 mils—as well as LSI sense amplifiers replacing hybrid and discrete circuitry. In addition to lower initial cost, the Navy should benefit from lower operating costs since the alternative versions of the AYK-14 core memory system are identical in all respects—whether built by EMM or by CDC.

The Navy, as part of the AYK-14 contract, required CDC to establish an alternate source for the memory card,

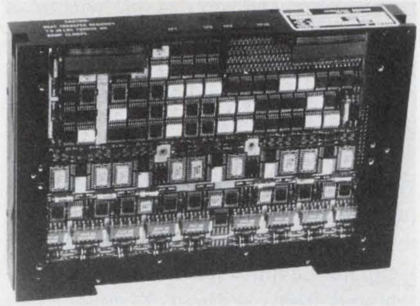
Andy Santoni
Associate Editor

but the alternate had to be equivalent in form, fit and function at the board level, not necessarily an exact copy, explains Rich Bolestra, hardware engineer on the AYK-14 project for the Avionics Division of the Naval Air System Command Headquarters in Washington. "Our goal is to duplicate functions at the board level so that we can second-source on the SRA (shop replaceable assembly) level," he says.

Since EMM was already working on 13-mil military core development, the firm found it convenient to approach CDC and agree to build an exact duplicate, says EMM's director of marketing, Dean Knutson. If the Navy finds it desirable, it can therefore stock spares beyond the SRA level for field repairs.

Later, the Navy will be looking for alternate sources for the rest of the AYK-14. At present, CDC is in the preproduction phase of the contract, with testing to be performed through most of next year. A provisional application for service use is expected by the end of next year, says the Navy's Bolestra, with production to begin in 1979.

Over the ten year production cycle the Navy expects for the AYK-14, the computer could be used on a wide variety of projects. "There could be as many as 10,000 built by the time it's over with," says Bolestra.



The standard memory for the AYK-14 is already available from two sources: CDC and EMM. It uses 13-mil cores to cut power consumption by almost half.

Standardization to be the norm

"I think there's a real effort now from the Department of Defense to standardize," says EMM's Knutson. Five years from now it's going to be the normal way of doing business at DOD, he adds.

Earlier DOD efforts to standardize have failed because of politics, a not-invented-here attitude, or because the standard product was not tailored to doing any specific job—a "standard" product might have all the bells and whistles for current applications yet lack adequate flexibility for future tasks. Perhaps this time the Navy will be successful.■■

Shifting control to firmware speeds computer operations

Moving more of a computer's control program from software into firmware cuts the time it takes to perform basic functions by as much as two-thirds.

As a result, the Royale small-business computer system from Microdata Corp., Irvine, CA, can perform central-processor calculations two to three times faster than Microdata's older Reality system and can handle terminal input/output functions twice as fast. Access to disc-stored data takes about as long.

Semi memory beats core

Speed is increased, in part, by storing instructions in semiconductor ROM rather than in core. Cycle time of the semiconductor memory used in the Royale system is about 200 ns, compared with 1 μs for core, says Ted Ellison, project manager. In addition, the Royale contains about 8 kwords of firmware in ROM, each word 16 bits long. The Reality system has only about 2 kwords of firmware.

In the Royale's 8-kword firmware space, six kwords are used for the computer's operating system, which determines the architecture of the machine, and controls virtual-memory operation and terminal input/output interactions. With virtual memory, there is more room to store programs and work in progress than there is actual memory space in the computer's resident memory—some of the stored data can be shifted out of the resident memory.

But virtual memory is normally controlled by disc or core-based software, and data are usually shifted back and forth to disc storage in "pages," which can be very time-consuming. In the Royale system, the ROM-stored firmware speeds operations by re-using some of the pages that are already in resident memory, instead of constantly calling up new pages.

An additional 512 words of Royale firmware contain an operating system that makes the computer look like Microdata's older 1600 series machines. Consequently, the Royale can use diagnostic programs developed and debugged on Microdata's older machines for tracking down computer and peripheral faults.

Moreover, a special diagnostic program housed in the rest of the Royale's 8-kword firmware can be called up not only by Microdata service technicians but also by users. Such programs are usually unavailable to users, but are stored on cards that a technician must bring to the ailing system and plug in, according to Ellison. With resident diagnostics, users can quickly pinpoint a problem without waiting for a technician to arrive. A service call may be eliminated altogether if the problem is in a peripheral, not in the computer, Ellison explains.

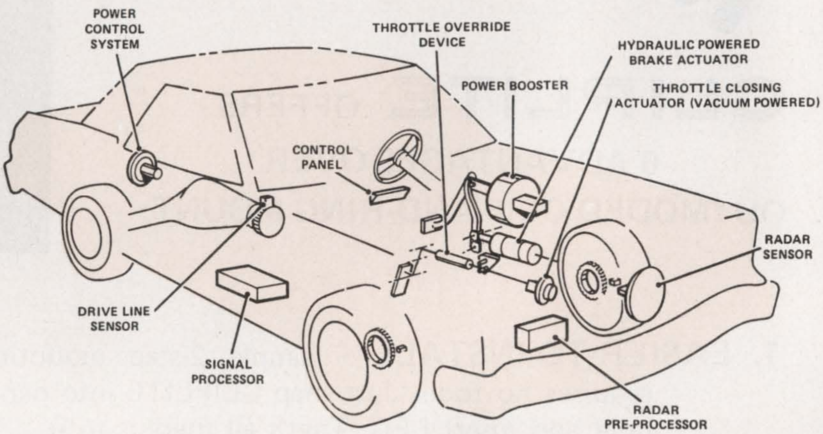
A step beyond reality

Microdata can convert a Reality system to a Royale system by changing a ROM card, adding a few resistors, and upgrading any boards already in the system that are not current enough to be compatible with the new equipment. Programs already written for the Reality system can then be run without modification, although they might not be as efficient as possible because they do not take advantage of the latest changes in the operating system, says Ellison, adding that conversion would keep Microdata's older Reality system down one or two work shifts.■■

With new radar braking system, your car won't stop at every tree

An automobile radar braking system using a small antenna beam width and a limited radar range is virtually unhampered by the false alarms plaguing other automatic-radar braking systems being developed.

According to Department of Transportation studies, automatic radar braking systems would prevent rear-end and head-on auto crashes, or at least reduce the seriousness of injuries received in those accidents. Noncooperative radar systems developed for this purpose do work—but they also apply the brakes when approaching obstacles not blocking the automobile's path—like roadside posts or trees.



An automatic noncooperative radar braking system by Bendix prevents the driver from crashing into cars, pedestrians or obstacles in the road. System elements are located in various parts of the car.

Down to almost nothing

These false alarms have been reduced almost to zero, however, by an unusual radar braking system developed for the DOT by Bendix.

Tests conducted by the company revealed that false alarms could be effectively suppressed by using a very narrow antenna beam and by limiting the radar detector range to restrict the distance at which brakes would be applied. Indeed, with a 2.5° beam width, false alarms were all but eliminated for a detection range between 100 and 300 ft. For example, the number of false alarms occurring on a divided highway was less than 2 at 200 feet for 57 runs.

To determine the value of small antenna beam width and radar-detection range cutoff, Bendix used a 22.125-GHz radar that fed range and rate-of-range-change signals into processing electronics. Car speed and steering angle were also fed in. Antenna beam width was varied between 10° and 2.5°, and radar-detection-range cutoff between 100 and 300 ft.

After 36 brake-system configurations were evaluated using computer models, Bendix concluded that a 300-ft radar was best for preventing head-on crashes. But because of the unsatisfactory number of false alarms projected at this range, a compromise had to be made. Based on the computer evaluations, the cut-off range was reduced to 150 ft. Eventually, however, the range was increased to 250 ft so that an early-warning function could be added.

To achieve a beam width of 2.5 to 4° with a 6-in. radar horn that wouldn't look too big on a compact car or require front-end modification to be installed, Bendix decided on a low-power, solid-state radar with a 25-mW Gunn oscillator operating at 36 GHz. A millimeter-wave band (above 40 GHz) had been considered, since the antenna would have been even smaller. But back scatter from heavy rain would have been a problem.

A nonstandard system

To obtain range information, the Bendix radar is not a standard FM-CW system, but what is termed a diplexed-CW system. Transmitted rf bursts in the system are alternately displaced 410 kHz above and 410 kHz below the 36-GHz carrier.

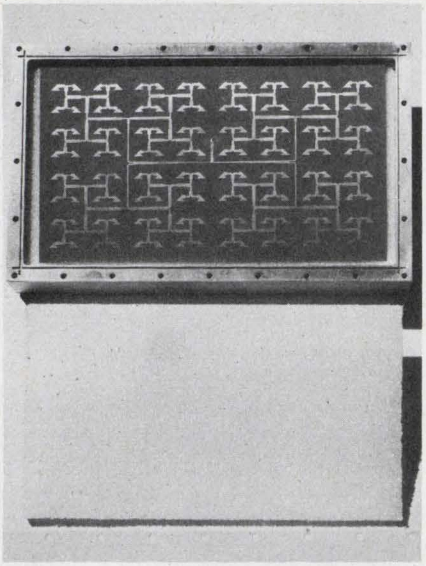
The Bendix radar system tends to provide more accurate, noise-free velocity data than conventional FM-CW systems, which calculate velocity with successive measurements. This diplexed-CW radar provides an accurate Doppler signal reconstruction, according to Carl P. Tresselt, senior staff engineer at Bendix Communications Division in Baltimore, and coauthor of an Eascon '77 paper entitled, "Highway Collision Avoidance—A Potential Large-Scale Application of MM Radar."

Braking commands are generated by both range rate and range data. Sampled data are produced by a homodyne receiver system that mixes the pulsed radar returns with the 36-GHz oscillator frequency. Doppler amplifiers, one for each alternate pulse, provide continuous Doppler signals from the vehicle or object ahead.

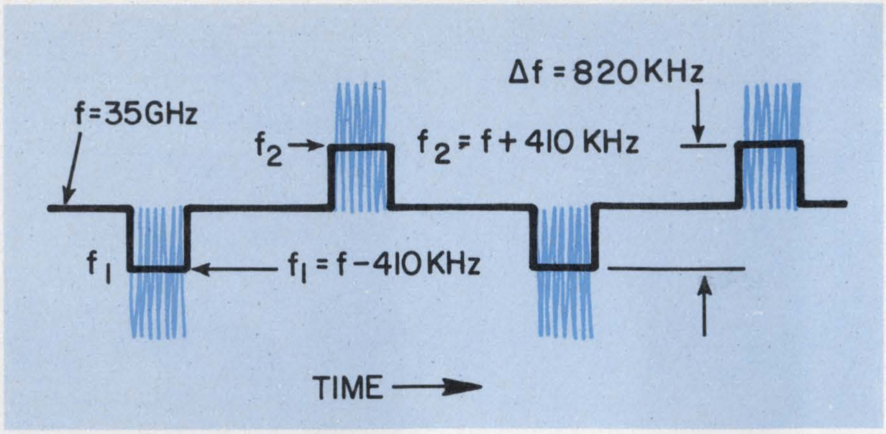
Range is obtained by comparing the phase between the two channels, while the relative velocity is obtained from the Doppler information in one of the channels. Whether the car is gaining on a car ahead or dropping back is signaled by a lead or lag between channel phases.

If, a car bearing the radar approaches another at an excessive speed, a warning sounds for the driver to start

Jim McDermott
Eastern Editor



Printed-circuit transmit/receive antenna is part of RCA's microprocessor-controlled, noncooperative X-band automobile radar system.



Wrong off periods between alternate rf transmission bursts of this Bendix diplexed-CW radar give range gating and suppress targets more than 250 ft ahead of the car.

This radome foran experimental radar braking system protects radar elements from the weather. Small antenna beam width and range gating minimize false alarms that have plagued similar systems.

braking. If he does not and the distance between the two closes to the computed danger limit, the brakes are automatically applied.

Although the returns from targets 250 ft away from the radar will be intermingled with more false alarms than would have occurred at 150 ft, actual braking will not be permitted by the Bendix system until the range is within the shorter, near-error-free distances.

Others working on problems

A number of other research organizations, notably RCA here and Standard Electrik Lorenz AG in West Germany, are working on the auto-radar problem.

RCA's system is being incorporated in a Research Safety Vehicle sponsored by the DOT. The objective is to develop a safe car in the 2000-lb class for the mid-1980s. The RCA contribution is a microprocessor-controlled noncooperative radar and an electronic dashboard display.

The radar is an X-band (10.575-GHz) FM-CW type with a sweep rate of 1 kHz and a frequency deviation of 25 MHz. Its printed-circuit transmit/receive antenna is mounted under a radome in the car hood. Beam width is larger than the Bendix system's—5° in azimuth and 10° in elevation. Shielding and damping material are located ahead of the antenna aperture to reduce side lobes to below −20 dB to eliminate false alarms. RCA is expected to go to higher frequencies in future versions of the radar.

False alarms from roadside and other targets are minimized in the RCA system by algorithms in a COSMAC CDP1801 microprocessor, which samples and evaluates the frequency content of the returns.

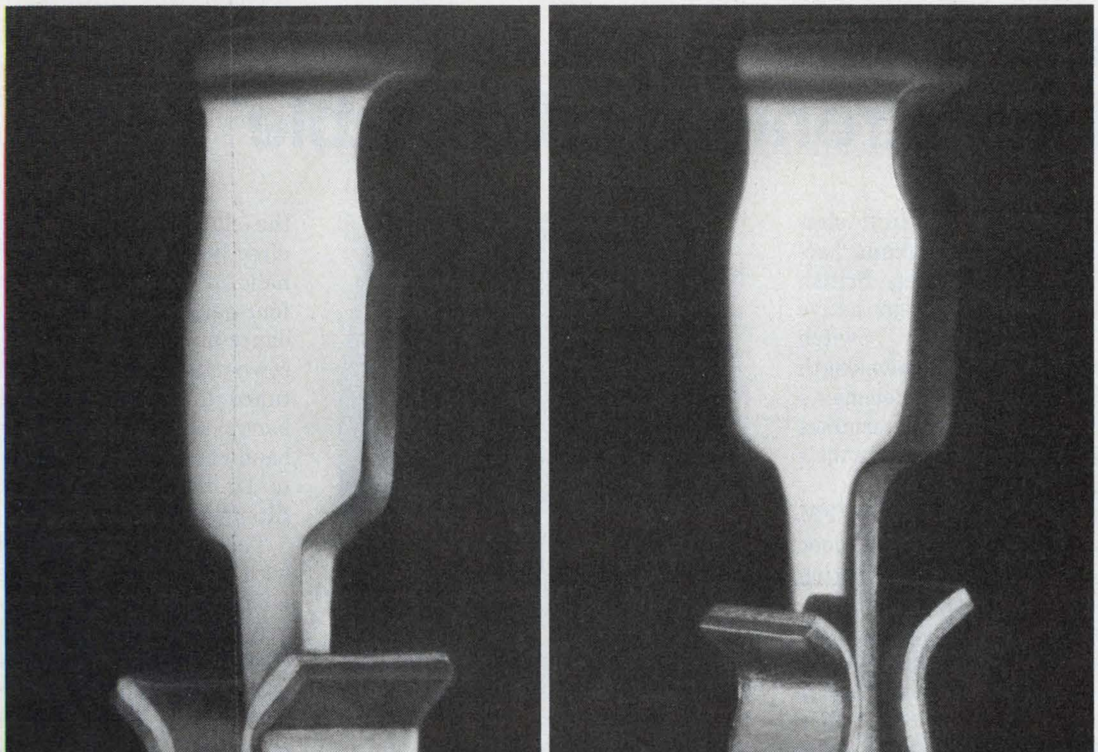
Targets rejected at 10 m

Standard Elektrik Lorenz, a German subsidiary of ITT, has been working on an anticollision radar with Daimler-Benz. The Lorenz system is an FM-CW radar operating on 16.5 GHz. To suppress false targets, the radar system rejects targets outside a moving range window of 5 to 10 m. To eliminate false targets appearing at curves in the road, the radar range is so limited that only targets in the driver's lane can be detected. Targets at turns—such as trees and lampposts—are distinguished in time with the help of a parameter that is proportional to the car's turn radius, which is signaled by a sensor on the steering gear.

The Lorenz FM-CW system is particularly suitable for suppressing false alarms caused by extended targets such as reflector fences. Their distance is indicated almost as a constant, whereas distance from a fixed obstruction on the highway decreases continuously.

Eventually, the 15.5-GHz unit will be replaced by a 35-GHz radar head. ■■

Choice grips from TI.



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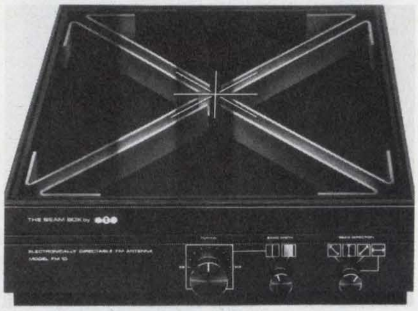
TEXAS INSTRUMENTS
INCORPORATED

Indoor FM antenna is tunable and 'electronically directable'

The Beam Box is "the first electronically directable FM antenna," according to its manufacturer, British Industries Co., yet it contains no active circuitry. A four-position switch selects which of four 1/8-wavelength extruded aluminum antenna elements will be paired, and thereby determines the orientation of the antenna's figure-8 pickup pattern.

The Beam Box is designed for FM listeners who cannot install outdoor antennas, but want better reception than they can get with common folded-dipole indoor antennas, explains Andrew Carduner, vice-president of the Westbury, NY, firm. "Most owners of FM receivers and tuners never realize the full reception capability of their equipment," he says. "The wire dipole antenna generally used with FM receivers can't be oriented easily to pick up strong signals from all the stations in a given area. Outdoor antennas are costly to install, impractical or, for apartment dwellers, prohibited—and they require a rotator in order to receive adequate signals from more than one direction."



FM antenna gains directionality by selecting a pair of dipoles.

Beyond the orientation switch, a wide/narrow bandwidth switch feeds the signal to an FM receiver either directly or through the Beam Box's handful of electronic components—a four-gang tuning capacitor and impedance-matching capacitors. In the narrowband mode, the antenna can be tuned to the station desired with a bandpass filter that has a 3-MHz bandwidth at the −3 dB points and 10 to 12 dB of suppression beyond the filter's skirt.

The antenna was designed by BIC with help from Channel Master, Ellenville, NY, which also makes antennas and has extensive antenna-testing facilities. Channel Master and BIC are both divisions of New York-based Avnet, Inc. The Beam Box will be manufactured at BIC's plant in St. Joseph, MI, where the firm also makes automatic turntables.

Suggested retail price for the Beam Box is $89.95. ■■

Tester 'learns' what it measures

Using known-good printed circuit boards as references, an automatic test system can program itself not only for the values that are acceptable, but also for the tolerances on those values. This self-learning method for generating test programs works with in-circuit PC board testers to check for open and short circuits, correct component values, and proper orientation of inserted components.

To generate a program for a particular board type, the operator keys in a list of all components connected to each node on the board. The tester then makes resistance and impedance measurements at each node on a known-good board and stores the results. Additional known-good boards are run through the tester. Whenever a new measurement is different from previous data, the tester alters its program to adjust the median value and the tolerance band for each measurement.

At first, the test system assumes a "default" tolerance of 5% for each measurement. But the wider the variation a functionally acceptable board can have, the wider the tolerance, which can reach 40% or more.

Developed at Teradyne Inc., Boston, the technique is used in the firm's Model L-529 test system. The system interfaces with a board under test via a bed-of-nails fixture that consists of a matrix of pins that are spring-loaded to make contact with test nodes.

Self-learn saves time

With self-learning, a test program for analog boards, where in-circuit testing is most valuable, can be written and be ready to run in about a day, says Jeff Hotchkiss, Teradyne product manager for in-process test equipment. Without self-learning, writing a program generally takes about three days and debugging the program another six.

In-circuit testers like the $54,500 L-529 are generally employed at the end of a production line to detect common assembly faults before the board is run through a functional tester. In this way many of the errors that a functional tester otherwise would have spent a great deal of time tracking down are weeded out. "By putting an in-circuit tester in front of a functional tester, you increase the yield of the functional tester," says Hotchkiss.

While in-circuit testers find only about 87 or 88% of the faults on a board, a functional tester can find 95% or more. However, a functional test system can cost an order of magnitude more.

For digital circuit boards, which have fewer discrete components and whose most common faults are shorts and opens, more effective prescreening can be done with a continuity testing system than with an in-circuit tester. ■■

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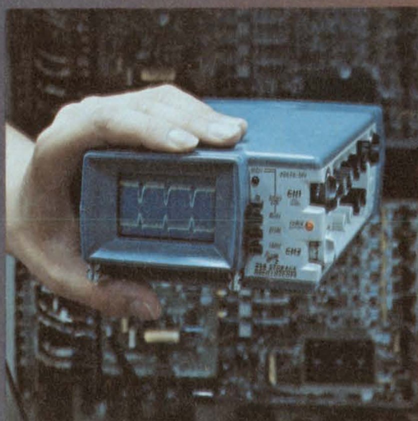

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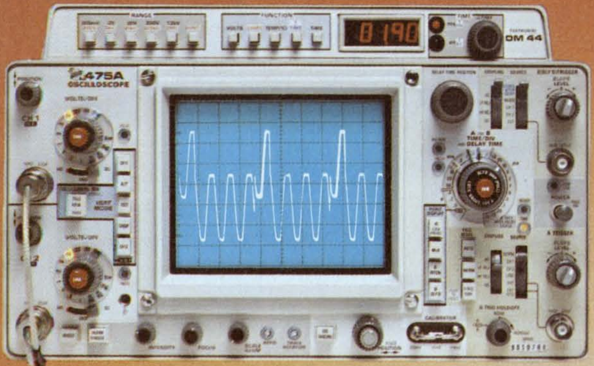

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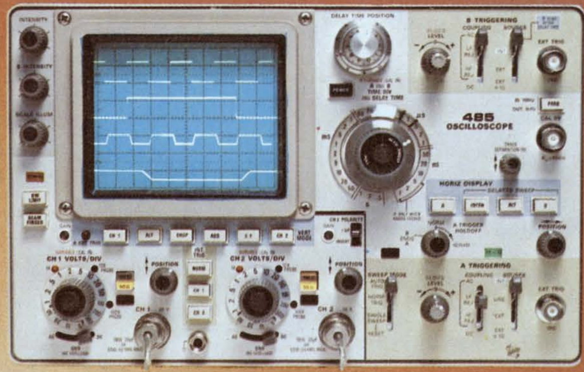

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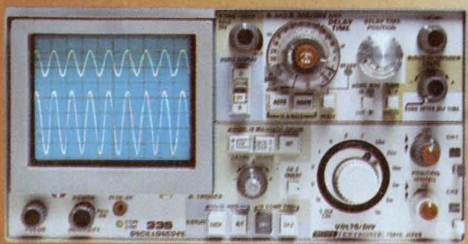

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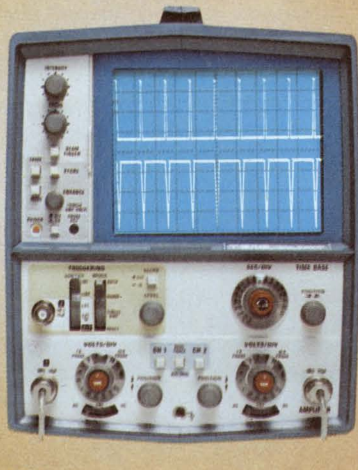

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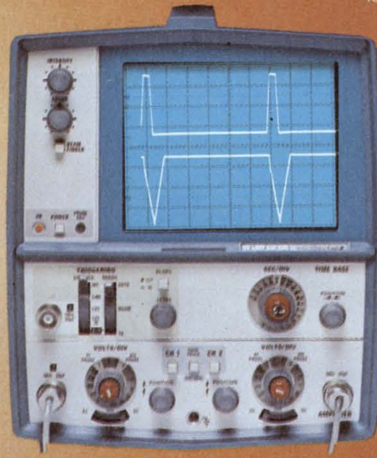

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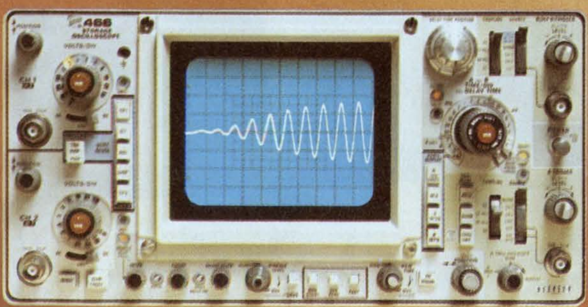

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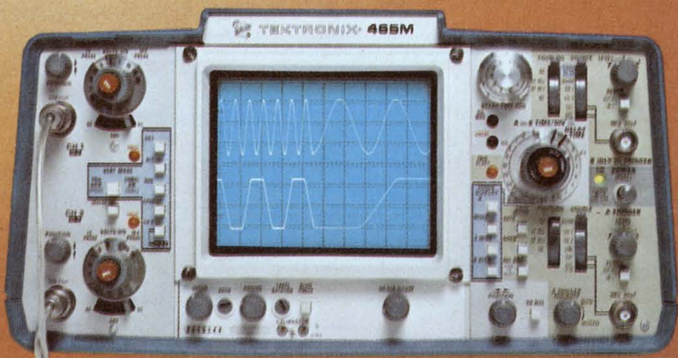

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	434	25 MHz @ 10 mV/div	yes		20 ns/div	Split-screen storage	3150
	314	10 MHz @ 1 mV/div	yes		100 ns/div	Only 10.5 lbs.	2385
	214	500 kHz @ 10mV/div	yes		1 μs/div	Only 3.5 lbs.	1475
	T912	10 MHz @ 2 mV/div	yes		50 ns/div	Low-cost bistable storage	1300
Nonstorage Models	485	350 MHz @ 5 mV/div	yes	yes	1 ns/div	Widest bw in a portable	5075
	475A **(New)**	250 MHz @ 5 mV/div	yes	yes	1 ns/div	High-performance 250-MHz portable	3450
	475	200 MHz @ 2 mV/div	yes	yes	1 ns/div	Highest gain-bw in a portable	3100
	465	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 100-MHz bw	2225
	465M **(New)**	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Triservice standard 100-MHz scope	2275
	455	50 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 50-MHz bw	1795
	335	35 MHz @ 10 mV/div	yes	yes	20 ns/div	Only 10.5 lbs.	1895
	326	10 MHz @ 10 mV/div	yes		100 ns/div	Internal battery	1995
	323	4 MHz @ 10 mV/div			500 ns/div	Only 7 lbs.	1445
	221	5 MHz @ 5 mV/div			100 ns/div	Only 3.5 lbs.	995
	213	1 MHz @ 20 mV/div			400 ns/div	DMM/Oscilloscope @ 3.7 lbs.	1475
	212	500 kHz @ 10 mV/div	yes		1 μs/div	Low cost for dual trace & battery	1050
	T935	35 MHz @ 2 mV/div	yes	yes	10 ns/div	Low-cost delayed-sweep model	1395
	T932	35 MHz @ 2 mV/div	yes		10 ns/div	Variable trigger-holdoff	1125
	T922	15 MHz @ 2 mV/div	yes		20 ns/div	Low-cost dual-trace scope	850
	T922R **(New)**	15 MHz @ 2 mV/div	yes		20 ns/div	Rackmount version of T922	1175
	T921	15 MHz @ 2 mV/div			20 ns/div	Lowest-cost TEKTRONIX Portable	695
Time Interval Readout	DM44	Optional, factory-installed, direct numerical readout of time intervals and DMM functions for the 464, 465, 466, 475, and 475A					445

*U.S. sales prices are F.O.B. Beaverton, OR. For price and availability outside the United States, please contact the nearest Tektronix Field Office, Distributor or Representative. Prices are subject to change without notice.

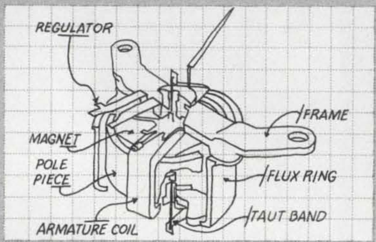
FOR DEMONSTRATION CIRCLE #22 ON READER SERVICE CARD

Specify the panel meter you'd be proud to have designed yourself

Panel meters from General Electric can add a lot to the overall quality of your product. Accuracy. Reliability. Attractiveness.

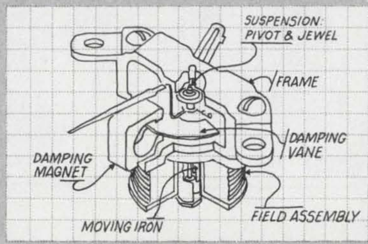
How do you design this kind of quality?

Start with the *suspension system*. The moving parts. You'll want one of two kinds (depending on what kinds of physical abuse your panel meter may be exposed to). In a *taut band suspension system*, the moving mechanism is suspended between two ribbons of platinum-nickel alloy welded securely to a resilient, shock-resistant anchor. This suspension system design keeps friction to an absolute minimum.



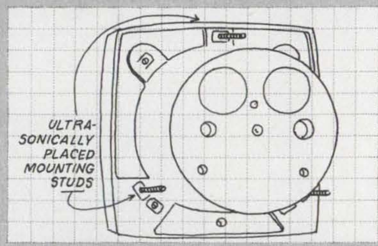
The aluminum pointer is attached to an oversized, high-torque armature coil of fine copper wire, for fast response and accuracy you can count on.

Pivot-&-jewel suspension maintains high performance and reliability in high vibration environments. The armature assembly is supported by highly polished, hardened-steel pivots selected for wearability. The pivots are designed with a radius that will minimize friction level to give maximum performance. The 1/10-carat jewel bearings are of ceramic material that is stronger than glass jewels and has greater scratch and impact abrasion resistance.



Pointers are tapered to a radius point as small as .38 mm, combining high readability with superior reading accuracy. Scales on the meter face are available with mirror backing that will align the reader's eye perpendicular to the face, eliminating parallax error.

Self-protecting features are important, too. All GE panel meters are housed in a tough, *molded case* of high-impact styrene. Special gaskets are available for assembly in BIG LOOK® type panel meters between the window and case to keep out contaminants. Ultrasonically placed mounting studs assure that the meter will fit your panel exactly. Choice of meter styling (BIG LOOK® or HORIZON LINE®) lets you pick the shape and appearance that will best enhance your product. (Color masks are also available for HORIZON LINE® in red, blue, green, black, yellow and white.)



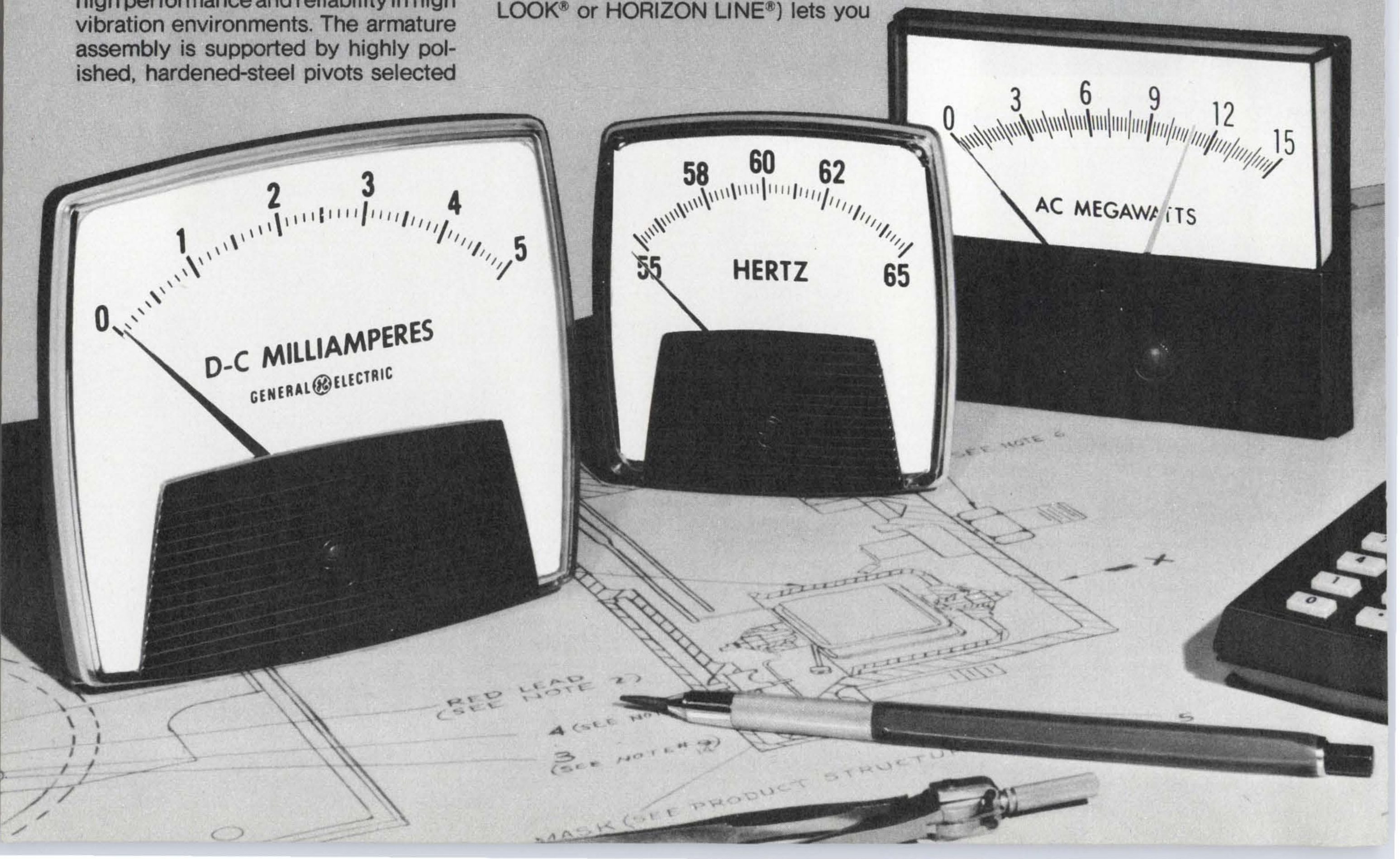
Hundreds of GE panel meters are available for almost any conceivable monitoring or measurement task.

And when you buy a GE panel meter, you also get more than 80 years of meter manufacturing experience and a sales network that is literally worldwide. For a free guide entitled, "Pick the Right Panel Meter," write to General Electric Co., Section 592-82, Schenectady, N.Y. 12345.

Specify General Electric... just for good measure.

GENERAL ELECTRIC

CIRCLE NUMBER 23



NOW

A magnetic circuit breaker that proves LESS is MORE!

The Airpax T11 is a single pole, single throw, series trip magnetic circuit breaker that combines power switching and accurate, reliable protection in one aesthetically pleasing package. It features a patented snap-action that assures immediate and positive opening or closing of the contacts. This snap-action results in an increase in operational life of up to 5 times that previously available. It also eliminates possible operator "teasing" of the contacts and minimizes arcing.

Airpax T11 Snap-Action Magnetic Circuit Breaker.

LESS COST. The T11 costs less than any other magnetic circuit breaker on the market today . . . under $5.00 in small quantites. Even less as the quantity increases. And the traditional Airpax Five-year warranty.
Result: MORE protection for your money.

LESS SPACE. The T11 combines power switching and current protection in one tiny package about 1 cubic inch in size. That's smaller than any other magnetic breaker. In addition, the T11 offers a choice of six attractive paddle handle colors and a variety of mounting hardware.
Result: MORE design flexibility.

LESS INSTALLATION COST. The T11 does the job of a power switch, fuse and fuse holder—all in one easy-to-mount unit. This means only one item to be installed instead of three, less assembly time, and one-third the inventory.
Result: MORE Productivity . . . and profit . . . for you.

LESS SERVICE REQUIRED. The T11 is immediately resetable to check if a fault has been removed. There's nothing to burn out. Nothing to replace. No annoying service calls.
Result: MORE happy customers for you.

LESS GUESSWORK. Airpax has a bulletin fully describing the T11 snap-action magnetic circuit breaker, including rating, delays, complete specifications, and a handy how-to-order chart.
Result: MORE information for you.

To get your bulletin, call your local Airpax representative or contact Airpax Electronics, Cambridge Division, Cambridge, MD 21613. Phone: (301) 228-4600. Telex: 8-7715. TWX: 865-9655. Other factories in Europe and Japan.

AIRPAX™

THE PRO IN PROTECTION

CIRCLE NUMBER 24

CIRCLE NUMBER 26

Washington report

DOD's flying air-traffic control works with FAA's

Two new airborne air-traffic control systems are electromagnetically compatible, according to flight tests conducted jointly by the Defense Department and Federal Aviation Administration.

The DOD is developing a new secure data link for communications and navigation in the 960 to 1215-MHz range under the Joint Tactical Information Distribution System (JTIDS) program. The FAA is testing a new direct-address beacon system (DABS), which has a VOR/TACAN format and is expected to replace the agency's current air-traffic control beacon system.

Since DABS will use a two-way digital data link instead of the vhf and uhf voice channels on the present FAA air-traffic control system, the all-digital JTIDS with capacities up to 57.6 kbits/s is considered a logical match for an integrated system. After more than 1000 hours of flight tests conducted this year, the agencies believe the JTIDS signal format will be compatible with the DABS's VOR/TACAN format, witnesses from the two agencies told the House transportation subcommittee.

In addition, while the FAA's current control system interrogates all transponder-equipped aircraft within the beam width of an air surveillance radar, DABS will selectively interrogate each aircraft as required.

Hughes wins second 14/12-GHz comsat award

By the end of the year, Hughes Aircraft Co. should receive a contract estimated to be worth about $60-million to build three 14/12-GHz communications satellites for Satellite Business Systems, Washington, DC. This is the second time Hughes has been selected for this type of contract over RCA and General Electric.

While both RCA and GE offered three-axis-stabilized aircraft, Hughes proposed a spin-stabilized satellite equipped with 10 transponders, each providing a 43-MHz bandwidth and operating with at least 20 W of output power. Launches, due to begin in 1980, will use either the Space Shuttle or a conventional Delta launch vehicle.

Hughes earlier beat the same two companies to a $70-million procurement of 14/12-GHz communications satellites for Telesat Canada. But that program has been held up by the refusal of the Canadian Radio-Television and Telecommunications Commission to permit Telesat Canada to join the Trans-Canada Telephone System.

Compass Tie ECM system to shield Air Force's F-4, A-10

The Air Force has chosen the Compass Tie electronic-countermeasures system to protect its F-4 fighters and A-10 close-support aircraft from radar-directed weapons. The system is supposed to not only warn against potential threats but also jam the incoming missiles.

One of the Air Force ground rules that the new system had to satisfy was to fit into the aircraft as modules so that no modifications to the airframe would be required. Compass Tie mounts the Westinghouse Electric Corp. ALQ-119 countermeasures pod on the wing and the ALR-69 radar warning receiver inside the aircraft. Parts of the receiver's detection subsystem are provided by the Applied Technology Div. of Itek and the Dalmo Victor Div. of Bell Aerospace Textron, which also contributes the digital processor.

British fault finder uses μPs, floppy discs

A British-developed fault-finding test set employing floppy discs and microprocessors will soon be available in this country. Earmarked initially for field maintenance of military radios and other tactical electronics equipment, it will later be geared to commercial applications as well.

Diagnostic routines written in simple English are stored on discs in the set to help semiskilled maintenance personnel check their progress at each step of a field repair job. A typical routine uses 45 of the 70 tracks on a disc (3000 bits per track), and the interactive graphics are displayed on a ruggedized CRT display controlled by a Motorola 6800.

Prototype models of the system were demonstrated by Racal-Tacticom Ltd., Reading, England, at the company's own trade show in London. Although the initial applications are military and Racal is trying to sell the system to NATO armies, company officials say the same simple diagnostic routines could be adapted to medical purposes or to checking out consumer items, such as television sets. Production cost for each unit should be about £7000, or almost $12,000.

Dutch, British to help keep NASA telescope in space

With the help of The Netherlands and Great Britain, a NASA cryogenically cooled infrared telescope will be orbiting the earth in 1981 and mapping the entire sky at infrared wavelengths. Such wavelengths can't be detected by earth-based telescopes because of the obscuring effects of the earth's atmosphere.

The IR telescope will be built for NASA by Ball Brothers Research Corp. of Boulder, CO. The orbiting satellite will be provided by the Netherlands Agency for Aerospace Programs, and the United Kingdom Science Research Council will operate a command, control and data-acquisition facility from the Appleton Laboratory near London.

Capital Capsules: The Cost Accounting Standards Board will relax its regulation of government contractors effective next March 10 unless its new guidelines are overturned by Congress. In the past all contractors have had to follow the board's accounting procedures, but **the new regulations will excuse companies determined by the Small Business Administration to be small business concerns . . . . The first fire-control unit for the U.S. version of the European Roland antiaircraft missile system will be delivered this month to the Army.** The unit was built by Boeing, subcontractor to Hughes Aircraft Co., which is building Roland under license to Euromissile, a Franco-German joint venture. Tests will be conducted at the White Sands Missile Range in New Mexico, the Aberdeen Proving Ground in Maryland, and in Alaska and Panama . . . . Under a $20.7-million grant from the National Science Foundation, Cornell University has begun building **a 12-billion electron-volt synchrotron to search for quarks in the nucleus of the atom.** The system, due to be completed by the fall of 1979, will store the energy of electron beams for several hours at a time in a 10-foot-long, 6-foot-diameter superconducting magnet . . . . NASA has given up on launching a spacecraft to investigate Halley's Comet when it approaches the earth in 1986, but is putting an extra $3-million into its planned **1982 launch of spacecraft to orbit Jupiter and to fire instrumented probes into the Jovian atmosphere.** The money was taken out of funds previously earmarked for additional spacecraft missions to Mars.

Fill in the Blank.

If you're concerned about fitting your test and measurement equipment to a specific application, take this test. There's only one question so give it a try.

See if you can answer this: The TEKTRONIX TM 500 family of modular instruments includes (check one)

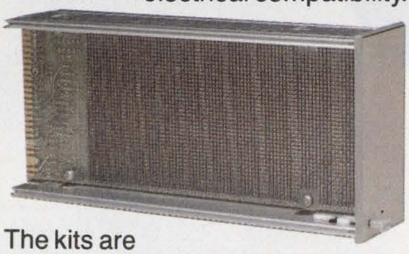
- ☐ DMMs
- ☐ Counters
- ☐ Generators
- ☐ Amplifiers
- ☐ Power Supplies
- ☐ Oscilloscopes
- ☐ Logic Analyzers
- ☐ Word Recognizers
- ☐ Digital Delay
- ☐ All of the above, plus

____________________________.

If you checked "All of the above, plus_____________," nice going. You're close. But what did you put in The blank? An analog multiplier? Relay circuit? Switches for signal routing? Test oscillators at pre-set frequencies? Digital logic circuits? Converters? Special processors?

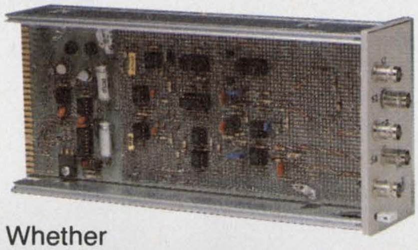
To be completely correct, your answer should include any one of these, or some other non-standard item, because TM 500 configurability not only allows you to choose from over 30 ready-to-go, compact plug-ins for testing and measuring, but the mainframe also makes room for compatible custom plug-ins you assemble yourself with a TM 500 custom Plug-in Kit.

A TM 500 custom Plug-in Kit includes a perforated main circuit board, all mechanical components to assemble a complete plug-in, plus instructions on mainframe electrical compatibility.



The kits are available in both single and double compartment sizes. One single compartment version includes all the components for 3 voltage regulators at the rear of the board. With your TM 500 you can receive on request TM 500 Construction Notes to build special-purpose instruments including parts lists and schematics.

So, by just filling in a blank plug-in, your TM 500 can measure up to just about any highly specialized application, saving you hours of set-up time.



Whether you need a rackmount, roll-around or go-anywhere portable, the TM 500 gives you one tidy instrument with a lot of plug-ins, not a lot of plugs. It's configurable other ways, too.

Ask your local Tektronix Field Engineer. He can fill in all the blanks.

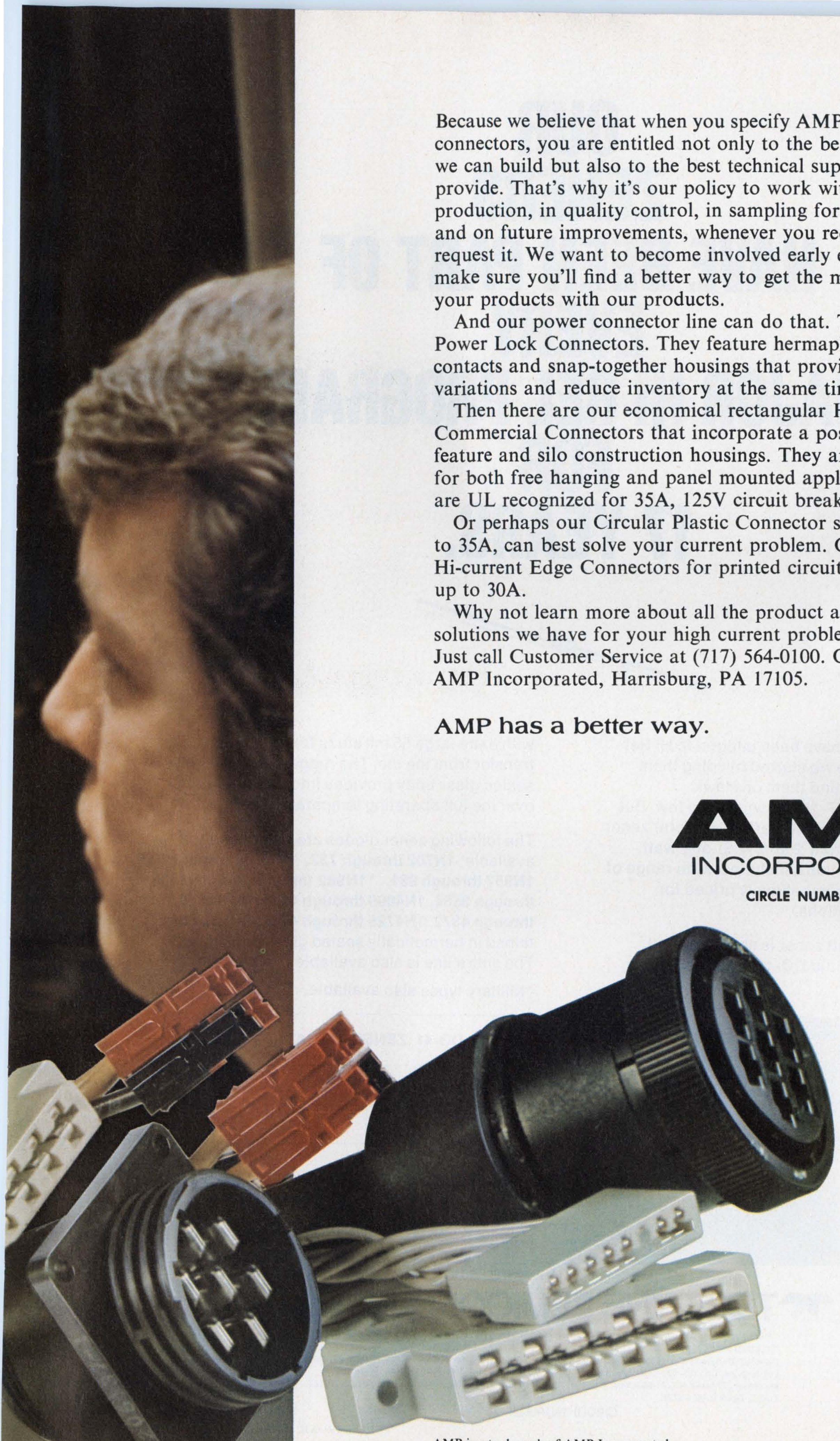
TM 500
Designed for Configurability

For configurable, accurate and reliable test and measurement instrumentation, contact: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077, (503) 644-0161 Ext. 5283. In Europe: Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

Tektronix®
COMMITTED TO EXCELLENCE

For Technical Data, Circle 125 For Demonstration Circle 126


AMP has many high powered solutions to your high current problems.
And they include our people as well as our products.



Because we believe that when you specify AMP high current connectors, you are entitled not only to the best components we can build but also to the best technical support we can provide. That's why it's our policy to work with you in production, in quality control, in sampling for prototyping and on future improvements, whenever you require or request it. We want to become involved early enough to make sure you'll find a better way to get the most out of your products with our products.

And our power connector line can do that. Take AMP Power Lock Connectors. They feature hermaphroditic contacts and snap-together housings that provide unlimited variations and reduce inventory at the same time.

Then there are our economical rectangular High Current Commercial Connectors that incorporate a positive locking feature and silo construction housings. They are suitable for both free hanging and panel mounted applications and are UL recognized for 35A, 125V circuit breaking.

Or perhaps our Circular Plastic Connector series, rated up to 35A, can best solve your current problem. Or our Hi-current Edge Connectors for printed circuit applications up to 30A.

Why not learn more about all the product and people solutions we have for your high current problems. Just call Customer Service at (717) 564-0100. Or write AMP Incorporated, Harrisburg, PA 17105.

AMP has a better way.

