VOL. 23 NO. 25

Electronic Design®

FOR ENGINEERS AND ENGINEERING MANAGERS

DEC. 6, 1975

Monolithic power Darlingtons fill the gap between the high-voltage, low-current switching transistors and the higher-power, but slower, thyristors. They can now deliver currents of over 20 A, peak, and sustain voltages that exceed 900 V. And storage times have been kept under 8 μs. For more Darlington details, see p. 101.

DALE FILM RESISTORS for single source versatility to help you get growing again.

Versatility makes the difference in Dale film resistors. Dale versatility lets you pinpoint exactly what you need in any standard size. Dale volume production and in-depth stocking lets you get what you need faster, while keeping inventories low. It's the right combination for getting recession-stalled projects moving again. Take a look at this chart... then call Dale at 402-371-0080.

WATTAGE	COMMERCIAL	PRECISION	E-REL	HI-VALUE	LOW VALUE
1/20	MF50 24.9-100K .1-1% RN-50	MF50 24.9-100K .1-1% RN-50	EMF50 49.9-100K .1-1%	HMF50 101K-700K 1%	
1/10	CMF-1/10 10Ω-499K .1-5%	CMF55, MF-1/10 30.1-499K .1-1% RN-55	EMF55 30.1-301K .1-1% RNR-55, RNC-55	HMF-1/10 500K-5M 1%	LMF-1/10 LFF-1/10 1Ω-30Ω 1%
1/8	CMF-1/8, MFF-1/8 10Ω-1M .1-5%	CMF60, MF-1/8 30.1-499K .1-1% RN-60	EMF60, EMF-50-10 10-499K .1-1% RNR-60, RNC-60, RLR-05	HMF-1/8 1.01M-10M	LMF-1/8 LFF-1/8 1Ω-30Ω 1%
1/4	CMF-1/4, MFF-1/4 10Ω-2M .1-5%	CMF65 24.9-2M .1-1% RN-65	EMF65 24.9-2M .1-1% RNR-65, RNC-65	HMF-1/4 2.01M-20M 1%	LMF-1/4 LFF-1/4 1Ω-30Ω 1%

FREE! Send for Dale's latest Resistor Wall Chart. A handy, comprehensive reference to more than 100 film resistor styles.

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8 Munchen 60,
Falkweg 51, West Germany