AMP
INCORPORATED

CIRCLE NUMBER 27

Editorial

'Road work'

At one stage in my army career, I managed to become a member of the camp's boxing team. I did this, not because I am overly fond of punching people—or being punched. Rather, it afforded special advantages on Saturday mornings when everybody else was engaged in policing the camp grounds or in close-order drill—activities that never ranked among my favorites.

At such times, if an officer telephoned the gym to check on members of our team, one of us would be on hand to say that we were out doing "road work." We never bothered to undeceive those officers who took this to mean that we were jogging or running to improve our stamina in preparation for matches with boxers from other camps. In fact, I now confess, our "road work" took the form of hitchhiking to the nearest city, where some of us wandered along Maiden Lane, seeking one.

Nobody suffered then from our improving the meaning of words, and some of us, indeed, derived pleasure from it. But today many of us are injured when words are used to mislead. When a power-supply manufacturer tells a customer, "This supply can deliver 5 volts and 40 amperes," and fails to add, "but not at the same time," he's hurting with our "road work" gimmick. When an instrument manufacturer hails his ultra-low "percent error," without telling the percent of what, he's injuring with our "road work" ploy. When an employer promises a salary hike, then reneges with "I meant next year," or "when business gets better," he's using "road work" to deceive and exploit.

"Road work" doesn't always hurt, even when it may deceive. A photographer friend who used to sell baby photographs to mothers was often compelled to comment on the attractiveness of an infant. Usually he had little trouble enthusing with "My, what a beautiful baby!" But sometimes the best he could manage was "My, that *is* a baby!" An admirable use of "road work."

But it's unfortunate that our language and morality are so flexible that they can be bent to hurt. It's unfortunate, too, that most of us must waste precious effort digging for the real meaning of "road work."

George Rostky

GEORGE ROSTKY
Editor-in-Chief

INTRODUCING DELCO ELECTRONICS' MONOLITHIC OPERATIONAL AMPLIFIER

If you're now using discrete power output transistors, we've got an alternative that gives you design versatility.

It's the DA-101—Delco's Monolithic Operational Amplifier—with all the circuitry you need in one compact package.

The Monolithic Operational Amplifier (MOA) has two separate gain and power stages contained in a modified dual-in-line package.

The DA-101 operates from a 10- to 16-volt DC supply and can be used in an audio bridge configuration with floating speaker output, or as two separate amplifier-speaker systems.

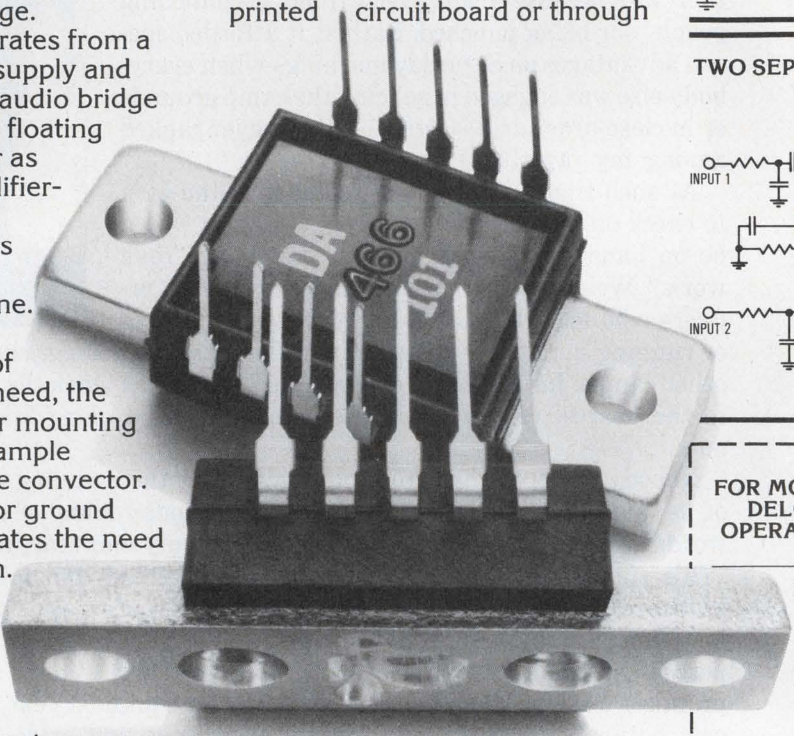
The MOA means weight savings in more ways than one. Besides reducing the total number of components you need, the MOA has a copper mounting surface to assure ample heat transfer to the convector. The tab negative or ground connection eliminates the need for mica insulation.

In fact, the design of one power megaphone showed a components weight savings of 65 percent.

Our new MOA means added design application flexibility, too. In automotive and home entertainment systems, two-way communication systems, power megaphones, motor controls, various H switch applications, and more.

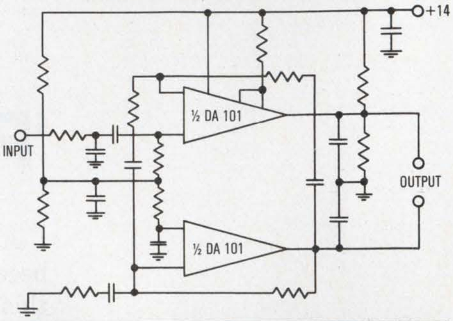
Another advantage of our Monolithic Operational Amplifier is its durability. It has integral protective circuitry for not only overvoltage, but temperature, current conditions and shorted outputs as well.

And it can be mounted by either direct soldering to a printed circuit board or through the use of a suitable socket.

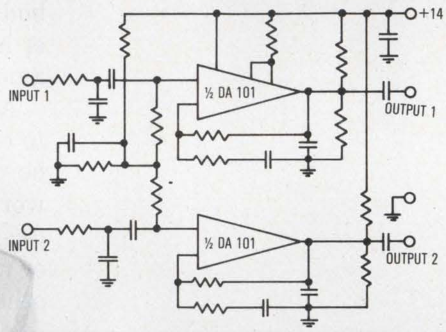


For more information, return the coupon on the right, contact an authorized Delco distributor, or call your nearest Delco sales office: **Kokomo, Ind. (317) 459-1271; Charlotte, N.C. (704) 527-4444; or Van Nuys, Cal. (213) 988-7550.**

AUDIO BRIDGE CIRCUIT



TWO SEPARATE AMPLIFIERS CIRCUIT



FOR MORE INFORMATION ABOUT DELCO'S NEW MONOLITHIC OPERATIONAL AMPLIFIER, MAIL THIS COUPON TO:

Delco Electronics Division
General Motors Corporation
Marketing Services MS A-213
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ABSOLUTE MAXIMUM RATINGS

Supply Voltage	24V
Operating Voltage	16V
Peak Current	3A
Storage Temperature	−55°C to 150°C
Power Dissipation	22W

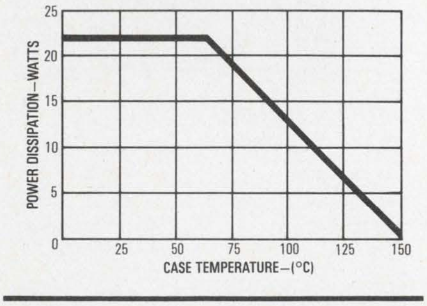
ELECTRICAL CHARACTERISTICS

	TYPICAL
V_{CC} = 14V dc	
I_{idle}, P_{out} = 0W	40mA
Differential Input Bias Current	0.80 µA
Open Loop Gain	90dB
Power Out @ 5% Distortion	
4Ω Bridge	6W
4Ω Non-bridge	3.5W

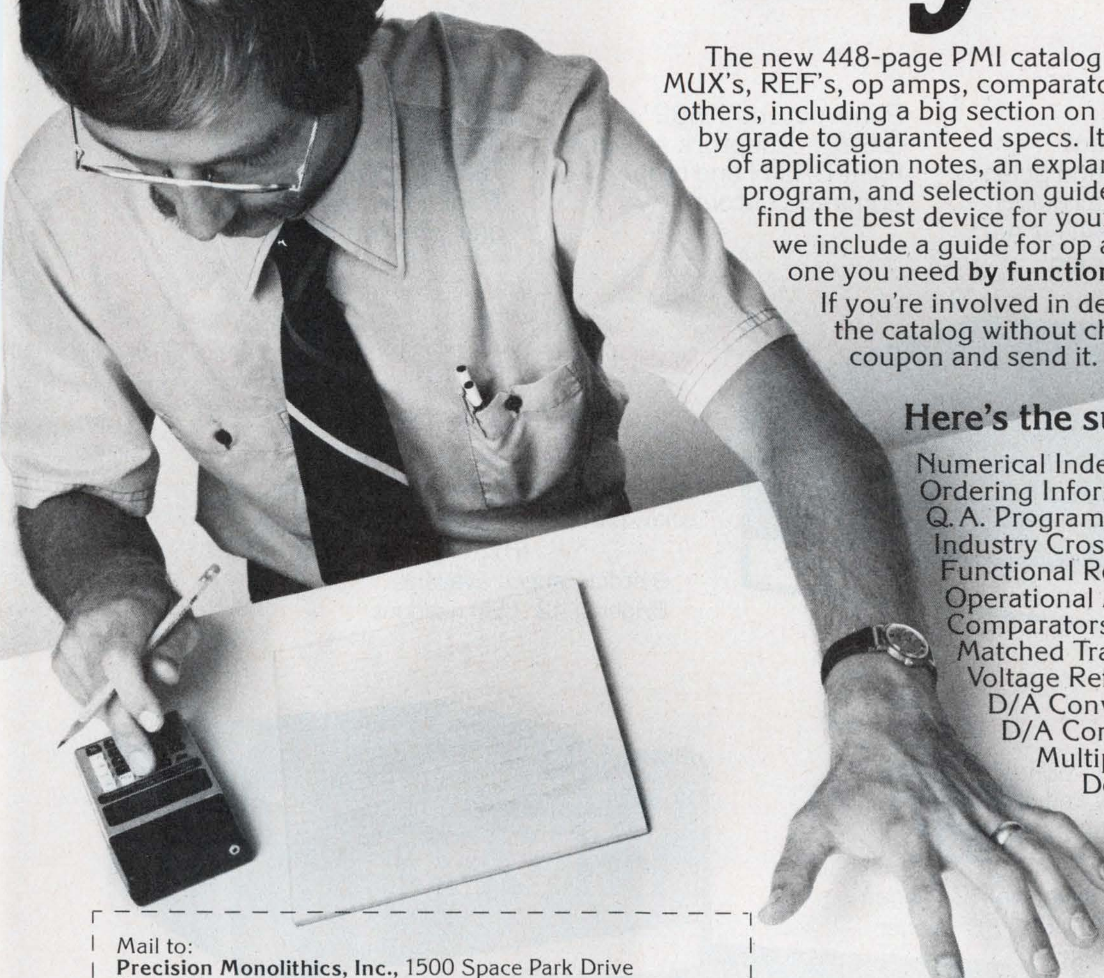
THERMAL CHARACTERISTICS

Thermal Resistance, $R\theta_{JC}$ (Typical)	4° C/W

DERATING CURVE



The catalog designers can't buy.*



The new 448-page PMI catalog is packed with parts—MUX's, REF's, op amps, comparators, DAC's, and plenty of others, including a big section on chips that you can order by grade to guaranteed specs. It also provides 91 pages of application notes, an explanation of PMI's QA program, and selection guides that make it easy to find the best device for your application. For example, we include a guide for op amps that lets you find the one you need **by function.**

If you're involved in design, we'll be glad to send the catalog without charge. Just fill out the coupon and send it. It'll be our pleasure.

Here's the subject index:

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Industry Cross Reference
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Matched Transistors
Voltage References
D/A Converters - Linear
D/A Converters - Companding
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PMI®

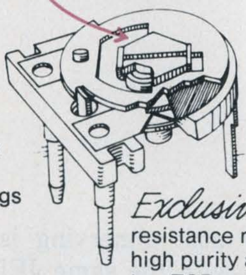
CIRCLE NUMBER 9

A-B quality trimmers for the same price as "B" trimmers.

Accept nothing less than Allen-Bradley quality in trimmers, especially when it doesn't cost you any more. The real decision is whether to use our Type 90 or Type D. Both are cermet, single-turn with a choice of top, side or through-the-board adjustment. We have what you need; our distributors have it when your need is now. Ask for Publication 5242 (Type 90) and 5240 (Type D).

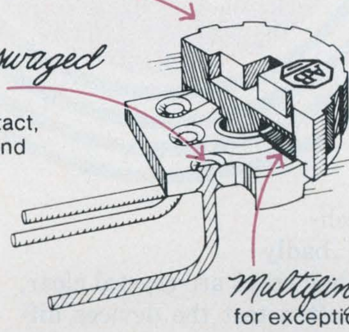
Front or Rear Adjust with rugged dust cover (Type D), metal actuator (Type 90).

Type 90
7/16" dia.
$.55 ea/1000
2 terminal options
0.5 Watts at 70°C
100 ohms to 2 megs



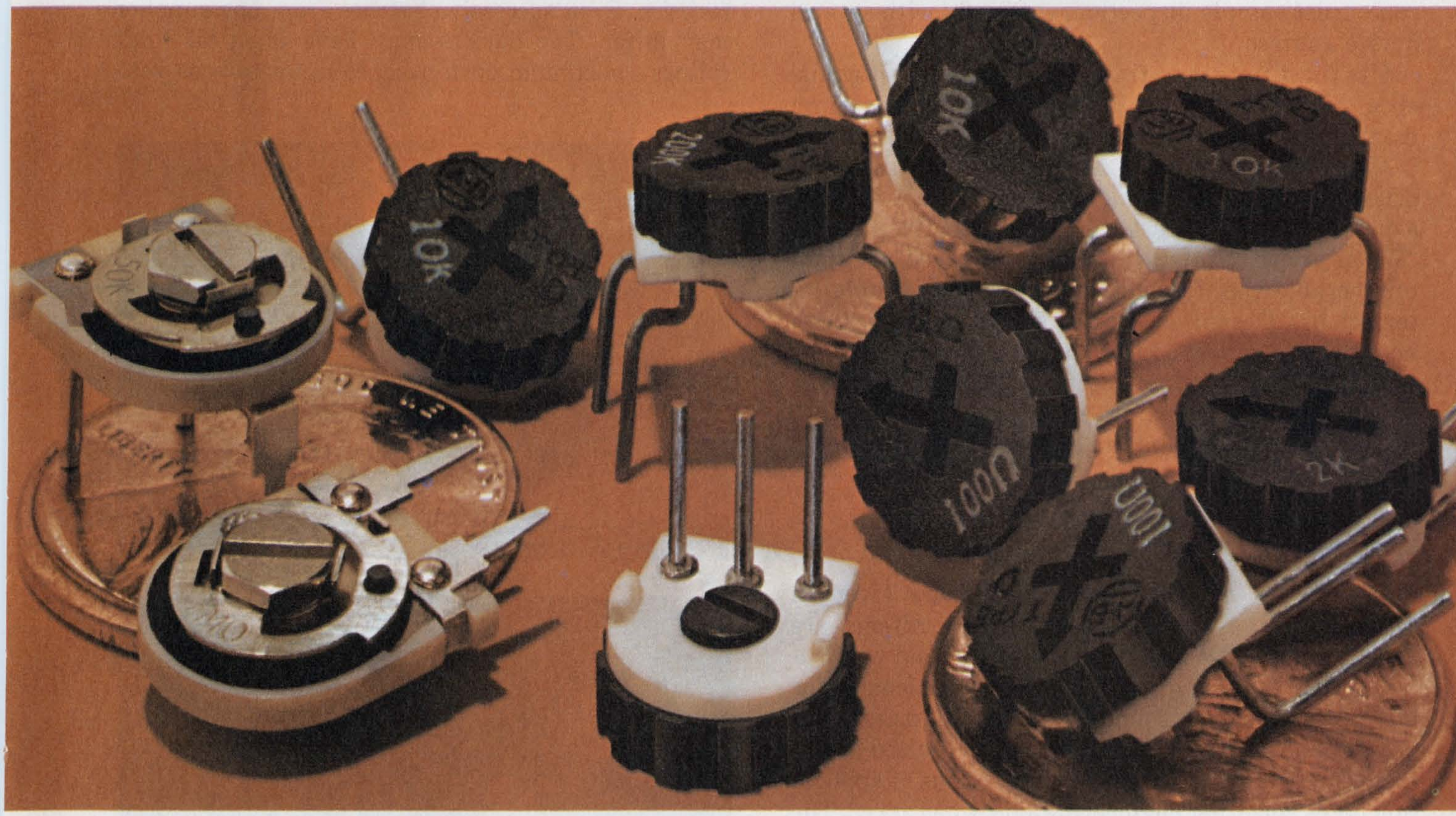
Specially swaged leads offer redundant contact, high strength and excellent solderability.

Exclusive resistance material on high purity alumina for low TCR and CRV. Typical TCR for Type D is less than ±35 PPM/°C.



Type D
3/8" dia.
$.37 ea/1000
8 terminal options
0.5 Watts at 70°C
10 ohms to 2.5 megs

Multifinger contacts for exceptionally low CRV.



Quality in the best tradition.

ALLEN-BRADLEY
Milwaukee, Wisconsin 53204

CIRCLE NUMBER 32

FOCUS on Power Transistors and Thyristors

Power transistors and thyristors, even after years of continuously improved manufacturing techniques, still suffer from badly defined specs. And even when specs are crystal clear, users and manufacturers often test the devices differently. The result? Users reject a great many devices and feel compelled to employ 100% testing. They still can't trust sample inspection, especially with several device sources.

Mix the different testing methods in with perennial spec misunderstandings and you have all the ingredients for costly errors and unreliable equipment.

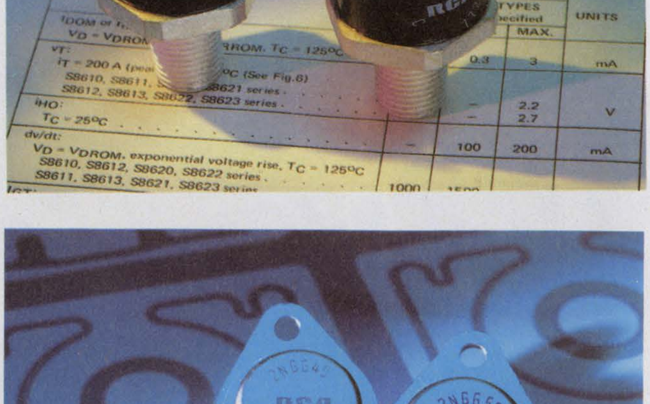
Moreover, spec sheets are often primarily sales-oriented. "Power-semiconductor specs are written in a positive sense," one advertising executive admits. "When properly interpreted, the spec need not state unfavorable specifications or reveal undesirable interactions. Design engineers should know enough about power-semiconductor performance so that, for example, they won't expect all maximums to be available at the same time," he explains. In other words: Be careful! What a spec sheet doesn't tell you can be hazardous to your circuit.

Let the buyer beware

Even when data for power semis are given in abundance, the specified operating conditions are usually unrealistic and almost never fit your particular needs. However, in fairness to semiconductor manufacturers, semiconductor-device characteristics are complicated, and spec sheets have limited space. Manufacturers will supply you with reams of application notes and other engineering aids, when asked. The response is often overwhelming in detail. But then, the problem is to separate the factual data from the sales pitch.

Morris Grossman
Associate Editor

Perhaps most unnerving is the knowledge that transistors with the same JEDEC (Joint Electronic Devices Engineering Council) number, but made by different manufacturers, can differ in crucial characteristics. Even successive batches from one supplier may differ. The devices may have identical limit ratings—maximum open-base, collector-to-base volt-



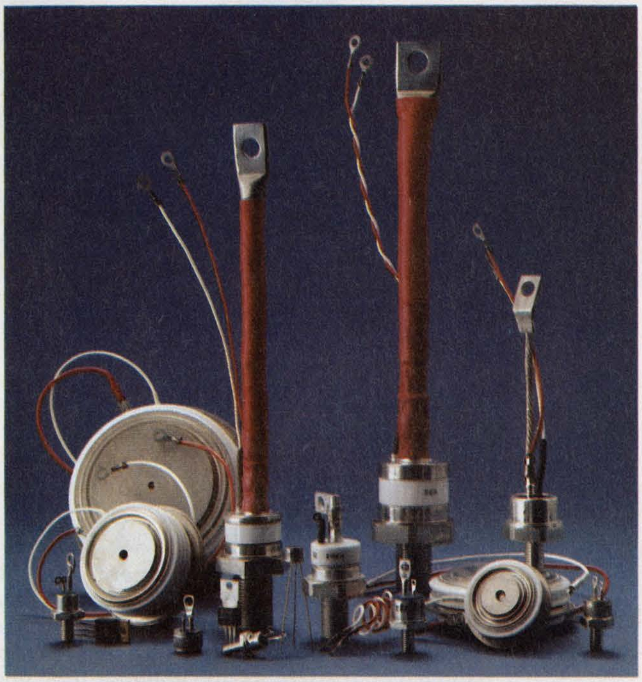
age (V_{cbo}), maximum collector current (I_c), etc. But temperature effects, various derating factors and detailed switching characteristics can be very dissimilar.

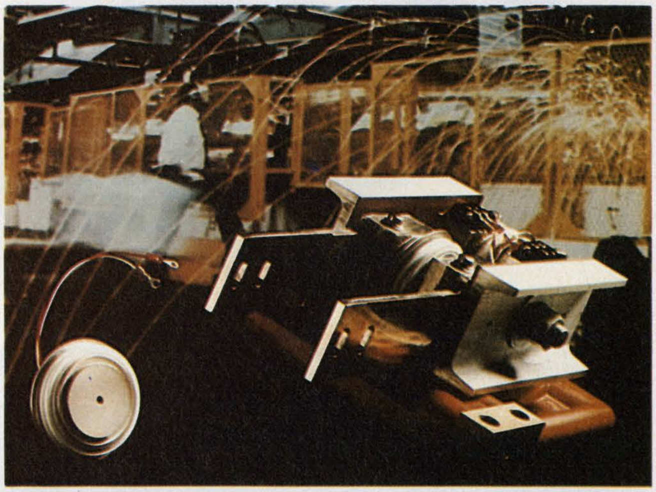
"Cut open and closely examine samples from each batch of devices you receive," advise many power-semiconductor users. "You could be getting satisfactory results from a manufacturer for months, even years. Suddenly, thousands of your widgets start coming back because of out-of-spec performance, or even worse, failure in the field." Unknown to you, the semiconductor-device manufacturer has changed his manufacturing process, perhaps quite subtly. So despite meeting published limit specs and satisfying even your own tests, the devices behave improperly in your circuit.

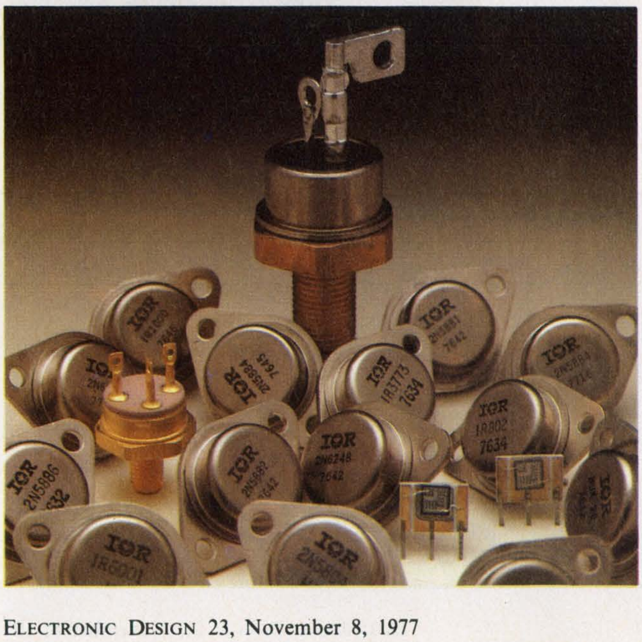
Chip size, structural geometry, dopant processing—even testing—may have been changed. What were formerly single-diffusion devices now may be made by double or triple-diffusion methods. And single or multiple-epitaxial processing may have been used instead of diffusion to form some of the device's elements. Mesa structures may have been replaced with planar, or vice versa. Your power transistor may indeed be improved—faster, for example—but in your circuit, the improvements can spell disaster.

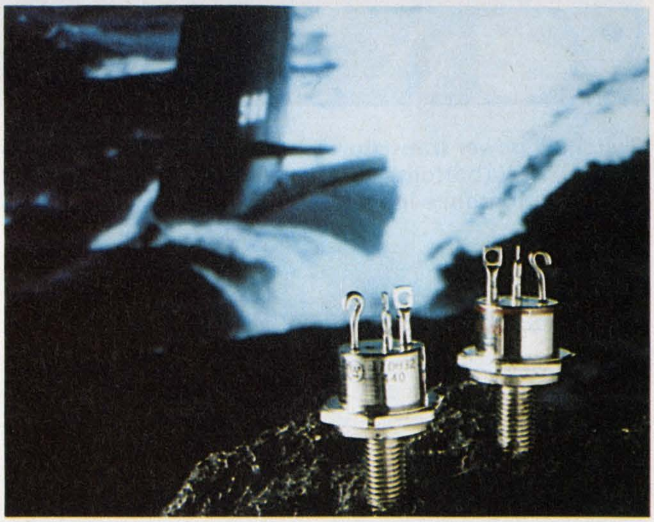
For example, an old and widely used transistor, the npn 2N3055, is listed by RCA as having a single-diffused (Hometaxial) structure that yields a gain-bandwidth product, f_T, of 0.8 MHz (RCA now also makes an epitaxial design, designated with an H suffix). But the same-numbered unit from Motorola, made with an epitaxial-base structure, has an f_T of 2.5 MHz. Fairchild doesn't say what structure it uses, and doesn't list a value for f_T in its "Power Data Book."

Try to compare the functional differences that

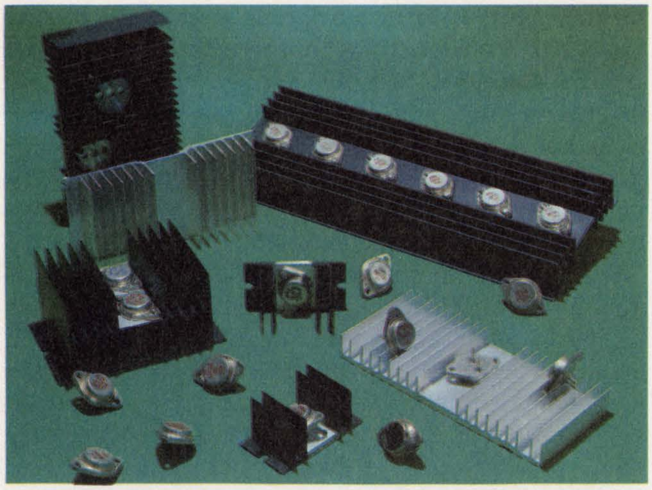


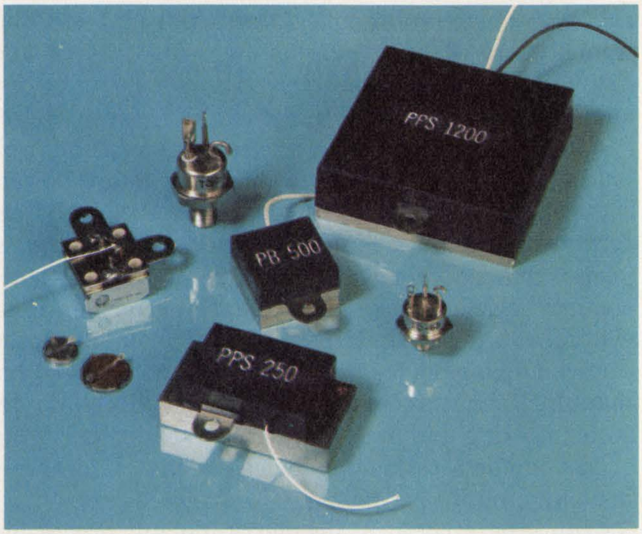


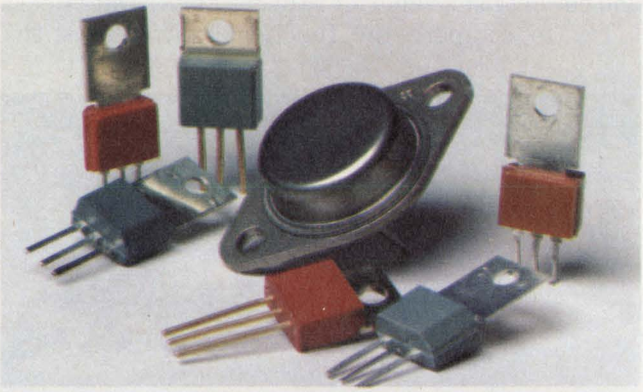


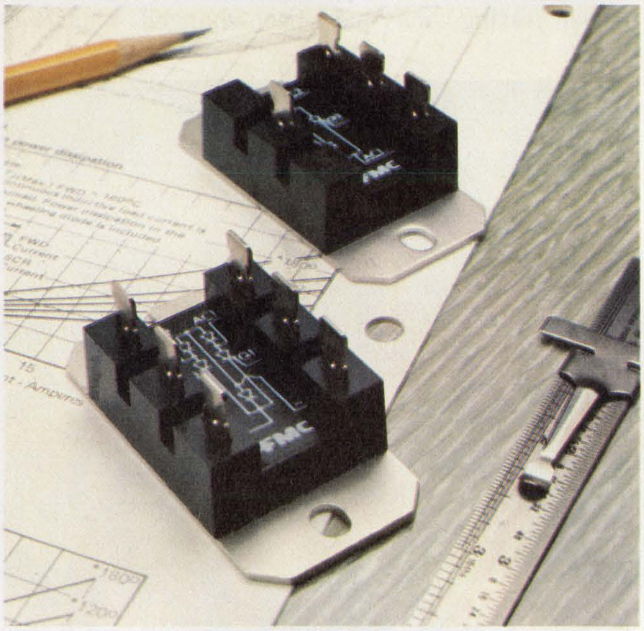


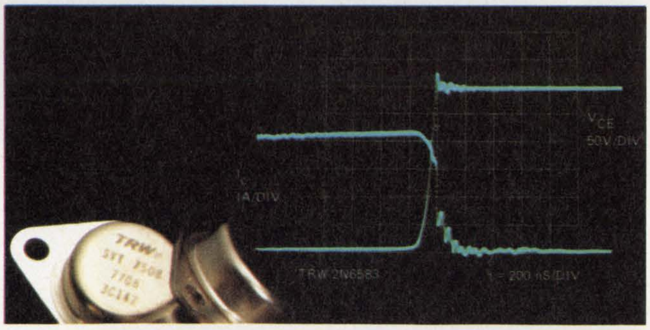
Many companies make both power transistors and thyristors. RCA concentrates on the lower and middle end of the power spectrum with a very extensive line of linear and switching power transistors, triacs, and SCRs (far left). Westinghouse, however, tends to handle mainly larger devices for power supplies, inverters and vehicle controls (right). And International Rectifier's devices overlap both groups (center).











Switching power transistors, such as made by Delco (top), GE and TRW (bottom), fill the needs of switching-power-supply, automobile-ignition and solid-state relay applications.

Specially packaged power devices for conveniently mounting or even eliminating heat sinks help ease design engineer's problems. PowerTech's blocks of matched series and parallel singly-diffused power transistors (top) allow you to handle higher currents and voltages than you can manage with single transistors. And FMC Corporation's encapsulated SCR assemblies (bottom), like these 30-A-rated bridges, cut costs by mounting several SCRs and diodes in a single assembly.

Transistor physical trade-offs

Physical variables		Electrical characteristics								
		f_T	t_r, t_f	V_{ceo}	$V_{ce(sat)}$	V_{be}	h_{fe}	I_c	$I_{s/b}$	$E_{s/b}$
Base width	↑	↓	↑	↑	↑	↑	↓	↓	↑	↑
Base resistivity	↑	—	↑	—	↓	↑	↑	↓	↓	↓
Collector width	↑	↓	↑	↑	↑	↑	—	↓	—	↑
Collector resistivity	↑	↓	↑	↑	↑	↑	—	↓	↓	↓
Emitter width (finger)	↑	↓	↑	—	—	↑	—	↓	↓	↓
Emitter ballast	↑	↑	↓	—	↑	↑	—	↑	↑	—
Collector ballast	↑	↓	↑	—	↑	—	—	↓	—	↑

follow from this difference in f_T. Study the three manufacturers' data books closely and you will discover that each has elected to publish a different set of characteristics curves—almost none corresponding to another. RCA's curves for the single-diffused 2N3055 appear more useful for general-purpose linear power-amplifier work. Motorola's curves are aimed at power-switching applications. And Fairchild's few curves are aimed both ways. Even taken together, the curve sets fail to describe all the device's properties.

You can have one or the other

If variations within a single type number make it difficult to compare devices from several sources, imagine how difficult it is to compare different types. For one thing, the trade-off possibilities are many. If you want speed, transistor base widths must be made thin and breakdown voltages must go down. If you want high gain, you must usually sacrifice high-current-handling capability. But the trade-offs aren't simple exchanges of desirable properties: Parameter interactions abound—and they are complicated (see trade-off tables). And the lack of clarifying data in the manuals and spec sheets doesn't help.

However, a data curve that is seldom missing, thanks to JEDEC, is the safe-operation-area (SOA) curve. But be careful: The curve is usually drawn for a case temperature of 25 C, and must be derated to get practical values.

Although 25 C is almost a universal standard, it is a completely unrealistic temperature for power semiconductors. Ambient temperature in the typical power assembly can easily run to 80 C; consequently, case temperature is enough to fry eggs.

"One of the most common misunderstandings of design engineers is to believe that maximum ratings are practical normal operating values," observes Pete Woods, application manager at TRW. "Some manufacturers' power ratings are at best only figures of merit," he warns. So, if a transistor's spec sheet claims "115-W dissipation at 25-C case temperature," don't jump to the conclusion that you really can use the transistor at 115 W. You can't even get near it.

Simple multiplication shows that if 115 W were dissipated with a typical thermal resistance of 1.5 C/W, a power transistor's case temperature would be 172.5 C above the junction temperature. To maintain the case at 25 C, the junction would somehow have to be held at −147.5 C. So now you are faced with having to derate the 25-C rating to get a practical value. And the derating is usually drastic.

After you are through derating the unit—you'll usually find the derating factor in the fine print, or a derating curve, on the next page—only about 10% of the 25-C values can be attained. And even this 10% provides hardly any safety factor.

Say the case-to-ambient thermal resistance for the unit rated at 115 W is 10 C/W and junction-to-case is 1.5 C/W. Then, for only a 10-W dissipation in an ambient of 80 C, the case temperature rises to 180 C. Also, the transistor junction temperature rises to 195 C, which is perilously close to the limit of 200 C for silicon units in metal cans.

Transistor electrical trade-offs

Major electric characteristics		f_T	t_d, t_r t_f, t_s	$V_{ce(sat)}$	h_{fe} (peak)	$I_{c(max)}$	Cost
$I_{s/b}$	↑	↓	↑	↑	↓	↑	↑
$E_{s/b}$	↑	↓	↑	↑	↓	↓	↑
$V_{ceo(sus)}$	↑	↓	↑	↑	—	↓	↑

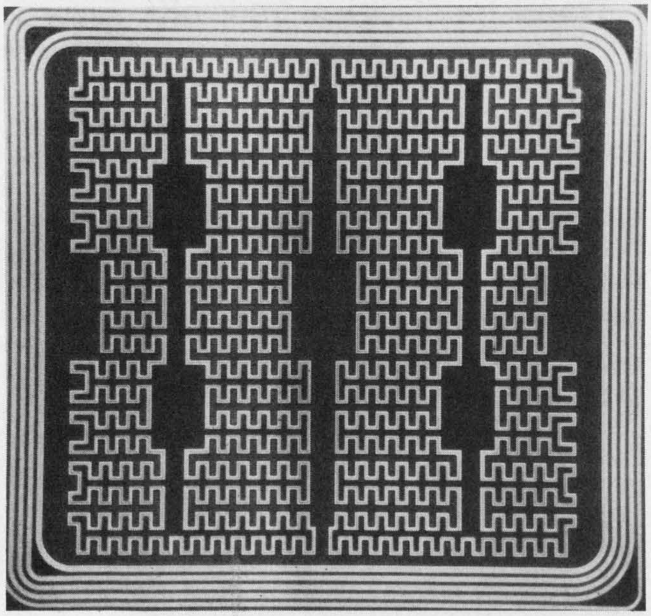
Transistor processing trade-offs

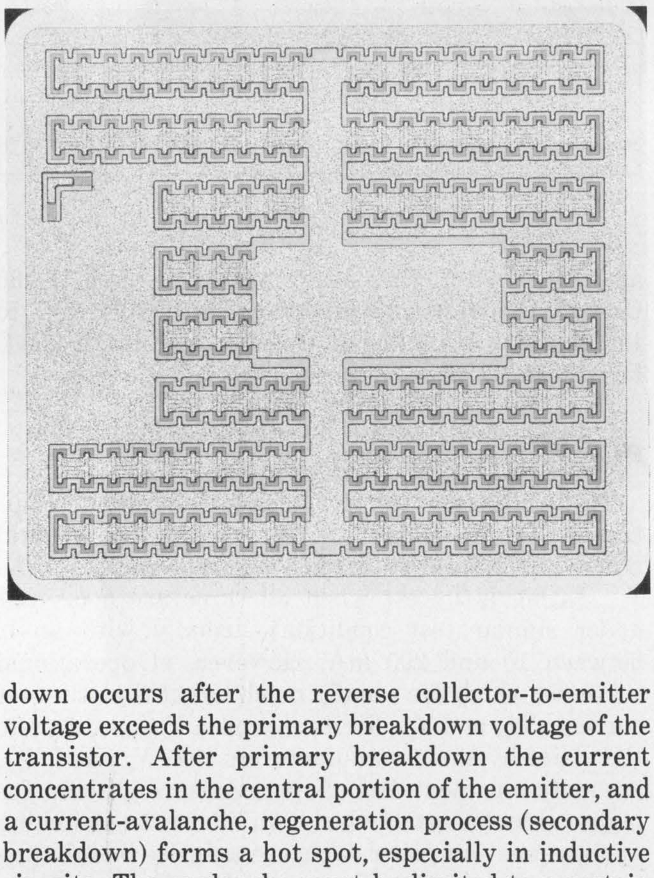
Impurity and structural processing techniques	Ruggedness ($E_{s/b}$)	Switching speed	Voltage (V_{ceo})	Production cost
Single diffused (mesa)	most (6 to 10 J)	slow (5 kHz)	lowest (to 250 V)	least
Triple diffused	medium (1 to 3 J)	medium (20-40 kHz)	medium (to 800 V)	med.
Epitaxial (planar)	least (0.1 to 0.6 J)	fast (to 100 kHz)	highest (to 2000 V)	most

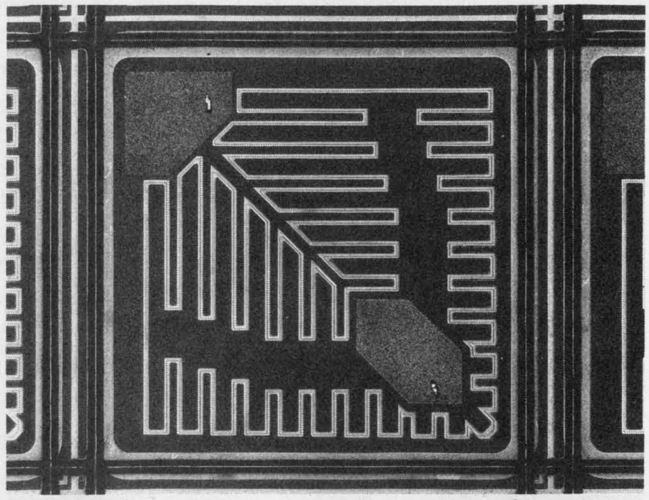
Be safe instead of sorry

Other rating parameters, which many design engineers fail to appreciate are not practical design data, are the maximum values for V_{ceo}, V_{cer} and V_{cex}. The V_{ceo} rating is lowest when all three are measured under similar test conditions—usually with an I_c between 10 and 200 mA. However, at operational currents, which are usually much larger than the test current, V_{cer} and V_{cex} limits approach V_{ceo}. So, despite the claim by some manufacturers that V_{cer} and V_{cex} are more representative of operational conditions, for high currents—particularly, in inductive-switching applications—in general, choose a device based upon the lower V_{ceo} rating. But remember, V_{ceo} is a figure of merit, not a design value. Some manufacturers, however, now define V_{cex} under high-current conditions, and even at a more realistic case temperature of 100 C than the usual 25 C.

Another specification many engineers don't understand is reverse-bias secondary-breakdown ratings ($E_{s/b}$). Many believe that you can determine $E_{s/b}$ from the SOA. Not so: Rating $E_{s/b}$ is divorced from anything that appears on SOA curves. This breakdown rating measures the energy (in joules) that can be "safely" absorbed when collector current avalanches under reverse-bias conditions. This secondary break-







Emitter geometry greatly affects power-transistor characteristics. The patterns are designed to maximize emitter periphery and reduce area so that V_{ce}(sat) is reduced and current handling capability increased. General Semiconductor industries' pattern (top left) contains charge-control rings (C^2R) in its XGSR15030/35/40 units. Fairchild's uses an "H" pattern in its 2N5840/6306 epitaxial-base mesa-constructed units (bottom left). And SGS/ATES prefers the distinctive pattern in its type B200—800-V, 10-A—pnp multiepitaxial mesa units (right).

down occurs after the reverse collector-to-emitter voltage exceeds the primary breakdown voltage of the transistor. After primary breakdown the current concentrates in the central portion of the emitter, and a current-avalanche, regeneration process (secondary breakdown) forms a hot spot, especially in inductive circuits. The avalanche must be limited to a certain amount of energy to prevent destruction of the transistor.

Furthermore, the $E_{s/b}$ rating given by manufacturers greatly depends on the test circuit used. The interrelated effects of inductance, turn-off base current (I_{b2}), base impedance and clamping voltage (if a clamp circuit is used) make this spec almost impossible to specify graphically. Therefore, the value given applies only to a single set of conditions. And since different manufacturers use different test conditions to make the measurement, the $E_{s/b}$ they give you can't be trusted—even as a figure of merit.

Since your transistor will probably operate under conditions different from those used in the vendor's test setup, check with the manufacturer to provide $E_{s/b}$ data for your specific use.

For these reasons, some manufacturers actually contend that $E_{s/b}$ is almost useless as a circuit-design parameter. They recommend instead that transistors never be operated anywhere near the primary breakdown voltage. Repeated primary breakdown shortens a transistor's life. It may be only coincidental that most of the criticism of $E_{s/b}$ ratings comes from power-transistor manufacturers whose devices don't have good $E_{s/b}$ ratings. But the manufacturers do have considerable technical justification to downplay $E_{s/b}$.

Still, no matter how they feel, manufacturers generally are forced to trade off high $E_{s/b}$ to get high speed. However, with the help of external networks you often can achieve what the transistor alone can't provide. In power-switching applications, for example, you can get both speed and high-voltage handling by "snubbing" inductive surges with suppressor devices and networks to relieve your transistor of the stresses of both high reverse voltages and high surge-power dissipation.

Although fast fall times inherently reduce the power that a switching transistor must dissipate when turning off—a major source of power loss (see illustration)—a snubber arrangement can cut the dissipation in half and reduce the power surges to 1/10 that of unprotected circuits. Moreover, relieving such high stresses improves reliability and removes a major source of "unexplained" field failures.

Of course, the price you pay for speed and reliability is the cost of the external snubbing network and the

The better they are, the faster they fall

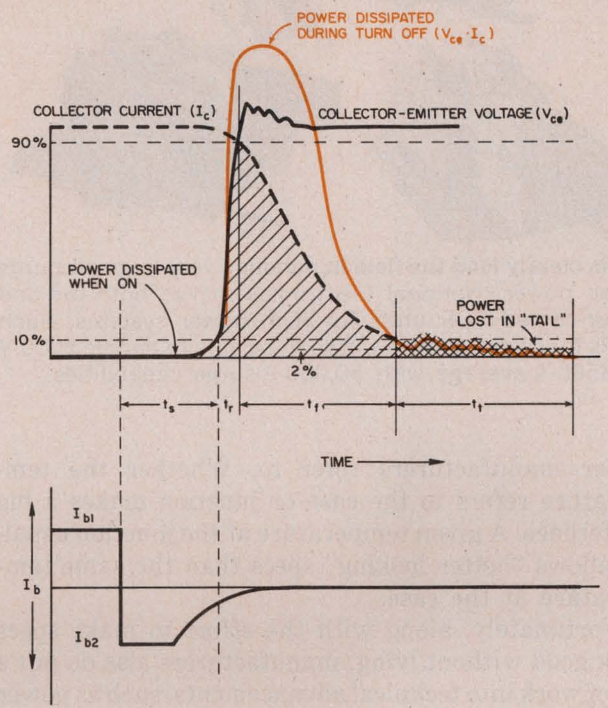
Traditionally, collector-current fall time, t_f, is a major power-transistor figure of merit for both designers and manufacturers: In switching applications, a major portion of a power transistor's losses occur during t_f. During t_f, the collector voltage is 90% of the supply (or clamp) voltage or higher, and the collector current falls from 90% of its maximum to 10%. Consequently, the power dissipated in the transistor is substantial (see figure).

But often ignored is the "tail" that some transistors exhibit on the collector-current waveform, before the collector current falls to zero. The tail's duration, t_t, usually is measured between the 10% and 2% points. Energy loss during this interval can be significant, if the tail extends a long time, since full voltage appears between collector and emitter. Unfortunately, tail time is rarely mentioned on spec sheets.

In addition, the emitter-collector voltage rise time, t_r, at turn-off also can contribute considerable loss, but this time usually is short. And since t_r varies little among different power transistors, and depends heavily on the circuit load, it isn't usually cited as a figure of merit.

For maximum safety, therefore, include all the turn-off times—t_f, t_t and t_r—in an over-all timing specification for your power transistors, from the 10% point of the collector-emitter voltage to the 2% point of the tail.

As a matter of fact, especially for high volume applications, you are well advised to develop your own



set of specs. Of course, the manufacturer should be called in to help. And obviously, don't overspecify: Besides raising your cost, overspecifying some characteristics can unexpectedly result in undesirable performance in other important areas.

usually even higher cost of a fast transistor. Nevertheless, while you're searching for reliability, you should go a bit further: You will usually be pleasantly surprised to find that, within a device family, the cost of a higher V_{ceo} rated unit—say, a 300-V vs a 200-V unit—is very moderate. But what you get is a vastly more reliable device.

You can't get something for nothing

You pay more for a "fast" power transistor, so make sure you get speed where it counts. In power switching, the critical speed parameter is fall time (t_f). In addition, don't overlook the test circuit and the reverse-drive current used by a manufacturer to measure t_f. Test turn-off current, I_{b2}, is often much higher than you would likely use, which makes the t_f spec look better than it actually is.

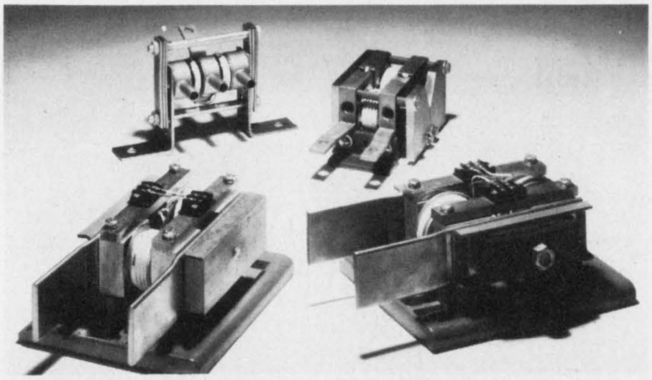
Also, as is the case with most specs, note the temperature at which the transistor's speed is specified—here, too, a 25-C case temperature is unrealistic. Some companies, like Unitrode, supply values at a much more practical 100 C.

Although high turn-off drive current (I_{b2}) shortens t_f, excessive turn-on base drive (I_{b1}) lengthens it. Therefore, in switching applications, the base drive should be just enough to drive the transistor into saturation at a specified collector current.

Of course, a low $V_{ce(sat)}$ spec is desirable for efficient switching, but make sure that the manufacturer determines the $V_{ce(sat)}$ under normal I_{b1} drive conditions. A long t_f is a major cause of power loss, which can easily cancel out any savings from an artificially lowered $V_{ce(sat)}$. Clearly, then, you should provide only just enough I_{b1} to minimize saturation losses, but have high enough I_{b2} to get a short t_f.

Another aspect of turn-off drive current that is often overlooked is its effect on the reverse-bias SOA. Very few manufacturers mention I_{b2}, here. One exception: General Semiconductor Industries not only makes a point of specifying the I_{b2} conditions for its XGSR1530-40 transistors on the reverse-bias SOA ($I_{b2} \le 0.2\ I_c$), but also provides an $E_{s/b}$-vs-base-bias-voltage (V_{bb}) curve.

Interestingly, General Semiconductor is one of a very few companies to provide a forward-bias SOA curve for 100 C in addition to the usual 25-C curves. But the General Semiconductor temperatures used for these curves, and most of its other specs, are junction temperatures—not the usual case temperatures most



SCRs clearly lead the field in handling very large amounts of ac power. National Electronics makes both air and water-cooled SCR units for high power systems. Such SCRs for phase control will soon be able to handle 5000-V at 3500-A-average with 50,000-A-surge capabilities.

other manufacturers refer to. Whether the temperature refers to the case or junction makes a big difference. A given temperature at the junction usually allows "better looking" specs than the same temperature at the case.

Fortunately, along with the effort to make specs look good without lying, manufacturers also do put a lot of work into technical advancements, such as power Darlingtons.

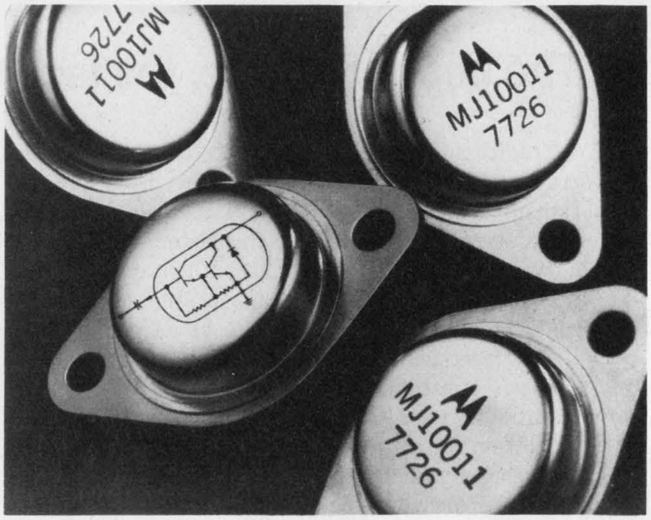
You can't have everything

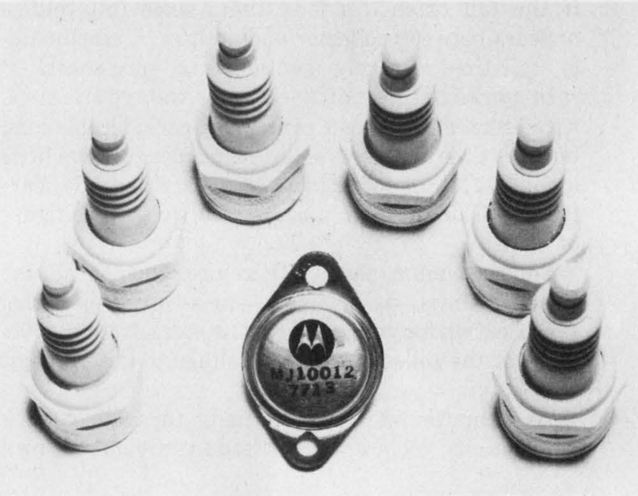
To get high V_{ceo} in power transistors, current gain (h_{fe}) is usually sacrificed. To get both properties with high capabilities requires high-resistivity silicon material. But then current capability and power efficiency are reduced. Drastically.

One solution to the high-gain problem is a power Darlington. Today's Darlingtons can handle 2 to over 20 A and have switching speeds that approach fast power transistors. But much possible gain is still sacrificed to get high switching speed. Still, Darlingtons substantially reduce the heavy loads that driver-transistor circuits encounter with ordinary power transistors. And power Darlingtons easily operate from logic-level signals.

A power Darlington can be considered a standard power transistor having "high" ccurrent gain. However, many potential users have expressed a desire for a fourth lead-out from the Darlington's output-transistor base to allow the base charge to be "pulled out." Also, switching speeds that are slower and saturation voltages that are higher than in standard power transistors still restrict the use of Darlingtons. Nevertheless, their future is considered bright.

Power FETs offer bright prospects too. Their very high input impedance requires very low drive power, which allows direct drive from CMOS, TTL and other logic families. And the secondary-breakdown problems of bipolars are absent. However, drain-source saturation resistances, and thus, voltages are still high —values of 1 to 2 Ω, or 2 to 10 V—and maximum





Monolithic Darlington transistors made by Motorola, MJ10012s, handle the high voltage, high current and harsh environment of automotive ignition systems. Other Darlingtons, such as the MJ10011 with built-in dampers, are specifically designed for TV-deflection circuits. They feature a gain of 40 and a 1400-V breakdown voltage.

allowed drain-source voltages are still low when compared to standard power transistors—around 80 V.

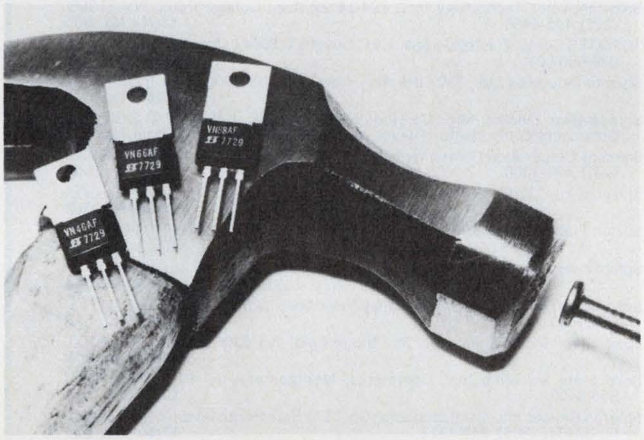
Although FET availability is still limited, almost every major power-semiconductor company is working on them and expecting to offer units, soon. But Siliconix has a brand new series of power FETs, now. They are VMOS (vertical metal-oxide semiconductor) n-channel units designated VN-46, 66 or 88-AF for 40, 60 or 80-V maximum drain-source voltages, respectively. They can handle a maximum 2-A continuous drain-current and operate with under 10-ns switching speeds. The V in VMOS comes from a V-shaped gate that gives the device a much higher current density than the conventional lateral construction of MOSFETs.

Power FETs still have some distance to go to effectively compete with power transistors—at least a 200-V capability is needed. But FETs could eventually exceed the capabilities of Darlingtons.

While both power FETs and Darlingtons have some way to go to compete strongly in the power semiconductor market, thyristors (triacs, SCRs, etc.) have been in there for a long time successfully slugging it out. While low-power dc requirements generally are met with transistors, most ac power-line-frequency applications employ triacs and SCRs, from very-low to very-high-power. However, a grey area is growing in the medium-power range—about 200 to 600 V and to about 450 A—where both transistors and SCRs compete head on.

Competition is healthy

Power-ransistors, generally faster than SCRs, are getting more and more competition from new, fast SCRs for switching-power-supply applications in the 20-kHz range. And gate-turn-off SCRs can operate effectively on dc-power loads. But don't reach for a thyristor without weighing such factors as efficiency, reliability, size, cost and auxiliary circuitry needed.



Power FETs promise to give bipolars and Darlingtons stiff competition. While many companies are still working on them, Siliconix has recently announced a new series of VMOS power FETs packaged in low-cost TO-202 plastic.

Tricky commutation, surge and overload-protection circuits needed in some thyristor applications can argue against their use. Also, thyristors in phase-controlled circuits create radio-frequency interference (RFI), which can obliterate most AM radio stations and play havoc with other control circuits on the same power line. Suppressing networks can eliminate almost all such interference—for a price. However, special loading requirements, such as needed by induction heating, might point to thyristors. The advantages of thyristors often justify the cost of any suppressors and commutation circuits.

The games people play

Thyristor manufacturers play the same games with specs as transistor makers, such as specing at unrealistic 25-C case temperatures. And many specs desirable in transistors are also desirable in thyristors—for example, fast turn-off and low forward-voltage drops. But both the turn-off and turn-on properties of thyristors are much more complicated than in transistors, so thyristor makers have more ways to play the game of "making it look good."

You might expect that the recommended gate current and voltage is enough to ensure that a thyristor is turned on. Not so. The conditions given on a spec sheet may not reflect your application. For one thing, anode and gate interactions are rarely described in full. Your anode circuit, for example, may not provide adequate latching current quickly enough, so the thyristor will fail to stay on consistently. Also, the rate of rise of the input-gate trigger current (di/dt) must be limited to prevent damage to the thyristor, a fact not always understood by design engineers. Transistors don't have such a limit spec.

Thyristors and SCRs from Teccor are in the low and medium-power range. They are appliance-grade units, some with lugs, others with push-on terminals and ruggedly packaged in TO-3 cases.

Turn-off properties are even more complicated. As many as 12 test conditions have been shown to have a measurable effect on turn-off performance. Not only that, but a thyristor may turn on when you don't want it to, because of too high a dv/dt at the anode that capacitively couples back to the input gate. The dv/dt spec is another you must carefully pay attention to. But you have no such spec with transistors.

Nevertheless, except for some special single-diffused high-power transistors—to 1200 A at about 80 V, and to 40 A at about 600 V—assembled in matched series and parallel power blocks by companies like PowerTech, Inc., you'll have to use thyristors in the 100 or 1000-A range, especially above 600 V. ■■

(continued on page 60)

(continued from page 59)

Need more information?

For further information on power transistors and thyristors readers may consult the manufacturers listed here by circling the appropriate numbers on reader service card. More vendors and information may be found in ELECTRONIC DESIGN's GOLD BOOK.

AEG Telefunken, 570 Sylvan Ave., Englewood Cliffs, NJ 07632. (201) 568-8570. **Circle No. 451**

Amperex Electronic Corp., Providence Pike, Slatersville, RI 02876. (401) 762-9000. **Circle No. 452**

Ampower Semiconductor Corp., 375 Kings Highway, Smithtown, NY 11787. (516) 582-6767. **Circle No. 453**

Calvert Semiconductors Inc., Semiconductor Div., 220 E. 23rd St., New York, NY 10010. (212) 889-8150. **Circle No. 454**

Crimson Semiconductor Inc., 440 Park Ave. S, New York, NY 10016. (212) 686-7590. **Circle No. 455**

Delco Electronics Div., 700 E. Firmin St., Kokomo, IN 46901. (317) 457-8461. **Circle No. 456**

Dionics Inc., 65 Rushmore St., Westbury, NY 11590. (516) 997-7474. **Circle No. 457**

Electramation, 666 E. 17 St., Santa Ana, CA 92701. (714) 541-4434. **Circle No. 458**

Electrol Co. Inc., 321 Dewey St., York, PA 17404. (717) 843-0242. **Circle No. 459**

Electronic Control Systems Inc., P.O. Box 1232, Fairmont, WV 26554. (304) 363-8632. **Circle No. 460**

Electronic Transistor Corp., 153-13 Northern Blvd., Flushing, NY 11354. (212) 539-6700. **Circle No. 461**

Elite Semiconductor Prod. Inc., 440 W. Merrick Rd., Valley Stream, NY 11580. (516) 825-1010. **Circle No. 462**

Emerson Electric Co., 7841 Thomas, Pittsburgh, PA 15208. (412) 242-6400. **Circle No. 463**

Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94042. (415) 962-5011. **Circle No. 464**

Ferranti Ltd., Hollinwood Lancashire OL97JS, England, 061-681-2000. **Circle No. 465**

EMC Corp., Semiconductor Prod Op., 800 Hoyt St., Broomfield, CO 80020. (303) 469-2161. **Circle No. 466**

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Optical-fiber transmission links

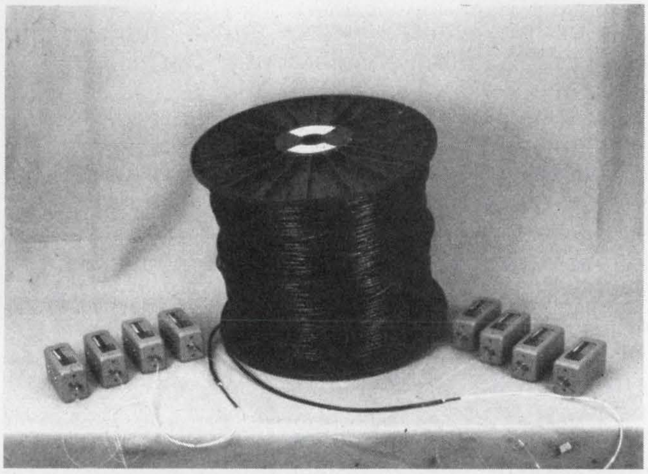
offer a valuable alternative to conventional cables. You can easily lay out such a link with the right design aids.

Whether you want to transmit analog or digital signals, you now have an alternative to conventional cables—optical fibers. Still in its infancy, optical-fiber communication already offers a number of performance advantages.

Bandwidth, for instance, is often wider than that of conventional links, and terminal or repeater spacing can be larger. Fiber "cables" need very little space (Fig. 1), and they are absolutely immune to electromagnetic interference. Nor do they cause any radiation themselves. Electrical isolation of the glass fibers is, of course, absolute—problems like ground loops or sparking simply don't exist. And in an increasing number of applications, fiber-optic links are proving to be cost-competitive with cable installations.

Once you are familiar with the basics of fiber-optic transmission, it's quite easy to lay out an optical link. A transmitter converts the digital or analog input by modulating the output of a light source, usually by varying the source drive current. Solid-state light-emitting diodes (LEDs) and laser diodes are suitable transmitters because their output can be rapidly controlled by varying their bias current. They also offer high brightness, small size, a desirable emission wavelength, and low drive voltage. Peak emission of these devices is often in the near infrared (about 840 nm), because at this wavelength optical fibers are most transparent, and silicon detectors are most sensitive. Lasers can produce over 10-dB higher optical power output than LEDs. Where the light leaves the source and enters the transmission fiber, coupling losses occur, the extent of which depends on the characteristics of the fiber and the light source.

Because lasers have both greater power output and a narrower emission angle, they typically couple 18 dB more power into a fiber than LEDs. But lasers must be operated in a restricted current range, just above the lasing threshold current, since this threshold may change with time and temperature, laser drivers need compensation circuitry. When the lasers' high coupled power is not required, therefore, LEDs are usually preferable because of their lower



1. **Fiber-optic links** come in small packages. Shown are four transmitter and receiver modules, and 1 km of cable.

cost, longer life, wider temperature range, and greater long-term stability.

In either case, the driver must supply the required current to the source's low dynamic impedance, at the desired modulation rate, and without exceeding recommended peak and average currents. For lasers, the recommended peak power output must also be observed.

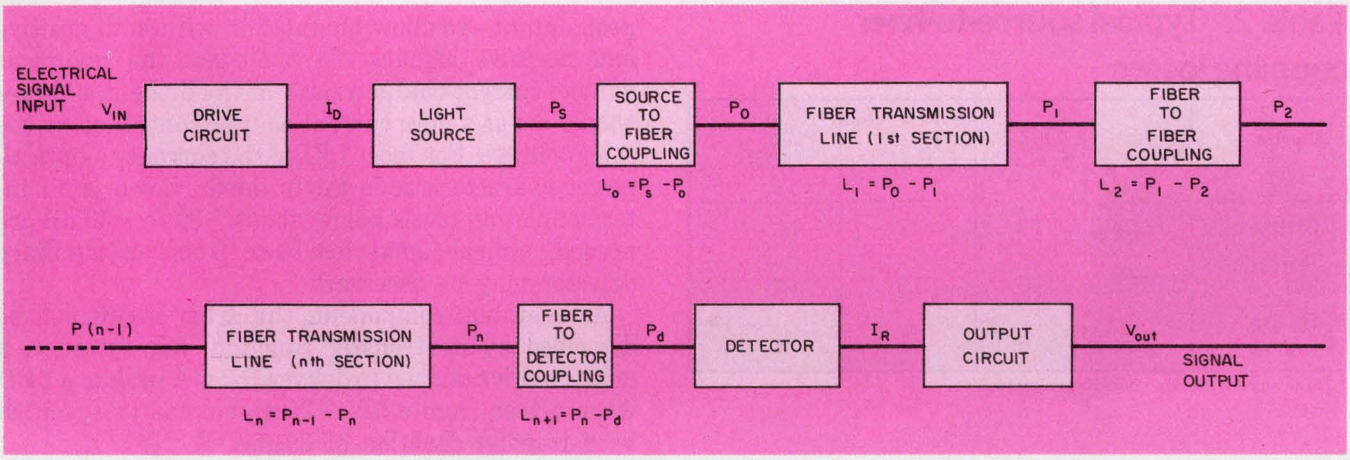
Not just a piece of glass

As an optical signal propagates along a fiber, its amplitude and bandwidth are reduced, but less so than in conventional electrical transmission lines. The bandwidth reduction, generally called dispersion, increases with cable length and is usually expressed in MHz-km. The resulting time spreading for pulse signals is generally given in ns/km. Attenuation is expressed in dB/km.

Three major kinds of low and medium-loss fibers are currently available. One is composed of a pure-silica core and plastic cladding, which produces a step profile for the refractive index. This configuration, known as plastic-clad silica (PCS), generally has higher loss and dispersion than the other types.

The second configuration also features a step index profile, but consists of a doped-silica core and doped-silica cladding produced by chemical vapor deposition (CVD). This fiber has very low loss and moderate dispersion.

Dr. Thomas A. Eppes, Manager, Systems and Applications Group and **James H. Bowen,** Applications Engineer, ITT Electro-Optical Products Div., 7635 Plantation Road B 7065, Roanoke, VA 24019



2. **The basic fiber-optic transmission system** must be broken down into all its components for proper system design.

The third configuration, also produced by CVD, consists of a doped silica core whose doping level varies in the radial direction. The refractive-index profile of this fiber is graded and tailored to compensate for multimode dispersion. Graded-index fibers offer the lowest dispersion of the three, and loss as low as that of step-index CVD fibers.

Optical fibers can be joined either with connectors or splices. Connectors are defined as demountable junctions, while splices are permanent junctions. Both connectors and splices produce optical loss due to the discontinuity at the junction. And in both cases, losses depend on fiber alignment and waveguide characteristics. Splice losses are typically lower than connector losses because in splices, precision fixtures are used and the fibers are permanently bonded together with a bonding agent that reduces discontinuity reflections.

Back to the signal

At the receiver, the optical signal is converted back to an electrical signal by an optical detector. After its conversion the signal is electronically restored to its original form. Detector and amplifier design determine the input noise level, and hence the receiver sensitivity.

The two solid-state detectors most suited for optical-fiber receivers of moderate to high bandwidth are the PIN diode and the avalanche photodiode (APD). Both diode types offer high efficiency and speed, but the APD's sensitivity is greater, due to its avalanche gain effect. However APDs are more expensive, and require an auxiliary high-voltage power supply.

For strong optical signals, the advantage of the APD over the PIN is meaningless because the signal-to-noise ratio of strong signals is determined by signal quantum noise stemming from the random arrival of the optical-signal photons.

The "front end" amplifier that's connected to the detector must provide low noise over the signal's bandwidth. To reduce noise, front ends are often intentionally designed with bandwidths smaller than the signal bandwidth. Equalization in successive amplifier stages flattens the over-all response. Such an amplifier is called an integrating front-end.

Another amplifier type is the resistively loaded front-end in which the detector-load resistor is chosen to give a time constant that's small enough to pass the desired bandwidth. In the transimpedance front end, however, the detector load resistor becomes the feedback resistor of the amplifier. The result is a low effective value of load resistance, combined with a less noisy feedback resistor of higher value.

FETs versus bipolars

All front-ends must accommodate the capacitance and current-source properties of the detector. At present, FETs are usually more sensitive below 10 MHz, and bipolar transistors above 10 MHz. Dynamic

Table 1. Semiconductor light sources from ITT

Device	Type	Rise/Fall Time (ns)	Suggested Peak Drive Current I_D (mA)	Peak Output Power, P (mW)	Peak Output Power, P (dBm)	Typical Transfer Function (mW/A)	Peak Emission Wave-Length
Stripe LED	T801-E	10	200	.8	−1	4	840 nm
Surface LED	T851-S	20	200	1.5	+2	7.5	840 nm
Stripe Laser	T901-L	4*	350	7.5	+9	21	840 nm

* Without prebias

Table 2. Typical source-to-fiber coupling losses

Device*	Type	Glass Step GS-02 (L_o) (dB)	Glass Graded GG-02 (L_o) (dB)	PCS PC-05 (L_o) (dB)
Stripe LED	T801-E	14	17	11
Surface LED	T851-S	16	19	10
Stripe Laser	T901-L	5	8	3

* Can be supplied with pre-aligned fiber pigtails

range, possible data-pattern dependence, low frequency cut-off, temperature stability, and isolation from extraneous noise sources must also be considered.

Each of the functional blocks in an optical-fiber transmission system (Fig. 2) can be specified by a transfer function. For convenience, each transfer function, L, is expressed in dB, where

$$L = 10 \log (P_{IN}/P_{OUT}).$$

The power relationships are noted in Fig. 2. A more detailed analysis of the system components follows:

The drive circuit accepts an input signal and converts it to a current drive for a specific light source. The drive circuit should supply no more than the recommended peak or average drive current for the chosen diode.

In digital signal transmission, the driver usually consists of a high speed pulser, which switches the diode on and off. Sometimes the driver is designed to produce turn-on and turn-off current spikes to shorten optical rise and fall times, thus compensating for the effect of diode capacitance.

For laser-diode sources, the driver may be designed to supply an additional pre-bias current, just below the lasing threshold. The diode can then be switched more rapidly into the lasing mode. Drive-current compensation may be necessary for the laser diodes, because the threshold current is temperature dependent. An auxiliary optical detector in the laser drive circuit can be used to compensate for possible threshold drift, and also to limit optical output power.

In contrast to pulse modulation, baseband analog-signal transmission requires that the driver supply a quiescent drive current to the diode—about half the peak output—to allow modulation with both positive and negative signals. To overcome the nonlinear voltage-current characteristic of the diode, the driver should act as a pure current source, controlled by the input voltage. For most LEDs, the current-to-optical-power characteristic is fairly linear; however, if intermodulation levels below about −30 to −40 dB are needed, optical-signal feedback from an auxiliary detector may be necessary.

As a system component, the drive circuit can be described by its transfer function. For instance, a drive circuit designed to deliver 150 mA peak to a LED when driven from a 5-V TTL signal can be specified by a transfer function of 30 mA/V.

Lasers have the edge

Light-source selection (LED or laser) depends on wavelength, modulation speed, optical-power output, and coupling efficiency. Low-cost wide-area LEDs (GaAsP for red and GaAs for infrared) can sometimes be used as light sources if the low coupled power of 1 μW or less is acceptable.

For high-performance systems, bright GaAlAs LEDs and laser diodes are available (Table 1). They inject much more optical power into the fiber than wide-area sources, at wavelengths where fiber attenuation is low.

Source-to-fiber coupling depends on both source geometry and fiber characteristics. A matrix of coupling losses for several sources and fibers is given in Table 2. Such diodes are often supplied with integral, pre-aligned fiber pigtails.

Fibers for an optical-fiber transmission system include a variety of types (Table 3). One or more fibers are normally incorporated into a strengthened cable for protection. The tabulated attenuation (dB/km) and bandwidth data apply to fibers that have been incorporated in cables, and are used at a wavelength of 840 nm. The total attenuation of the fiber in a system is found by multiplying its length in km, with the tabulated attenuation factor.

Don't overlook dispersion

The fibers' bandwidth factor is expressed in MHz-km, and represents the 1-dB bandwidth factor. For a given system, the tabulated bandwidth factor is divided by the fiber length in km. The 3-dB bandwidth for a fiber is approximately twice the 1-dB bandwidth. Table 4 also lists the fibers' multimode dispersion factor and the rise-time factor, expressed in ns/km.

Fiber-to-fiber joints have a coupling loss transfer characteristic, L (Table 4), which varies from fiber to fiber. Right now, standard cables are supplied in continuous lengths up to 1 km, so at least one joint per km is required.

Fiber-to-detector coupling loss can be assumed as 1 dB for all fiber and detector types.

Detectors that match the existing light sources are PIN-diode and the APD types. Note that the APD detector has an inherent internal gain, which leads to higher responsivity (Table 5). The detectors' transfer function (optical power to electrical current) is expressed in A/W.

Receiver circuits have an over-all input-to-output transfer function that's defined at a given signal level by the ratio of output voltage to input current from the detector. The transfer function is also known as "transimpedance," since it is dimensionally equivalent to an impedance. For example, a receiver may be designed to produce a 5-V signal output when receiving a 1-nW optical signal with an APD detector of 50 A/W responsivity. The receiver transfer function is then 1×10^8 V/A, equivalent to a receiver transimpedance of $1 \times 10^8\ \Omega$.

It's what's up front that counts

The first stage of an optical-fiber receiver is a low-noise front-end amplifier, optimized for use with a specific detector. The detector current produces a voltage across a load resistor, or across a feedback resistor. It is calculated by multiplying the received power, the diode responsivity, and the effective load resistance.

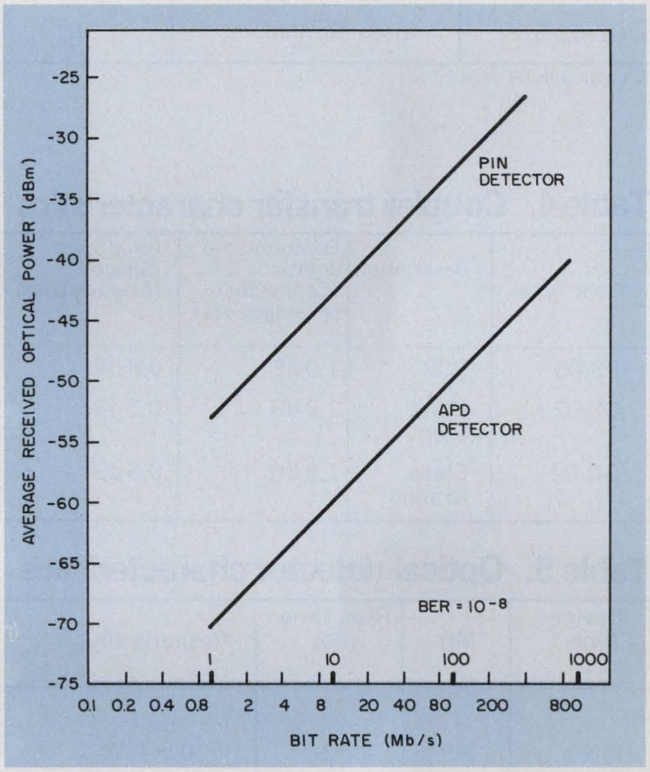
The receiver must have enough additional voltage gain to boost this signal to a usable voltage—typically the same voltage level as the input to the transmitter. For this, several amplifier stages with automatic or manual gain control are needed to adjust signal level. The gain control has to vary the over-all transimpedance by an amount sufficient to convert both the highest and lowest anticipated input signal to the desired output voltage. Pulse-code modulated receivers may also include additional electronic signal processing circuits that restore the output pulse's height and shape.

In a well-designed receiver, sensitivity is set by input stage noise. Wideband, high-gain, low-noise transistors in the front-end will minimize noise. Due to the very weak signals present at the input, electrical shielding and extensive power-supply decoupling are often required to achieve good sensitivity.

As with electrical-transmission systems, noise leads to errors in digital data, and reduces the S/N ratio in analog systems. The total noise increases with receiver bandwidth, so a receiver front-end should therefore be designed for the specific bandwidth at which it will be used.

The most important performance parameter for a digital system is the bit-error rate (BER), which is defined as the ratio of incorrect bits to total bits in a received data system. The BER decreases dramatically as the receiver's S/N ratio passes through the neighborhood of 20 dB. For instance, if a system is operating at a BER of 10^{-8}, an increase in received optical power of only 1 dB reduces the BER to about 10^{-10}.

In analog systems, noise and harmonic distortion are important measures of a received signal's quality.



3. **Required optical power for digital receivers** depends on both the bit rate and the acceptable bit error rate.

While a properly designed receiver is highly linear, a light-source's nonlinearity can cause harmonic distortion. Since in analog systems the signal level can vary widely, the S/N ratio in these applications is defined as the ratio of signal rms to noise rms for maximum signal excursions.

Graphs for the nitty-gritty

Fig. 3 shows the receiver sensitivity at a BER of 10^{-8} for digital receivers as a function of bit rate. The sensitivity (average received optical power at a given bit rate) is roughly the same for return-to-zero (RZ) and nonreturn-to-zero (NRZ) digital data. The graph is calculated from data for available APD and PIN detectors and receiver front-end components, and

Table 3. Transmission data for various fibers

Fiber Type	Description	Attenuation (L) (dB/km)	Multimode Dispersion (−3dB points) (ns/km)	Rise Time (ns/km) (10%-90%)	Bandwidth (MHz-km) −1 dB
PS-05-35	PCS	45	30	21	7.5
PS-05-20	PCS	35	30	21	7.5
PS-05-10	PCS	20	30	21	7.5
GS-02-12	Glass Step	20	15	−11	15
GS-02-8	Glass Step	10	15	11	15
GS-02-5	Glass Step	6	15	11	15
GG-02-12	Glass Graded	20	2.5	1.8	90
GG-02-8	Glass Graded	10	2.5	1.8	90
GG-02-5	Glass Graded	6	2.5	1.8	90

* If used with ITT sources

Table 4. Coupler transfer characteristics

Fiber Type	Description	Demountable Joint (Connector) (Average Loss)	Fixed Joint (Splice) (Average Loss)
PS-05	PCS	1.0 dB	0.3 dB
GS-02	Glass Step	1.0 dB	0.3 dB
GG-02	Glass Graded	1.5 dB	0.5 dB

Table 5. Optical-detector characteristics

Device Type	Mfr.	Rise Time (ns)	Responsivity
PIN Diode	HP	>1	0.5 A/W
APD	RCA	2	5-100 A/W

assumes that the front end is re-optimized for each bit rate. Manufacturers' data sheets contain specific data on a particular receiver.

In baseband analog systems, the receiver S/N ratio is determined by the received optical power and the front-end noise. For current APD receivers, Fig. 4 shows the receiver sensitivity vs bandwidth, for a range of S/N ratios. Fig. 5 gives similar representative curves for receivers with PIN diodes, while curves for specific systems are found in manufacturers' data sheets.

The over-all bandwidth for fiber-optic transmission systems can be approximated from the bit rate. In the NRZ-mode, 1 Mbit/s corresponds to 1 MHz, while the RZ-method requires only half as much bandwidth. But in digital transmission systems it's usually more convenient to express bandwidth in terms of rise and fall times (Fig. 6).

In any cascade-connected system, such as an optical-fiber transmission system, the over-all rise time is approximately 1.1 times the square root of the sum of the squares of the cascaded components' individual rise times. For a digital system, the rise time should be less than a bit interval for NRZ data, or half a bit interval for RZ data. To allow for the finite rise time of the amplifiers, the rise time of the system up to and including the detector should be no more than 70% of a bit interval for NRZ data, or 35% of a bit interval for RZ data. (One bit interval is defined as the reciprocal of the bit rate.)

Analog future is bright

Analog signals are usually transmitted by amplitude (or intensity) modulation, but pulse-width, pulse-position, and frequency modulation are also used. With intensity modulation, LED-driven systems have a bandwidth of about 100 MHz (15 TV channels), while that of injection-laser systems is several times larger.

The over-all rise time for an analog system, including the optical receiver, must be less than the specified rise time for the transmission link alone. Receiver rise time (in s) is given approximately by 0.35 divided by the receiver's 3-dB bandwidth in Hz. Refer to manufacturers' data sheets for more precise data.

By tailoring the receiver's bandpass characteristic to equalize dispersion and source rise times, total system rise time can be reduced below the rise time of the received optical signal. But this form of equalization results in a large sensitivity loss at the receiver, and should therefore be avoided.

The rise times for those components that can significantly limit system speed are given in Table 1 for the light sources, Table 3 for the optical fibers, and Table 5 for the detectors.

In addition to the multimode dispersion given in Table 3, the fiber exhibits a *material* dispersion which may be significant when a LED is used as the light source. Material dispersion depends on the spectral width of the source—with available fibers, it is significant for LEDs but not for lasers. For LEDs with about 40-nm spectral width, the material dispersion is approximately 5 ns/km, leading to an additional rise time of approximately 3.5 ns/km.

Fiber-optics design—made easy

Now that you are familiar with fiber-optics terminology, try yourself on this design example. Your inputs for the design of a fiber-optical transmission system are normally the following parameters:

- The signal to be transmitted.
- The link length.
- The tolerable signal impairment levels such as S/N ratio, BER, and/or rise time.
- Cost constraints.

You must now select a combination of source, fiber and detector which best meets all system requirements. To simplify the design, make out worksheets for alternative approaches as in Fig. 7. Begin by entering the required system bandwidth and SNR (if analog) or bit rate and BER (if digital), and link distance. Then, select a fiber type based on attenuation and rise time.

For an analog system, the fiber's 1-dB bandwidth should equal or exceed the over-all 3-dB bandwidth specified for the system. If you divide the fiber bandwidth in MHz-km by the required system bandwidth, you get the maximum distance for which the selected fiber can be used. But the final fiber selection is still subject to a comprehensive rise-time analysis. However, power analysis and rise-time analysis should be carried out in parallel.

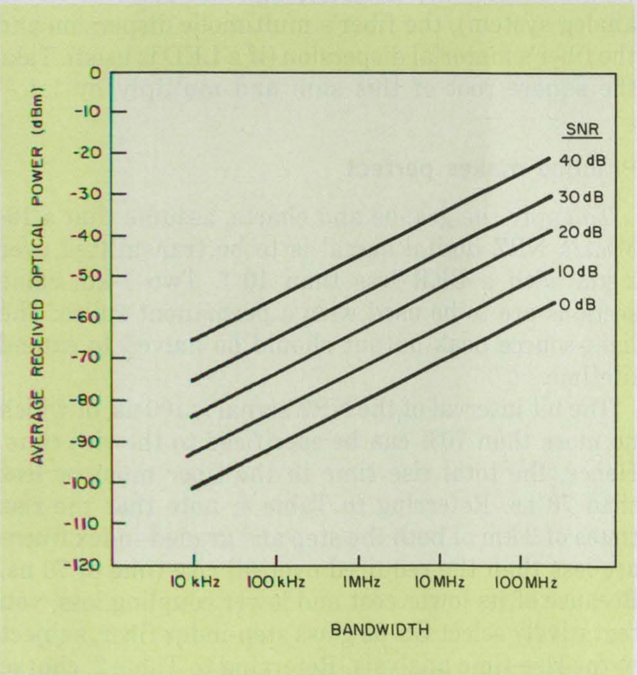
As the first step in the power analysis you have to determine the power margin—the difference between the light source output power and the required received power. Once a fiber has been chosen, you can determine the power margin by selecting a light source and a detector.

The light source's average output must be adjusted as a function of duty cycle and sometimes reduced to improve life. For digital data with 50% density of ONEs, the average source output power is 3 dB less than the peak power given in Table 2 for NRZ signals, and 6 dB less for RZ signals. For an analog system, the average output power is 3 dB less than the peak power given in Table 1.

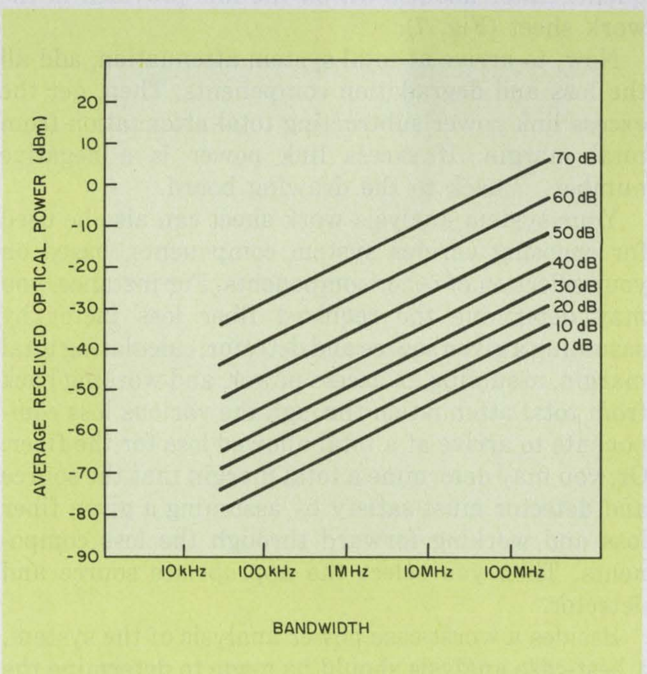
Again, it may be desirable to reduce peak drive current to extend source life. In this case, you must reduce the average output power appropriately. Enter the resulting average source output power in the space provided. Next, determine the receiver sensitivity from the source output power.

Adding up your losses

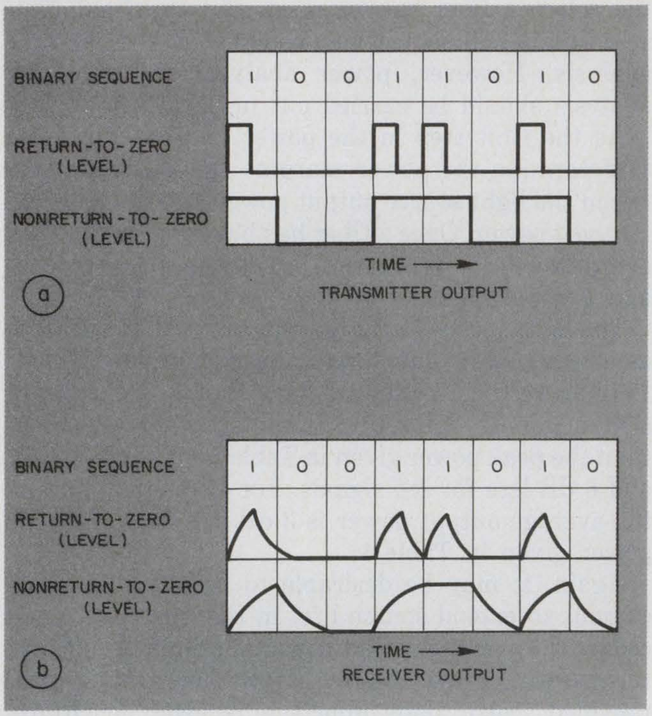
Now you can tackle total link loss. After you decide on the source type, determine total fiber loss by multiplying the fiber loss per km by the total fiber length. Identify the number of connectors required in the system and multiply by the loss per connector to determine total connector loss. Do likewise for any required permanent splices. Allow typically 1 dB for detector-coupler loss.



4. The power required by analog receivers is a function of the bandwidth and the signal-to-noise ratio.



5. **Optical-power requirements for PIN-detectors** in an analog receiver depend on the bandwidth and S/N ratio.



6. **Return-to-zero binary signals** have about twice as many transitions as the nonreturn-to-zero mode. The latter therefore tolerates longer rise times (bottom).

POWER THROUGHPUT ANALYSIS WORKSHEET

Required bandwidth orbit rate: 10 Mbits/s NRZ
Required distance: 2 km
Required BER or S/N ratio: 10^{-9}

		REFER TO:
Fiber type: GS-02-8		
Total fiber bandwidth 15 MHz - km ÷ 5 MHz =	9 km	Table 3
Source type: T-801E Average source output power, P_S:	−7 dBm	Table 1, Text
Detector type: Receiver sensitivity, P_R:	−59 dBm	Figs. 2, 3, 4
Total Margin, (P_R−P_S):	52 dBm	
Source coupling loss, L_O:	14 dB	Table 2
Total fiber loss @ dB/km:	25 dB	Table 3
# connectors: 2 Total connector loss @ 1 dB/conn:	2 dB	Table 4
# splices: 3 Total splice loss @ .3 dB/splice:	1 dB	Table 4
Detector coupling loss:	1 dB	Text (1 dB typ.)
Allowance for temperature degradation:	3 dB	Text
Allowance for time degradation:	3 dB	Text
Total Attenuation:	49 dB	
Excess power (total margin-total attenuation:	3 dB	

7. **Use this power-analysis worksheet** when you design a fiber-optic transmission system.

Degradations from room temperature values can occur in optical fiber systems that haven't been temperature compensated. Both transmitter-output power and receiver sensitivity can vary over a given operating temperature range. For a typical range of −30 to +70 C, include 3 dB to cover these effects.

Source output and receiver sensitivity may also degrade with time. Allow for such degradation so that component-replacement cycles are not overly frequent. Enter about 3 dB on the line provided in the work sheet (Fig. 7).

Now, to arrive at total system attenuation, add all the loss and degradation components. Then, get the excess link power subtracting total attenuation from total margin. If excess link power is a negative number. . .back to the drawing board.

Your system analysis work sheet can also be used for choosing various system components, based on your selection of other components. For instance, you may determine the required fiber loss factor by assuming a given source and detector, calculating total margin, assuming an excess power, and working back from total attenuation through the various loss components to arrive at a total allowed loss for the fiber. Or, you may determine a total margin that the source and detector must satisfy by assuming a given fiber loss and working forward through the loss components. Then you select the appropriate source and detector.

Besides a worst-case power analysis of the system, a best-case analysis should be made to determine the required optical dynamic range of the receiver. And you need a complete rise-time analysis of the system to ensure that the selected components will have the required speed.

A rise-time analysis work sheet (Fig. 8) helps you compare alternative approaches. To obtain the total system rise time, add the squares of the rise times of the source, the detector, and the receiver (if an analog system), the fiber's multimode dispersion and the fiber's material dispersion (if a LED is used). Take the square root of this sum and multiply by 1.1.

Practice makes perfect

To apply the graphs and charts, assume that a 10-Mbit/s NRZ digital signal is to be transmitted over 2 km with a BER less than 10^{-9}. Two 1-km cable sections are to be used with a permanent splice. The light-source peak output should be halved to extend lifetime.

The bit interval of the NRZ signal is 100 ns, of which no more than 70% can be sacrificed to the rise time. Hence, the total rise time in the fiber must be less than 70 ns. Referring to Table 4, note that the rise times of 2 km of both the step and graded-index fibers are less than the required over-all rise time of 70 ns. Because of its lower cost and lower coupling loss, you tentatively select GS-02 glass step-index fiber, subject to the rise-time analysis. Referring to Table 2, choose a T801E LED with a peak output power of 1 dBm. Since the data-transmission format is NRZ, the aver-

RISE TIME ANALYSIS WORKSHEET

Required system rise time:
Required fiber length, type:

	RISE TIME	RISE TIME SQUARED	REFER TO:
Source type:	ns		Table 1
Total fiber rise time due to multimode dispersion @ ns/km:	ns		Table 3
Total fiber rise time due to material dispersion @ 3.5 ns/km: (Typically 3.5 ns/km for LEDs, negligible for lasers.)	ns		Text
Detector type: APD	ns		Table 5
Receiver:	ns		Text, Data Sheets

SUM OF SQUARES

System rise time, (1.1) (Square root of sum): ns

Analog system −3dB bandwidth, (.35 ÷ system rise time): MHz

8. **A rise-time analysis worksheet** simplifies the chore of selecting the right components.

POWER THROUGHPUT ANALYSIS WORKSHEET

Required bandwidth orbit rate:
Required distance:
Required BER

		REFER TO:
Fiber type:		
Total fiber bandwidth ___MHz - km ÷ ___MHz =	___km	Table 3
Source type: T-801E Average source output power, Ps:	dBm	Table 1, Text
Detector type: Receiver sensitivity, PR:	dBm	Figs. 2, 3, 4
Total Margin, (PR−Ps):	dBm	
Source coupling loss, Lo:	dB	Table 2
Total fiber loss @ dB/km:	dB	Table 3
# connectors: Total connector loss @ 1 dB/conn:	dB	Table 4
# splices: Total splice loss @ dB/splice:	dB	Table 4
Detector coupling loss:	dB	Text (1 dB typ.)
Allowance for temperature degradation:	dB	Text
Allowance for time degradation:	dB	Text
Total Attenuation:	dB	
Excess power (total margin-total attenuation:	dB	

9. **The power worksheet for the design example** indicated no excess power, but 3 dB have been included to allow for degradation.

age LED output is 3 dB less (for a data stream containing approximately 50% ONEs). For extended lifetime, the peak drive current is halved, which reduces power an additional 3 dB. The 10-ns rise time of the LED is fast enough by far.

Assume you have chosen an APD receiver for the system. From Fig. 2, the receiver sensitivity for an

RISE TIME ANALYSIS WORKSHEET

Required system rise time: 70 ns (70% of bit interval)
Required fiber length, type: 2 km

	RISE TIME	RISE TIME SQUARED	REFER TO:
Source type: T-801E	10 ns	100	Table 1
Total fiber rise time due to multimode dispersion @ 11 ns/km:	22 ns	484	Table 3
Total fiber rise time due to material dispersion @ 3.5 ns/km: (Typically 3.5 ns/km for LEDs, negligible for lasers.)	7 ns	49	Text
Detector type: APD	2 ns	4	Table 5
Receiver:	50 ns	2500	Text, Data Sheets
SUM OF SQUARES		3137	

System rise time, (1.1) (Square root of sum): 62 ns

Analog system −3dB bandwidth, (.35 ÷ system rise time): MHz

10. **System rise time for the design example** is well below that required.

APD receiver operating at 20 Mbit/s and at 10^{-8} BER is found to be −57 dBm. For a BER of 10^{-9}, only a fraction of a dB of additional optical power is required. The receiver sensitivity, therefore, is at least −56 dBm. Subtracting sensitivity from output power, you find the total system margin to be 49 dB (Fig. 9).

To determine the maximum acceptable fiber attenuation, assume an excess power of 0 dB, which gives a total attenuation of 49 dB. Referring to Table 3, you find that the source-coupling loss for the selected source and fiber is 14 dB. A connector is required at the transmitter and one more at the receiver. Table 5 indicates a connector loss of 1 dB each, or a total of 2 dB. One cable-to-cable splice is required at 0.3 dB loss (Table 4). Allow a generous 1 dB for splices—enough for two possible repairs. The detector coupling loss is 1 dB, and you allow time and temperature degradations of 3 dB each. The total loss, not including the fiber, is thus 24 dB, which leaves 25 dB, or 12.5 dB/km for fiber loss. A cable with fiber type GS-02-8 satisfies the requirements, with an excess power of 5 dB (see Table 3).

Now use the rise-time analysis work sheet (Fig. 10) to verify that the system rise time will be rapid enough to properly pass the data. With NRZ data, the rise time must be no more than 70% of the bit width of 100 ns, i.e., 70 ns. From Table 2 you find the rise time of the T-801E to be 10 ns. From Table 3, the GS-02-8 fiber rise-time factor is 11 ns/km. For 2 km, the total fiber rise time due to multimode dispersion is 22 ns. But since a LED is used, material dispersion will contribute an additional rise-time factor of 3.5 ns/km in the fiber, or an additional 7 ns. The APD detector has a rise time of 2 ns.

The sum of the squares of all rise times is 637 ns². By taking the square root and multiplying with 1.1, you obtain a total system rise time of 28 ns at the detector output—much less than the required 70 ns. You're home free.■■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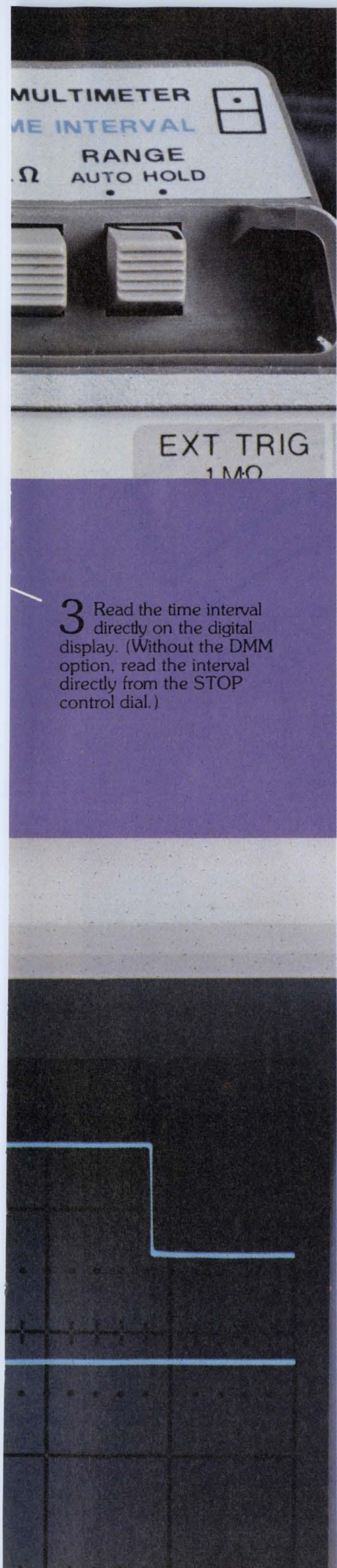

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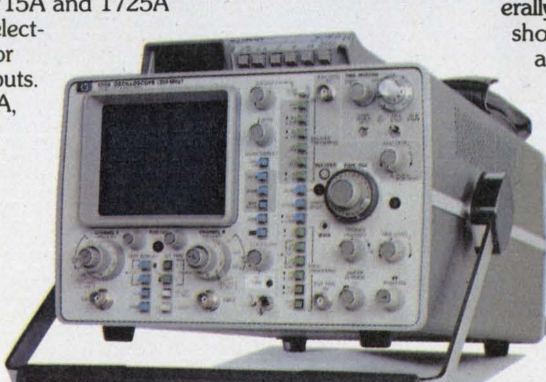

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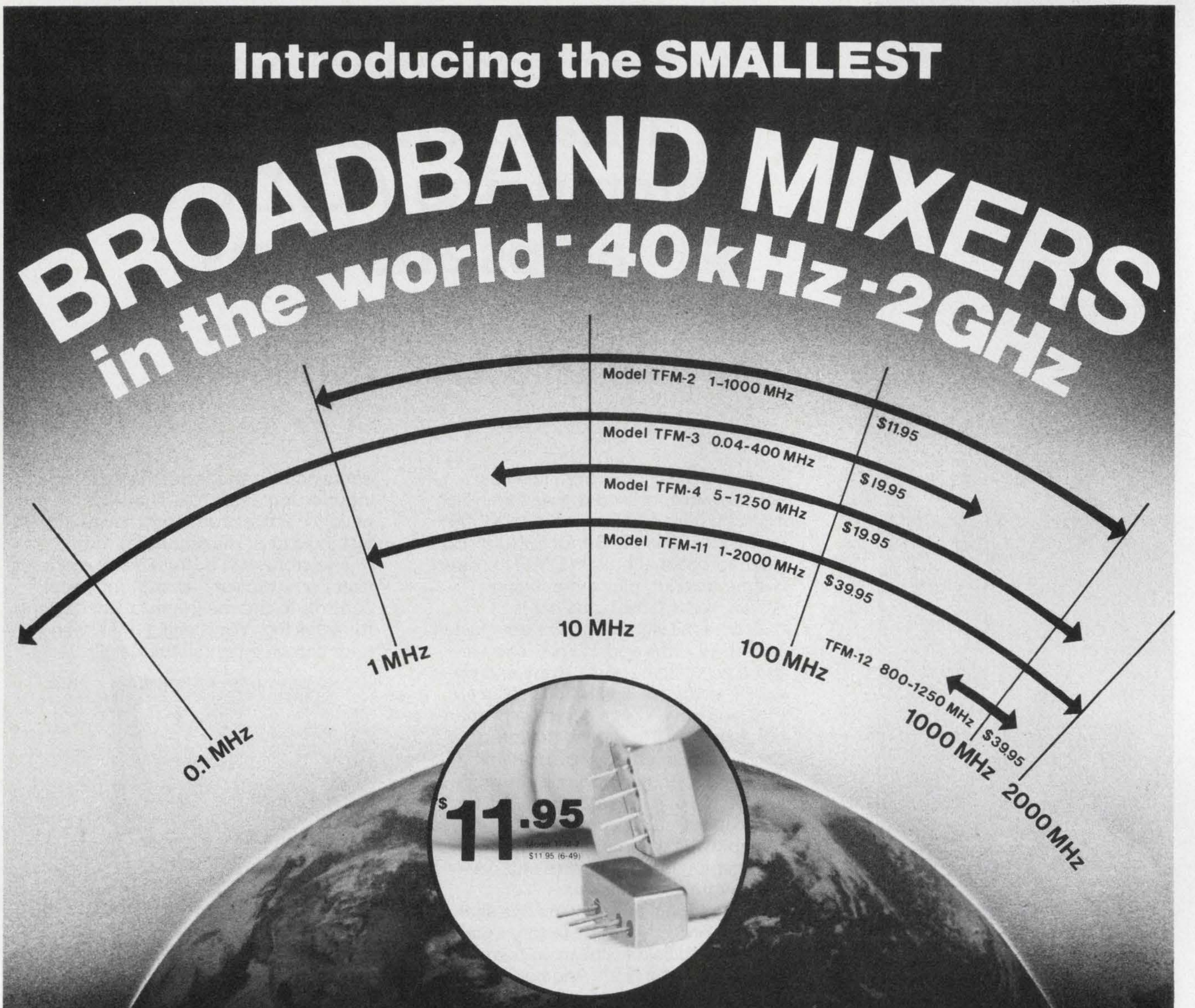

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Model No	LO	RF	IF	Typ	Max	Typ	Max	Typ	Min	Typ	Min	Typ	Min	Typ	Min	Typ	Min	Typ	Min	Quantity	Price
TFM-2	1-1000	1-1000	DC-1000	6.0	7.5	7.0	8.5	50	45	45	40	40	25	35	25	30	25	25	20	6-49	$11.95
TFM-3	.04-400	.04-400	DC-400	5.3	7.0	6.0	8.0	60	50	55	40	50	35	45	30	35	25	35	25	5-49	$19.95
TFM-4	5-1250	5-1250	DC-1250	6.0	7.5	7.5	8.5	50	45	45	40	40	30	35	25	30	25	25	20	5-49	$19.95
TFM-11	1-2000	1-2000	5-600	7.0	8.5	7.5	9.0	50	45	45	40	35	25	27	20	25	20	25	20	1-24	$39.95
TFM-12	800-1250	800-1250	50-90	—	—	6.0	7.5	35	25	30	20	35	25	30	20	35	25	30	20	1-24	$39.95

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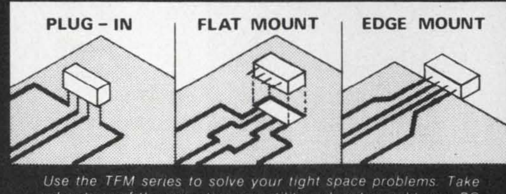

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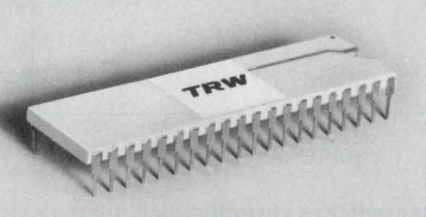

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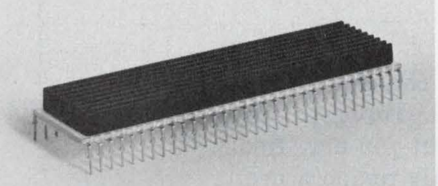

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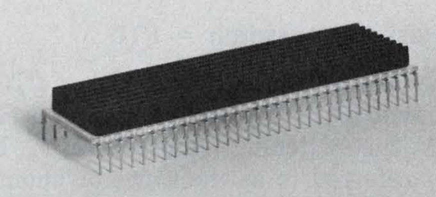

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Heat switches the PTC thermistor.

And the large resistance swing of this positive tempco device makes it look almost like an ideal switch.

A positive-temperature-coefficient thermistor (PTC) works like an ordinary resistor for most of its temperature range. But when sufficient heat is applied, it switches abruptly to a very high resistance. And unlike the resistance of its more popular cousin, the negative-temperature-coefficient thermistor, a PTC's resistance can change by as many as seven orders of magnitude over a 100-C temperature span. Over the same range, an NTC will change by less than three orders of magnitude.

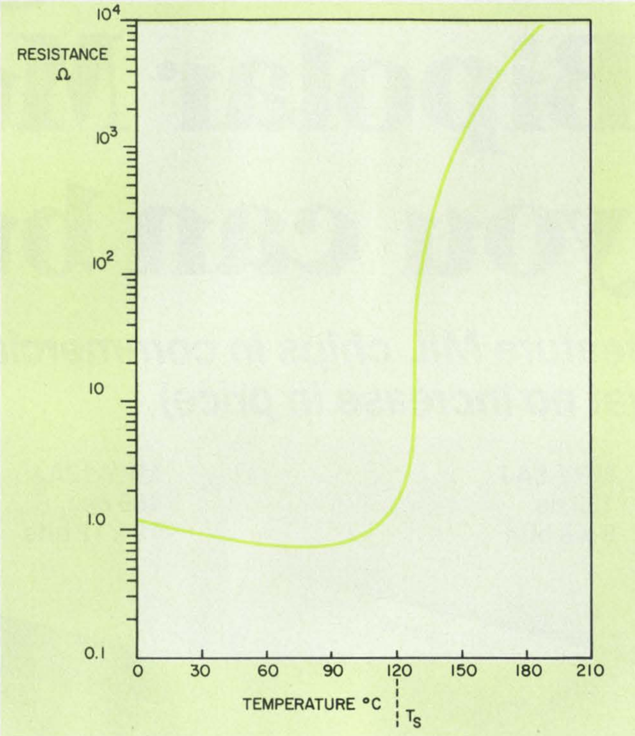
PTCs can replace bimetal switches, fuses, heating elements and even capacitors. But to apply a PTC properly, you must have a thorough understanding of its electrical, mechanical and thermal specifications. Then you'll see why its range of applications covers motor starting, color TV degaussing and even working as a carburetor choke heater in automobiles.

Resistor + switch = PTC

The temperature at which a PTC changes from a low to a high resistance element is called appropriately, the switching temperature, T_S. But you may find it referred to as the Curie or anomaly temperature, depending on whose catalog you're reading. Furthermore, notice in the resistance-temperature plot of Fig. 1 that a PTC's resistance increases sharply at the switch temperature, which in this case, is about 120 C. Devices can be made with switching temperatures ranging from 0 C to over 150 C, but the largest temperature coefficients are found in the 120-C units.

When a PTC is internally heated to a temperature below T_S, it has an approximately linear voltage-current characteristic between the origin and the switch current, I_S, (see Fig. 2). In this region, a PTC operates somewhat like an ordinary resistor. Power dissipation within the device causes the internal temperature to rise. When the current reaches I_S, enough heat is produced for the PTC to reach the switching temperature. Any further increase in the voltage required to produce I_S causes current flow through the device to be reduced abruptly as shown in Fig. 2.

The exact value of I_S is a function of ambient temperature, T_S, of the PTC and the thermal re-



1. **A PTC thermistor switches abruptly** when heated to the switching temperature. Resistance changes by four decades as shown in this resistance-temperature graph.

sistance of the PTC to ambient. If a PTC is internally heated, an approximate equation for its behavior is

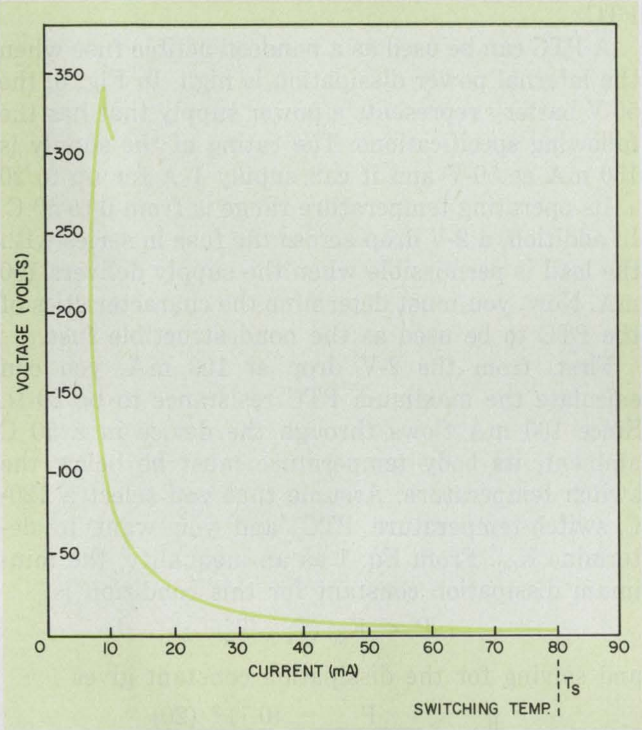
$$P = K_{dc} (T_p - T_A) \qquad (1)$$

where P = power generated in the PTC in mW
K_{dc} = dissipation constant in mW/°C
T_p = body temperature of the PTC in °C
T_A = ambient temperature in °C.

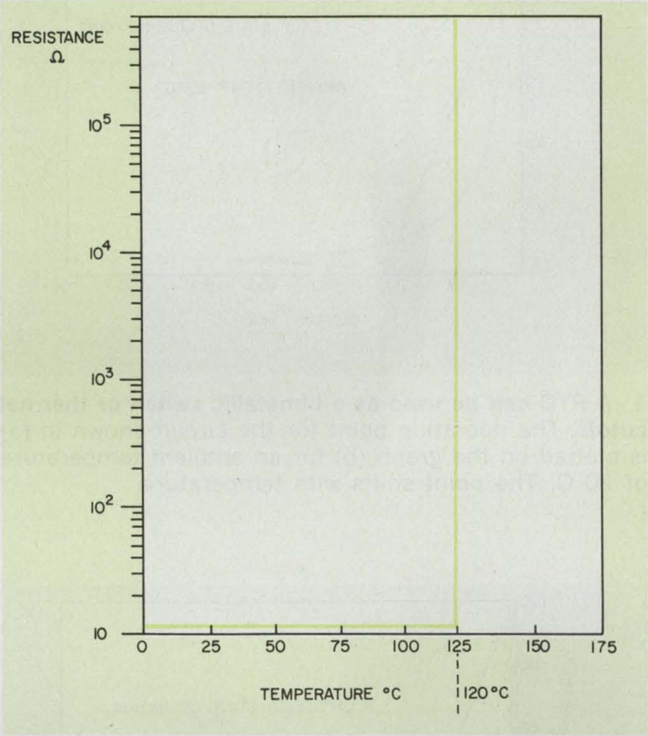
The dissipation constant K_{dc} is a measure of how efficiently a PTC sheds heat to its surroundings. It is a function of any parameter that can change heat flow, such as mounting method, air flow, or PTC size. Strictly speaking, K_{dc} is a constant only under a given set of conditions. However, using one value of K_{dc} for the entire operating temperature range gives sufficiently accurate results for most engineering problems.

An ideal model of the PTC gives you a good idea of its operating characteristics when internally

Ted Krellner, Manager of Design Engineering, Keystone Carbon Co., St. Marys, PA 15857.



2. **Two operating regions are possible for a PTC** as the V-I curve shows. Note the colored line near the horizontal axis to show the linear region clearly.



3. **An ideal PTC has an ideal R/T graph.** The mathematical model is used only to illustrate the basic operation of a theoretical thermistor.

heated. The following assumptions are made for the ideal device:

$$R = \text{Constant, for } T < T_s \quad (2)$$

$$R = \infty\text{, for } T > T_s \quad (3)$$

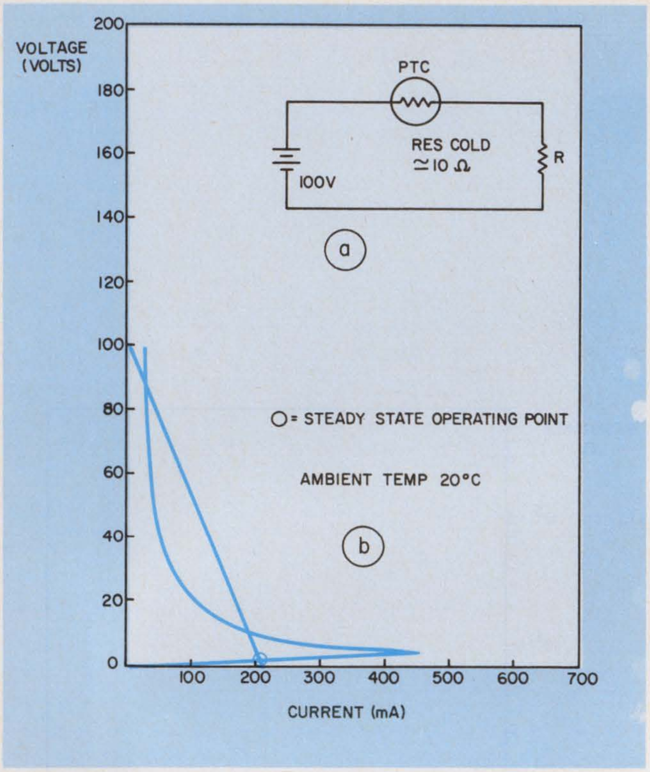
$$\text{Power generated} = V \times I = K_{dc}\,(T - T_A) \quad (4)$$

The resistance-temperature graph of Eqs. 2 and 3 is shown in Fig. 3. From Eqs. 2 and 4, the following conditions emerge: Below the switching temperature, the temperature rise of a PTC is directly proportional to the power being generated within the device. That is, the current flowing through is proportional to the voltage across the PTC and it acts like an ordinary resistor. When the switching temperature (T_S) is reached, the power remains constant and any increase in voltage reduces the current.

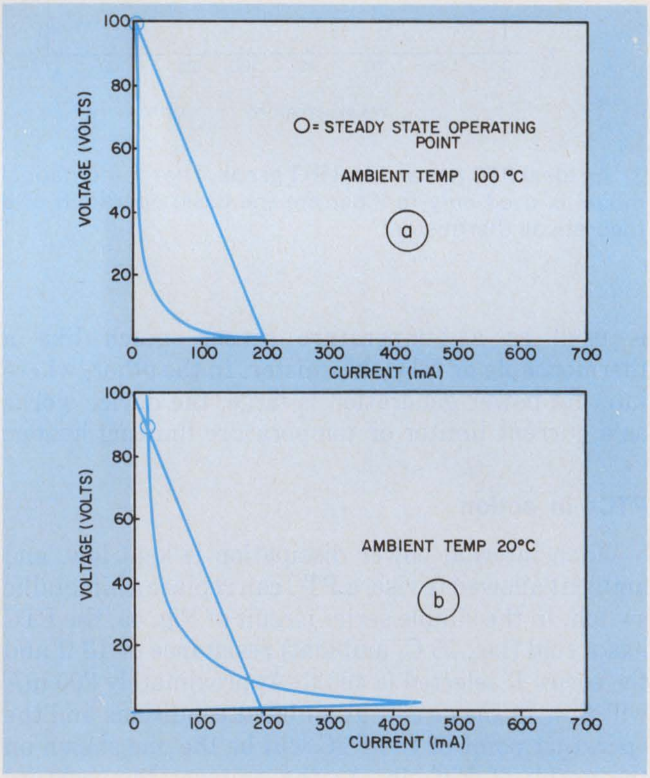
Armed with the fundamentals of PTC operation, let's examine two typical applications. In one, where power generation in the PTC is minimized, the device is used as a temperature sensor, much like a thermocouple or NTC thermistor. In the other, where internal power generation is large, the device works as a current limiter or temperature limiting heater.

PTCs in action

When internal power dissipation is kept low, and ambient allowed to rise, a PTC can replace a bimetallic switch. In the simple series circuit of Fig. 4a, the PTC has a cold (i.e., 25 C, ambient) resistance of 10 Ω and the series R selected is 490 Ω. Approximately 200 mA will flow in the circuit at ambient conditions and the operating point of the PTC will be the one shown on the graph of Fig. 4b. As the ambient temperature increases, the V-I curve of Fig. 4b will move towards the left until the switching temperature is reached. Beyond this temperature, no low-resistance stable operating point exists for the PTC and most of the available voltage is impressed across it. This condition



4. **A PTC can be used as a bimetallic switch or thermal cutoff.** The operating point for the circuit shown in (a) is plotted on the graph (b) for an ambient temperature of 20 C. The point shifts with temperature.



5. **External heating causes a shift in the operating point.** This swings the low resistance point of Fig. 4b up to the high resistance point shown in (a). Internal heating keeps the PTC at a high resistance (b), even after the high temperature condition has passed and the ambient returns to 20 C.

is shown in Fig. 5a.

When the ambient temperature drops, the V-I curve moves to the right as shown in Fig. 5b. But the PTC is kept in a high resistance state by the heat generated within itself. To get the device to return to its original state in Fig. 4b you've got to either decrease power input to it, or provide additional cooling. In this example, with a load resistance of only 490 Ω, the PTC works quite well. For high values of load resistance, less self-heating takes place and switching becomes less pronounced. The high-load-resistance application requires a more sophisticated detection circuit for this PTC.

A PTC can be used as a nondestructible fuse when the internal power dissipation is high. In Fig. 6, the 50-V battery represents a power supply that has the following specifications: The rating of the supply is 150 mA at 50-V and it can supply 1 A for up to 20 s. Its operating temperature range is from 0 to 50 C. In addition, a 2-V drop across the fuse in series with the load is permissible when the supply delivers 100 mA. Now, you must determine the characteristics of the PTC to be used as the nondestructible fuse.

First, from the 2-V drop at 100 mA, you can calculate the maximum PTC resistance to be 20 Ω. Since 100 mA flows through the device in a 50 C ambient, its body temperature must be below the switch temperature. Assume that you select a 120-C switch-temperature PTC, and you want to determine K_{dc}. From Eq. 1 as an inequality, the minimum dissipation constant for this condition is

$$P < K_{dc}\,(T_s - T_A).$$

and solving for the dissipation constant gives

$$K_{dc} > \frac{P}{T_s - T_A} = \frac{(0.1)^2\ (20)}{120-50}$$

$$K_{dc} > 2.86\ \text{mW/ C}.$$

To ensure that the PTC will switch at the coldest ambient under fault conditions, the minimum resistance and maximum dissipation constant must be selected to allow the inequality below to be true.

$$P > K_{dc}\,(T_s - T_A).$$

And since $P = I^2R$, substituting for P gives

$$\frac{R}{K_{dc}} > \frac{T_s - T_A}{I^2} \qquad (5)$$

where $I = 1.0\text{A}$,

$T_s = 120$ C

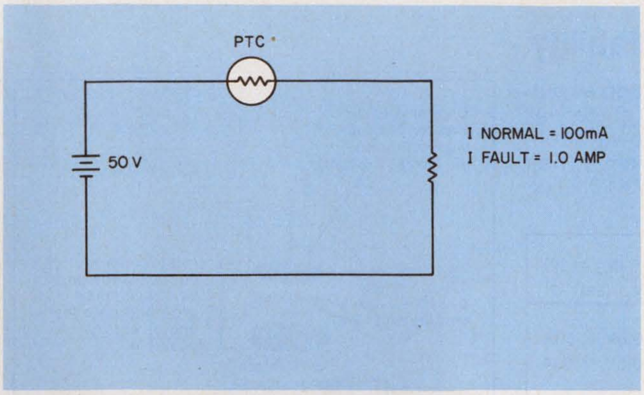
$T_A = 0$ C = (lowest power-supply ambient).

A trial value for the minimum PTC resistance, R is selected to be 10 Ω. Solving Eq. 5 for K_{dc} gives a value of K_{dc} less than 83.3 mW/°C.

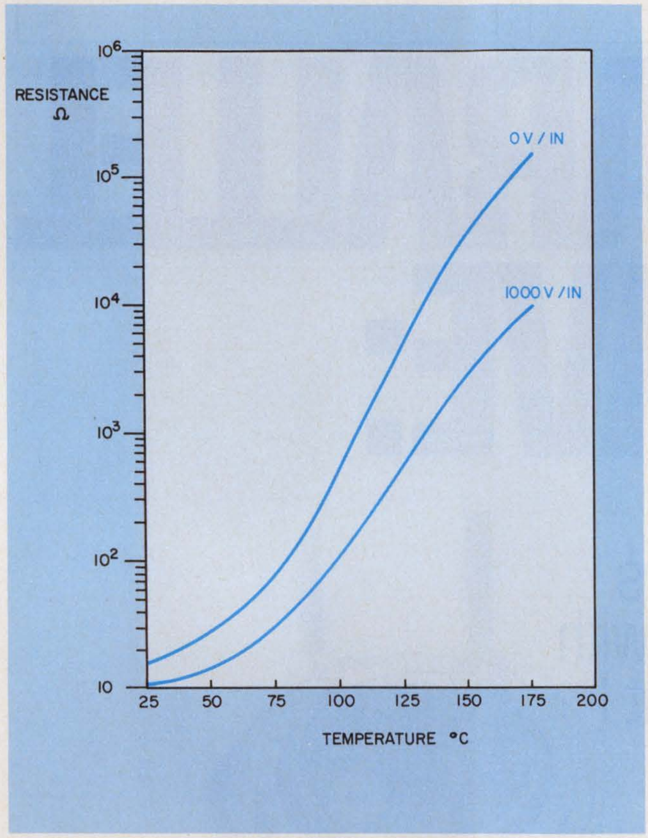
Having calculated upper and lower limits for K_{dc}, you must specify the heat capacity of the PTC, which is found from the following relationship.

$$\text{Power } dt > \text{Heat capacity } dT + (T - T_A)\,dt \qquad (6)$$

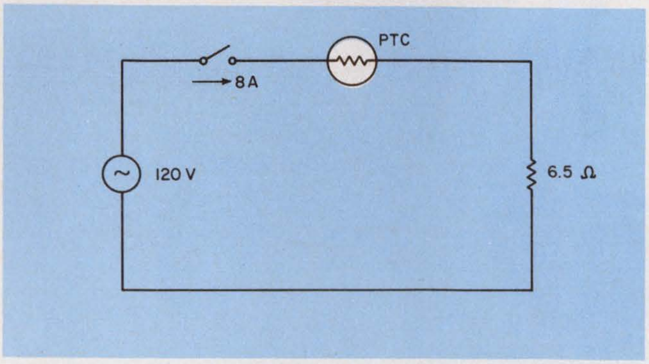
But in most practical cases the $(T - T_A)$ term can



6. **Operating as a nondestructible fuse,** the PTC can dissipate considerable power under fault conditions.



7. **Voltage gradient determines resistivity of a PTC.** Using curves similar to this one helps optimize designs.



8. **You need more than Ohm's Law to find the PTC's resistance in this circuit.** A graph of voltage sensitivity of resistance should also be used.

be neglected. Replacing the dt by Δt and dT by ΔT, and solving for heat capacity gives,

$$\text{Heat capacity} < \frac{\text{power } \Delta t}{\Delta T} = \frac{I^2R\ (\Delta t)}{\Delta T} \qquad (7)$$

where I $= 1.0$ A = fault current
R $= 10\ \Omega$ = trial value of resistance
$\Delta t = 20$ s = fuse timing requirement
$\Delta T = 120$ C

Solving Eq. 7 gives a value of heat capacity less than 1.67 W/°C.

Now you have calculated all the important parameters for specifying your PTC.

1. $10\ \Omega < R < 20\ \Omega$.
2. 2.86 mW/°C $< K_{dc} <$ 83.3 mW/°C.
3. Heat capacity < 1.67 W/°C.
4. $T_s = 120$ C.

You're almost ready to begin designing the PTC into your circuit. But first, look at some not so obvious characteristics of this device. Understanding them will allow you to optimize the selection of your PTC.

Voltage specs can be tricky

Below the switching temperature, the PTC behaves, as you've seen, very much like a resistor. But the device also exhibits a non-ohmic characteristic as the voltage across it increases. The materials used to make PTCs—powders containing barium titanate, strontium or lead and traces of rare earth elements—are responsible for a PTC behaving somewhat like a varistor.

In Fig. 7, the sensitivity of resistance to voltage is shown for a PTC having voltage gradients of 0 V/in. and 1000 V/in. It's not uncommon for resistance to decrease by an order of magnitude due to voltage sensitivity.

To see how to use the resistance-voltage characteristic, examine the circuit of Fig. 8. When the switch is closed, the required peak-surge current is 8 A. The peak value of the 120-V-rms waveform is approximately 170 V, and from Ohm's Law you can see that the total circuit resistance required to give 8 A is 21.25 Ω. You would assume that the maximum PTC resistance allowed is 14.75 Ω. But because of the voltage sensitivity of resistance, devices with zero-power resistance as high as 30 Ω will produce surge currents of 8 A. Not being aware of this characteristic could lead you to specify unnecessarily tight tolerances for your PTCs. When you read a spec sheet, beware of maximum voltage ratings. They're normally specified in dc volts or 60-Hz, rms volts. Because of the voltage sensitivity of resistance, rms values have little meaning unless you know what your waveform will be.

When you're ready to install the PTC in your circuit, don't use any coatings or potting compounds to cover it, until you check with the manufacturer. This also applies to operating the device in any atmosphere other than air. And if you are going to mount it rigidly, select expansion coefficients of your materials that will prevent the PTC from being fractured. ■■

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PT-6502	200A	80V	0.7V @ 100A
PT-9502*	500A	80V	0.5V @ 300A

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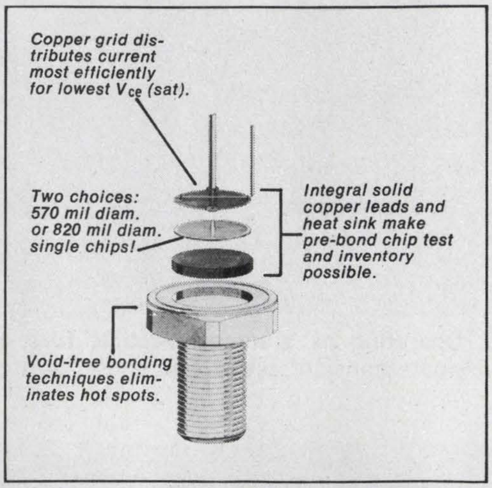

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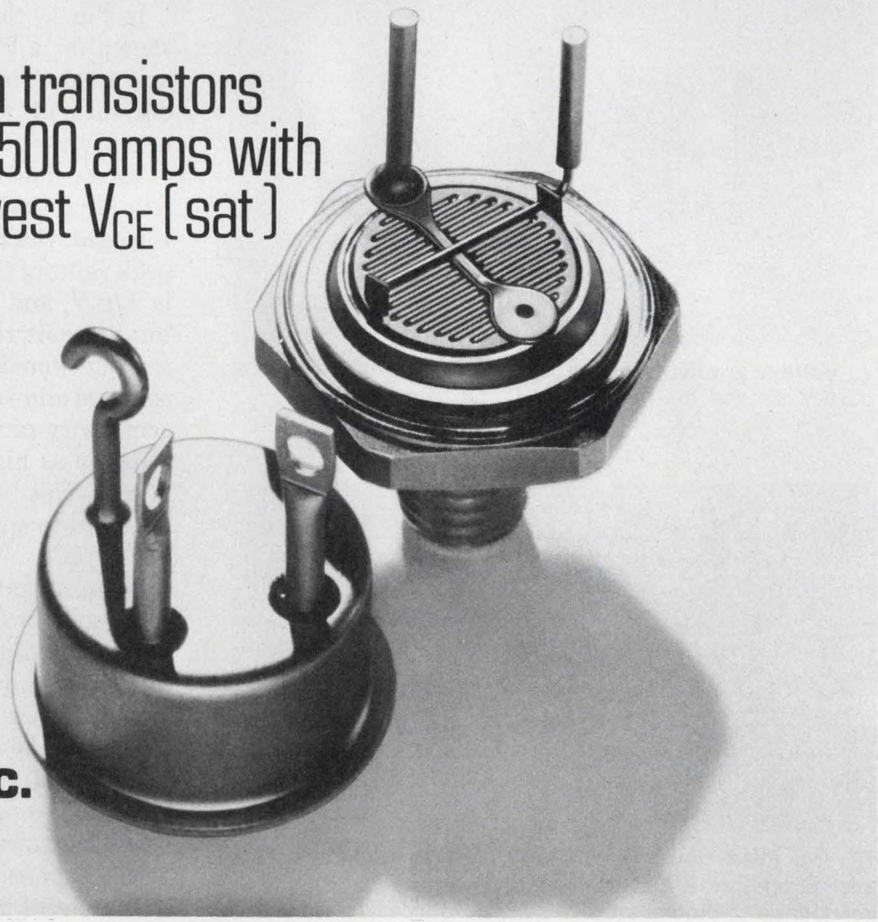

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CIRCLE NUMBER 39

Break the 65-kbyte address barrier in microprocessor systems by using addressing techniques that make use of bank switching and overlapping to add an Mbyte or more.

Don't let the 65-k direct-addressing range of most microprocessors stop you from addressing larger memories. With memory-bank switching memory mapping, overlapping and multiplexed addressing, you can add a megabyte or more of randomly accessible memory.

Right now, most popular microprocessors can address no more than 65 kbytes of memory. This figure results from using a 16-bit address bus, which leads to $2^{16} = 65{,}536$. The 16-bit address was selected by the pioneer μP manufacturers. One reason was that since the number of bits associated with an address increases as the address size increases, address size was pin-limited because of the small size of the chips available then.

Address-bus multiplexing (half the address now, half later) would have solved the size problem, but also would have added more complexity and cost to the system than was warranted by the applications of the day. So while a 24-bit directly addressable address eventually would have proven more useful, the 16-bit address and its implied limit of 65 kbytes of memory became the *de facto* standard.

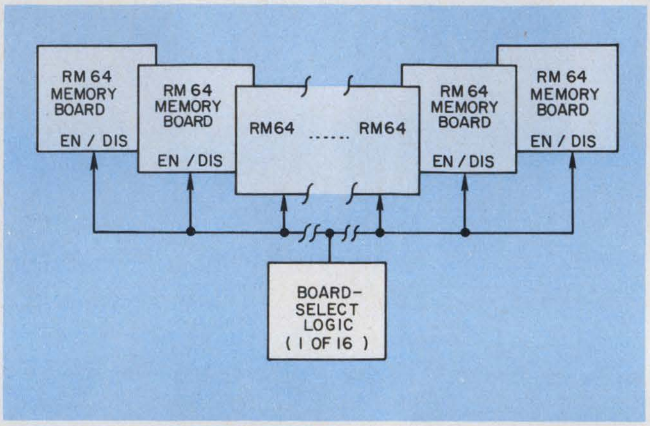
Today, however, with technology improving, capabilities increasing and costs going down, microprocessors are being used in many applications that require more and more memory capacity. Moreover, the use of higher-level languages also demands more storage capacity.

The small-computer problem

Random-access memory—without which you can't run your computer—is very expensive. It costs more per byte than either tape (cassette) or rotating (disc) memory. But it's faster than both—and that's what you pay for.

Today, you need at least 16 kbytes of RAM storage to do something that's fairly complex or to run a high-level language such as Fortran. And for many applications, 65 kbytes of storage—and more—is what you really need.

As a way to increase memory storage, bank switching is an old technique used for years in large, mainframe machines. In bank switching, one of many memory modules is selected (switched on-line and enabled), while all other modules are de-selected (disabled). A software routine tells the CPU when to switch to the next memory bank, and where it is located—that is, which memory module to select.



1. **Bank-switching control logic** can be distributed through a microcomputer system. Each memory board contains enable/disable logic, but the board-select board actually selects a given bank. Under software control, it can select any one of 16 boards.

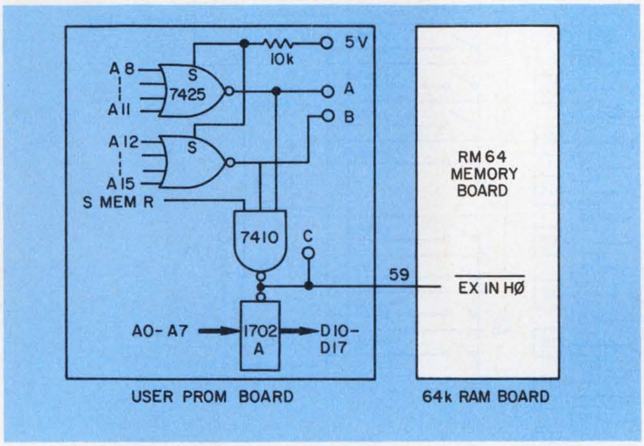
Currently, two microcomputer memory boards feature bank switching. Introduced late in the spring of this year, both use S-100 microcomputer-bus protocol, and normally handle as much as 65 kbytes of usable semiconductor random-access memory on a single board. One bank-switching board, marketed by Imsai of San Leandro, CA, costs more than $3500. The other board, the RM64 from Extensys, costs about half as much, even though it uses twice as many memory chips.

The price gap is directly related to the RAM chip each manufacturer uses. The Imsai uses the more expensive Intel 2116, 16-k dynamic RAM. But the Extensys uses the less expensive Intel 2108—an 8-k RAM derived from the 2116.

Board-control logic can be kept minimal

Either board holds part of the logic necessary to enable and disable the board. But the logic that actually bank-switches a given memory board is

Sam Holland, Director of Research and Development, Extensys, 592 Weddell Dr., Suite 3, Sunnyvale, CA 94086



2. **Memory overlap prevents bus conflicts** by inhibiting the memory board's bus drivers. $\overline{\text{EXINHØ}}$ is an Extensys-defined signal located at pin 59 of the S-100 bus.

external. After all, it can be in only one place in any one system.

Much of the Extensys control logic—the enable/disable function—has been distributed to each RM64 board. An external 1-of-16 decoder selects the desired memory bank (Fig. 1).

Beware, however. Bank-switching to expand your μP's memory capacity may cause a problem during operation. When frequently used code resides, say, in PROM, you don't want to hand-load RAM in order to fetch larger routines from other storage media. Avoid this problem with a bootstrap approach using a memory-overlap technique—simply apply the system PROM's chip-select signal to the RAM card's select input. When the signal is Low, it turns off the RAM board's bus drivers and prevents bus conflicts. The signal that does this on an Extensys RAM board is designated $\overline{\text{EXINHØ}}$.

"Memory overlap" is special to the RM64 board. It allows you to designate a piece of memory in your system to have precedence over any memory board that you select. As a result, you can store instructions —such as a memory-manipulating program—in some desired address range within a memory dedicated to that purpose. You don't have to duplicate the program in any other memory. The dedicated memory can be a portion of another RM64 board, or it can be external ROM or RAM. Once the program is accessed, all other memory boards that share the same address range are disabled by the $\overline{\text{EXINHØ}}$ signal.

One megabyte, anyone?

You don't lose much storage with the memory overlap technique because the forbidden address range (the overlapped memory area) is ordinarily no more than 256 bytes. But if the program gets very large, the technique proves self-defeating. Should it need, say, 32 kbytes, you end up using only half the capacity of each memory board. And with multiple memories, you can indeed write a very small piece of code that will do the job.

Fig. 3 shows a one-megabyte memory system that includes a signal for disabling all boards so that PROM takes precedence over RAM in the memory-overlap state. Bank-switching via the 75154 decoder controls the 16 RM64 boards.

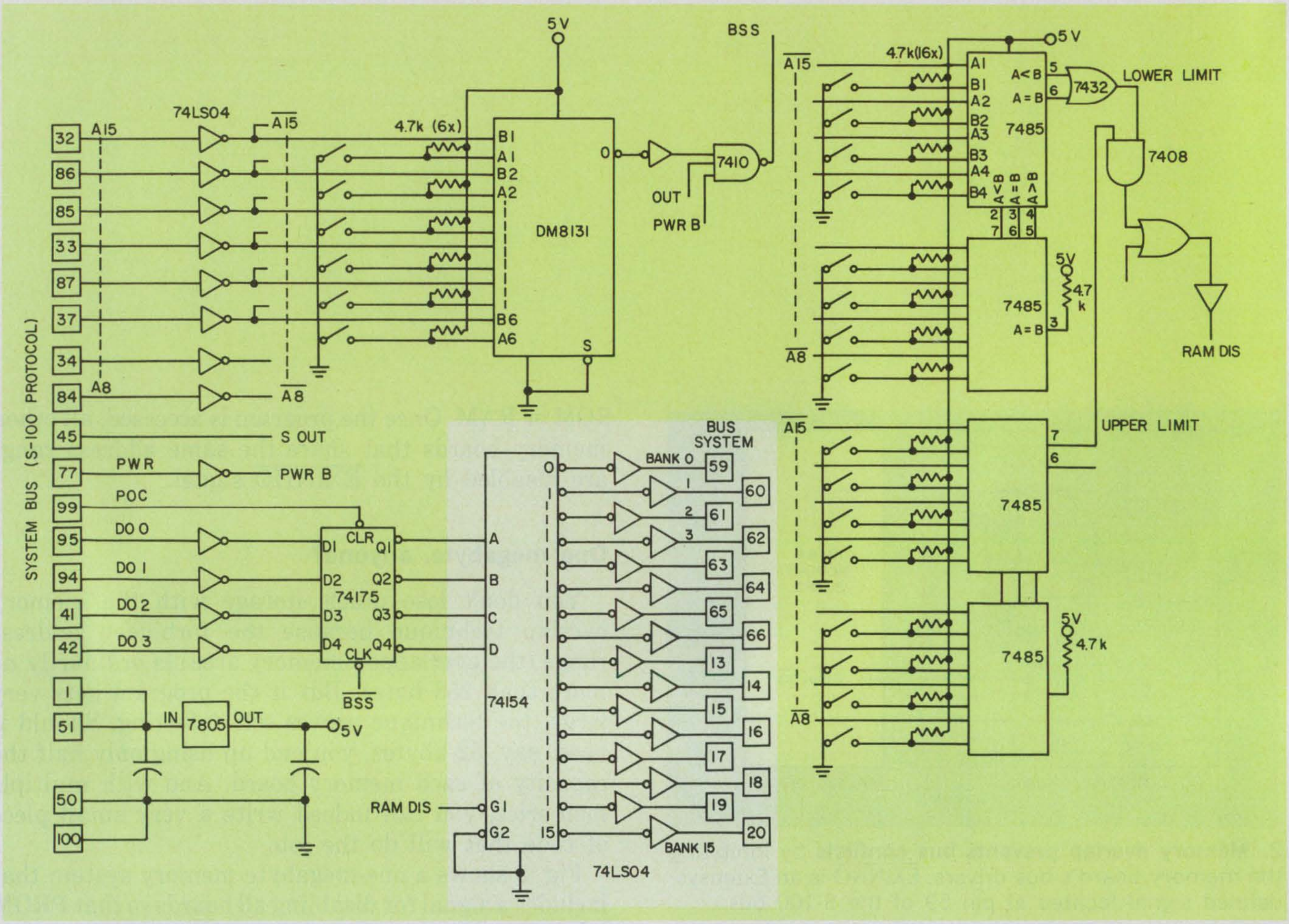
If, by the way, you store the memory-manipulating program on an RM64 board, you can use bank-switching to store data in the other boards in the previously forbidden address range. The data remain accessible because of the RM64's board-disable capability—which most ROM and other RAM modules don't have.

In the circuit of Fig. 3, output port 0 is used to select one of 16 modules. A Power on Clear signal from the system bus clears a 74175 latch, so bank 0 can be accessed after every power-on. A 7410 gate provides address decoding and gating for the processor's Write pulse. The gate, in conjunction with signals A, B and SOUT, fixes the address of the latch as output port 0. (There are, of course, other ways to do the job.)

Signal C disables all boards to permit a memory-overlap state. As a result, a ROM or PROM read can take place.

The memory-control-board pinouts shown are for the S-100 bus developed by MITS for the Altair microcomputer. However, pins 59 through 66 and 13 through 20 of the bus are lines that may be used with the Imsai microcomputer system. If you use any of these lines, make sure they haven't already been assigned functions in the system: Some companies set aside these "unassigned" pins for special functions.

To switch from one 65-k memory bank to another;



3. **This 1-Mbyte RAM system** consists of 16 RM64 65-k RAM modules, and uses bank switching, the EXINHØ RAM-module-select line, and a user-provided output port to select one of the 16 RAM modules.

you must develop a software routine that writes to port Ø. The routine to generate the needed hardware signals should be similar to the following:

```
MVI A, BANK#     ;BANK# FROM
                  BELOW
OUT PORTØ        ; WRITE PORT
```

The bank numbers and data representation are

BANK#	DATA
Ø	ØØH
1	Ø1H
.	.
.	.
.	.
.	.
.	.
14	ØEH
15	ØFH

The routine produces an immediate switch and fetch of the next instruction from the selected board. Therefore, to prevent the program from jumping to an unknown address, you will need a transfer code located at the same address in each board.

For example, you can use a portion of a 1702A PROM for the common bank-switch code. Both the address of the bank being jumped to and the return address of the main program should be loaded into the CPU to facilitate the jump and the return. The routine listed in Fig. 4 is an example of the bank-switch software necessary for an 8080A processor.

When large blocks of data are being transferred between peripherals and RAM memory, as happens in large-scale applications, data-transfer rates under memory-mapped control can slow system operation. But direct memory access permits fast and efficient data transfers, improves the system's data throughput, and increases the efficiency of its management capabilities.

You can easily implement a system that features both bank switching and DMA (Fig. 5). To do the interface, the controller board can be expanded to include the DMA-control circuitry. The MM16 board from Extensys has both these capabilities.

In particular, DMA provides efficient transfers to and from I/O boards and between multiple memory boards. Suitable programs in your microprocessor will set up the DMA channels and allow the DMA transfers

What is the S-100 bus?

Many different bus protocols are used today: the IEEE Digital Group protocol, 6800 protocol, 6502, among others. But the RM64 memory board makes use of the S-100 protocol structure.

Introduced by MITS for its Altair microcomputer, S-100 protocol is now used very widely and is almost a *de facto* standard.

A product compatible with the S-100 bus will work properly in any S-100 bus machine—in theory. In reality, however, some modifications may have to be made. The S-100 scheme defines a 100-pin structure and assigns certain signals to certain of these pins, as shown in the table. But from machine to machine, the number of required signals, the type of signals, and the timing of the signals can vary. What's more, there may be differences among the various specified signals in I/O structures and peripheral equipment.

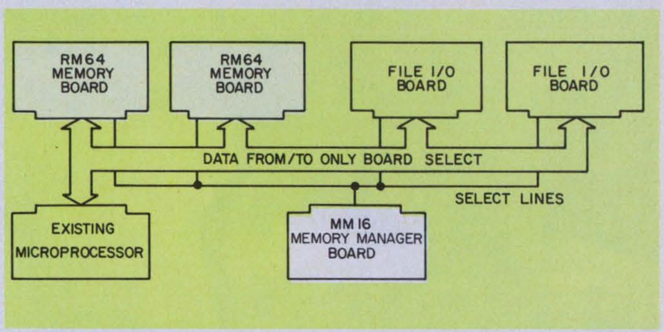
The 100-pin structure of the S-100 bus is split into two groups of signals: One group consists of the basic machine-operating signals—address and data-bus lines, power-supply lines and basic control signals for reading and writing data. This group accounts for 53 of the 100 pins. The memory boards use pin 59 of the bus—a pin that hasn't been "officially" assigned a specific function (a spare). This pin is used for the $\overline{\text{EXINHØ}}$ signal, which enables or disables the board. Other pins on the bus have been assigned for interrupt functions, others for special reset and timing signals and others for spares.

For more information about the S-100 bus structure and protocols, contact

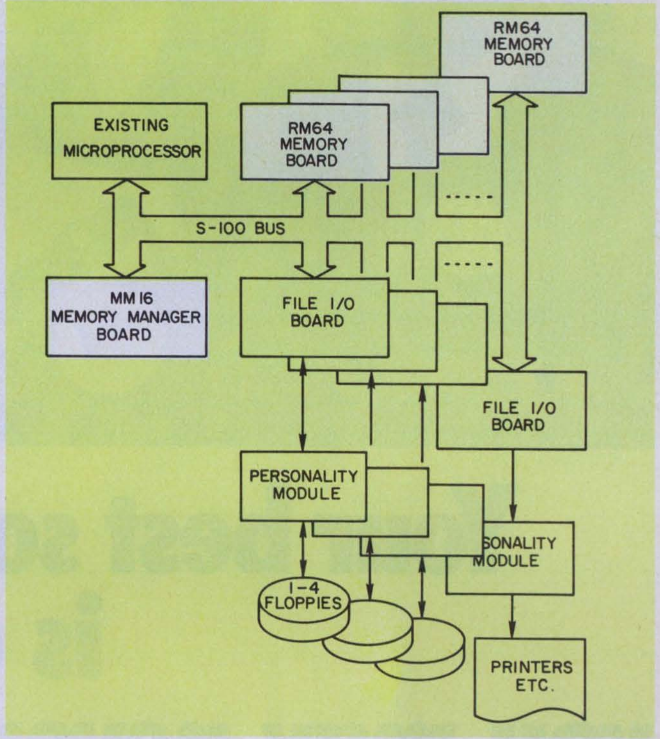
MITS **CIRCLE NO. 318**
Imsai **CIRCLE NO. 319**

```
Main Program, Bank Ø.
          .
          .
          .
     LXI            H, (JUMP ADDRESS)
     LXI            D, (RETURN ADDRESS)
     MVI            B, (CURRENT BANK)
     JMP            SWITCH
     NEXT INSTRUCTION (RETURN ADDRESS)
The PROM code is
     SWITCH:        OUT        Ø
                    PUSH       B
                    PUSH       D
                    PCHL
     RETURN:        POP        H
                    POP        B
                    MOV        A, B
                    OUT        Ø
                    PCHL
The program in the new bank is
     CODE:          PROGRAM
                       .
                       .
                       .
                    JMP RETURN
```

4. **Software for this bank-switching program** can be stored in a PROM and accessed when needed by using jump and return instructions. The example shown is for an 8080.



5. **Direct memory access combined with bank switching** yields a multiple-memory system with high-speed memory-to-memory moves and highly efficient data-processing. Most control logic can be put on a separate board.



6. **Simultaneous I/O transfers** from multiple File I/O and memory boards result in extremely high I/O rates. This complete and very powerful system disperses its data through a large memory arrray.

to take place.

An even larger, more powerful processing system can be configured by adding memory boards (totaling more than a megabyte) and File I/O boards (Fig. 6). The MM16 memory manager board contains the system control logic necessary for selecting the memory boards and the File I/O boards.

With the system's multiple File I/O boards and memory boards, several I/O transfers can be made simultaneously. As a result, this system is capable of extremely high I/O rates. And with its ability to handle multiple RM64 boards, the system can disperse data into large arrays of memory for high-speed data processing. ■■


TECCOR

Let microprocessors communicate

directly with each other, register to register. When data exchange is moderate, it's often the simplest solution.

When the central processing units of "mainframe" computers were large and expensive, it made a lot of sense to time-share them for many tasks. With the low price of μPs, however, you can feel free to use a separate CPU for each separate task your system has to perform—and to link the μPs only when information must be passed. Therefore, multiprocessor systems are becoming very popular.

One way to let μPs communicate with each other is by common memory (Fig. 1a). In such a system, certain memory locations act as "mail boxes" for the individual processors.[1] Each processor periodically scans its "mailbox" to see if any of the other processors has placed an "order."

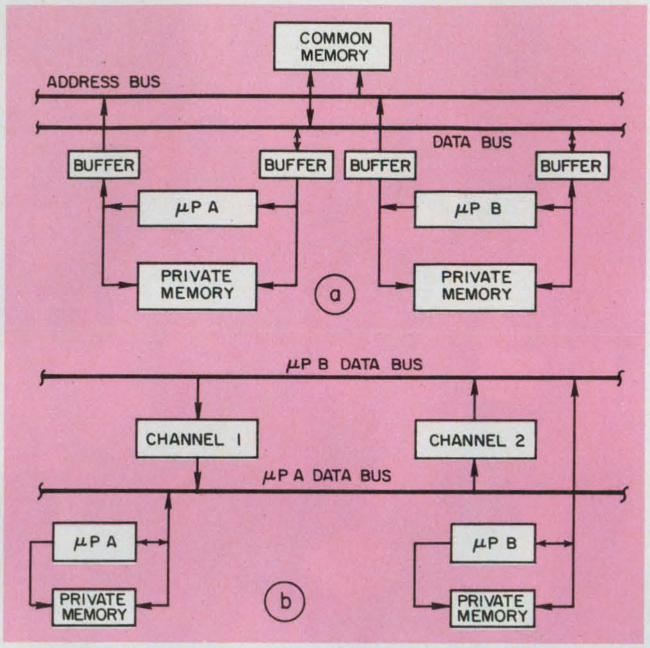
This method is practical for systems requiring sizable information transfers between processors, but becomes wasteful if interprocessor transactions are no more than a few status or data words.

"Registered mail" is cheaper

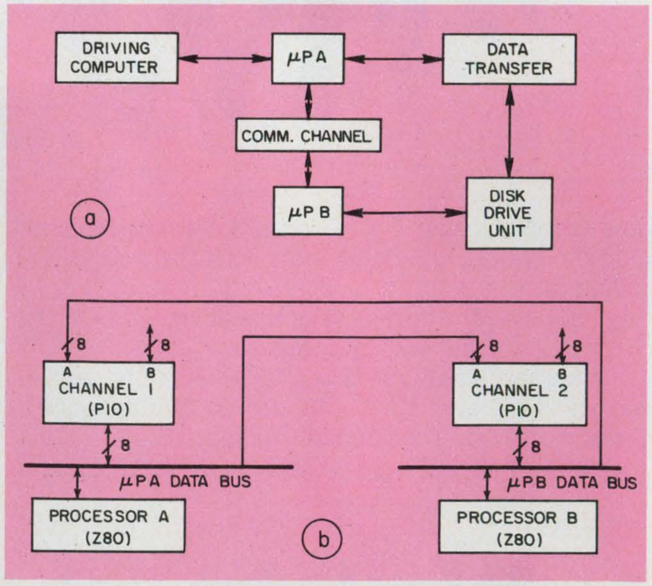
Instead of sending its "mail" to shared memory, a processor can simply send it right to the other processors' registers (Fig. 1b). One processor talks to the other by preloading its communication register with data and generating a transfer signal. A receiving processor responds through interrupts or by polling the activation line periodically. When the receiving processor is ready, it fetches the data and controls the activity specified by the message. Because the communication protocol can be tailored to fit specific applications, this approach provides a high degree of flexibility.

Suppose that the system in Fig. 2a is the heart of a magnetic-disc controller. As supervisor, processor A is responsible for interfacing with the driving computer and for servicing the data-transfer logic. Processor B monitors the disc's rotational speed and controls the carriage movement for accessing a specific track.

When processor A receives an instruction from the driving computer requiring action by processor B, it decodes the instruction, modifies it to comply with established protocol, loads it into communication channel 2 (Fig. 1b), and generates an interrupt. This

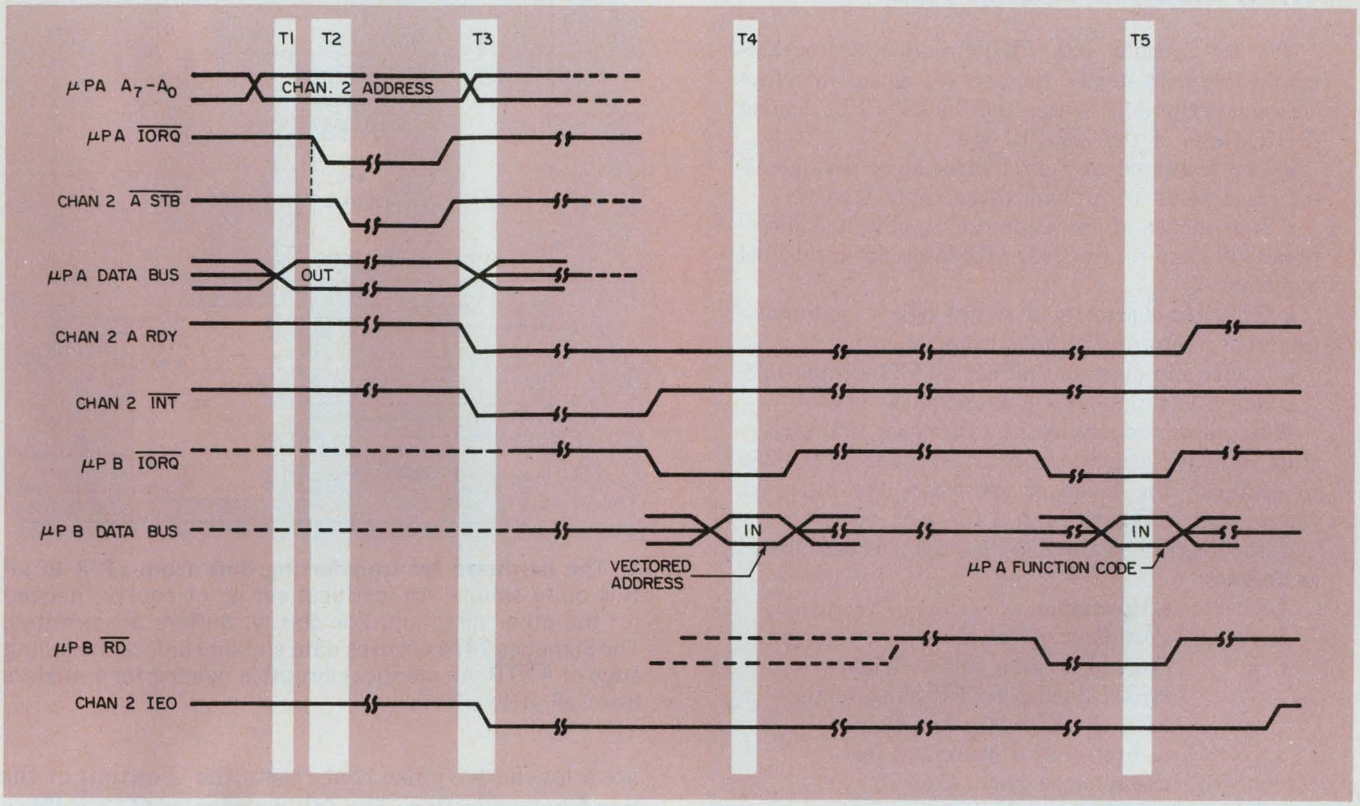


1. **Multiprocessor systems often use a common memory** to communicate with each other (a). But in many cases the μPs' registers can serve the same need (b).



2. **In a disc controller,** μP A takes care of the data transfer. It passes the host computer's instructions on to μP B, which monitors disc speed and carriage movement for track selection (a). You can implement the circuit with two Z80s and two PIO chips (b).

Robert M. Pond, Electronic Engineer, Naval Surface Weapon Center, Dahlgren, VA 22448



3. **A simple handshaking procedure starts a data exchange.** In this timing diagram, the transfer is from μP A to μP B, using the circuit of Fig. 4. Time points T_1 through T_5 are further described in the text.

signal informs processor B that a valid function word is located in channel 2.

If processor B accepts the interrupt, it fetches the information from channel 2 and acknowledges the transaction with status bits in channel 1. Processor B performs the task (e.g., Direct seek to track), then informs processor A by updating the job status in channel 1.

In the example of Fig. 2, the function code may consist of a 4-bit op code and a data 4-bit word count. If this count is greater than zero, a data-word transfer is performed after each subsequent interrupt from A until the word count equals the specified number. Once the count is completed, B interprets the next interrupt by A to be a new request. Processor B's status information may be included in the op code, or it may occupy bit positions set aside for the data-word count.

Any microprocessor with interrupt capability can be used in the example. The Zilog Z80, for instance, allows three kinds of maskable interrupts, one of which (mode 2) requires that an 8-bit vectored address be placed on the data bus by the interrupting device during the interrupt-acknowledge cycle. The address is concatenated with the interrupt page address register (I-Register) to form a 16-bit pointer to the starting location of the servicing routine. The Z80 can therefore be used as the CPU in processor A and processor B (Fig. 2b).

The Parallel I/O (PIO) chip uses the Z80's interrupt system. It contains two independent programmable ports that can operate in four modes: byte output, byte input, bidirectional byte or bit control. The byte-input mode allows a peripheral device to write data into a PIO port (Fig. 2b). An active-low signal on the strobe-pulse line loads the data into the port and generates an interrupt to the CPU. If the interrupts are enabled, the CPU responds by generating a special memory cycle that fetches a vectored address from the PIO through the bidirectional CPU/PIO interface. This address has been written earlier into the PIO—preferably during the power-up initialization sequence—and resides there until it is altered under program control, or until the power is turned off. Communication channels 1 and 2 in the PIO are set to the byte-input mode.

Handshake before execution

"Handshaking" begins when processor A wishes to transfer a decoded instruction to processor B (Figs. 3 and 4). When processor A executes an output instruction to channel 2 (T_1), the address of channel 2's port A is placed onto the lower half (A_0-A_7) of processor A's address bus. At T_2, lines A_7, Input/output request (IORQ), and Write (WR) gener-

What the Z80-PIO chip does

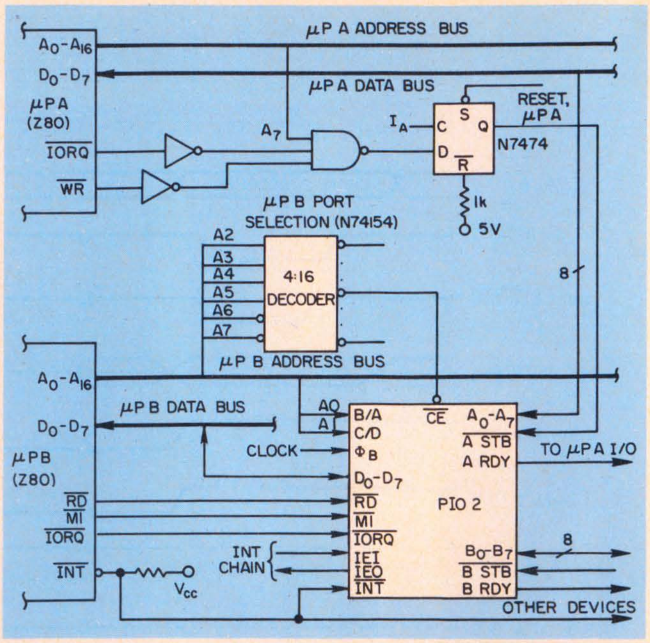
The Z80 Parallel I/O (PIO) circuit is a programmable two-port device that serves as an interface between peripheral devices and the Z80-CPU. Among the features of the Z80-PIO are:

- Two independent 8-bit bidirectional peripheral-interface ports with "handshake" data transfer.
- Four modes of operation (input, output, bidirectional bus, and control), all with interrupt-controlled handshake.
- Daisy-chain priority interrupt logic for automatic interrupt vectoring without external logic.
- Inputs and outputs that are all TTL-compatible.
- One 5-V supply and a single-phase clock.

When power is applied, the PIO goes into a reset state until it receives command words from the Z80 to establish the mode of operation, the interrupt vector, and interrupt control for each port.

In the diagram of the Z80-PIO, the pins are labeled as follows:

CE	Chip enable.
B/A	Port B or A select.
C/D	Control or data select: When HIGH during a CPU-write to the PIO, the Z80 data bus is interpreted as a command for the selected port (A or B); a LOW level indicates a data transfer between the CPU and PIO.
Φ	System clock.
D_7-D_0	Z80-CPU data bus.
$\overline{RD}$	Read-cycle status: a signal from the CPU that indicates a memory read or I/O read is in progress.
$\overline{MI}$	Machine cycle one: a sync pulse from the CPU to control internal PIO operations.
$\overline{IORQ}$	Input/output request: signal from the CPU to transfer commands and data between the CPU and PIO.
IEI, IEO	Interrupt enable: signals used to form a priority-interrupt daisy chain.
$\overline{INT}$	Interrupt request.
A_7-A_0	Port A bus.
$\overline{\text{A STB}}$:	Port A strobe pulse: for input mode a signal sent by a peripheral device to load data into port A.
A RDY:	Register A ready: for input mode the signal indicates that the port A register is ready to accept data.
B_7-B_0:	Port B bus.
$\overline{\text{B STB}}$:	Port B strobe pulse (see $\overline{\text{A STB}}$).
B RDY:	Register B ready (see A RDY).



4. **The hardware for transferring data from μP A to μP B** is quite simple. An identical set is, of course, needed for the other direction. For clarity, buffers are omitted. The Signetics 7474 ensures data stability before the falling edge of $\overline{\text{A STB}}$. An identical circuit is needed for transfers from μP B to μP A.

ate a low-active pulse that resets the Q-output of the handshake flip-flop. The falling edge of Q ($\overline{\text{A STB}}$ in PIO 2) loads the data from processor A's data bus into PIO-port A. The rising edge of an STB generates an interrupt (T_3) to processor B and deactivates channel 2 with "A RDY" (I/O port A ready in PIO 2). When the interrupt-acknowledge response (T_4) occurs, the PIO places the vectored address onto the CPU/PIO interface. Now processor B starts the servicing routine that reads channel 2. An input instruction to PIO 2 loads the information into the CPU and activates PIO 2's A RDY (T_5). This action informs processor A that information sent to channel 2 has been received. The PIO port is now able to accept new data.

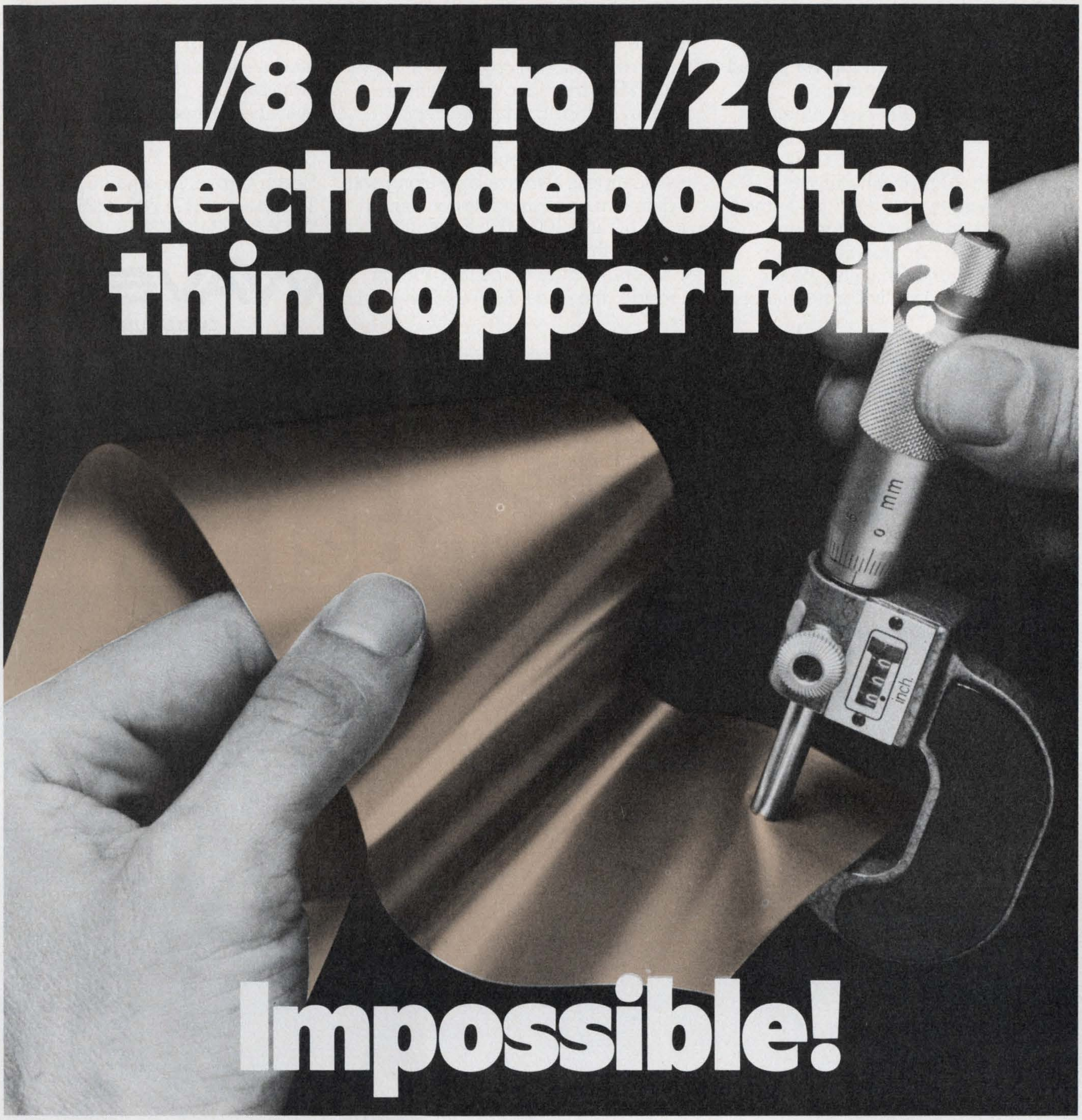
While register-to-register communication is ideally suited to a dual-microprocessor system that requires small amounts of servicing data, it may not be the best solution for a system of three or more processors. If you anticipate expansion, decide which method affords a simpler more economical approach. Ask yourself:

- What are the present requirements of each processor?
- Will expansion affect servicing data throughput? If so, how will this affect processor response time and software?
- Which method is easier to maintain and service?

The last point is often overlooked, much to the grief of all concerned—especially if you are dealing with a critical path within a military-defense system. ■■

Reference

1. Chung, D., "Microprocessor Control Systems," *Electronic Design*, June 7, 1976, p. 132.



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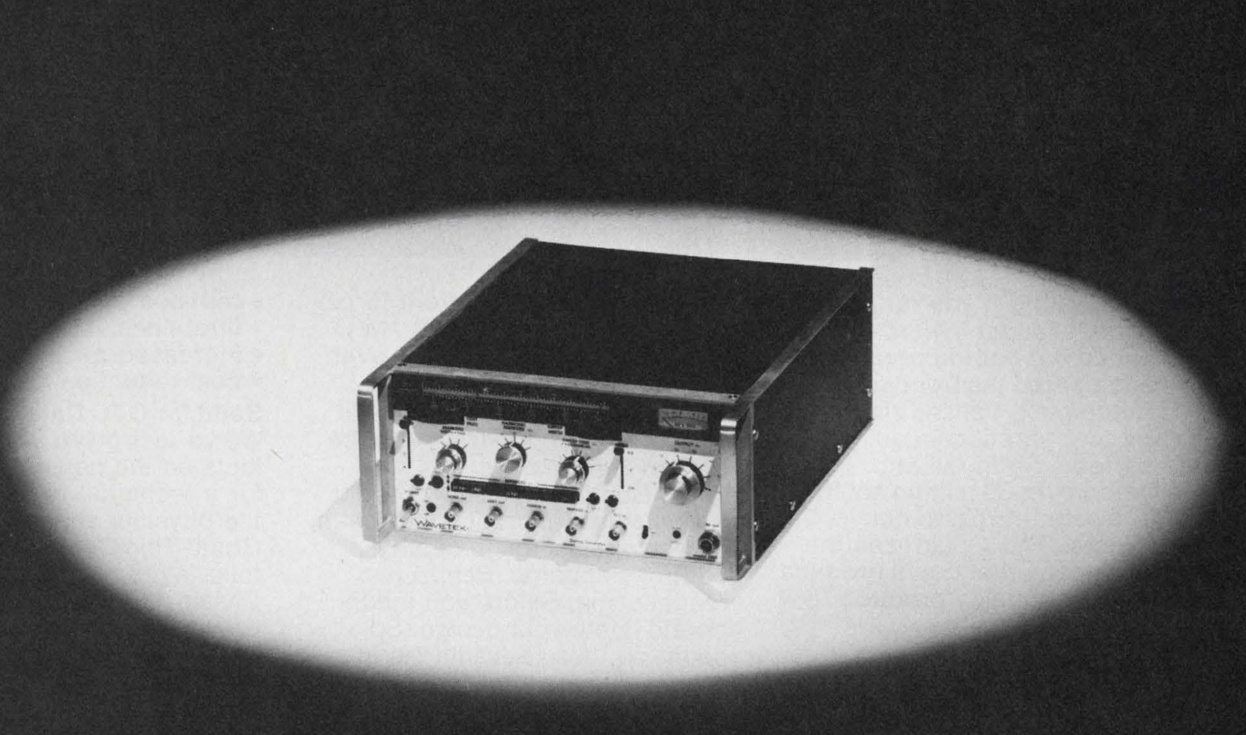

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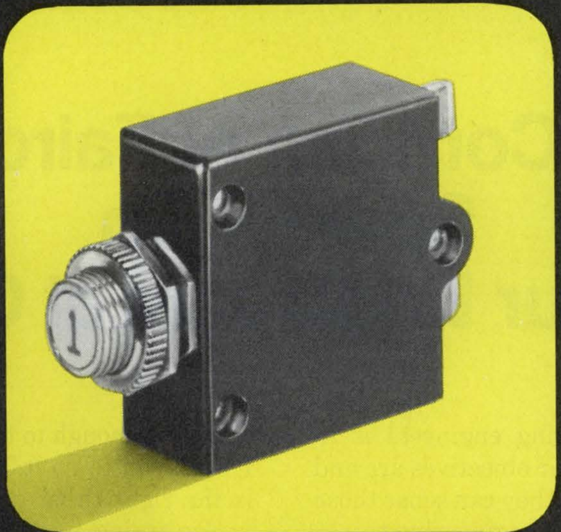

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CIRCLE NUMBER 43

Wilf Corrigan of Fairchild Speaks On
Aiming Your Engineers at Objectives

The essential point in managing engineers is to make certain they know what your objectives are and to push them high enough so that they can sense those objectives. You've got to integrate engineering thinking into the over-all thrust of the business, so it's important to make your engineers part of the over-all business plan.

Then, to make sure your engineers know how to assign priorities, you have to measure what they do. That's not easy. So it's essential to get the engineer to want to do what's needed by the corporation. You have to get inside him and try to get him to understand the objectives of the business. Then you can assume that he'll do what's consistent with the objectives.

That's a lot different from saying, "I want this guy to do the following and I will manipulate him to do these things." That you can't do.

It's not enough to tell an engineer: "Do this because I want you to do it." You must persuade him that it is the right thing to do. He must understand what you're trying to do.

If he doesn't understand the priorities, he will decide that his own priorities are right. Once he decides that, it's almost impossible to turn him back.

This is important because you can look back and say that every major successful product in history had five fathers. But how many major products were killed five times by management and kept alive by a bootleg in the back room? Of course, years later, the president explains it as a magnificent strategic decision. So you have to keep an eye open for the rebel with brilliant foresight.

Nevertheless, in general, you have to make sure that you're all going in the same direction. If the engineer and his management can't agree on objectives, there must inevitably be a parting of the ways. But, once you feel you share the same objectives—you still have the problem of how to measure a man's performance. And that also isn't very easy.

It starts with priorities and the obvious question is, "How do we prioritize?" We're dealing with human beings. And most individuals, even engineers, tend to do first what they like to do. So you have to keep exposing them to the numbers and explaining the market implications of what they do.

And then you have to check. You attempt to do it with a few adroit questions, but none of us is adroit enough. The answers an engineer provides may not always reflect the reality of what he's doing. Once the engineer knows what you want to hear, he will probably tell it to you.

If you say, "I want you to spend 80% of your time on this project, and 20% of your time on that project," he'll probably say, "Sure, that's what I'm doing."

However, if the project you want on second priority happens to be first on his priority list, that's where all the attention goes. So the only way to cope with that is to come up with estimates of how long it's going to take to do something—say, develop a particular product—and what the product performance will be. Then you must frequently review progress against that objective.

But you must let the engineer prepare his own milestones. And that brings us back to the basic point that you must involve the man in your objectives as much as you possibly can. You can't simply give instructions. And of course, you can't put him in a boat without a paddle. You have to make sure he has sufficient control over his work so that he can meet the objectives.

Now this brings you back to an old problem: You discuss objectives with the engineer and he agrees in all sincerity that he wants to do this. But he's agreeing to what he thinks he heard you say. So we're down to our ability to communicate and this, we must all admit, is relatively poor. But if our communications are 20% better than they are in another company, we are going to do one helluva lot better over-all.

Once you realize that your communications may not be perfect, you can take measures to check—not only on a man's understanding of the objectives, but also on the wisdom of those objectives.

You can ask a man which product he's working on. Then you look at the list of his projects and ask yourself how much future revenue there is for the company in each. You must ask what is the certainty of success for each project and how much it will cost. Then you must ask yourself the paramount question —how much you really will have to invest to get into a particular business. Too frequently, too many of us get into a business without asking those questions.

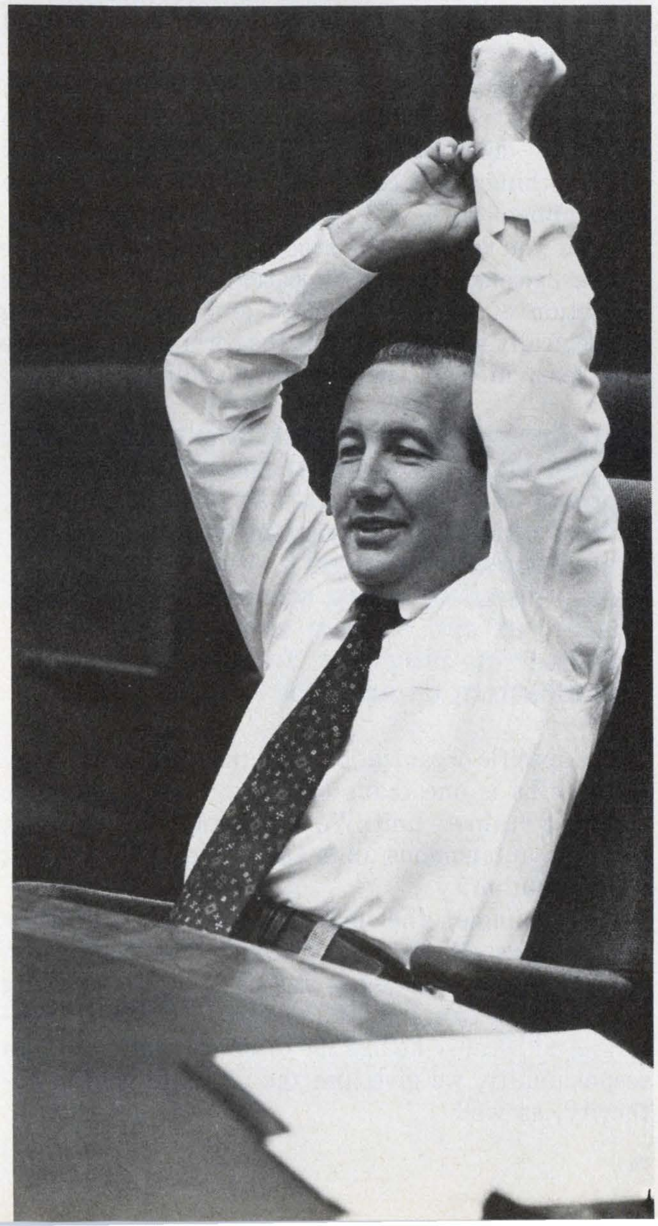
When you plan to extend an engineer's project into a real investment, you often forget the follow-on implications—the amount of capital that gets tied up in receivables, inventory and so on. So you have to get your engineers to work more and more towards disciplined forecasting.

You must ask yourself if you are willing to step up to success in a business, and sometimes you have to say no. But then you shouldn't spend the engineering effort.

You also have to ask yourself if a product has synergism with other things you're doing. Might a new product, for example, provide support for an end-product marketplace that you're developing? Or, perhaps, do you have a strategy that can donate instant market to your product.

Once you've asked all the important questions and developed the right answers, you must organize to develop your objectives into reality. But there's no single concept that's good for everybody.

A popular one, the program-manager concept, has an individual with nobody reporting to him, and he



cuts across several different organizations. That's been very effective for a number of aerospace companies, but we have never been able to make it work.

If you have a seven or 10-year task—as you might in the aerospace industry—and if you have a very stable structure, the program manager might work out beautifully. Eventually everybody gets to know who he is and everybody gets to know what the program is. Everybody knows that he'll have the same assignment two years after. So the program manager can keep track of everybody. An individual might be able to wriggle out of something for a while, but eventually, things catch up with him. In the semiconductor business we don't have the time.

I think the difference lies in the time constants. We have to get things done in a very short time. And we have a highly mobile industry. People move around within the organization and they move a lot between organizations. That's the nature of the semi business.

We need an organization structure like a train on the tracks. As long as a fellow is on the right train, he's going to move down the right tracks. There's no danger that an engineer in our transistor division, for example, will be trying to develop a new MOS memory. At least on a macro basis, I have focused him by making him part of an organization with defined objectives.

Now an individual engineer might move too fast; he might be trying to reach too far beyond what we're capable of doing at this moment. But he won't work on something that's completely away from where we want him to go.

Once you've got such a structure, you can make macro decisions by the allocation of capital, by the allocation of spending budget and by determining strategically where you want the corporation to move —at least in terms of over-all spending.

In other words, if you want Division A to have three times as much manufacturing emphasis as Division B, you can give Division A three times as much capital. Whether or not the people there spend it wisely is a secondary discussion. In a somewhat narrower way, you can use the same approach in engineering programs. You can double the emphasis by doubling the funding.

The specific organization structure that works very well for us is one that's based on what we call the strategic business unit. We break our company down to small, autonomous units and give each one a great deal of authority.

For example, the manager of our Transistor Division has complete control over that business on a worldwide basis. He has authority over everything relating to design, manufacture and sales of transistors. And because he has the ultimate profit-and-loss responsibility, we give him the ultimate pricing authority, as well.

Each division manager has his own product-marketing people, his own engineering people and his own manufacturing people. He can buy the services of one of our offshore plants. But he retains the authority to specify how a product is to be made. He's the one who specifies what the production people—in the United States or abroad—must do to reduce cost, for example. And he's also the one who gets the engineer intimately involved with the P&L of his division.

The engineering manager of a division will be closely coupled with the division manager, who will be closely coupled with the marketing guys. There will be ongoing discussions among them about costs, market price, cost reduction, new-product development and so on. Because the business units are fairly small, there is a high degree of identity between the engineer, engineering manager and the division manager.

What we're doing is making the business unit smaller while we're pushing the engineer's responsibilities higher than they might be in a company where he might simply be a cog.

Now our pushing an engineer closer to profit-and-loss consideration isn't valid for, say, an engineer working in research and development. But even there, we tend to relate that R&D activity to a team on a given task with defined objectives.

There's another aspect to our business-unit structure. In many corporations there's a vice-president of engineering and a vice-president of manufacturing and, perhaps, a vice-president of marketing. They tend to come together only in meeting with the chief executive. Now that approach might be appropriate for a single-product company or one with a small number of products.

But in the semiconductor business we are essentially a thousand little companies. Each product line has almost its own marketplace, its own structure, its own set of competitors. So we try to group our products into logical groupings that then make up strategic business units or divisions. And we further try to pull the divisions together into logical groupings. Our semiconductor business, for example, has two pieces —Components, which includes transistors, diodes, digital and linear circuits; and LSI Products, which includes bipolar and MOS-based products.

Now George Wells, who is Group Vice-President for Components, has his own engineering and sales force. And Dave Marriott, who is Group Vice-President for LSI has his. We have two entirely different engineering and sales forces, so when I have a discussion with Marriott or Wells, it's a clear discussion. One guy can't complain that the salesmen or engineers are spending too much time on the other guy's products.

Of course, this means that we may have two salesmen calling on the same customer. But we get compensating advantages. Consider this:

Everybody goes through life with a set of lists. We all make up lists that show what's the number one

Who is Wilf Corrigan?

Right after he obtained his BS in Chemical Engineering at the Imperial College of Science in London, Wilfred J. Corrigan hitchhiked around the United States, then settled in Boston. Almost immediately, the 22-year-old son of a Liverpool dockworker married Sigrun Walla and joined Transitron as a production engineer on grown-junction silicon transistors.

He stayed at Transitron only six months before Dr. C. Lester Hogan, then executive vice-president of Motorola, invited him to Motorola Semiconductor in Phoenix. There he did much of the basic research on epitaxial growth and earned a patent for his original work in hydrogen chloride gas etching. He was soon running Motorola's silicon transistor operations.

In 1968, almost seven years after he had joined Hogan at Motorola, he left Motorola as one of "Hogan's Heroes" who followed him when he was appointed president of Fairchild.

Corrigan started his career at Fairchild as group director of discrete devices. He was elected executive vice-president and a member of the board of directors in September 1973, president and chief executive officer in July 1974, and chairman of the board in May 1977. Last year, Fairchild enjoyed revenue exceeding $450 million.

In his spare time, what little there is of it, Corrigan likes to read—almost anything. His greatest pleasure, aside from work, comes from the time he spends on weekends with his wife and their four children, 8 to 15, Elsa, Sean, Erik and Christine.

thing we want to do and what's the number two thing, and so on. Now, when you have an engineer customer and a salesman sitting across the desk, each has his own list, whether it's on paper or in his head.

One engagement of these individuals may be good for covering, perhaps, Items 1, 2 and 3 on a list. If that relationship is to encompass everything from a diode through a memory system, what happens to the fourth item on either fellow's list? It gets shoved down the ladder.

One would think that the engineer would like to have everything taken care of all at once. But I don't believe that's what really happens. If you narrow the scope of a sales call, you have a much higher degree of focus.

Further, if the customer has a problem, he might spend the first 30 minutes talking, perhaps, about late delivery or nonresponsiveness to a request for a quote, or whatever. After that, it's pretty hard for the salesman to say, "OK, now let's talk about my product line." And still further, if you have a broad line, it's extremely difficult for a salesman to develop great proficiency in everything. He can't be an expert in everything from diodes to microprocessor systems, and the engineer might be very comfortable buying his MOS from one place and his TTL from another. Finally, the duration of a meeting can be very wearing when you're trying to sell or buy a wide range of types of products.

So our system pays off, even if it seems inefficient to have two salespeople call on the same engineer. It's even possible to have a different kind of individual selling each line. A fellow selling newer products can aim at design-ins while a fellow selling more mature products can go after immediate orders.

Let me show you another advantage of the business-unit structure. Years ago we had a very large central R&D organization. Those were the days when there was a raging controversy over whether you could move a product from a lab in one location to a production facility a few miles away.

Today we completely dodge that question. Each division develops its own technology and its own products. We do have an R&D facility, but that's concerned with the next generation of technology. A few years ago, for example, R&D was working on charge-coupled devices. Now that CCDs are a real, manufacturable product, we've moved that responsibility into the MOS division. Today R&D focuses on injection logic. When we have that as a well-defined product, we'll move that into one of the divisions.

Of course, you can't divorce R&D completely from product ideas because you can't normally develop technology in a vacuum. You usually need a product vehicle. But in the R&D group, the product is not the reason; it's just the vehicle. The product becomes almost irrelevant, but we naturally try to pick one that makes sense for a particular technology.

The R&D effort highlights still another advantage of our business-unit structure. If you go back to the 1950s and 1960s, you can see that we were all in a phase that I call serial development. You start by making a diode and the next step is a transistor—say, a germanium transistor. Everybody makes that. You start with a germanium mesa and then you try to make a germanium planar and that doesn't work. So you try for a silicon planar. And that works.

So you move on to a switching circuit and you develop DTL. Then TTL. Then MSI and LSI. For a long period you had serial development; you developed things step by step by step. And everybody moved along pretty much the same path—maybe at a different pace. Everybody's central R&D was pretty much two steps ahead of where he was in production.

But in the past 10 years or so, as the technology broadened, you had to go into parallel development where you have multiple technology that can do the same thing—low-power Schottky, high-voltage CMOS, low-voltage CMOS, n-channel and p-channel MOS. And you have injection logic. And ECL. And silicon on sapphire. And all these technologies are available in parallel.

Now if you tell a single R&D organization that it must be at the leading edge of six or seven technologies, there's no way to manage it. The only way I can see is to tell my MOS division manager that he is responsible for extrapolating MOS technology. And I tell my bipolar-memory-division manager that he's responsible for extrapolating bipolar-memory work. And now if there's a technology that doesn't have a home and a tree to grow on, we put it in R&D.

All of this becomes part of the over-all philosophy of maximizing the individual engineer's decision-making influence. We try to push his every decision higher and closer to the over-all objectives. One reason is that the rate of obsolescence of semiconductor products gets higher all the time. The life cycle in consumer products is even shorter.

The time constant of any phase in the system—research, development, pilot production, manufacturing—becomes equal to the whole product life cycle. We must find a way to reduce the time constant. The only way to do that is to operate within a relatively small unit.

That's what happens in small companies. They don't have the breadth that we have, but they can give us a hard time in an individual product or market area. So we try to cope with that, in effect, by having a bunch of our own small companies. Even if this had no other advantage, it helps us push our engineers up where they count. ■■

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SDT 55407	75A	200V	TO-63
SDT 55456	75A	250V	TO-63
SDT 55460	75A	300V	TO-63
SDT 55462	50A	350V	TO-63
SDT 55464	50A	400V	TO-63
SDT 55470	40A	450V	TO-63
SDT 55472	40A	500V	TO-63
SDT 55474	25A	550V	TO-63
SDT 55476	25A	600V	TO-63
SDT 55503	150A	100V	TO-68
SDT 55504	150A	125V	TO-68
SDT 55505	100A	150V	TO-114
SDT 55507	100A	200V	TO-114
SDT 55556	75A	250V	TO-68
SDT 55560	75A	300V	TO-68
SDT 55903	150A	100V	TO-114
SDT 55904	150A	125V	TO-114
SDT 55905	100A	150V	TO-114
SDT 55907	100A	200V	TO-114
SDT 55956	75A	250V	TO-114
SDT 55960	75A	300V	TO-114

TYPE NO.	I_C (Max)	V_{CEO}	CASE
SDT 96301	70A	60V	TO-3*
SDT 96302	70A	100V	TO-3*
SDT 96303	70A	140V	TO-3*
SDT 96304	70A	200V	TO-3*
SDT 96305	70A	250V	TO-3*
SDT 96306	70A	300V	TO-3*
SDT 96401	70A	60V	TO-63
SDT 96402	70A	100V	TO-63
SDT 96403	70A	140V	TO-63
SDT 96404	70A	200V	TO-63
SDT 96405	70A	250V	TO-63
SDT 96406	70A	300V	TO-63
SDT 96501	100A	60V	TO/68
SDT 96502	100A	100V	TO/68
SDT 96503	100A	140V	TO/68
SDT 96504	100A	200V	TO/68
SDT 96505	100A	250V	TO/68
SDT 96506	100A	300V	TO/68
SDT 96901	100A	60V	TO-114
SDT 96902	100A	100V	TO-114
SDT 96903	100A	140V	TO-114
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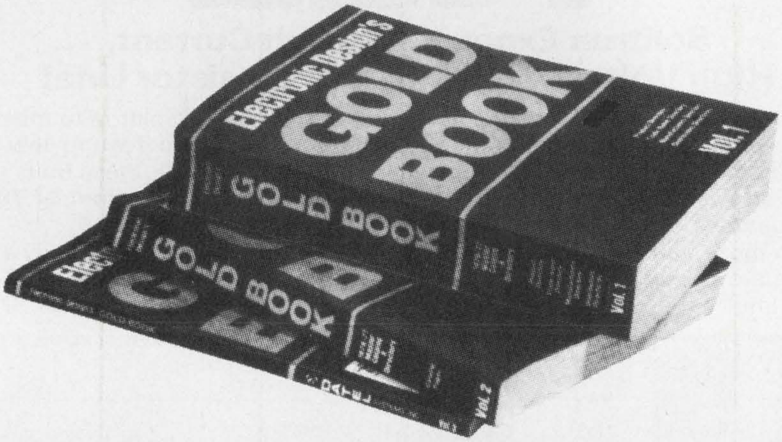

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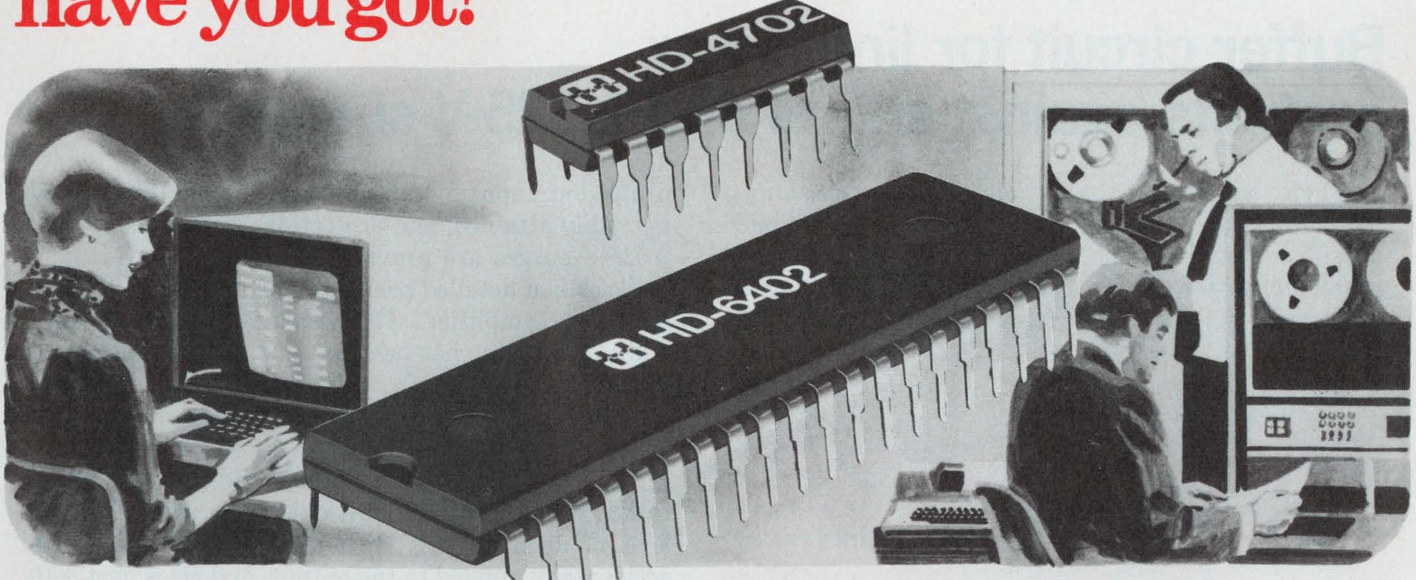

The first programmable CMOS Communications System.

With the Harris HD-6402/6402A CMOS/LSI, and HD-4702/6405 CMOS Bit Rate Generator, you can convert parallel data to serial and back again asynchronously, substantially reducing the amount of interconnect in your data acquisition systems.

Now, all it takes is two lines to connect terminals to computers, for example, instead of the spaghetti of wire used in older systems.

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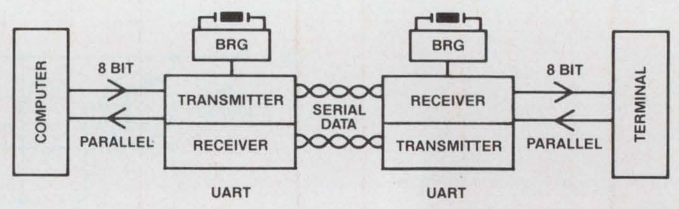
The Harris HD-6402/6402A, designed to replace the older and slower P-channel types, is the industry's first CMOS UART. It features an industry standard pinout. Single power supply—operates on 4 to 11 volts. And it's fast... 125K Baud... the *fastest* UART in operation today.

The Harris all-CMOS Bit Rate Generator provides the necessary clock signals for the UART. The HD-4702 generates 13 commonly used bit rates, while the HD-6405 provides two additional bits and consumes significantly less power, with no pull-up resistors.

If you've been waiting for CMOS for your modems, printers, peripherals, and remote data acquisition systems designs, your wait is over! Now Harris technology has something you can really work with. And you can start *today!*

For full details, call the Harris Hot Line, or write:
Harris Semiconductor, P.O. Box 883, Melbourne, FL 32901.



HD-4702/6405 FEATURES

- CMOS
- TTL Compatible
- Low Power Dissipation: 4.0mW TYP. (6405); 4.5mW TYP. (4702)
- Conforms to EIA RS-404
- One unit controls up to eight transmission channels
- On-chip input pull-up circuit (4702 only)
- 16 pin Cerdip and Epoxy dual-in-line packages
- Second source available

HD-6402/6402A FEATURES

- CMOS
- Operation from D.C. to 4.0MHz
- Low power—TYP. 10 mW @ 2.0MHz
- 4V to 11V operation
- Programmable word length, stop bits and parity
- Automatic data formatting and status generation
- Compatible with industry standard UART's
- Second source available

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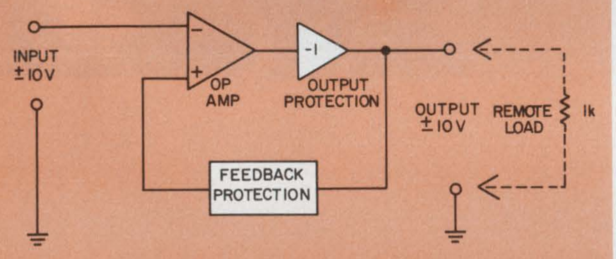
SEMICONDUCTOR PRODUCTS DIVISION

CIRCLE NUMBER 108

Buffer circuit for line driver protects against shorts and ±325-V surges

When you send an analog voltage to remote equipment, to make sure that a fault at the remote end doesn't damage the sending circuit, use a protector/buffer circuit. Simplified in Fig. 1, such a buffer consists of a voltage follower with added output protection. Input-to-output accuracy to within 1.5 mV is readily attained, and protection against shorts and ±325-V surges are provided.

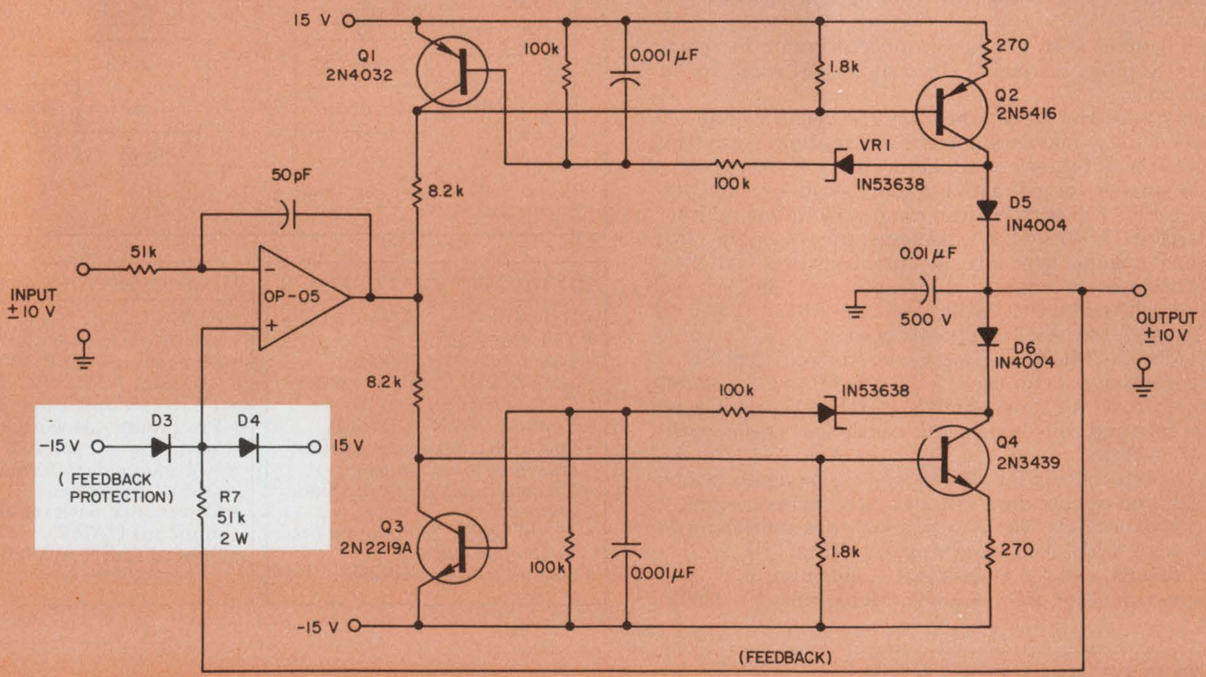


1. **A simplified circuit of a protected line driver** shows where the protection circuits must be located.

Fig. 2 is a detailed schematic of a buffer that uses an OP-05 amplifier. This circuit's input-to-output transfer function has been measured to provide unity gain within ±1.5 mV from 0 to 70 C. The op amp feeds a complementary output circuit that can drive a load as low as 1 kΩ shunted by 0.1 μF to ±10 V.

If the output is shorted, the base and emitter biasing resistors of Q_2 and Q_4 limit output current to a safe level of about 15 mA. If a positive-fault voltage is accidentally applied to the output, and rises past +10 V, diode D_5 protects Q_2 by becoming reverse-biased. And although Q_2's complementary transistor, Q_4, conducts, the circuit's current-limiting bias resistors prevent dissipation of excessive power.

Should the fault voltage rise above +40 V, zener diode VR_2 turns on and provides base current to Q_3, which saturates and cuts off transistor Q_4. When cut off, Q_4 can withstand about 350 V on its collector. Thus, positive fault voltages to 325 V should definitely cause



2. **A complementary protector/buffer circuit, driven by an op amp,** and a pair of clamp diodes in the circuit's feedback path protect fully against shorts and accidental voltage surges to ±325 V.

no damage to the output stage.

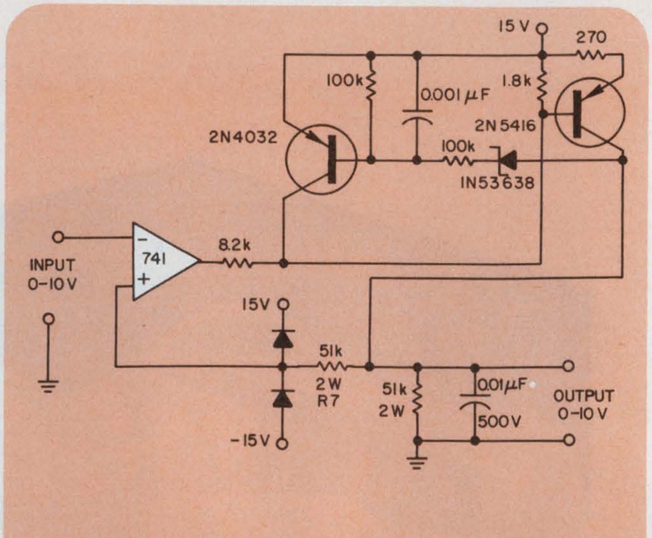
For negative swings of the fault voltage, diode D_6, zener VR_1, and transistors Q_1 and Q_2 perform just like their counterparts in the complementary part of the circuit just described.

The feedback path to the op amp's noninverting input terminal is protected by a simple resistor-diode clamp, which limits the terminal to maximums of about ±15.7 V. The bypassing and shunting capacitors in the circuit keep the circuit stable.

Where less accuracy and only a unipolar signal voltage are involved, a simpler circuit employing a 741 can be used. Only half the output protection is needed. Fig. 3 shows a minimum circuit that provides 0 to +10-V output at about 10-mV accuracy. Nevertheless, the circuit can provide ±325-V protection.

Roxton Baker, Design Engineer, C-E Power Systems, Combustion Engineering, Inc., 1000 Prospect Hill Rd., Windsor, CT 06095.

CIRCLE NO. 311



3. **A simpler less-accurate protected circuit,** which handles only one polarity, needs about half the parts of a bipolar circuit.

Circuit generates almost any sequence of fixed-width timing pulses

Very often, logic systems need a sequence of narrow pulses at specific, selectable times that start after an initiating signal and then can repeat after self-generated reset pulses. The circuit in Fig. 1 produces sequences of 1-µs fixed-width pulses at almost any repetition rate. The timing parameters are chosen simply by picking different selections from three decades of timing pulses and connecting them to three-input positive-NOR gates.

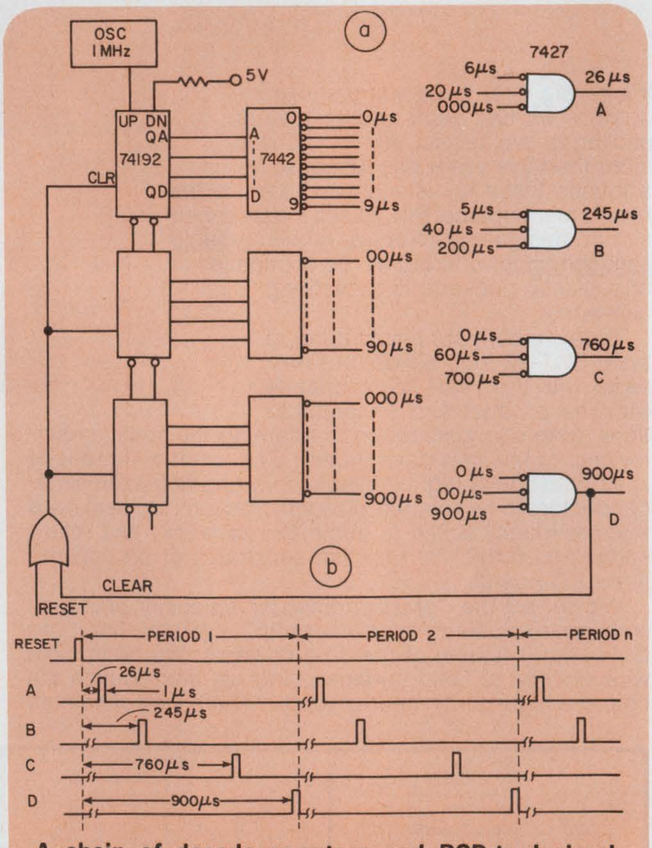
In Fig. 1, a TTL-compatible 1-MHz oscillator drives three 74192 decade counters. The counters' BCD outputs are converted to decimally related intervals by three 7442 decoders. Thus, each output pulse, A, B, C or D, can be made up of selections, as needed, from each of the decade decoders by "ANDing" one output pulse from each of the decoders. Each output pulse occurs only once per sequence, and has the same width as that of the oscillator period.

The sequence is started by releasing the Reset line. In the example of Fig. 1, pulses A, B and C are generated at 26, 245 and 760 µs, respectively. At 900 µs, a Clear pulse, D, resets the counters causing the sequence to repeat.

Of course, circuitry can be added to control the start of the sequence externally and to generate only a single sequence. Also, switches can be added to simplify selecting the timing.

Ronald Winter, Santa Barbara Research Center, 75 Coromar Dr., Goleta, CA 93017.

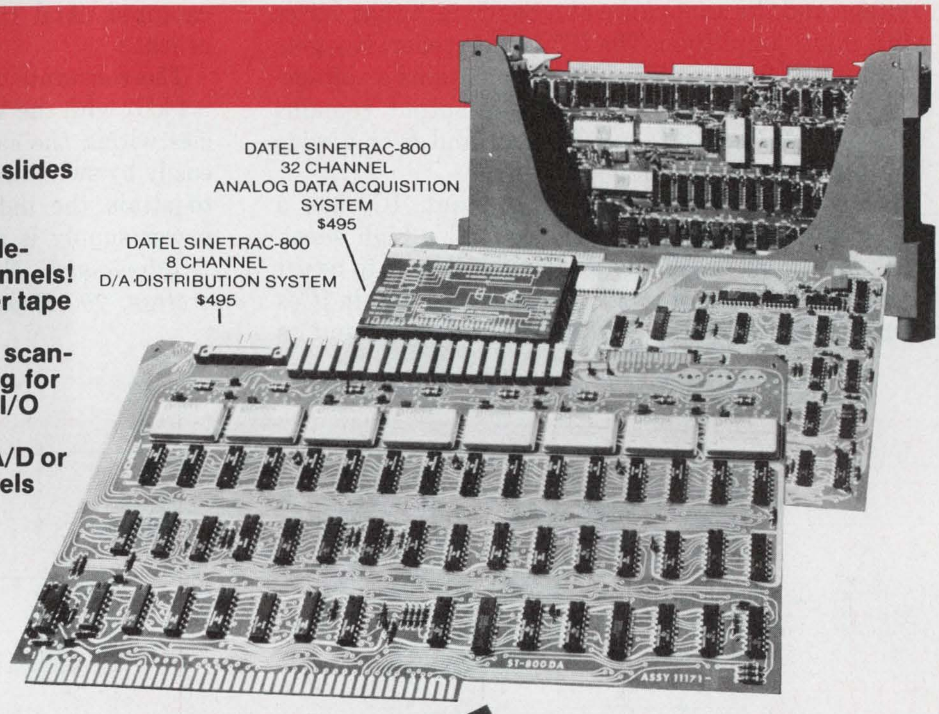
CIRCLE NO. 312



A chain of decade counters and BCD-to-decimal decoders (a) generates three decades of pulses that are combined to form a sequence of 1-µs pulses at selected intervals (b).

Datel's 8080 A/D-D/A Advantage

SINETRAC 800



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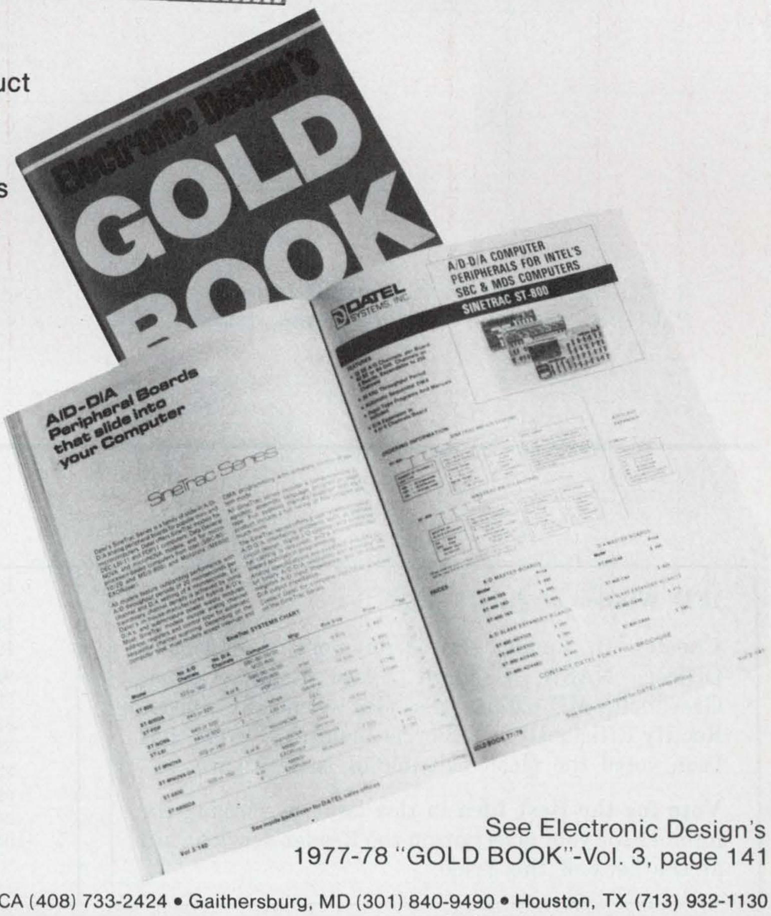

DATEL SYSTEMS, INC.
1020 Turnpike St., Canton, MA 02021
Phone: (617) 828-8000

See Electronic Design's 1977-78 "GOLD BOOK"-Vol. 3, page 141

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CIRCLE NUMBER 49

Constant-bandwidth PLL tone decoder accepts wide range of input voltages

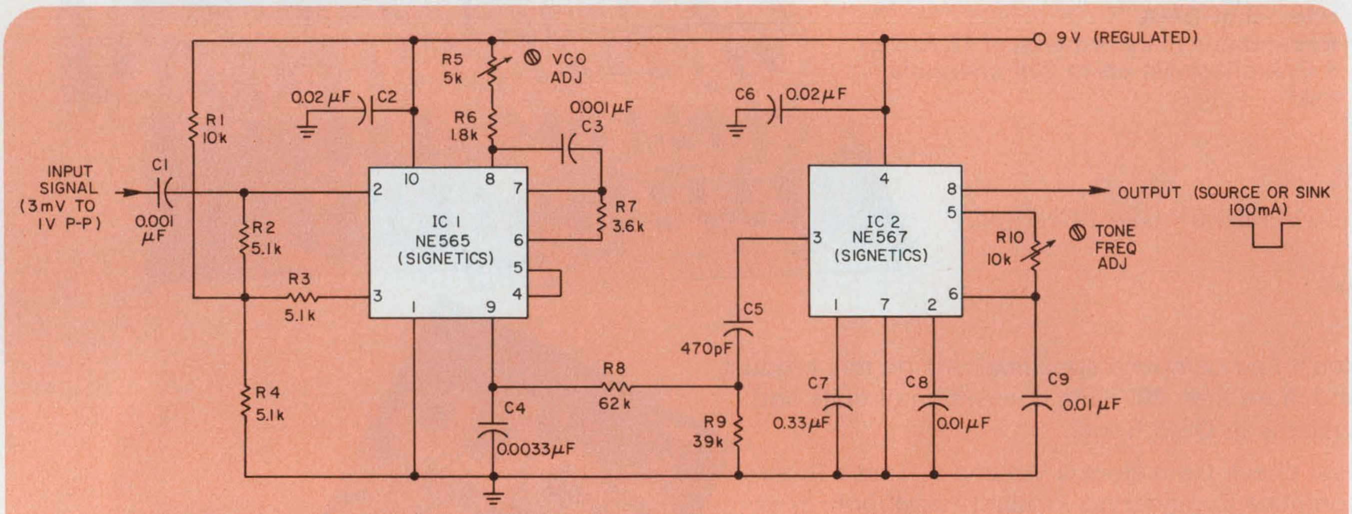
The circuit in the figure solves two problems encountered when using a 567 tone-decoder phase-locked loop (PLL): the need for a relatively high input-signal voltage and the annoyance of a bandwidth that varies with input amplitude. The 567 tone decoder, IC_2, gets its input from IC_1, a 565 PLL that contains a voltage-controlled oscillator (VCO), whose output remains constant over a 3-mV-to-1-V input and over a wide input-frequency range.

Since the VCO's output is constant, IC_2 has a constant bandwidth. Furthermore, IC_1's high sensitivity and very broad capture range allow it to be set outside IC_2's capture range, yet be pulled within IC_2's range. When IC_1 locks onto the desired signal and its VCO frequency pulls into the capture range of IC_2, less than 10 cycles are needed for IC_2's output to go cleanly to zero and indicate that a signal has been captured. And the circuit's noise immunity is excellent.

The constants in the figure tune the circuit to 20 ±1 kHz with the VCO set to about 18.5 kHz. Frequencies within the capture range of IC_1 can be selected easily by switching-in other values of R_{10} and C_9. But to attain the indicated stability, regulation of the power supply is a must.

Raymond K. Ferris, Supervisor, Program Support, Actron, 700 Royal Oaks Dr., Monrovia, CA 91016.

CIRCLE NO. 313



A PLL with a constant VCO output converts another PLL into constant-bandwidth tone decoder. The circuit accepts a wide range of input volts—from 3 mV to 1 V—and is tuned to 20 ±1 kHz.

IFD Winner of July 5, 1977

Chesley H. Looney Jr., Equipment Management Officer, NASA, Goddard Space Flight Center, Greenbelt, MD 20771. His idea "Schottky Diodes Rectify Efficiently in a Bicycle-Lighting System" has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Reader Service Card at the back of this issue.

SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of $1050 (cash)! Here's how. Submit your IFD describing a new or important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive $20 for each published idea, $30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of $1000.

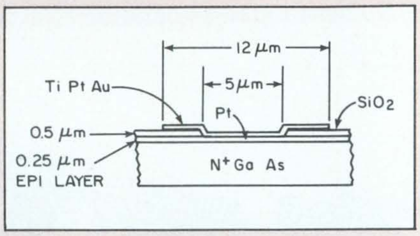
Noise factors improve with gallium arsenide diodes

Noise figures are 10 to 20% better than those for conventional silicon Schottky mixer diodes with an unusual approach to fabricating gallium arsenide devices. The mixer noise factors of gallium arsenide diodes tested over a range of 4 to 40 GHz are 0.5 to 1 dB better than those for the best silicon diodes. For example, a noise factor of 5.2 dB has been obtained at 40 GHz.

The technique, developed by Thomson-CSF in Orsay, France, uses organometallic cracking to produce the gallium-arsenide diodes on an epitaxial layer 0.25 μm thick. The layer is made by cracking $Ga(CH_3)_3$ in the presence of arsine (A_sH_3). The substrate material is heavily doped with tellurium, which gives a resistivity of 0.006 Ω-cm.

Tellurium, which is very soluble in GaAs, allows low resistivities to be obtained. But this kind of substrate cannot be used in conventional atmospheric-pressure epitaxy processes because an autodoping effect resulting from gas-phase impurities prevents a sharp transition between substrate and epilayer.

The Thomson process uses a low pressure of 76 torr and a large 18-litre/min. flow of hydrogen. Impurities in the gas phase diffuse much more rapidly, and impurities that leave the substrate are carried away before they can re-enter the growth area.

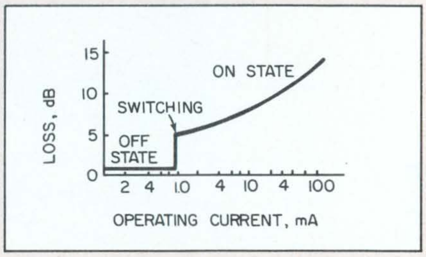


Once the epitaxial layer is grown, a 500-Å layer of silicon dioxide is deposited and the Schottky contact area is defined by etching 5-μm circular holes. Platinum is sputtered into the holes and sintered. Then a contact layer of titanium, platinum and gold is deposited. The result is easy contact metallization and good adherence to the oxide layer, which help make the gallium arsenide diodes highly reliable. Circular patterns of 12-μm diameter are then etched to form the completed device as shown in the figure.

μW modulator replaces p-i-n diodes with semis

An efficient microwave modulator that exploits the impedance variation of amorphous semiconductors rather than single-crystal p-i-n or varactor diodes has been demonstrated at the Indian Institute of Science, Bangalore. The amorphous switch can be manufactured by simple, thin-film evaporation techniques instead of precise impurity diffusions into single-crystal growths.

Although p-i-n diode isolation is better, the easy way to manufacture amorphous switches could lead to their widespread use in low-cost, low-power microwave-switching applications where high reverse-breakdown voltages are not required.



Amorphous semiconductors, or chalcogenides, consist of germanium-tellurium-arsenic materials deposited by electron-beam evaporation onto a metal electrode. Typical deposition thickness is 0.5 μm. Tungsten or molybdenum-point contacts are applied to the top surface of the material.

The experimental amorphous device is mounted in an X-band waveguide of reduced height. A Gunn oscillator supplies 1.5 mW or input power at 9.3 GHz. With a driving voltage of 10 to 30 V applied to the modulator contacts through a limiting resistor, outputs of 10 mV are obtained for modulation frequencies from 100 kHz to 1 MHz, with no detectable switching delay in this frequency band.

The modulation mechanism is straightforward. When the driving voltage is below the threshold value of about 10 V, the amorphous switch is in its off state and exhibits a high impedance. Above the threshold, the switch presents a low impedance that increases the amount of microwave power reflected back down the waveguide. The result is more loss.

The switch is as efficient as that of p-i-n diodes. Insertion loss is 0.5 to 0.6 dB with 18-dB isolation for 100-mA operating current (see figure). Frequency response can be extended to 10 MHz with delay times less than 10 ns if the switching voltage is 50% greater than the threshold voltage.

Entry controlled with magnetically coded cards

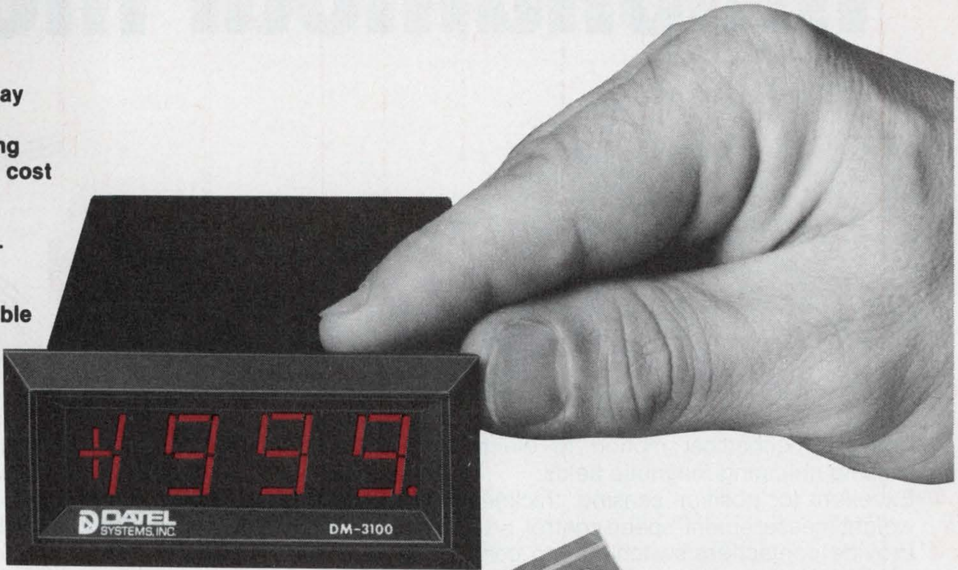
Sipass, a computerized access control system developed by Siemens, uses a Siemens 300 minicomputer to read a magnetically coded card that identifies its user. The system checks the computer's memory before authorizing entry.

Datel's New Low Priced Digital Panel Meter

MODEL DM-3100

FEATURES

- ▶ Miniature case with 0.5″ LED display
- ▶ Bipolar, differential ±2VFS input
- ▶ 3½ Digit resolution with Autozeroing
- ▶ LCD display available at additional cost
- ▶ Additional ranges — customer programmable
- ▶ 4½ digit resolution also available— $59 (100's)
- ▶ Additional current and ohmmeter capability — customer programmable



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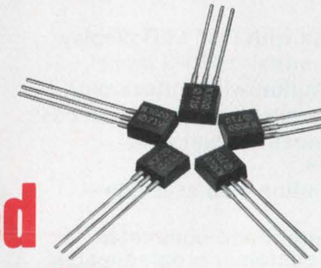
CIRCLE NUMBER 51

There's a better way to measure or monitor mechanical motion–

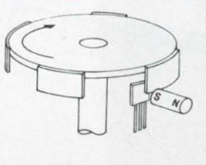
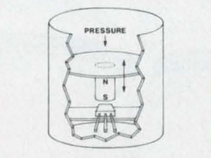
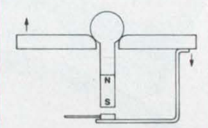


magnetically-activated 'Hall effect' integrated circuits

- Convert mechanical motion to electronic signals by sensing changing magnetic fields.
- Excellent for position sensing, thickness determination, weight measurement, speed control, pressure monitoring.
- Provide contactless switching—no contacts to wear, no contact welding.
- Highly reliable under adverse environmental conditions.
- None of the contamination problems suffered by mechanical or photo-electric switches.
- No moving parts to cause spurious signals often associated with conventional switches.
- Economical transistor-style package.
- Ideal interface between mechanical motion and electronic controls, counters, etc.

TYPE UGN-3020T DIGITAL SENSORS

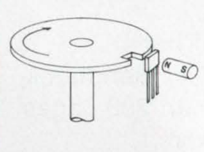
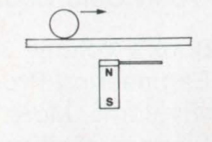
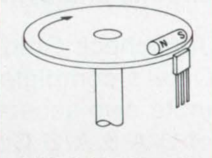
TYPICAL APPLICATIONS

		
VANE INTERRUPTER (ignition switch, etc.)	LIMIT SWITCH (pressure monitor, etc.)	ANGLE SENSING (tilt switch, etc.)

- Designed for use with readily-available samarium cobalt or sintered alnico VIII permanent magnets.
- Operate at any voltage from 4.5 to 24 VDC.
- Constant amplitude output, independent of frequency up to at least 100 kHz.
- Higher sensitivity, wider operating temperature range, smaller physical size, more economical than any other device of its type.

TYPE UGN-3501T LINEAR SENSORS

TYPICAL APPLICATIONS

		
CHANGE IN FLUX PATH (notch sensor, etc.)	FERROUS METAL SENSOR (pinball detector, etc.)	ANGLE OF ROTATION (antenna position, etc.)

- Voltage ouput of these devices is proportional to magnetic field intensity.
- Will operate if slightest change in flux path is made.
- Operate at any voltage from 8 to 12 VDC.
- Hall cell and linear differential amplifier integrated in one monolithic device to simplify problems relating to handling of millivolt analog signals.
- Exceptional temperature stability.

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THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

CIRCLE NUMBER 52

New products

Cost-effective systems are for users and OEMs

Texas Instruments, P.O. Box 1444, M/S 784, Houston, TX 77001. (512) 258-7305.

Three new members of the DS990 family of disc-based minicomputer systems, Models 4, 6 and 8, are specifically structured for commercial end users and systems OEMs. They offer extensive file management capabilities that support multiple interactive users in a multilanguage environment. The Model 4 serves as a small multistation, full-function software development system or a medium-scale application system. It includes a 128-kbyte 990/10 processor, a 1920-character Model 911 video display featuring function keys and a separate numeric pad, a 5-Mbyte fixed platter and 5-Mbyte removable cartridge disc drive. The Model 6 includes a 128-kbyte 990/10 processor, a 911 video terminal, and two 25-Mbyte removable-pack disc drives. The Model 8 is for applications requiring a large data base and includes a 128-kbyte processor, a 911 video terminal, and two 50-Mbyte disc drives.

CIRCLE NO. 301

Use single card for programmed logic

Pro-Log, 2411 Garden Rd., Monterey, CA 93940. (408) 372-4593. $195 (100 qty).

A single card 8080A-based programmed-logic system has 1 k of RAM, sockets for an additional 1 k of RAM and sockets for 8 k of TMS-2716 PROM. The PLS-888 card also includes an 8080A microprocessor, a crystal clock, built-in power-on reset, 16-k lines of TTL input and 24 lines of TTL output.

CIRCLE NO. 302

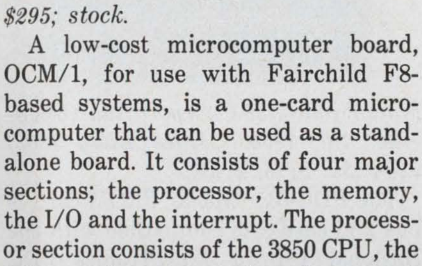
μC is on one card for low-cost system

Fairchild Camera and Instrument, 1725 Technology Dr., San Jose, CA 95110. Gordon Daggy (415) 962-2521. $295; stock.

A low-cost microcomputer board, OCM/1, for use with Fairchild F8-based systems, is a one-card microcomputer that can be used as a standalone board. It consists of four major sections; the processor, the memory, the I/O and the interrupt. The processor section consists of the 3850 CPU, the 3853 static memory interface, clock generation and reset circuitry. The memory section can use four different types of memory. Contained on the board are 1 kbytes of RAM. The I/O portion consists of the 3850 CPU and the 3851 PSU, each containing two 8-bit I/O ports.

CIRCLE NO. 303

Mini tape transport gives maxi bits-per-buck

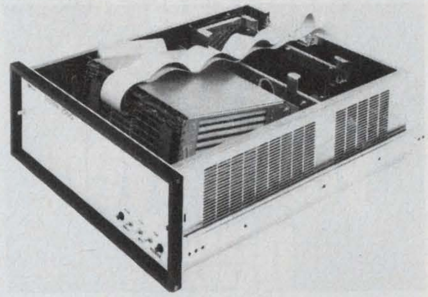


Quantex, 200 Terminal Dr., Plainview, NY 11803. Leon Malmed (516) 681-8600. $250; 4 wk.

Model 200 Minidrive storage module, a low-cost, compact tape transport for the 3M Company's miniature data cartridge, forms the basic electromechanical building block for data-storage systems. It measures 3 × 4 × 4⅛ in. with cartridge in place, weighs about 1 lb and stores up to 720 kbytes of unformatted data on the cartridge's 140 ft of magnetic tape. One version provides single track recording at 800 bits/in. to yield 168 kbytes unformatted capacity and 24 kbits/s read/write rate. A dual-track version can provide 772 kbytes on two tracks, at 1.6 kbit/in. and 48 kbit/s data-transfer rate.

CIRCLE NO. 304

Box claustrophobia gone using data collector



ADAC, 15 Cummings Park, Woburn, MA 01801. A.L. Grant (617) 935-6668.

The 1000 system can be used in a variety of applications as a stand-alone control/monitoring data-acquisition system. It also can work as a satellite data-collection system, communicating bidirectionally to a host computer. Some of the features are its LSI-11 configured backplane and its capability of accommodating either 11 quad-size or 22 half-quad-size or any combination of LSI-11 compatible cards. Compatible cards can be inserted into the system's backplane. Some of the cards from ADAC include low-level cards, 1108 and 1116, which feature 250-V common-mode isolation, and a programmable-gain amplifier with six gain codes that can be changed on a channel-to-channel basis.

CIRCLE NO. 305

Print 40 columns with μC-compatible printer

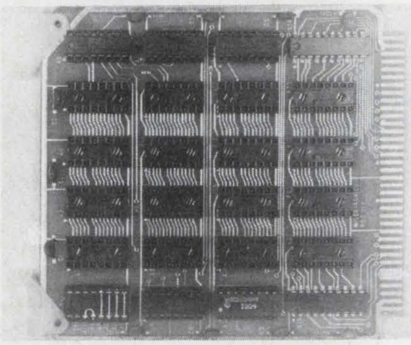
Datel Systems, 1020 Turnpike St., Canton MA 02021. (617) 828-8000. $425 to $695.

AIP-40 is a stand-alone impact printer for teletypewriter use with mini and microcomputers. It includes printhead, paper-feed mechanism, choice of electronics, and power supply. Both 8-bit parallel and full serial interfaces are accepted to print the standard 64-character ASCII font. Average printing rate is 50 characters/s (1.25 lines/s). Serial interfaces can sustain a continuous 300-baud printing rate. Each unit includes a choice of interface electronics.

CIRCLE NO. 306

MICRO/MINI COMPUTING

Do away with EPROMs by using bipolar PROMs

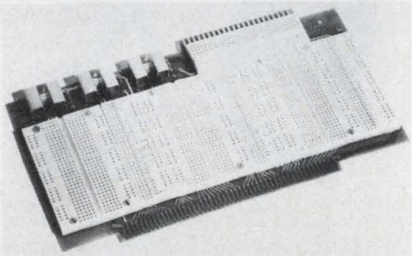


MilerTronics, 303 Airport Rd., Greenville, SC 29607. Miles Eudy (803) 242-9232. $115; 4 wk.

The PDC-311 bipolar PROM card is bus and card-size compatible with the National ISP or MilerTronics PDC family of cards. It is an inexpensive substitute for more costly EPROMs. The card uses any standard open-collector or three-state 256 × 4 or 512 × 4 bipolar PROM. 2 k of memory is possible with 256 × 4 PROMs, 4 k is possible with 512 × 4 PROMs. It allows full 65 k address decoding, comes complete with PROM sockets, and requires just a 5-V supply.

CIRCLE NO. 307

Interface S-100 bus μCs with breadboarding card



E & L Instruments, 61 First St., Derby, CT 06418. R. Vuillequez (203) 735-8774. $75; stock.

A universal breadboarding card for interfacing S-100 bus μCs with peripheral devices or experimental circuitry makes it easy to integrate add-on memory. Audio cassettes or floppy-disc drives, and other compatible devices from different manufacturers can also be interfaced. Lines on the S-100 card are divided into address, data and control sections and the user has access to every signal generated by the μC. Each card is equipped with three voltage regulators: +5, +12, and −12 V, as well as points for obtaining unregulated voltage.

CIRCLE NO. 308

Test μP prototypes with development system

Tektronix, P.O. Box 500, Beaverton, OR 97077. Wyn Giluck (503) 644-0161. $7650.

Prototype testing for five μP types with one development system can be done with the 8001 μP Development Lab. It provides in-prototype emulation for an expanding set of 8 and 16-bit μPs including the 8080, 6800, Z-80, TMS9900 and 8085. Functions of the system are: accept program load from an RS-232-C source, interactive software emulation, in-prototype hardware and software emulation, debug control, memory mapping, real-time trace (optional) and built-in PROM programming (optional).

CIRCLE NO. 309

Test and debug PACE designs at low cost

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Howard Raphael (408) 737-5956. $585.

The low-cost LCDS development system, on one PC card, tests and debugs PACE hardware and software. The board contains a 16-bit PACE μP, 1 kword of RAM, sockets for 1 kword of PROM, a 20-key dual-function keyboard, a 6-digit LED display, a system timing element, I/O buffers and bidirectional-transceiver elements. Build application routines by entering code directly through the LCDS keyboards or an external terminal. View, print and modify the content of memory and registers. Check out programs in either the single-step mode or continuous mode with break points.

CIRCLE NO. 310

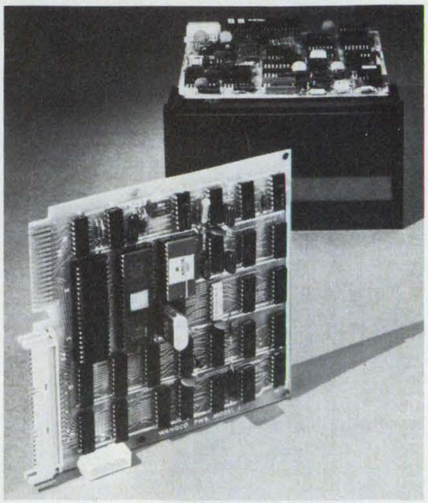
Disc system interfaces with DEC computer

DIVA, 607 Industrial Way W., Eatontown, NJ 07724. William Thomas (800) 631-2141. See text.

DD70 Series disc system features a computroller that interfaces directly to the DEC PDP 11/70 computer and communicates directly with the cache-bus controller. This interface allows the disc system to transfer full 32-bit words directly into the memory without Unibus intervention. The DD70 consists of a microprocessor-based disc controller, 4-board PDP-11/70 interface, and a choice of disc drives ranging in capacity from 80 to 300 Mbytes per spindle. Single-drive systems are priced from $22,000 to $30,000, depending on capacity.

CIRCLE NO. 320

Small controller is for micro-size diskettes



Wangco, 5404 Jandy Pl., Los Angeles, CA 90066. (213) 390-8081. $490; 4 wk.

In a compact 5½-in. square, the 8201 Micro-Controller provides a general purpose host interface for use in 6800 and 8080-based microcomputers, minicomputers and other byte-oriented systems. The principal component is the Intel MCS 8048, a microprocessor providing 1k of ROM, plus RAM and I/O ports on a single chip. It facilitates a nine macro-command structure in the system. Formatting is of a soft-sectored, modified IBM type of 16 sectors per track, 128 bytes per sector. It provides for a 128-byte sector buffer or multiple sector transfer without buffering.

CIRCLE NO. 321

μC system is 12-bit and thrifty

Pacific Cyber/Metrix, 3120 Crow Canyon Rd., San Ramon, CA 94583. Ted Netoff (415) 837-5400. $989; 3 wk.

A μC system, Model IM6100, is software-compatible with DEC's PDP-8 mini family. The system includes an IM6100 12-bit CMOS μP, memory expandable to 32 k, front-panel module with built-in bootstrap loader and control PROMs, power supply, backplane-bus structure, aluminum cabinet with slots for up to 15 plug-in modules, and a set of user manuals. The system can add vectored priority interrupts and has direct memory access. Other features are 80-line TTL compatible bus with 18 unassigned lines and address space for up to 63 I/O devices.

CIRCLE NO. 322

Now the selection, availability, price, and performance you want in Open Frame Power Supplies

- Fifty-five models; single and dual outputs.
- Seven industry-standard sizes.
- In stock.
- Full performance over a wide 100-125 or 200-250 VAC input range.
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Common Specifications:

AC Input: 100-125 or 200-250 VAC, 47-440 Hz.
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Operating Temperature: 0°-60°C.
Transient Response: 50 μsec.
Cooling: Convection.
Stability: ±0.2%.

ALM Single Output Units:

A Series — Price: $27

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	1.5	ALM 2-1.5
5	1.5	ALM 5-1.5
6	1.3	ALM 6-1.3
12	0.7	ALM 12-0.7
15	0.7	ALM 15-0.7
20	0.5	ALM 20-0.5
24	0.5	ALM 24-0.5

Overvoltage Protector — OVM-1 $8.00
Overall dimensions: 3.03 x 3.78 x 1.28.

B Series — Price: $31

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	4.0	ALM 2-4.0
5	4.0	ALM 5-4.0
6	3.3	ALM 6-3.3
12	2.0	ALM 12-2.0
15	1.7	ALM 15-1.7
20	1.4	ALM 20-1.4
24	1.3	ALM 24-1.3

Overvoltage Protector — OVM-1 $8.00
Overall dimensions: 4.00 x 4.87 x 1.76

C Series — Price: $54

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	7.5	ALM 2-7.5
5	7.5	ALM 5-7.5
6	6.5	ALM 6-6.5
12	4.0	ALM 12-4.0
15	3.5	ALM 15-3.5
20	3.2	ALM 20-3.2
24	3.0	ALM 24-3.0

Overvoltage Protector — OVM-1 $8.00
Overall dimensions: 4.87 x 5.62 x 2.50

D Series — Price: $72

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	11.0	ALM 2-11
5	11.0	ALM 5-11
6	10.0	ALM 6-10
12	6.0	ALM 12-6
15	5.0	ALM 15-5
20	4.0	ALM 20-4
24	3.8	ALM 24-3.8

Overvoltage Protector — OVM-2 $16.00
Overall dimensions: 4.90 x 7.03 x 2.78

E Series — Price: $88

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	15.0	ALM 2-15.0
5	15.0	ALM 5-15.0
6	12.5	ALM 6-12.5
12	8.8	ALM 12-8.8
15	8.0	ALM 15-8.0
20	7.0	ALM 20-7.0
24	6.5	ALM 24-6.5

Overvoltage Protector — OVM-2 $16.00
Overall dimensions: 4.87 x 9.00 x 2.75

F Series — Price: $106

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	20.0	ALM 2-20.0
5	20.0	ALM 5-20.0
6	17.0	ALM 6-17.0
12	13.0	ALM 12-13.0
15	10.7	ALM 15-10.7
20	9.0	ALM 20-9.0
24	8.2	ALM 24-8.2

Overvoltage Protector — OVM-2 $16.00
Overall dimensions: 4.88 x 4.88 x 13.75

G Series — Price: $128

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	25.0	ALM 2-25.0
5	25.0	ALM 5-25.0
6	23.0	ALM 6-23.0
12	16.0	ALM 12-16.0
15	14.0	ALM 15-14.0
20	11.5	ALM 20-11.5
24	10.5	ALM 24-10.5

Overvoltage Protector — OVM-2 $16.00
Overall dimensions: 4.88 x 4.88 x 16.75

ALM Dual Output Units:

Adjust Range	Current Rating @ 40°C.	Model No.	Series	Price
12-15	0.55	ALM 15D-0.55	B	$ 45.00
12-15	1.10	ALM 15D-1.1	C	55.00
12-15	2.20	ALM 15D-2.2	D	68.00
12-15	3.30	ALM 15D-3.3	E	91.00
12-15	4.40	ALM 15D-4.4	F	114.00
12-15	8.00	ALM 15D-8.0	G	136.00

Overvoltage Protector — Two OVM-1 $8.00 Each.

POWER HOUSE

Phone (716) 968-2400 TELEX 91-6451 TWX 510-245-2700

Acme Electric Corporation
Cuba, N.Y. 14727

CIRCLE NUMBER 56

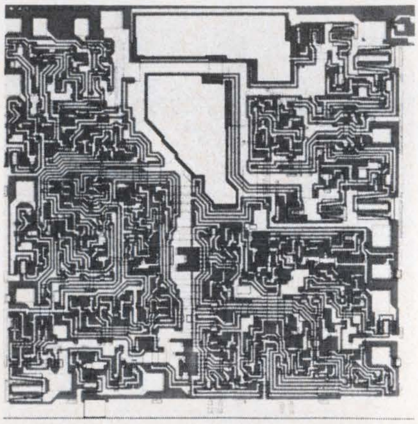
Dual peripheral drivers boast 70-V outputs

Texas Instruments, P.O. Box 5012, Dallas, TX 75222. Dale Pippenger (214) 238-3527. $1.21; stock.

Four dual-peripheral-driver ICs deliver high current, high output voltage and fast switching times. The SN75416, SN75417, SN75418 and SN75419 provide AND, NAND, OR and NOR functions, respectively. These drivers are characterized for use to 500 mA for each output. They feature 500-mA, 70-V outputs and 50-ns typ transition time for high-to-low-level output. Inputs are TTL or MOS compatible and feature pnp inputs for low-input current. Each device dissipates 2 W. Output diodes suppress inductive voltage spikes.

CIRCLE NO. 323

IC μP clock replaces hybrids and discretes



Motorola Linear Prod., 2200 W. Broadway, Mesa, AZ 85202. Bill Carns (602) 962-2294. $3.45/1000; stock.

The monolithic MC6875 is an alternative to hybrid or discrete clock generators for μPs. Using an external quartz crystal, the series-compatible clock provides buffered two-phase outputs, internal control logic (implementing all popular modes of direct memory accessing), internal "handshaking" logic (needed to interface with slow memories and I/O peripherals), and a power-on and reset control function. The package is a ceramic 16-pin DIP.

CIRCLE NO. 324

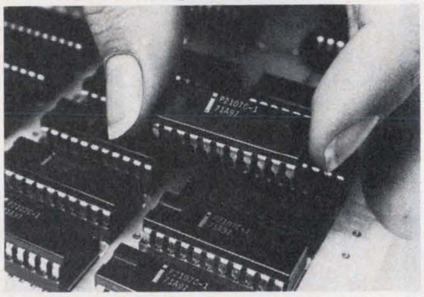
Darlingtons are rated 1000 V and 125 W

International Rectifier, 233 Kansas St., El Segundo, CA 90245. (213) 322-3331.

A series of high-voltage monolithic Darlingtons with power ratings to 125 W, IR5063 through IR5066, has collector-to-base ratings to 1000 V and collector-to-emitter ratings to 900 V. Peak collector current for all units is 20 A. The devices are suited for high voltage inverters, motor-drive circuits and high-voltage switching power supplies.

CIRCLE NO. 325

RAMs upgrade speed and power performance



Intel, 3065 Bowers Ave., Santa Clara, CA 95051. Rob Walker (408) 246-7501. $7.90 to $17.25; stock.

The 2107 C family of 22-pin 4-k RAMs in ceramic and plastic offers upgraded speed and power and noise immunity with no changes required in system designs. The family offers a range of access times from 150 to 250 ns, 10% supply tolerances, and low-power requirements. They are available in three speed categories ranging from 150-ns-max access, 380-ns read or write cycles and 450-ns read-modify-write (RMW) cycle to 250-ns maximum access, 430-ns read or write cycles and 550-ns RMW cycle. Typical power dissipation is 420 mW in active operation.

CIRCLE NO. 326

Multigate chips operate to 7 MHz

International Microcircuits, 3004 Lawrence Expressway, Santa Clara, CA 95051. Orhan Tozun (408) 735-9370.

MasterMos family has 10 semi-custom chips ranging in size from the equivalent of 50 two-input gates to 550 two-input gates in 50-gate intervals. They operate up to 7 MHz at 15 V. Each chip includes additional buffers for interfacing with LS-TTL or TTL logic.

CIRCLE NO. 327

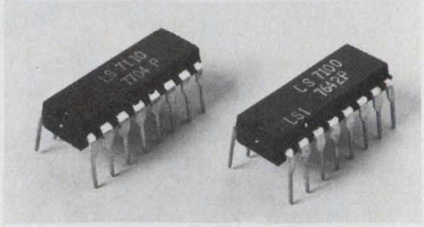
Drive thermal printheads with linear IC

Texas Instruments, P.O. Box 5012, M/S 308, (Attn; SN75490), Dallas, TX 75222. Dale Pippenger (214) 238-3527. See text; stock.

A linear IC, the SN75490, drives many popular thermal printheads. The circuit, offered as either a 16-pin plastic or ceramic DIP, features six AND drivers with a common strobe. Operation is from ±15-V supplies. This allows the totem-pole outputs a −4.75 to +3.5-V nominal range. Inputs are compatible with TTL and 5-V CMOS. At 0 to 70 C the device sources 30 mA and sinks 50 mA. Prices (100-qty): $2.82 for plastic and $3.53 for ceramic.

CIRCLE NO. 328

Drive LCD displays as large as 8 inches

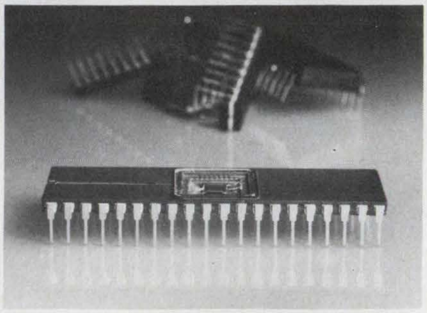


LSI Computer Systems, 1235 Walt Whitman Rd., Melville, NY 11746. Ron Colino (516) 271-0400. $1.19 to $1.39 (1000 qty).

The LS7100 and LS7110 are p-channel-MOS circuits capable of driving large LCDs that require 5 to 60-V segment drives. The circuits are input compatible with CMOS and TTL. The LS7100 is a BCD to 7-segment latch/decoder/driver that operates at 5 to 80 V. With little added circuitry it interfaces with a 120-V-ac line and drives an LC or gas-discharge display. The LS7110 is a combination binary-addressable, latched 8-channel multiplexer, demultiplexer and driver operating at 5 to 80 V.

CIRCLE NO. 329

Device does the job of five or more memories



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Hash Patel (408) 737-5175. $8.75; stock.

An n-channel LSI device combines memory storage and peripheral-interface capability and does the job of five or more standard memory and I/O parts. The INS8154, a combined RAM and I/O chip, is suited for low-end microprocessor-based systems that may require a relatively small memory capacity but still need a number of peripheral interfaces. The 40-pin circuit, which directly interfaces with SC/MP II, INS8080A and other μPs, contains 128 eight-bit words of static RAM together with two 8-bit parallel I/O ports that are bit-programmable to provide maximum flexibility.

CIRCLE NO. 330

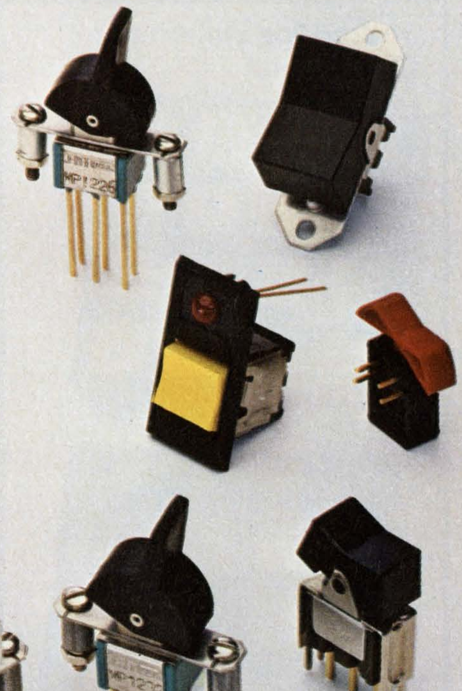
Four very small ways to improve on your PC design.

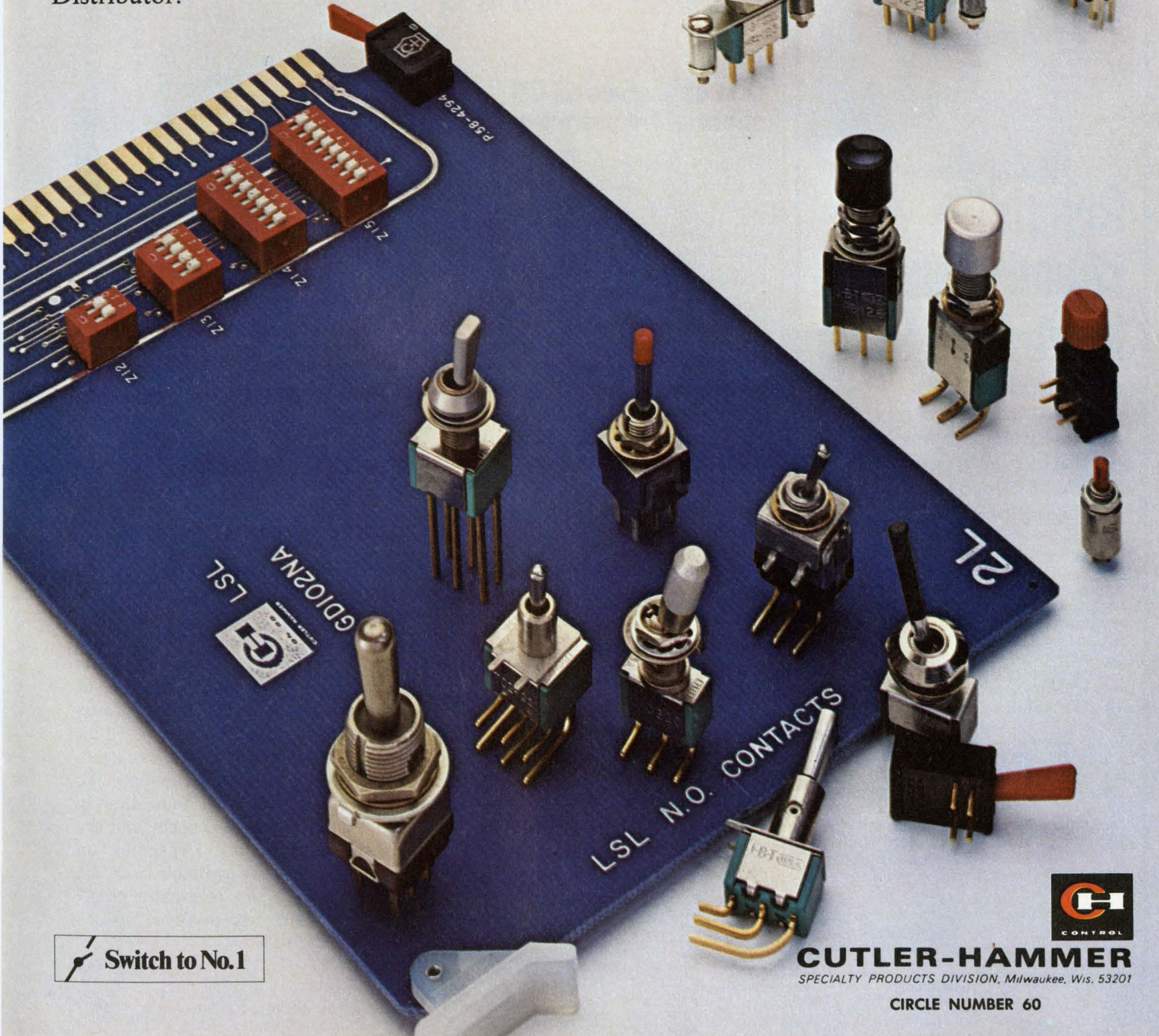
With four types of switches—rockers, pushbuttons, toggles and DIPs—Cutler-Hammer offers one of the industry's broadest and most unique selections of PC subminiatures.

Each of the hundreds of available styles provides the reliability you've come to expect from Cutler-Hammer. With ratings to 6 amps, each conforms to standard circuit board mounting requirements.

PC switches, along with accessories and decorative hardware, are distributor stocked for local availability. And since most are manufactured in the United States, we offer fast reaction time on solder lug and wire wrap terminal variations, as well.

To improve your next design in any number of small ways, contact your Cutler-Hammer Sales Office or Switch Distributor.





Switch to No.1

CUTLER-HAMMER

SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

CIRCLE NUMBER 60

Line driver features three-state outputs

Texas Instruments, P.O. Box 5012, M/S 308 (Attn: SN75159), Dallas, TX 75222. Dale Pippenger (214) 238-3527. $2.47 to $2.82; stock.

SN75159, a dual-differential line-driver IC, meeting EIA RS-422 standards, features three-state outputs and addition input logic. The three-state-output feature with individual disable controls permits connecting many devices on the same line. The outputs can neither drive nor load the bus in the disabled or high-impedance state. The outputs are capable of sinking and sourcing 40 mA with 0.25-V (low) and 3.0-V (high) levels. Transition time: 4 ns, delay time: 13 ns.

CIRCLE NO. 331

One chip gives all CB channel frequencies

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 737-5000. $7.00; stock.

Designated DS8900, a 28-pin device is a single-chip frequency synthesizer/programmer for CB equipment. It is the equivalent of a 40-channel phase-locked loop and programmer. Also included on the chip are LED driver/decoders. Some features are: a 40-MHz input capability without using external mixers; 2-speed channel selection; mask-programmable i-f code capability; channel memory capability.

CIRCLE NO. 332

Photodiodes detect full visible spectrum

EMDEX, 540 New Haven Ave., Milford, CT 06460. Seymor Merrin (203) 877-3271.

A family of enhanced-silicon photodiodes responds throughout the visible range of the spectrum. The devices will not exceed a responsivity ratio of 2.5 between 800 and 400 nm. Other characteristics are compatibility with 2 to 15-V logic high-temperature stability. The device's active areas measure 1.2 to 5.8 sq mm and the units are packaged in TO-18 and TO-5 metal cases with dual terminals.

CIRCLE NO. 333

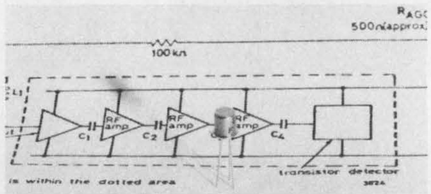
Sense and hold analog peak voltages

Optical Electronics, P.O. Box 11140, Tucson, AZ 85734. Mrs. Mac (602) 624-8358. $45; stock.

The main purpose for the 5902 IC device is to sense and hold positive analog peak voltages. The 100-ns-max acquisition time allows it to peak-sense high-speed pulse-type signals. It may also be used for envelope detection and, with the addition of one external op amp, performs dc restoration. Digital command inputs are TTL and 5-V CMOS compatible. Sensing error is ±1-mV max.

CIRCLE NO. 334

Amplifier/detector tunes from 0.15 to 3 MHz



Ferranti Electric, E. Bethpage Rd., Plainview, NY 11803. Ken Kushman (516) 293-8383. $0.49 (1000 qty); stock to 4 wk.

Monolithic AM/i-f amplifier/detector, type ZN414, can be tuned with external components from 150 kHz to 3 MHz. The TO-18 packaged unit operates from 1.2 to 1.6 V dc, drawing only 300 μA. Threshold sensitivity is 50 μV with the supply voltage at 1.3 V. Power gain is 72 dB.

CIRCLE NO. 335

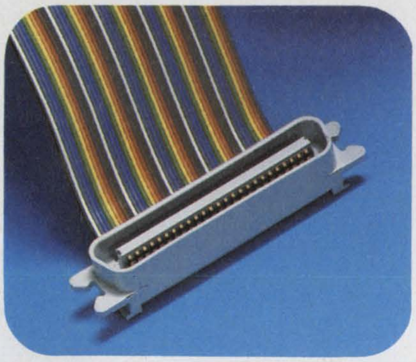
IC puts more 4-bit μC functions on chip

Panasonic, 1 Panasonic Way, Secaucus, NJ 07094. William Bottari (201) 348-7276. $8.50 (1000 qty); stock to 4 wk.

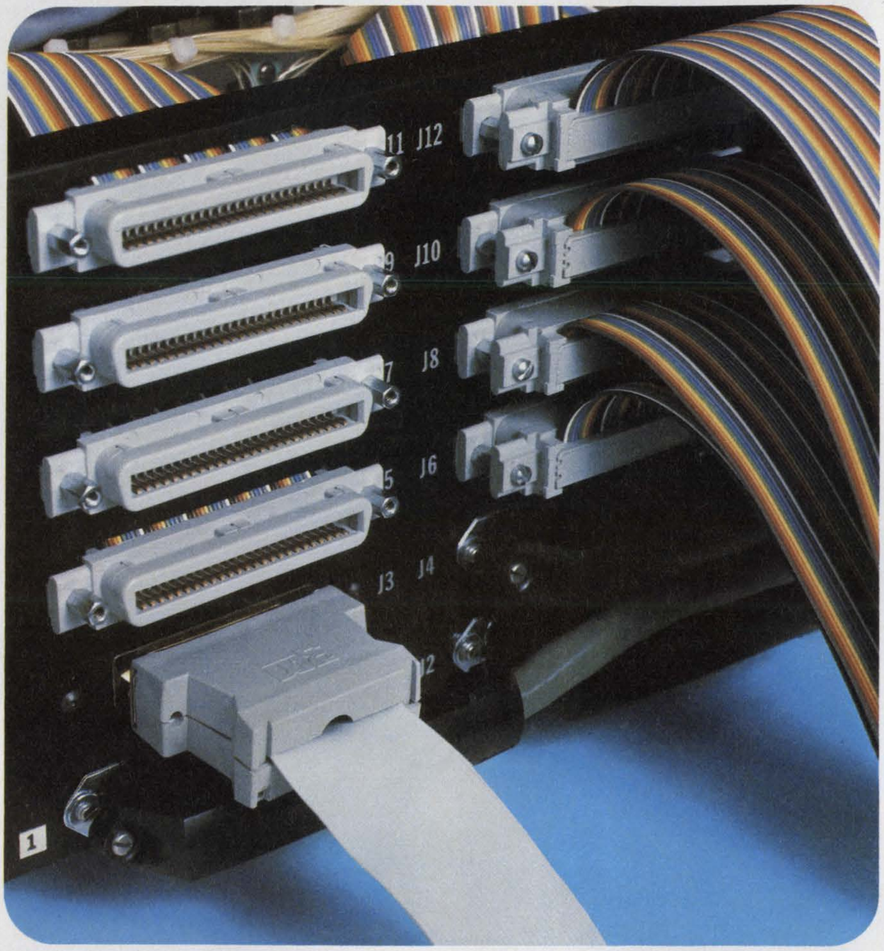
Three μPs, Models MN1400, MN1402, and MN1498 built with the n-channel E/D MOS process, have a number of functions previously included in auxiliary circuitry. These include an 8-bit presettable counter-timer, a clock generator, a 1024 × 8-bit-instruction ROM, 64 × 4-bit RAM with four directly addressable words, I/O ports, and the arithmetic-logic unit. Depending on the model, they are available in 28, 40, or 64-pin DIPs. An "evaluator chip," Model MN1499, can perform various tests on the μPs.

CIRCLE NO. 336

Now you can mass terminate with ribbon connectors.



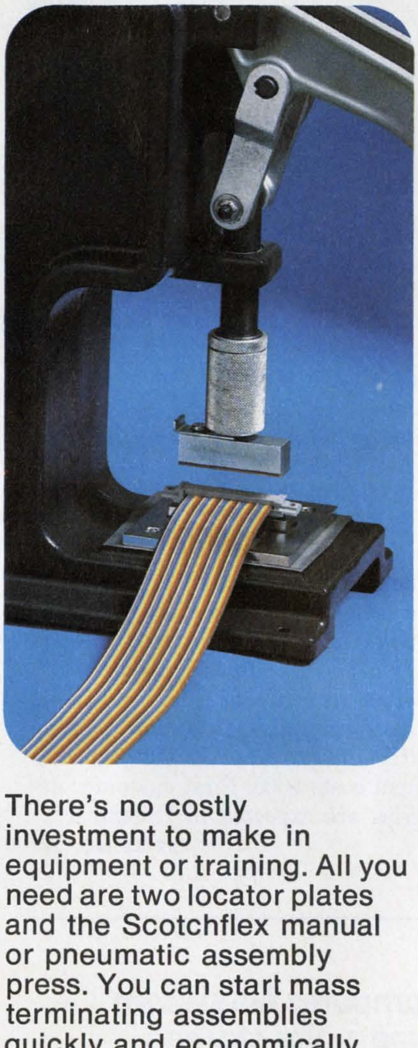
Here's another industry first from 3M that's good news for you: the Scotchflex brand Delta Ribbon Connector System for intra-system or I/O interconnections. In computer applications, in telecommunications, in any place or any way you want to use flat cable and ribbon connectors, this versatile system can do the job at sharply reduced assembly time and labor costs.



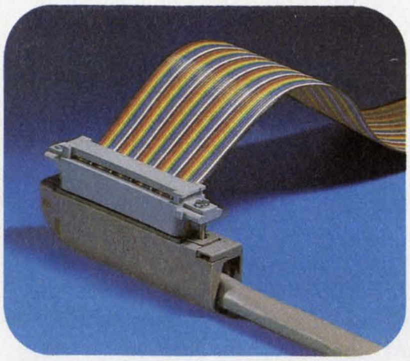
With Scotchflex Delta Ribbon Connectors, no stripping, soldering or other wire preparation is necessary. You can mass terminate a parallel-lay 50-conductor (25-pair) .0425″ center-spaced flat cable in less than 30 seconds with one step. That's about ten times faster than other available methods. And thanks to 3M's field-proven, gold-plated berylium copper U-contacts, all connections are reliably corrosion-resistant and gas-tight.

After termination, there are more savings. You can buss from point to point without disassembling or breaking existing cables. And there's no need to redesign or rework first generation components. This Scotchflex system mates perfectly with all standard miniature ribbon connectors.

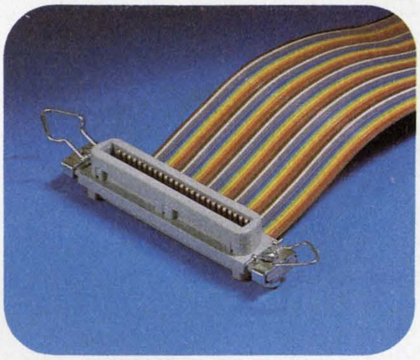
...in 30 seconds or less!



There's no costly investment to make in equipment or training. All you need are two locator plates and the Scotchflex manual or pneumatic assembly press. You can start mass terminating assemblies quickly and economically. No special operator skills are required. Rejects and reworking are greatly minimized.



The Scotchflex Delta Ribbon system includes 50-position male and female connectors, plus appropriate bail mount, screw mount and jack screw kits, strain relief clips and dust covers. Color-coded flat cable is available in parallel-lay conductors #28 AWG stranded or #26 AWG solid.



Only 3M offers you so broad a range of flat cable and system components. A nationwide network of stocking distributors. Best off-the-shelf availability. Proven performance. And the unmatched experience of the people who pioneered mass terminations.

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Scotchflex® systems from 3M. The source.

3M COMPANY

See our catalog in EEM, page 2256

CIRCLE NUMBER 63

DATA PROCESSING

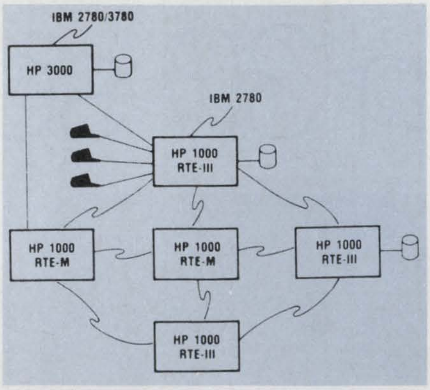
Firmware, software package shapes distributed systems network

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. P & A: See text.

With Distributed System/1000's software and firmware package, HP-1000 systems can interconnect in an almost unlimited number of interconnections. What's more, high-level intercommunication is now possible, such as interconnecting the HP-1000, HP-2026, and HP-3000 Series II computer systems. With the DS/1000 package, networks can be formed from HP-1000 systems that use the memory-based RTE-M, as well as the older RTE-III, operating system.

The DS/1000 package's nodal-addressing scheme gives store-and-forward capability to each node. Any HP-1000 can thus address any other HP-1000, and communicate through any other nodes that may intervene. So, networks can readily be configured as a star, a ring, a string, or a combination of these. Since node addresses stay valid, nodes can share links (reducing line costs), and networks can be reconfigured without affecting previous application programs.

The HP-1000's console can also be a virtual terminal, with full access to the power of the HP-3000, or it can operate unattended. The DS/1000 contains a microcoded driver that is so fast that it can concurrently service multiple communications lines from HP-1000s.



The previous limit of two concurrently active lines no longer applies. At any node, the HP-1000 can access records in remote files (or transfer whole files) on other 1000s, or on a remote HP-3000, using simple calls.

Data integrity in the network is protected with parity checking: Once received, blocks of data are checked, vertically, horizontally, and diagonally, for parity. This checking method can be implemented in microcode, while preserving high line integrity.

In single quantities, the DS/1000 firmware and software used to form one network link between two HP-1000s, cost $6200. Additional network links are $3700 each. Linking an HP-1000 to an HP-3000 series II system costs $500. First customer deliveries are expected in December.

CIRCLE NO. 337

Acoustic coupler gives high data speed

Omnitec, 2405 S. 20th St., Phoenix, AZ 85034. Paul Shatusky (602) 258-8244).

The 401D originate-only acoustic coupler operates with the latest high-speed conversational terminals at data speeds in excess of 300 baud, or optionally to 600 baud. In addition to this speed capability, the 401D offers TTY and EIA RS232 interfacing acoustic, half or full duplex operation, and ultra-high sensitivity. Each coupler has built-in 20-mA TTY current loop and RS232 interfaces.

CIRCLE NO. 338

Computer file system quadruples storage

Inforex, 21 North Ave., Burlington, MA 01803. (617) 272-6470.

Disc-storage capacity of System 5000, a computerized file and records management system, has been quadrupled by the addition of dual-density disc storage units. They are the 62-Mbyte, Model 5303, and the 235-Mbyte, Model 5304. Up to four drives of either density can be attached to each System-5000 terminal control unit, providing maximum capacity of 940 Mbytes.

CIRCLE NO. 339

The Sinclair PDM35. A personal digital multimeter at only $49.95

A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It's got all the functions and features you want in a digital multimeter, yet they're neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 gives you all the benefits of an ordinary digital multimeter – quick clear readings, high accuracy and resolution, high input impedance. Yet at $49.95 it costs less than you'd expect to pay for an analog meter!

The Sinclair PDM35 is tailor made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, and computer specialists will find it ideal.

With its rugged construction and battery operation, the PDM35 is perfectly suited for hand work in the field, while its angled display and optional AC power facility make it just as useful on the bench.

Features of the PDM35

3½ digit resolution.
Sharp, bright, easily read LED display, reading up to ± 1.999.
Automatic polarity selection.
Resolution of 1 mV and 0.1 nA.
Direct reading of semiconductor forward voltages at 5 different currents.
Resistance measurement up to 20 MΩ.
1% of reading accuracy.
Operation from replaceable battery or AC adapter.
Industry standard 10 MΩ input impedance.

Technical Specification

DC Volts (4 ranges)
Range: 1 m V to 1000 V.
Accuracy of reading: 1.0% ± 1 count.
Note: 10 MΩ input impedance.
AC Volts (40 Hz-5 kHz)
Range: 1 V to 500 V. Accuracy of reading: 1.0% ± 2 counts.
DC Current (6 ranges)
Range: 1 nA to 200mA.
Accuracy of reading: 1.0% ± 1 count.
Note: Max. resolution 0.1 nA.
Resistance (5 ranges)
Range: 1Ω to 20 MΩ.
Accuracy of reading: 1.5% ± 1 count.
Note: Also provides 5 junction-test ranges.
Dimensions: 6 in x 3 in x 1½ in.
Weight: 6½ oz.
Power supply: 9 V battery or Sinclair AC adapter.
Sockets: Standard 4 mm for resilient plugs.
Supplied with: Leads, test prods, operating instructions, carrying wallet.
Options: AC adapter for 117 V 60 Hz power. De Luxe padded carrying wallet. 30kV high-voltage probe.

The Sinclair credentials

Sinclair have pioneered a whole range of electronic world-firsts – from programmable pocket calculators to miniature TVs – holding a world-lead in innovative electronics. The PDM35 embodies six years' experience in digital multimeter design, in which time Sinclair have become one of the world's largest producers.

Find out more!

You can see the PDM35 at any of the Sinclair distributors listed on this page. Or, if you'd like full details of operation and performance, and a complete distributor list, just send the coupon below. We'll send you all the facts by return.

The Sinclair PDM35 will make your life a lot easier – send the coupon today!

Send to: Sinclair Radionics Inc, Galleria, 115 East 57th Street, New York, N.Y. 10022, U.S.A.
Please send me full illustrated details of the Sinclair PDM35 personal digital multimeter, without obligation.

Name..........
Position..........
Company..........
Address..........
....
.... ED

1975
sinclair
World leaders in fingertip electronics

Sinclair Radionics Inc, Galleria, 115 East 57th Street, New York, N.Y. 10022, U.S.A.

See the PDM 35 at: Carter McCormic & Peirce Inc., Farmington, Mich. 313 477 7700; Crane & Egert Corp., Elmont, N.Y. 516 488 2100; F. L. W. Inc., Costa Mesa, California. 714 751 7512; International Standard Components, Los Altos, California. 415 941 2600; Ossmann Instruments Inc., Syracuse, N.Y. 315 437 6666; Par Associates, Denver, Colorado. 303 355 2363; PVA Company, La Grange, Ill. 312 352 1037; Scientific Associates, Washington D.C. 703 573 8787; Southern Peripherals & Instruments Inc., Atlanta, Georgia. 404 455 3518.

CIRCLE NUMBER 65

Dual-channels generate 16-bit words

Dytech, 2725 Lafayette St., Santa Clara, CA 95050. (408) 241-4333. $995; stock to 6 wk.

A 16-bit word length is the capability of the Model 8000 dual-channel word generator. Both RZ and NRZ data are available from each word output at all times. Two rows of data-content switches control each bit of both words. First and last bits are available for both words at all times. Serial and parallel modes are provided and a fine-delay control provides for delay between serial words or between successive parallel A and B cycles.

CIRCLE NO. 340

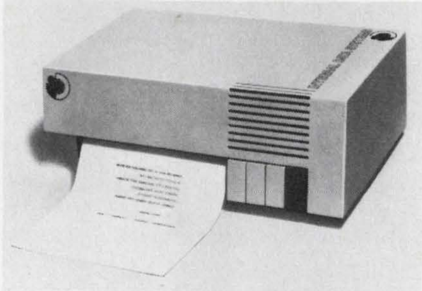
Expand DEC capability with core memory

Ampex, 200 N. Nash St., El Segundo, CA 90245. Clyde Cornwell (213) 640-0150. See text; stock.

Three models of ARM-1170 plug-compatible core memory are offered to expand DEC PDP-11/70 memory. These memories are available in increments of 64-k processor words (16 bit) ranging in size from 64 k to 2048 k. Throughput enhancement is possible with the two or four-way internal interleaving features in the three models. Using four-way interleaving, the effective cycle time is 345 ns, and PDP-11/70 throughput is typically increased by 16% or more for system-job configurations that are now memory limited. The memory modules employed use 13-mil temperature-independent Unibit cores to ensure wide operating margins and performance stability. Prices are $12,875 for 128 kwords, $23,865 for 256 kwords, and $43,205 for 512 kwords.

CIRCLE NO. 341

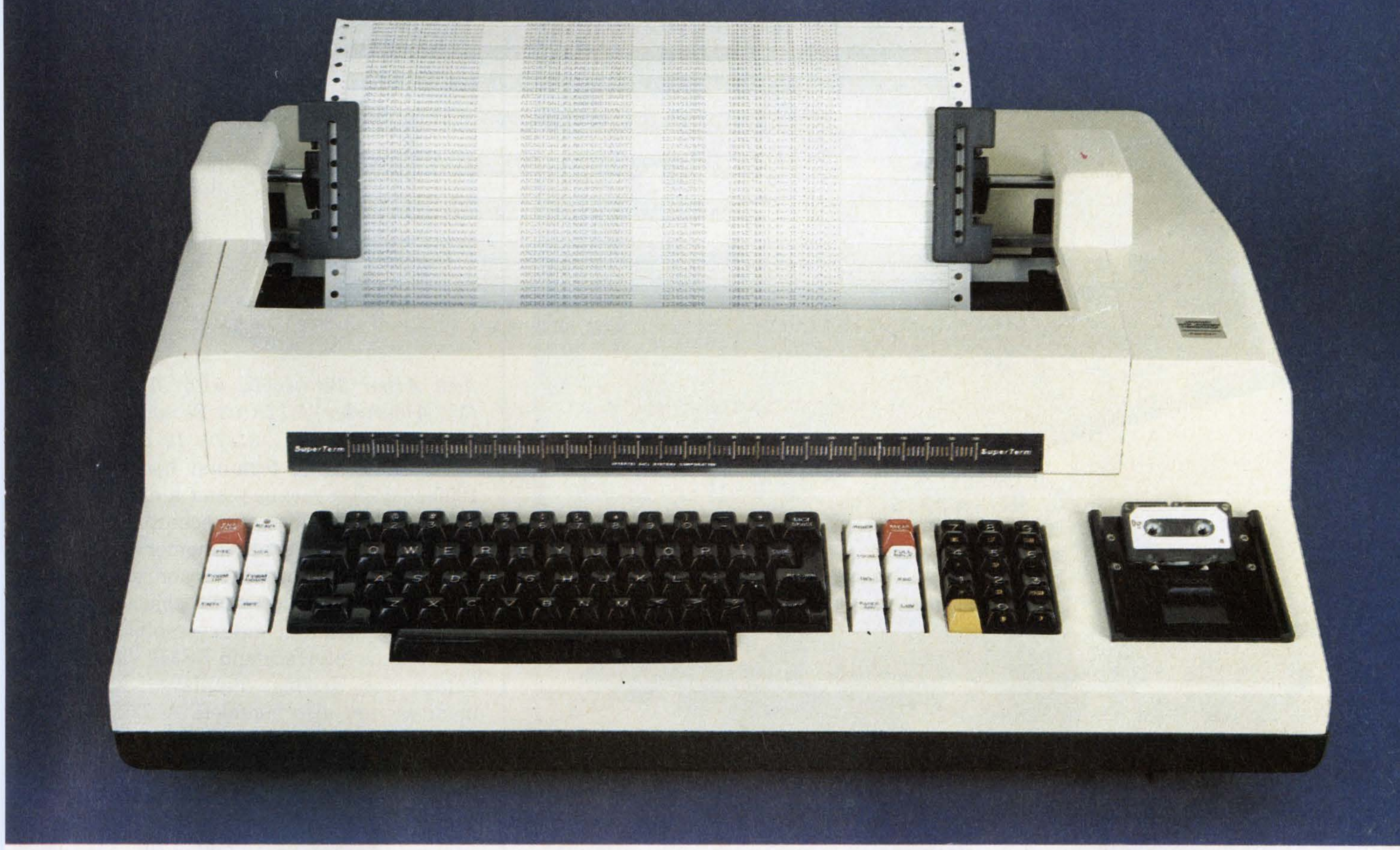
Compact printer runs at rates to 120 char/s



Integral Data Systems, 5 Bridge St., Watertown, MA 02172. (617) 926-1011. $745; 4-8 wk.

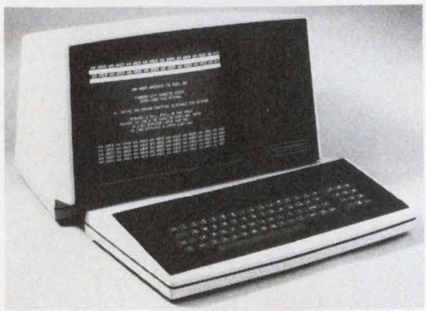
A dot-matrix impact printer, Integral Impact, prints at rates to 120 char/s with up to 132 char/line. It includes an RS-232 and current-loop serial interface, enhanced-mode characters and selectable character and line sizes. Multiple copy on both fan-fold and roll paper is provided. The printer can be integrated into any mini or microcomputer system by connecting it to any serial port.

CIRCLE NO. 342



DATA PROCESSING

CRT-terminal remembers 2000 characters

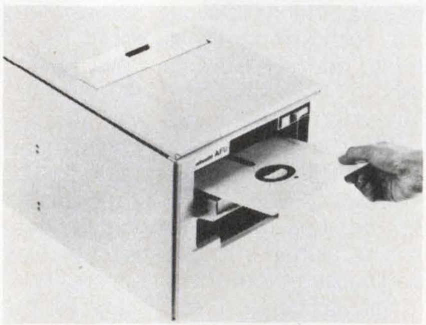


Ann Arbor Terminals, 6107 Jackson Rd., Ann Arbor, MI 48103. Sarah Freeman (313) 769-0926. $1470; 12 wks.

The 400D CRT terminal boasts a 2000-character memory and a display format with 24 lines of 80 characters. An extra line of hidden memory can be accessed in either roll or scroll modes. The 400D has three character accents—blink, dim and reverse-video. RS232 data interface and RS170 video output for driving auxiliary video monitors are also included. A 72-key detachable keyboard generates the full 128-character ASCII set and has cursor control keys with separate numeric pad.

CIRCLE NO. 343

Convert media with floppy-disc unit

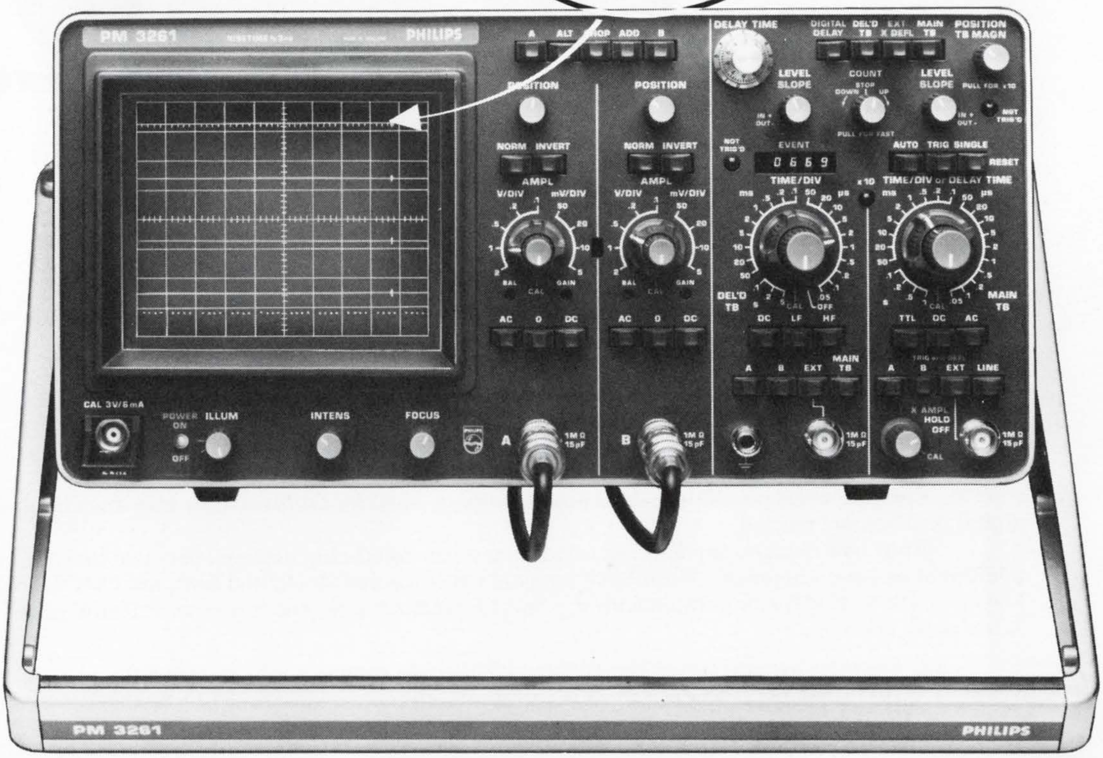


Olivetti, 500 Park Ave., New York, NY 10022. Mike Manno (212) 371-5500. $4560.

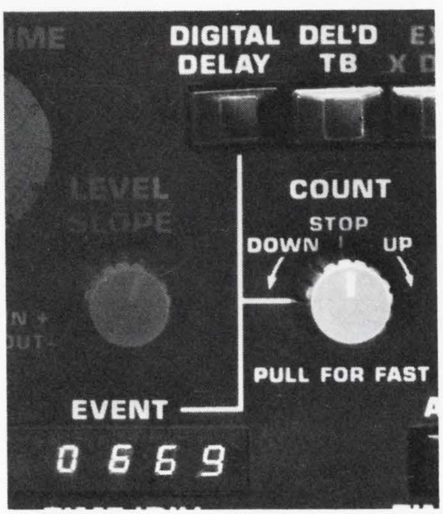
With the automatic floppy-disc unit, data from various diskette recording stations can be pooled and converted into magnetic-tape media for input to a mainframe. It is made up of an automatic loader, dual read/write floppy-disc unit, and a power supply. It holds a maximum of 20 diskettes, stacked one on top of the other. The length of the loading cycle is about 5.5 s. A separate feed slot is available for changing diskettes manually.

CIRCLE NO. 344

Display the 669th bit...



and be sure it's not the 670th or the 671st...



Finding the 669th bit takes quite a while, and then you're not sure you have the right one. The solution is **programmed digital delay.** On the Philips PM 3261, you can program the delayed timebase to start on the n^{th} bit.

By means of an internal variable-speed clock, the events counter can be preset from 1 to 99,999 events, with complete trigger level setting control. Press DEL'D TB and there you see the 669th bit big and rock steady to measure or photograph.

Special TTL triggering selection allows the PM 3261 to react just as logic does, a TTL level window prevents false triggering on rising or falling edges.

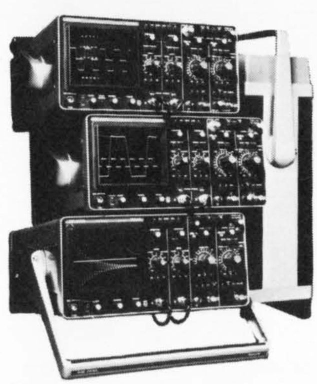
Another addition to the Philips family of HF portable oscilloscopes, the 120 MHz PM 3261 adds easily programmable digital delay to the already completely separate delayed timebase control section found on its predecessors.

The PM 3261 list price is only $ 2795.00 **U.S. domestic price only.** Utilize our tollfree HOT LINE number 800 631-7172. New Jersey residents call (201) 529-3800 collect.

For further information contact Philips Test & Measuring Instruments, Inc.

In the United States:
85 McKee Drive
Mahwah, New Jersey 07430
(201) 529-3800

In Canada:
6 Leswyn Road
Toronto, Ontario Canada M6A 1K2
(416) 789-7188



PHILIPS Test & Measuring Instruments

PHILIPS

CIRCLE NUMBER 10

Put it all together for as little as $12.*

Intersil's new single chip 3½-digit 7106 and 7107 A/D converters for LCD or LED displays.

Meet the latest in A/D converters: Intersil's 7106, the first single-chip CMOS A/D for driving LCD displays—including backplane—directly.

And the 7107, first single-chip CMOS A/D for driving instrument-size LED displays directly without buffering.

Each provides parallel seven segment outputs, ideal for DVMs, DPMs and anywhere modern digital displays are needed.

Both new devices provide cost advantages over multi-chip designs, because they require no additional active components. Both have internal reference and clock, and both are CMOS so you get low noise (12 to 15μV) comparable with the finest bipolar devices, and low power (10mW max.@ 10V). A few more features:

- ±1-count accuracy over the entire ±2000-count range.
- Guaranteed to read Zero for 0 Volts input.
- Provides true polarity at Zero count for precise null detection.
- Differential input from 200mV to 2.000V full scale.

Get additional technical information, including detailed data sheet and application notes, from Intersil, 10710 North Tantau Ave., Cupertino, CA 95014.

Build a working DPM in ½ hour with these complete evaluation kits.

Test these new parts for yourself with Intersil's low-cost prototyping kits, complete with A/D converter and LCD display (for the 7106) or LED display (for the 7107). Kits provide all materials, including PC board, for a functioning panel meter. Available from Intersil stocking distributors.

Kit No. ICL7106EV/KIT (LCD) $29.95 complete.
Kit No. ICL7107EV/KIT (LED) $24.95 complete.

Intersil sales offices: Boston (617)861-6220; Chicago (312)986-5303; Dallas (214)387-0539; Dayton (513)278-4837; Denver (303)750-7004; Los Angeles (213)532-3544; Ft. Lauderdale (305) 772-4122; Minneapolis (612)925-1844; New York (201)567-5585; San Francisco Bay Area (408) 996-5000.

INTERSIL

CIRCLE NUMBER 16

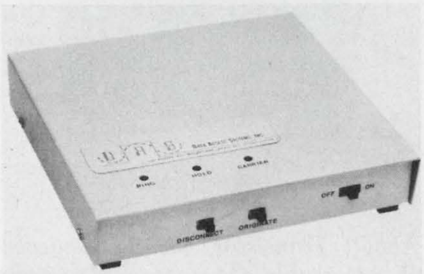
Remote batch and key entry from same terminal

Consolidated Computer Int., 275 Wyman St., Waltham, MA 02154. P.L. Shannon (617) 890-0920. $1350/mo lease.

Key-Edit 80 is a modular data entry system that enables the user to prepare, edit, sort, merge, reformat and check key-to-disc data input prior to mainframe entry. It will interface with any mainframe system's output from a remote site. A system can accommodate 2 to 8 data terminals with English language programming to define input formats, edit and validate data and/or previously entered background material. The unit is a 32-k CPU, 1.4-Mbyte disc unit with speeds of 2000 to 9600 baud. Also included is a 300 cards/min card reader and a 300 lines/min line printer.

CIRCLE NO. 345

Modem needs no Ma Bell protective device



Data Access Systems, 100 Route 46, Mountain Lakes, NJ 07046. Sandra Watkins (201) 335-3322. $375; stock.

The 68-01 modem may be directly connected to the telephone network without the use of telephone-company installed protective devices (DAA). The unit can replace acoustic couplers. Because the modem is hardwired into the telephone network, ambient noise and machine vibration is eliminated. The unit conforms to FCC rule 68.

CIRCLE NO. 346

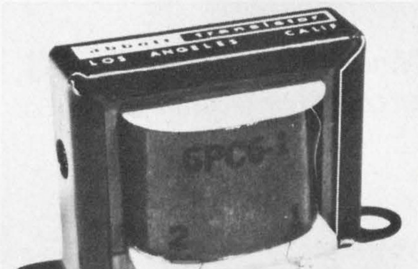
Power generators provide 3 and 4.8 kW to 111 kHz

ENI Power Systems, 3000 Winton Rd. S., Rochester, NY 14623. L.M. Salmen (716) 473-7330. $5475-$7460; 4-5 mo.

Operating over a frequency range of 8 to 111 kHz, and with output powers of 3 and 4.8 kW, the EGR3200 and EGR4800 frequency sources offer variable tuning and power output control. Long-term stability is 0.1% over an ambient temperature range of 0 to 40 C and resolution is ±2 Hz. A power meter permits monitoring of the output and the power actually absorbed by the load.

CIRCLE NO. 347

Power transformer mounts on PC board

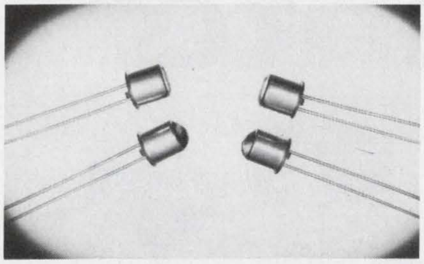


Abbott Transistor, 639 S. Glenwood Pl., Burbank, CA 91506. W. Lovett (213) 841-3630. $5.10 (1-9 qty); stock to 10 days.

A PC-board power transformer, the Model 6PC5-1, supplies 5 V ac at 300 mA or 10-V center-tapped at 150 mA. Output-voltage tolerance is within 5% when measured at full load and 115 V ac. Voltage regulation is 20%, no load to full load. Insulation tested at 1000-V ac. The transformer operates at 85-C ambient. Input: 115 or 230-V-ac, 50 to 400-Hz, single phase.

CIRCLE NO. 348

Infrared LEDs last 10 years

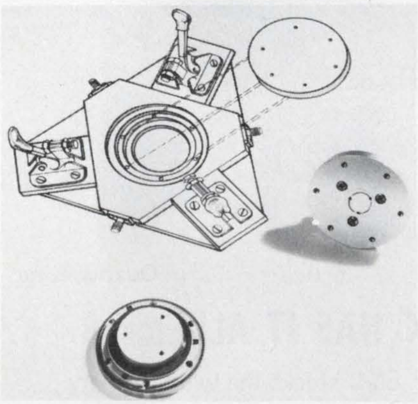


Optron Inc., 1201 Tappan Circle, Carrollton, TX 75006. (214) 242-6571. $1.44 (1000 qty).

Light-emitting diodes designed for pulsed applications feature a stable power output over a 10-year operating life by using solution-grown epitaxial gallium-arsenide chips. The OP 135 is available in a standard TO-18 package, with either lens or flat window, and outputs 20 mW at an input pulse of 1 A, 10 μs, 10 pulses per second. The average power output degradation is less than 10% after 1,000,000 hours of operation. A 35-mW model is also offered.

CIRCLE NO. 349

Ferrite circulator plugs into stripline

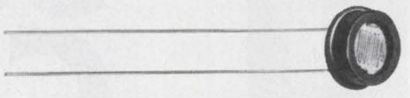


Microwave Associates, South Ave., Burlington, MA D. Landry (617) 272-3000.

Operating at 3.5 to 4.2 GHz, the MA-7L801 plug-in ferrite circulator is designed for direct insertion into strip transmission-line circuits. It provides simultaneous center-conductor and ground-plane contact, which minimizes electrical and mechanical interface problems. Major features include a VSWR of 1.25:1, 19dB min isolation, 0.5-dB insertion loss and dimensions of 11/16 in. (dia) × 1/2 in.

CIRCLE NO. 350

Photodetector gets turned on by blue



Hamamatsu Corp., 120 Wood Ave., Middlesex, NJ 08846. R. Eno (201) 469-6640.

The P1024 photoconductive cell peaks between 400 and 500 nm and thus provides high sensitivity in the near-UV and blue visible range, for brightness controls and colorimeters.

CIRCLE NO. 356

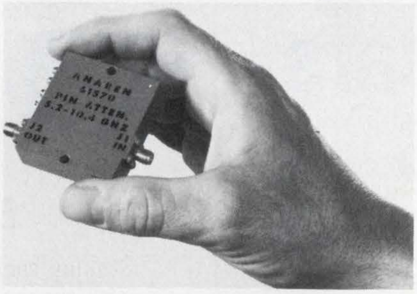
Acoustic-wave source has low fm noise

Thomson-CSF, 750 Bloomfield Ave., Clifton, NJ 07015. (201) 779-1004.

A bulk-acoustic-wave (BAW) oscillator can achieve output power to 250 mW at 800 MHz and its fm noise is 100 dB down, 2 kHz from center frequency. Frequencies to 2 GHz are feasible. Because the acoustic cavity acts as a phase lock on a free-running oscillator, stability is very good. For frequencies below 800 MHz, the company also offers a surface-acoustic-wave (SAW) device which permits tuning.

CIRCLE NO. 357

Fast p-i-n attenuator spans 1 to 12.4 GHz



Anaren Microwave, Inc., 185 Ainsley Dr., Syracuse, NY 13205. (315) 476-7901.

Seven models of absorptive, voltage-variable p-i-n attenuators cover 1 to 12.4 GHz. They provide 60 dB attenuation, with low VSWR at any level. Switching speed is less than 500 ns at 400 mW rf input power. Input control function is 6 dB/V with typical linearity ±1 dB. The series meets Level B of MIL-STD-883, and temperature variation is typically ±1 dB from −55 to +95 C.

CIRCLE NO. 358

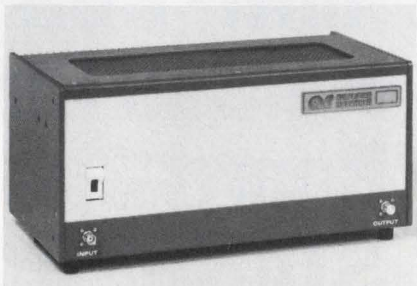
Two-way power divider covers 2 to 18 GHz

Technical Research & Mfg., Grenier Field, RFD #3, Manchester, NH 03103. Art Marin (603) 668-0120. $299; stock.

A two-way power divider, DMS 221, covers the frequency range of 2 to 18 GHz. Specifications include: 20-dB isolation from 2 to 10 GHz, 18-dB from 10 to 12.4 GHz and 15-dB from 12.4 to 18 GHz. VSWR goes from 1.4:1 at 12.4 GHz to 1.8:1 at 18 GHz. Insertion loss over the band is 1.5 dB with an amplitude balance of 0.4 dB and phase balance of 10 degrees.

CIRCLE NO. 359

Amp delivers 4 W from 1 to 1000 MHz



Amplifier Research, 160 School House Rd., Souderton, PA 18964. (215) 723-8181. See text; 4 wk.

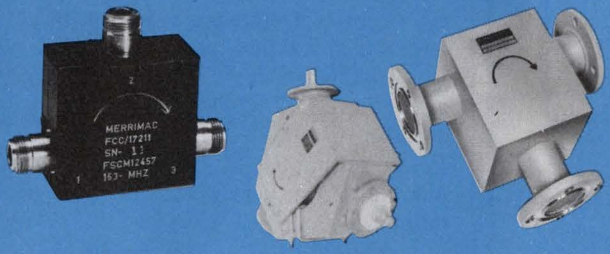
Model 4W1000 is an ultra-wideband, solid-state power amplifier that can deliver 4 W of swept power from 1 to 1000 MHz instantaneously. The amp provides up to 6 W and a min of 4 W of linear power at less than 1-dB gain compression. Fixed power gain is 36 dB min and is flat to within 1.5 dB. In the linear mode, harmonics in the output are at least 20 dB below the fundamental frequency. The amplifier is available as a lab unit complete with power supply or as an OEM module. Lab model price is $2700; OEM model, $2100.

CIRCLE NO. 360

now, coax and waveguide ferrite circulators from one source

. . .it's the winning combination from Merrimac

HIGH POWER COAXIAL FERRITE CIRCULATORS AND ISOLATORS 140 MHz TO 3 GHz



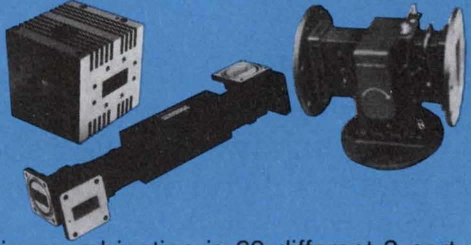
The winning combination is 39 different, standard, 3 port coaxial junction circulators and isolators capable of handling high average and peak powers, with low insertion loss.

Models with various connectors such as N, HN, 7/8", 1 5/8" and 3 1/8" EIA are available.

Following are 4 coaxial circulators, illustrating Merrimacs' capability in high power ferrite components.

MODEL NO.	FREQUENCY RANGE	AVERAGE POWER	PEAK POWER (WATTS)	CONNECTORS
FCC-11230	205-225 MHz	4.5KW	70KW	1 5/8" EIA
FCC-1203-460	450-470 MHz	350 W	—	N FEMALE
FCC-1115	890-940 MHz	3 KW	100KW	1 5/8" EIA
FCC-1109	1.7-2.4 GHz	1.2KW	CW	1 5/8" EIA

HIGH POWER WAVEGUIDE FERRITE CIRCULATORS AND ISOLATORS 1 TO 18 GHz



The winning combination is 60 different 3 port junction and 4 port differential phase shift circulators capable of handling extremely high average and peak powers with low insertion loss.

A wide variety of waveguide types/flanges are available and are suited for the proper waveguide cut-off frequencies.

Following are 4 standard high power waveguide circulators popular in the fields of industrial heating, earth stations and radar systems.

MODEL NO.	FREQUENCY RANGE(GHz)	AVERAGE POWER	PEAK POWER	NO. OF PORTS
FCW-1521	2.425-2.475	6 KW	CW	3
FCW-1528	5.9-6.4	3 KW	CW	3
FCW-1914	7.9-8.4	3 KW	CW	4
FCW-1937	8.5-9.6	1.2 KW	1.2 MW	4

For additional detailed information on Merrimacs' high power ferrites or other IF and microwave components, please request the following Merrimac catalogs.

☐ M-129-High Power Ferrite Catalog; **CIRCLE NUMBER 141**

☐ M77-3-Condensed Catalog of all Merrimac Signal Processing Components, **CIRCLE NUMBER 142**

SPORTS ILLUSTRATIONS SUITABLE FOR FRAMING.
Football, Basketball, Soccer and Hockey, Two Color reproductions FREE on request.

CIRCLE NUMBER 143

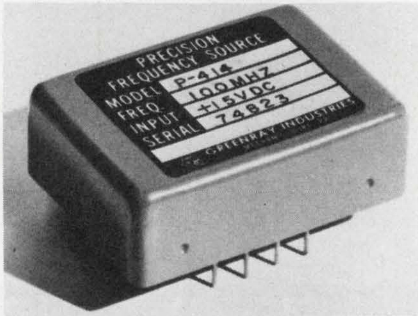
now there is one... in signal processing

Merrimac
INDUSTRIES, INCORPORATED

POST OFFICE BOX 986, 41 FAIRFIELD PL., W. CALDWELL, N.J. 07006
• 201 575-1300 • TWX 710-734-4314

EXPORT REPRESENTATIVES DAGE CORP.
STAMFORD, CONNECTICUT 06902
(203) 324-3123 TWX 710-474-2490 Telex: 96-5928

Small VCO swings in phase-lock loops

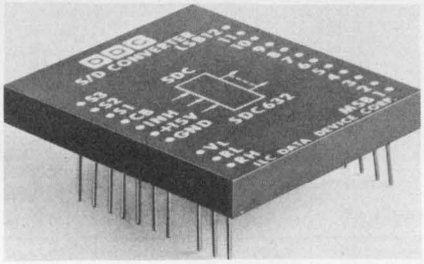


Greenray Industries, 840 W. Church Rd., Mechanicsburg, PA 17055. (717) 766-0223. $70 (1000 qty); 8 to 10 wk.

For phase-locked loops, the Model P-414 voltage-controlled LC oscillator offers ±10% frequency deviation in a 1.63 × 2.25 × 0.5-in. package. The unit is available at any frequency in the range from 20 to 200 MHz and offers stability of ±0.5% from 10 to 60 C. Power output is +7 dBm into 50 Ω. Modulation rate is up to 1% of the output frequency.

CIRCLE NO. 361

12-bit converters run with fast synchros

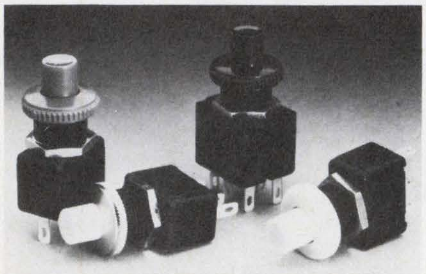


ILC Data Device, Airport International Plaza, Bohemia, NY 11716. (516) 567-5600. From $345; 4 wks.

The SDS-632 series convert continuously three-wire-synchro or four-wire-resolver outputs into 12-bit angle data, error-free at rates to 300 rpm. These third generation modular converters use a true Type-two servo loop. The converters operate on inputs of between 360 Hz and 1 kHz and produce ±8.5-arc minutes accuracy insensitive to voltage and frequency variations. Data is always fresh and available: Converter Busy and Inhibit signals ease interfacing with computers. The 4-oz encapsulated modules draw 225 mW. Units are fully trimmed at the factory and require no adjustments or calibrations in the field. 3.13 × 2.53 × 0.42 in.

CIRCLE NO. 362

Get high safety factor with pushbutton switch

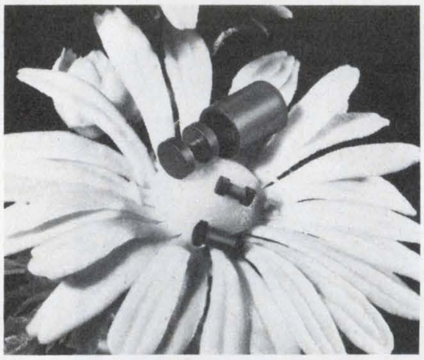


Alco Electronic Prod., 1551 Osgood St., North Andover, MA 01845. Clemens Czapinski (617) 685-4371. $1.48; 2-3 wk.

SPV pushbutton power switches have fully insulated bushings and buttons to provide a high safety-factor in service to 250 V ac and 5 A. Features include wide-spaced terminals that accept two 18-gauge wires or 0.110-in. quick-connect receptacles. Switching is positive snap-action for long contact life and tactile feel. Switches are available in six colors.

CIRCLE NO. 363

Use mini-ferrite cores for RFI coils

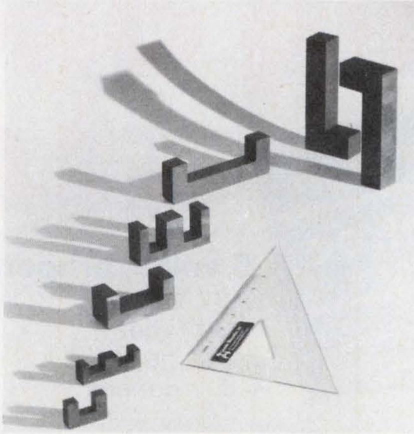


Siemens, 186 Wood Ave. S., Iselin, NJ 08830. T. Pate (201) 494-1000. $0.05; stock.

A series of ferrite cores, for use as miniature rf choke coils, covers a frequency range of 10^3 to 10^8 Hz. Four sizes of bobbin cores and two sizes of drum cores are available. The cores range in size from 0.125 × 0.25 in. to 0.275 × 0.3 in., and have inductance values ranging from 13 to 85 mH/N². Basic shapes are cylindrical cores featuring a single layer winding and axial leads. Cores with side flanges, that can be wound in multilayer construction, are available for higher inductance values.

CIRCLE NO. 364

Power transformer cores have unusual forms

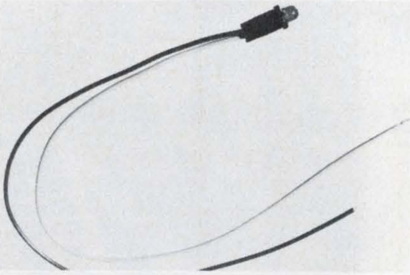


Ceramic Magnetics, 87 Fairfield Rd., Fairfield, NJ 07006. (201) 227-4222.

Ferrite cores, for general-purpose power transformers used in wideband coupling and for switching-inverter power supplies, have a wide variety of configurations. Typical of these cores are E, U, and L shapes in any size with square or round posts. They provide the exact geometry for maximum transformer performance to avoid compromises resulting from use of standard shapes. Prototypes in any geometry are available. Precision ferrites used for these cores are chosen for their low loss and high permeability, or very high flux density and high Curie temperature, depending on the performance parameters desired.

CIRCLE NO. 365

LED indicator snaps into panel hole

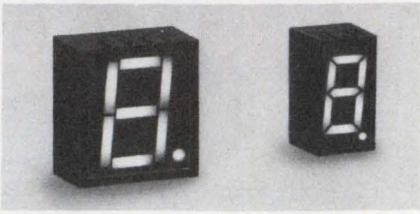


Sloan, 7704 San Fernando Rd., Sun Valley, CA 91352. (213) 875-1123. $0.65 (1000 qty); 2-3 wk.

LED indicator lights, 5L4 series, snap into 0.156-in. panel holes without the use of mounting hardware. Recommended center to center mounting is 1/4 in. They are available with a T-1 size red diffused LED and offer light outputs of 0.5 mcd minimum at 20 mA. Forward voltage is 1.8 V at 20 mA and maximum continuous forward current is 70 mA. No lens is required.

CIRCLE NO. 366

LED digital displays have high efficiency

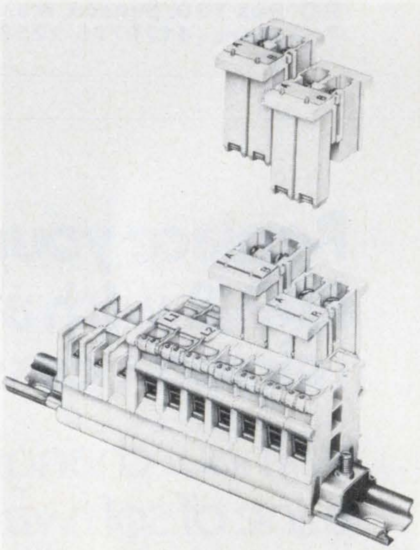


ITAC, 2045 Martin Ave., Santa Clara, CA 95050. Dan Davis (408) 985-2290. $1.35 (5000 qty).

A series of high-efficiency FND LED digital displays gives about 60% greater axial luminous intensity per segment than standard FND versions. These red GaAsP displays are available, with common cathode or anode 7-segment right-hand decimal, in character heights of 3/8 and 1/2 in. Except for the higher efficiency, the displays have the same characteristics and are pin-compatible with the standard FND versions.

CIRCLE NO. 367

Speed installation time of small terminal block



Underwriters Safety Device, 7300 W. Wilson Ave., Chicago, IL 60656. James Van Cura (312) 867-4600.

Medium-duty 600-V terminal blocks, Series 32000, speed installation time and reduce space requirements. They are UL 1059 recognized for #8 to #22-AWG-wire sizes. Features of the blocks include: captive-connector screws to meet UL/NEMA probe test, edge-tab markings for error-free installation, panel or track mounting, two and three-circuit quick-disconnects, tabs for snap-out removal of internal sections, nylon-block construction.

CIRCLE NO. 368

Don't waste money and ruin PROMs. Move up to a first-rate programmer.

What defines a first-rate programmer?

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Our systems take the mistakes out of programming.

Our Series 90 PROM Programmer walks you through the programming process so there's less chance for misprogramming. Separate sockets for master and copy PROMs make it impossible to accidently destroy a valuable master.

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A Series 90 master control unit costs only $1,800. A Series 92 PROM Duplicator master control unit costs only $1,145. Single PROM personality modules cost from $325 to $450. Generic modules start at $350. Gang modules which program 8 PROMs simultaneously are $895. All modules come U.L. listed and fit both the Series 90 and the Series 92. Options include CMOS RAM buffer (to 4K bytes), RS-232 (terminal or modem) interface, TTY, parallel interfaces, paper tape reader, U.L. listed erase light, check-sum option, and Auto-baud.*

Find out what else a truly first-rate programmer has to offer.

Call or write for a free pamphlet giving you comparison checkpoints. Pro-Log Corporation, 2411 Garden Road, Monterey, CA 93940. Phone (408) 372-4593.

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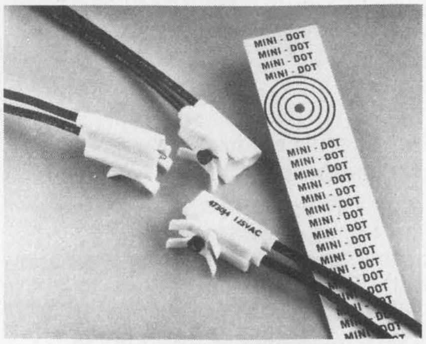
CIRCLE NUMBER 77

COMPONENTS

Indicators produce mere pinpoints of light

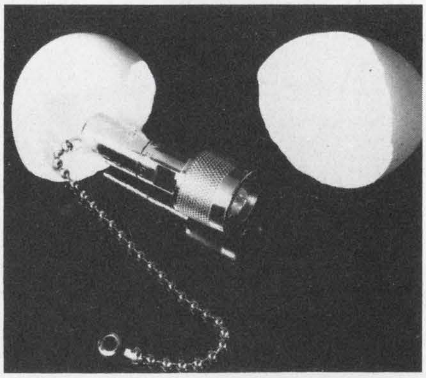


Industrial Devices, 7 Hudson Ave., Edgewater, NJ 07020. (201) 224-4700.

Indicator lights, which produce pinpoints of light, are called the Mini-Dot 4730 series. These assemblies produce spots of light measuring only 3/64 in. diameter. A panel-mounting hole the size of a #16 drill is all that is required to mount them. Each unit is a two-piece light consisting of a lens assembled from the front of the panel, plus a lamp-housing which slides on from the rear. The neon or incandescent lamp is positioned directly behind the lens to provide maximum brightness. A variety of clear and colored polycarbonate lenses are available.

CIRCLE NO. 369

Coax plug has resistor termination

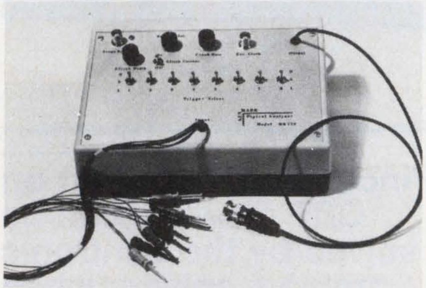


ITT Pomona Electronics, 1500 E. 9th St., Pomona, CA 91766. Carl Musarra (714) 623-3463. $8.85; 2 wk.

Model 4240, a type-N resistor-terminated plug, terminates coaxial lines and is available in 50, 75, 93, 100 and 600 Ω resistance. It has a 1%, 1-W deposited-carbon resistor, Teflon insulation, nontarnish finish and a gold-plated male contact. The VSWR is 1.15 maximum from dc to 100 MHz.

CIRCLE NO. 370

Logic analyzer catches high-speed glitches



Kenmark Development Group, 6 Meadowlark Dr., East Northport, NY 11731. Mark Chomet (516) 368-3314. $225; stock to 4 wk.

A real-time digital logic analyzer, Model RK 778, has high-speed glitch-catching on each of its eight channels, and works with any triggered oscilloscope. It provides eight-channel logic-timing display with the following features: eight channels of input, either sampled by an internal adjustable clock or external clock; self-triggered alternate mode; adjustable glitch-width-display control; catches and displays positive and negative-going glitches on all channels; buffering of each input.

CIRCLE NO. 371

Portable counter can resolve 0.01 Hz

Ballantine Lab, P.O. Box 97, Boonton, NJ 07005. (201) 335-0900. $195; stock.

Frequency counter, Model 5720A, covers a direct-count range from 10 Hz to more than 80 MHz and features an audio-tone multiplier circuit that provides resolution of 0.01 Hz in 1-s measurement time. Frequency and ratios are read out on a nonblinking 8-digit LED display. Direct readings are in MHz, kHz and Hz as selected by a front panel switch. In the three modes, the decimal point in the readout is automatically positioned to give resolutions of 1 kHz, 1 Hz and 0.01 Hz.

CIRCLE NO. 372

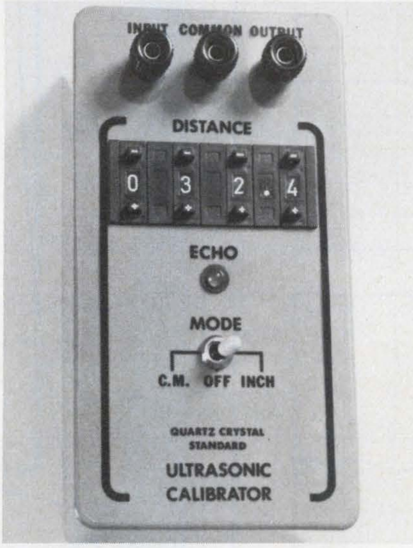
Find cable faults to 80,000 ft with radar

James G. Biddle, Plymouth Meeting, PA 19462. (215) 646-9200.

Two radar cable test sets offer simple operation and true digital readout. Using the pulse reflection principle, the distance to the fault is shown on a digital display. The sets will locate faults from 3 to 80,000 ft in any type of cable, regardless of the insulation, with accuracies better than 1% of range. Two models are available: a general-purpose set and a telephone set for locating faults on twisted pairs. They are completely portable with internal rechargeable batteries.

CIRCLE NO. 373

Test ultrasonic devices with echo calibrator



NASA Instrument, 425 Capitola Ave., Capitola, CA 95010. Carl Levonius (408) 475-0518.

Calibration and verification of ultrasonic level and flow measuring equipment can be done by substituting the calibrator for the transducer and dialing in the desired reading. An echo LED flashes each time an echo is returned. 0.05% accuracy is maintained by the use of a quartz-crystal time reference. The unit is powered by an internal 9-V battery.

CIRCLE NO. 374

Measure pressures in the 10^{-3} to 10^{-10} Torr range

Aremco Products, P.O. Box 429, Ossining, NY 10562. Herb Schwartz (914) 762-0685. $47 to $56; stock.

Ionization gauges used for precision measurement of high-vacuum pressures in the 10^{-3} to 10^{-10} Torr range are available in six standards. The type 126 gauges have two filament styles; the burnout-proof thoria-coated iridium and the twin-tungsten filament, each in ¾ in. Nonex, Pyrex and Kovar tubes.

CIRCLE NO. 375

Monitor process system with calculator control

Doric Scientific, 3883 Ruffin Rd., San Diego, CA 92123. Mike Vaughn (800) 854-2708.

Temperature, flow, pressure and other data from up to 1000 points can be scanned, measured, linearized and processed by a calculator-assisted process-monitoring system. Used with an HP 9825A calculator, the Digitrend 240 measures outputs from sensing devices. From the data collected, manipulations such as averages, integration, trending, proportioning and alarm processing are possible with appropriate calculator programs. Alarm setpoints, functions, scan rates and data processing are under control of the calculator.

CIRCLE NO. 376

Tester eases digital servicing problems

Tektronix, P.O. Box 500, Beaverton, OR 97007. (503) 644-0161. $1995; 8 wk.

Digital Tester, Model 851, is for the front-line digital-service engineer. Its functions include alignment and adjustment and electromechanical/electronic troubleshooting. Voltage, timing, resistance, temperature and logic states can be measured and gated counting performed. Some features are: 13-lb weight, digital readout, automatic ranging, single-function switch, logic-state indicators, color-coded probes, and front-panel controls.

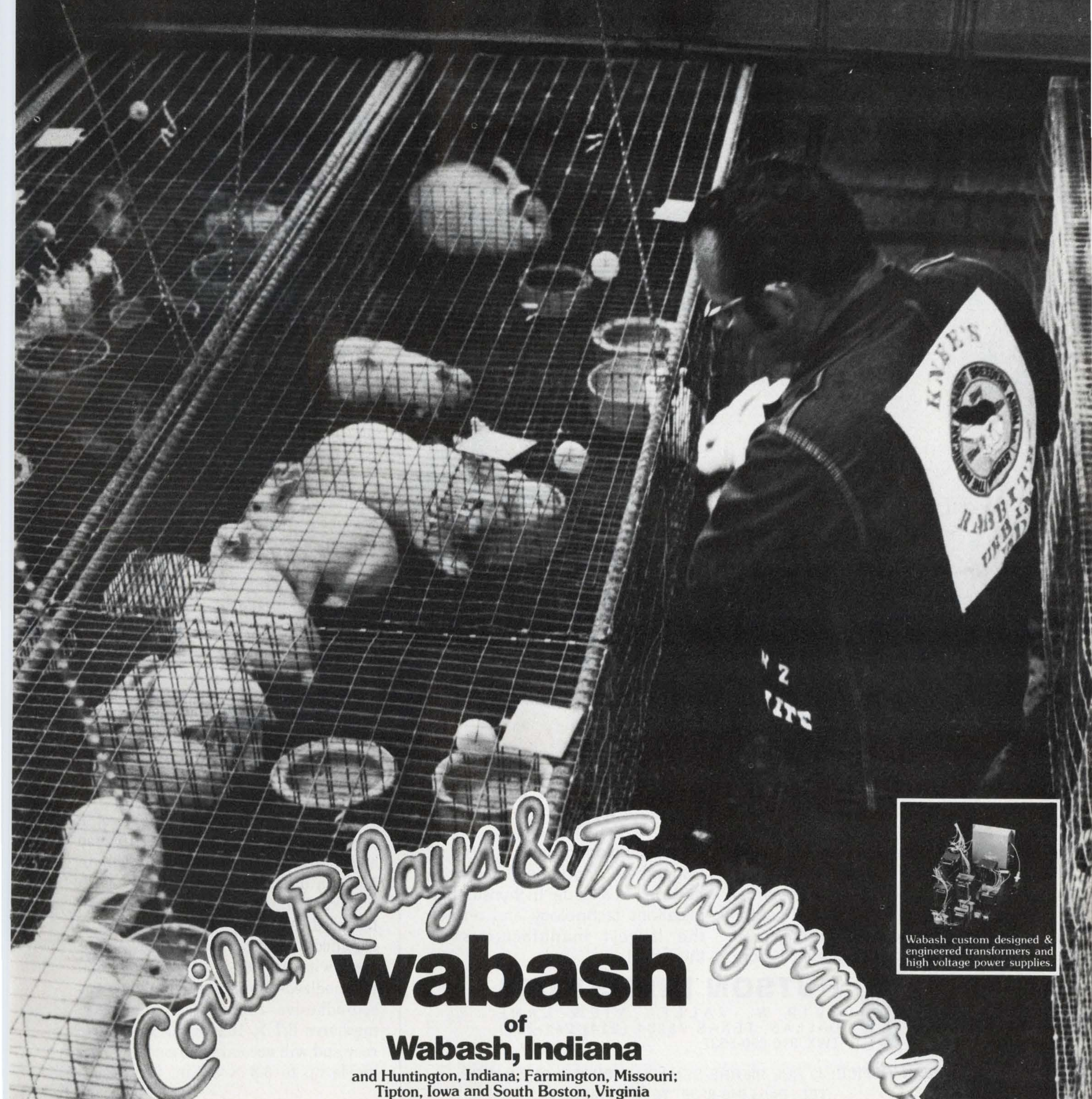
CIRCLE NO. 377

There are two places in Wabash, Indiana with economical, high volume production capability.

Knee's Rabbitry is one. Wabash Transformers is the other. And it's a generally held local opinion that Wabash has got the edge. Not just in sheer numbers—but in variety. While Knee's Rabbitry can produce only two genders of rabbits, Wabash produces literally thousands of different types of transformers.

Not only that—Wabash custom designs their product to precisely suit the application—any type of transformer or high voltage power supply application. A few where Wabash is a leader are air cleaners, photocopying and VRT equipment.

With their engineering expertise, sophisticated products, automated winding and high volume production capability, Wabash is a standout among the hundreds of transformer manufacturers. But, in turning out sheer numbers, Knee's Rabbitry is pretty stiff competition.



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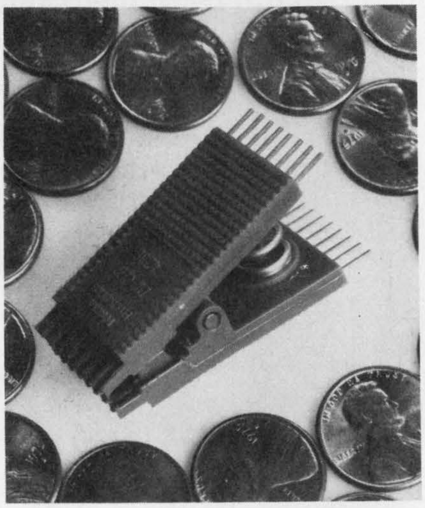
CIRCLE NUMBER 81

DIP test-clip eases testing dense packages



ITT Pomona Electronics, 1500 E. Ninth St., Pomona, CA 91766. Carl Musarra (714) 623-3463. $5.75; 2 wk.

Model 4236 is a 14 or 16-pin dual in-line test clip with reduced thickness for testing ultra-dense packages. It measures 1.5 × 0.8 in. and contains non-tarnish nickel-silver contacts. The serrated contacts at the DIP end provide a positive electronic connection and assist in the removal of foreign material from the DIP. The serrated test points on the upper end will accept wrapped wires or mini test-clips. A molded barrier between each contact allows connections to be made on live boards without accidental shorting of adjacent contacts.

CIRCLE NO. 378

Vacuum-formed case houses digital displays

Electronics Inc., 171 Bridge Rd., Hauppauge, NY 11787. (516) 234-0400. $25.70 (unit qty); stock.

Verocase 75-1800J is the first of a series of attractive vacuum-formed enclosures, specifically designed to house a digital display together with a keyboard. Made of 0.118-in. thick textured A.B.S. plastic, the case is supplied as a two-piece assembly complete with a 0.062-in. thick 5.7 × 5.9-in. anodized-aluminum panel and four self-adhesive rubber feet. The case measures 8.7 × 10.9 × 3.9 in. at the rear and will accommodate a PC board inside up to 6.3 × 8.7 in. in size.

CIRCLE NO. 379

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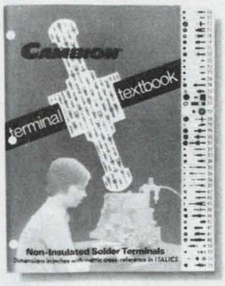
The world's most comprehensive source book of Solder Terminals.



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CIRCLE NUMBER 84

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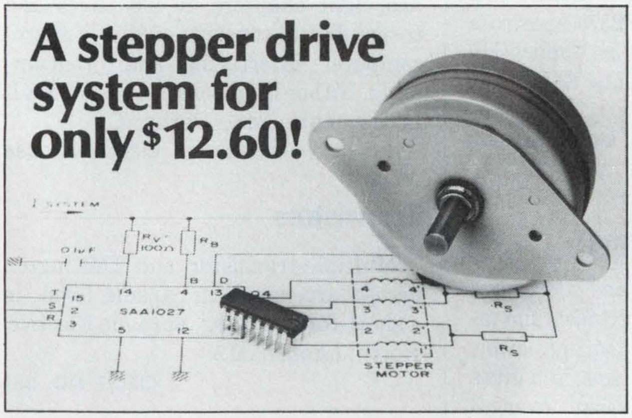

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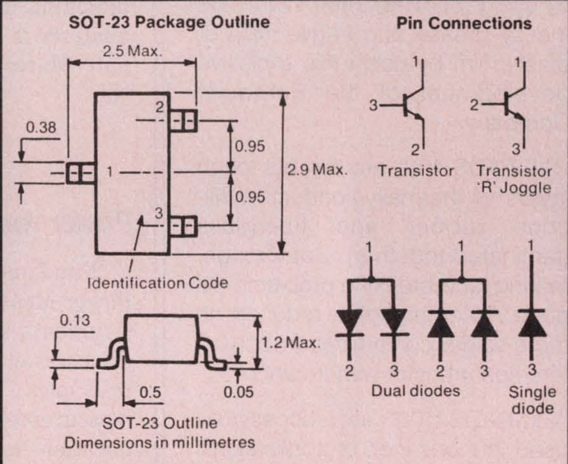

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CIRCLE NUMBER 86

Application notes

Quartz-analog timekeeping

The three basic functions of all quartz-analog timekeeping systems—the crystal-controlled oscillator, the frequency divider, and the electromechanical-clock movement—are detailed in a 16-page catalog. Solid State Scientific, Montgomeryville, PA

CIRCLE NO. 380

Thyristor gating

"Thyristor Gating for Microprocessor Applications," an 11-page report, covers the use of common thyristors, triacs and SCRs, in microprocessor-based control systems for appliance and industrial control applications. Texas Instruments, Dallas, TX

CIRCLE NO. 381

Spectrum analyzers

Impedance measurement and matching using the TF2370 spectrum analyzer is described in an application note. Marconi Instruments, Northvale, NJ

CIRCLE NO. 382

Power measurements

"Fundamentals of Rf and Microwave Power Measurements" reviews the instruments used for measuring power, discusses error mechanisms, and gives principles for calculating over-all measurement accuracy. An HP application note index is also available. Hewlett-Packard, Palo Alto, CA

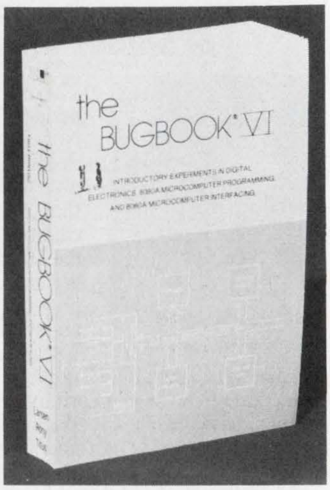
CIRCLE NO. 383

Spike suppressors

A fine analysis of important (and sometimes hidden) characteristics of voltage-surge suppressors and a comparison of the company's TransZorbs with metal-oxide varistors appear in a new printing of an eight-page app note. General Semiconductor Industries, Tempe AZ

CIRCLE NO. 384

New literature



Microcomputer course

A two-volume course, Bugbook V and VI integrates introductory experiments in digital electronics with programming and interfacing an 8080A-based microcomputer. Bugbook V contains 15 chapters in 493 pages and covers the basics of 8080A microcomputer programming. Bugbook VI has eight chapters in 490 pages and covers digital concepts of 8080A microcomputer interfacing and programming. Either Bugbook costs $9.50. E&L Instruments, Inc., Derby, CT

CIRCLE NO. 385

Transistors

Multiple-transistor and Darlington arrays are listed, in capsule form, in a short-form catalog. Sprague Electric, North Adams, MA

CIRCLE NO. 386

Transformers

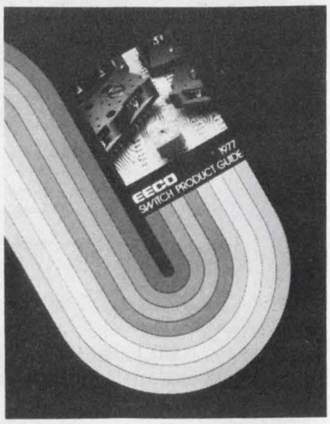
A wide variety of transformers is described in a 12-page catalog. Electrical data, load curves and mounting data are provided. Dormeyer Industries, Chicago, IL

CIRCLE NO. 387

Nematic-liquid crystals

Physical and optical properties of nematic-liquid crystals, electronic grade, are described in an information sheet. 3M, Industrial Optics, St. Paul, MN

CIRCLE NO. 388



Switches

Photos, descriptions, features, options and specifications of PC-board and thumbwheel switches are provided in a catalog. EECO, Santa Ana, CA

CIRCLE NO. 389

Faire proceedings

Proceedings of "The First West Coast Computer Faire" held April 15 to 17 includes copies of the original papers and a list of most commercial exhibitors. Copies of the Proceedings are available for $12. Peoples Computer Co., Menlo Park, CA

CIRCLE NO. 390

SCRs

Photos of silicon-controlled rectifiers for electronic and phase-control applications, dimensional drawings and electrical and mechanical specifications are given in a four-page catalog. International Rectifier, Semiconductor Div., El Segundo, CA

CIRCLE NO. 391

Electronic components

More than 8000 electronic components are presented in an 80-page catalog. Mallory Distributor Products, Indianapolis, IN

CIRCLE NO. 392

Programmable calculators

Forty new books provide owners of HP-67 and HP-97 programmable calculators with solutions to problems in such fields as personal finances, statistics and the natural sciences. The books are priced at $10 each. Hewlett-Packard, 1501 Page Mill Rd., Santa Clara, CA 95051

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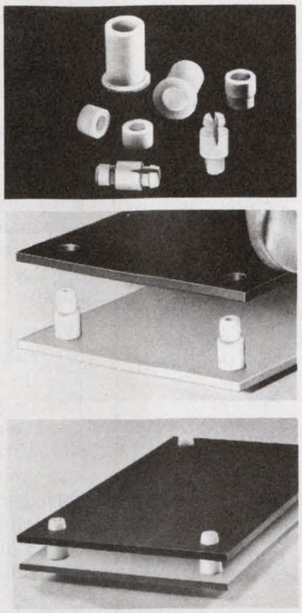

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CIRCLE NUMBER 94

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CIRCLE NUMBER 95

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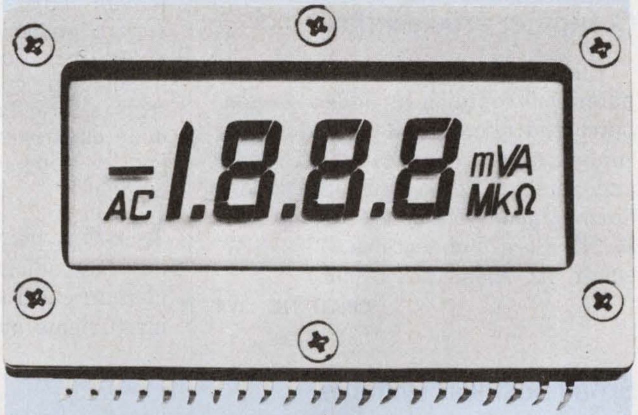
2½'' × 1½''



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CIRCLE NUMBER 96

VMOS

VMOS (V-groove metal-oxide-silicon) technology is the topic of a 16-page brochure. American Microsystems, Santa Clara, CA

CIRCLE NO. 393

Computer article index

The "Periodical Guide for Computerists" contains an index of computer and microcomputer articles, by subject, that have appeared in 23 trade and personal computing publications during January to June, 1977. It costs $3. E. Berg Publications, 1360 S.W. 199th Ct., Aloha, OR 97005.

CIRCLE NO. 394

Small business systems

ANSI-standard COBOL, interactive real-time systems features, the range of applications, and sample configurations of the recently announced CS/40 system are discussed in a brochure. Data General, Westboro, MA

CIRCLE NO. 395

Rental instruments

A 76-page catalog illustrates the latest in analyzers, frequency counters and timers, generators, oscilloscopes and microprocessor design and test systems available for rental. U.S. Instrument Rentals, San Carlos, CA

CIRCLE NO. 396

Cable ties

Cable ties, clamps, marker ties, push-mount ties, and cable-tie-installation tooling are covered in an eight-page brochure. Panduit, Tinley Park, IL

CIRCLE NO. 397

Solenoids

A 40-page solenoid-design manual and catalog includes data on U frame, box frame and cylindrical types in a complete range of sizes and force characteristics. Each model is comprehensively described including operational graphs for each operating mode. Regdon, Brookfield, IL

CIRCLE NO. 398

Vendors report

Annual and interim reports can provide much more than financial position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

Tech-Ops. Radiation monitoring; industrial radiographic equipment; solid-state electronic controls; scientific instruments and broadcasting.

CIRCLE NO. 403

Ocean Data Systems. Minicomputer-based information storage and display systems.

CIRCLE NO. 404

Youngwood Electronic Metals. High-precision metal stampings for semiconductor components.

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quick ads

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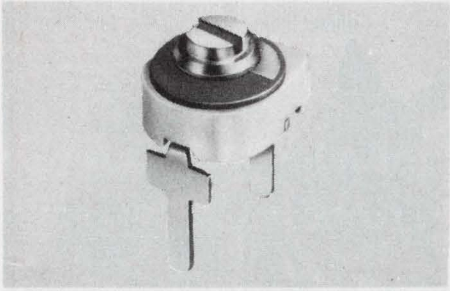

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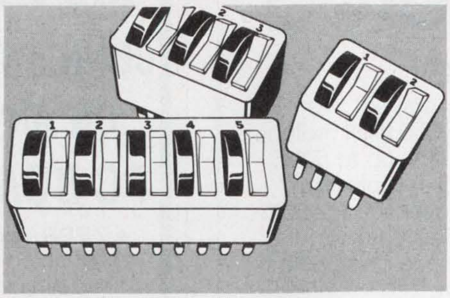

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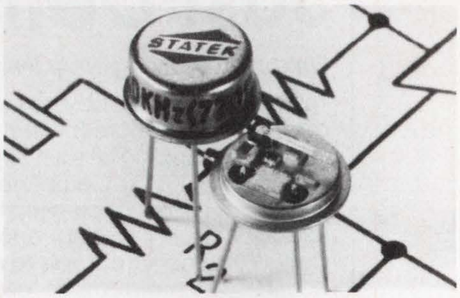

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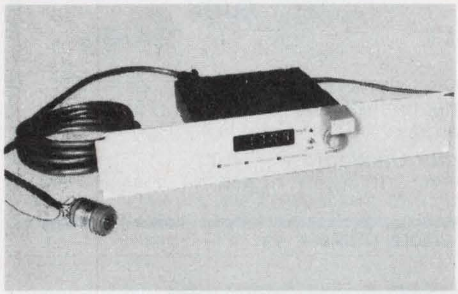

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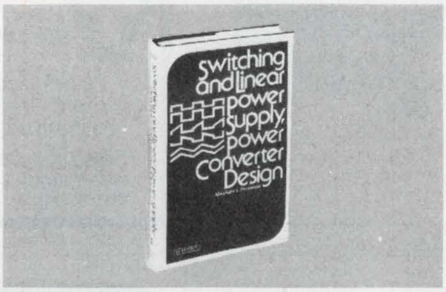

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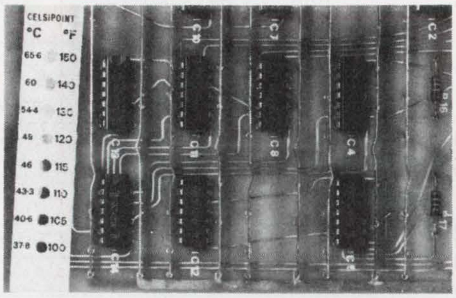
185



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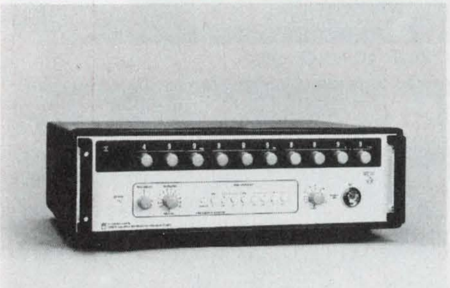

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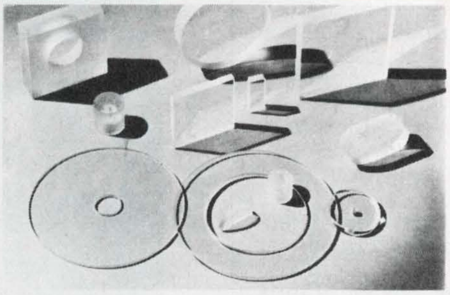

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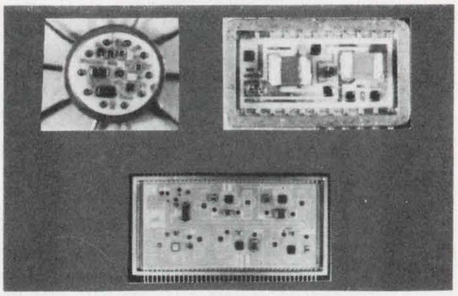

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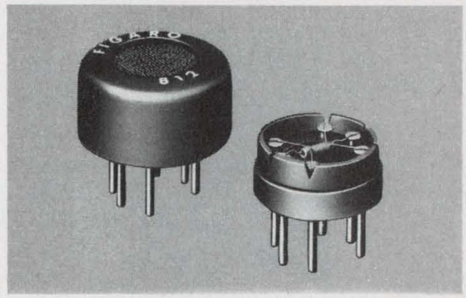

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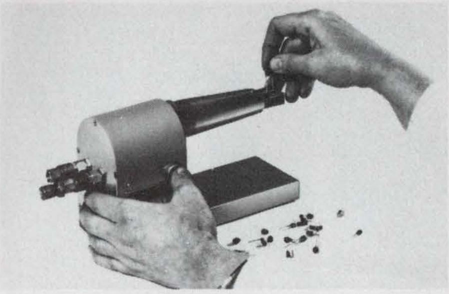

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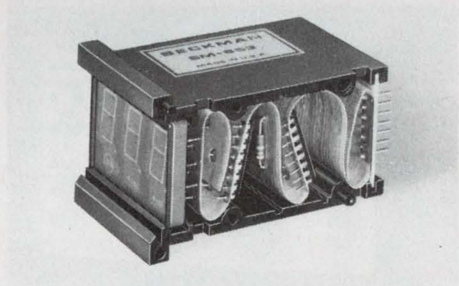

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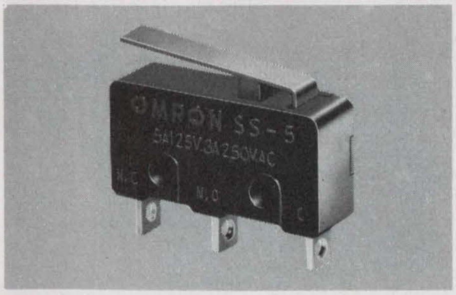

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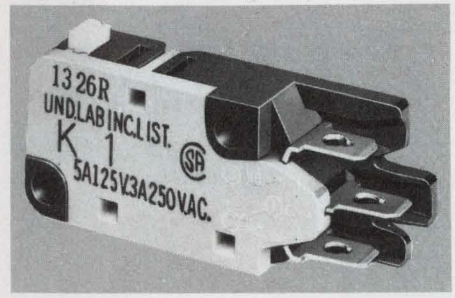

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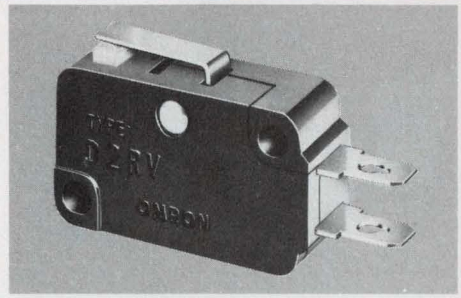

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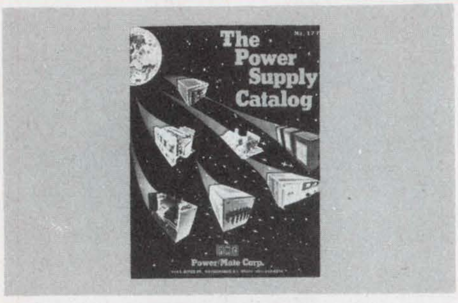

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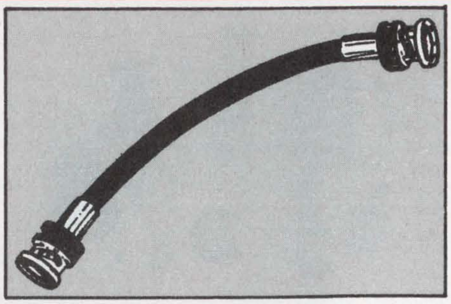

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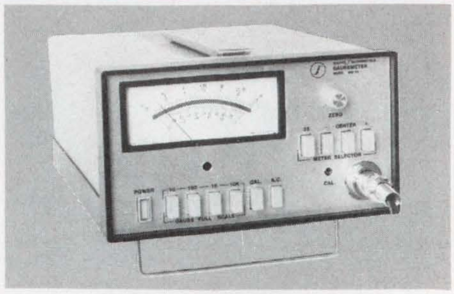

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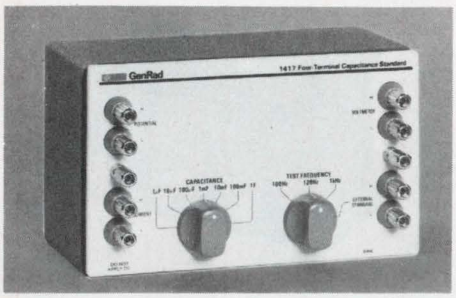

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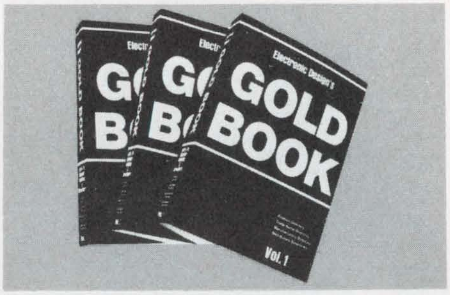

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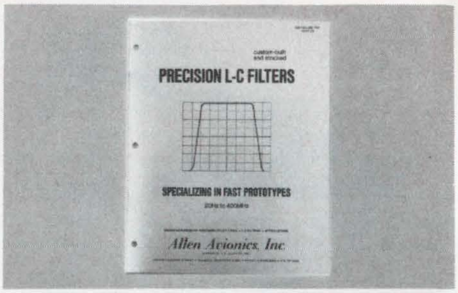

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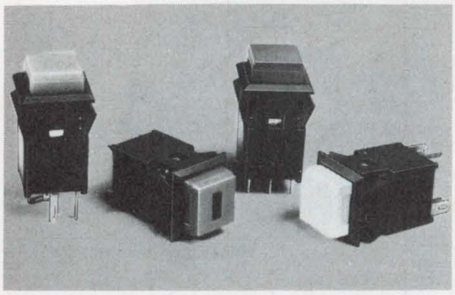

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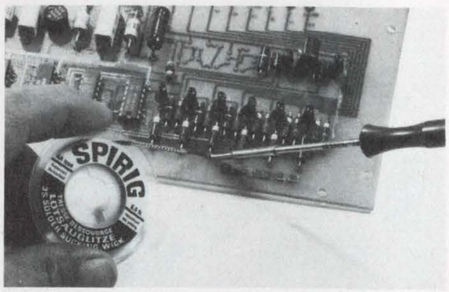

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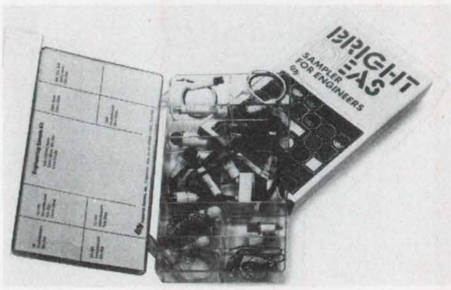

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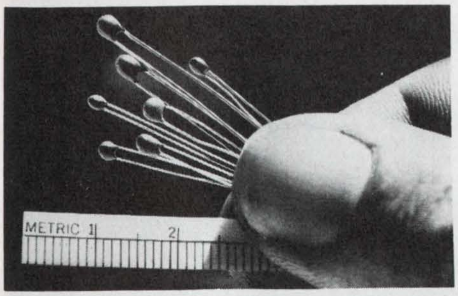

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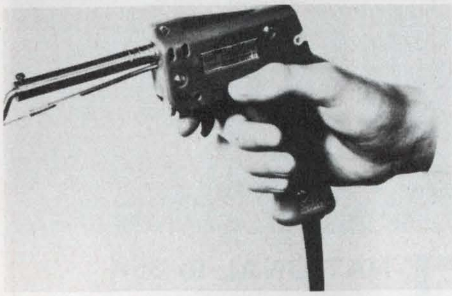

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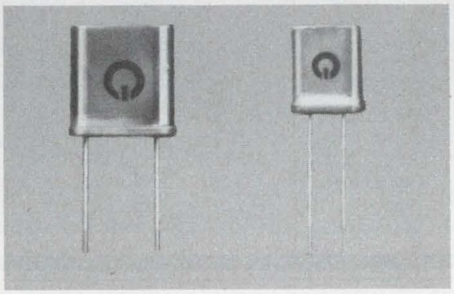

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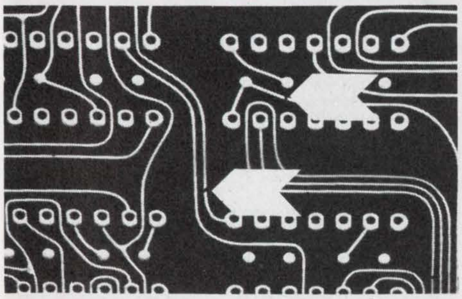

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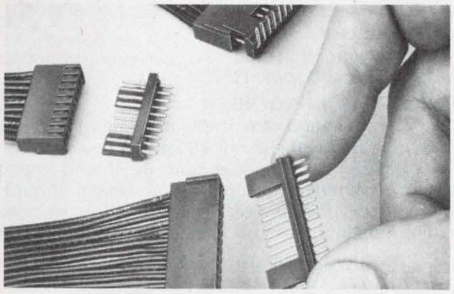

NEW "POL-R-LOK" MINIATURE CONNECTORS FEATURE POLARIZED LOCKING INTERCONNECTS ON .100 CENTERS for consumer electronic applications. Locking polarizing header and mating crimp receptacle available with 2-28 positions. Straight or right angle .025" square pins. Receptacle bellow contacts accommodate 22-30 AWG leads. Flame retardant 94V-O thermoplastic molded connector bodies. 3.5 amp nominal at 250VAC. METHODE ELECTRONICS, INC 1700 Hicks Road, Rolling Meadows, ILL 60008. (312) 392-3500.

MINIATURE CONNECTORS 213

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Electronic Design is mailed every two weeks. Because of its timeliness, personnel recruitment advertising closes only two weeks before each issue's mailing date.

1977 Mailing Date	Recruitment Closing Date	Issue Date on Cover
Oct. 21	**Oct. 7**	Nov. 8
Nov. 4	**Oct. 21**	Nov. 22
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Advertiser's index

RECRUITMENT

**Advertisers in non-U.S. edition* (marked *)

Product index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Reader Service numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

new literature

application notes

New Data Generator
Lets you program and edit with keyboard, then display Hex-Octal-Binary and timing formats.

ides 16 parallel channels - 64 bits deep - bits serial...at data rates to 20 MHz.

odel tes ing

one bit or a continuous run of pre-programmed data at TTL levels.

MICROPROCESSOR INTERFACE... The Microprocessor control allows easy interface with other instruments or systems.

MODEL 720, only $3,950 mplete. Write or call Tom Clark ct for additional information.

Add a **MODEL 741** Logic Analyzer . . . the perfect companion to the Data Generator . . . and observe/analyze parallel or serial data from many subsystems . . . only **$2,750** . . . much below stand-alone cost.

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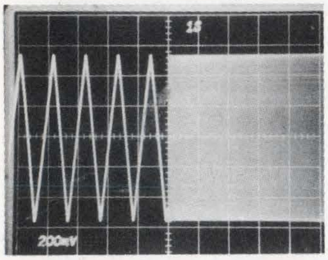
MBER 231

Hot new circuit ideas with RCA op amps and arrays.

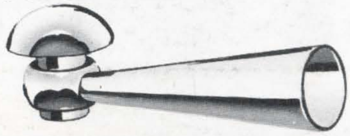
When you put RCA BiMOS op amps together with other RCA op amps and arrays, they have a way of making circuits easier, more effective and often less expensive.

One-knob function generator.



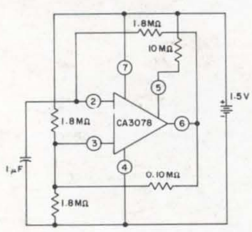
1,000,000/1 frequency range—1 Hz to 1 MHz—with a single control knob and just three op amps. Two CA3080 variable op amps (one on input, one as output hysteresis switch), plus one CA3160 internally compensated BiMOS op amp as buffer.

Electronic alarm.



Wide signal swing of the CA3130 combined with the variable gain control features of the CA3094 produce yelp, wail, two-tone and other sounds in sirens and alarms.

Low-power timing signal.

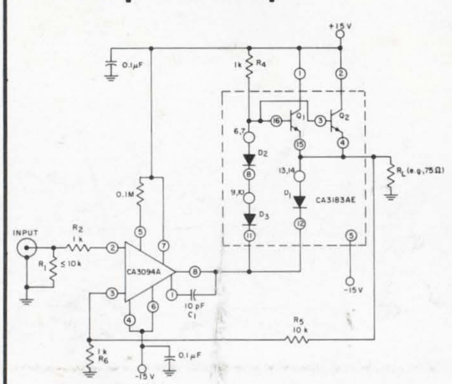


Multivibrator using CA3078 micropower op amp generates a timing signal from a 1.5 V battery supply with just 3 microwatts of power. A CA3078 exclusive.

Bandgap reference supply.

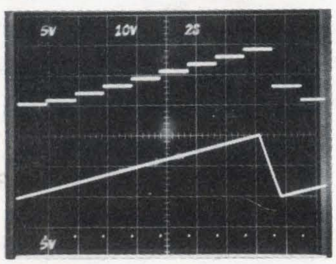
For power supplies and DVMs, it provides 2.35 V reference. Uses a CA3078 micropower op amp as a buffer for the bandgap reference, the CA3086 transistor array. Eliminates need for discrete diodes.

Audio power amp.



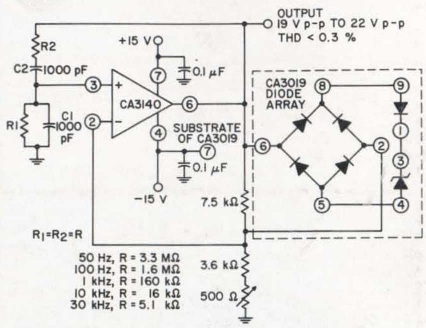
A CA3094 variable op amp plus a CA3183 transistor array provide push-pull output of 100 mA average. Drives high impedance speakers.

Sample-and-hold system.



Ideal for single supply, low-cost applications. Samples inputs ranging from 0 to 10 V. The BiMOS CA3140 makes it possib

Wien bridge oscillator.



CA3140 op amp and CA3019 diode array combine to produce a low-cost wien bridge with 50 Hz to 30 kHz range.

Battery voltage monitor.

CA3097 array h
transistors, SCR
need to provide
signal indicating
charge.

There's a lo
with RCA's f
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