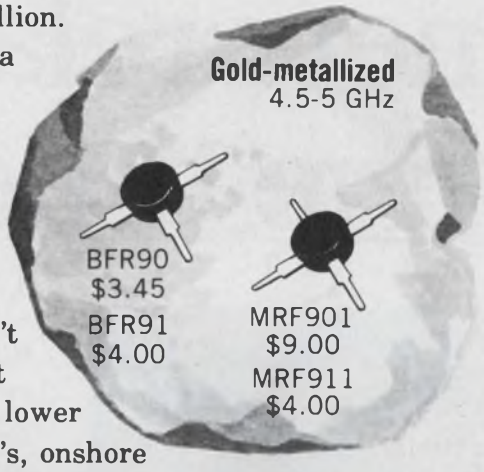
DEPENDABLE DALE®

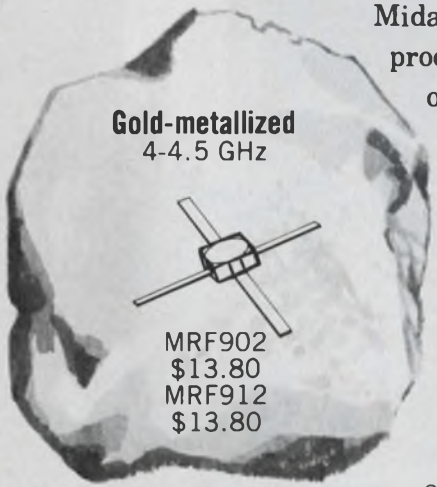
INFORMATION RETRIEVAL NUMBER 246

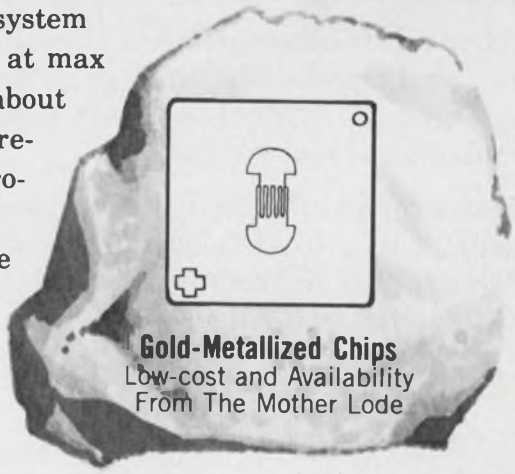
Finding lower cost GHz parts that last is like finding gold.

Lots of you prospect around for low noise, high gain RF devices and end up paying 20 or 30 bucks a throw. And maybe pick up units that soon turn insensitive in your amplifier. Your design's neither economized nor optimized and that's a lot of bullion.

We're introducing a bank of gold-metallized RF pieces that eliminate those problems, have equal or better specs and are priced so low your front end won't believe what it hears. Priced lower than anyone's, onshore or off. ■ Size up the popular plastic BFR90 with 3 dB noise figure and 10 dB gain at 1 GHz. It's just $3.45 . . . more than 27% less than a comparable. Cross-check the new $13.80 ceramic MRF902 furnishing better noise figure — 2 dB at 1 GHz — with another assaying more than double. ■ Explore the metal can MRF904. This gem produces just 1.5 dB noise figure at 0.5 GHz with a price tag of only $3.20. Otherwise, your cost can be an unbelievable $16.50! ■ With our little nuggets and chips it's like being Midas. ■ If you're not turned on by the crass approach, consider the process. Gold-metallization is unquestionably the key to rugged, reliable operation in all military/commercial RF designs. No exception here. Metal and ceramic are qualifiable to MIL Std 19500E and have a theoretical metallization system MTBF of 2.5 x 10^7 hours at max conditions. (Aluminum's about 3 x 10^3 hours.) ■ That's reliability. ■ That's mass production technology. ■ That's Motorola. □ Write us at Box 20912, Phoenix 85036 for data; or, see your authorized Motorola distributor. ■ Get our gold. Don't be touched for yours.







*All prices 1-up.

MOTOROLA RF *Practically Priceless.*

INFORMATION RETRIEVAL NUMBER 2

DC solid state update: new relays now handle five times the voltage.

Not long ago we introduced a line of 50VDC solid state relays. But a lot of circuit designers told us they needed higher voltage switching capability. To deliver meant coming up with an industry *first.* We did. Now Teledyne's new DC solid state relays provide a maximum load rating of *5 amps at 250VDC,* with two control voltage ranges.

PART NUMBER	OUTPUT CURRENT RATING (AMPS)	OUTPUT VOLTAGE RATING (VDC)	
603-1	2	50	
603-2	5	50	
603-3, -4	5	250	
603-21	2	50	Controlled Rise and Fall Time
603-22	5	50	

Our new 603-3 relay offers a TTL compatible 3-10VDC input, and the 603-4 a high level logic compatible 10-32VDC input. What's more, they feature transformer coupling to provide 1500V input/output isolation, and direct drive from the control source for low off-state leakage.

Package configurations provide three mounting options. You can select screw terminals, quick-disconnect terminals, or solder pins for direct pc board mounting.

All in all, Teledyne now has DC solid state relays to handle special high voltage switching problems —particularly for those heavy industrial machine and process control jobs.

For detailed information or applications help, contact your local Teledyne Relays people. They're sure to bring you up-to-date on high voltage DC switching.

TELEDYNE RELAYS

3155 West El Segundo Boulevard, Hawthorne, California 90250
Telephone (213) 973-4545

INFORMATION RETRIEVAL NUMBER 3

VOL. 23 NO.

Electronic Design 25

FOR ENGINEERS AND ENGINEERING MANAGERS

DEC 6, 1975

NEWS

TECHNOLOGY

PRODUCTS

Departments

Cover: Photo by Jerry Nichols, courtesy of International Rectifier.

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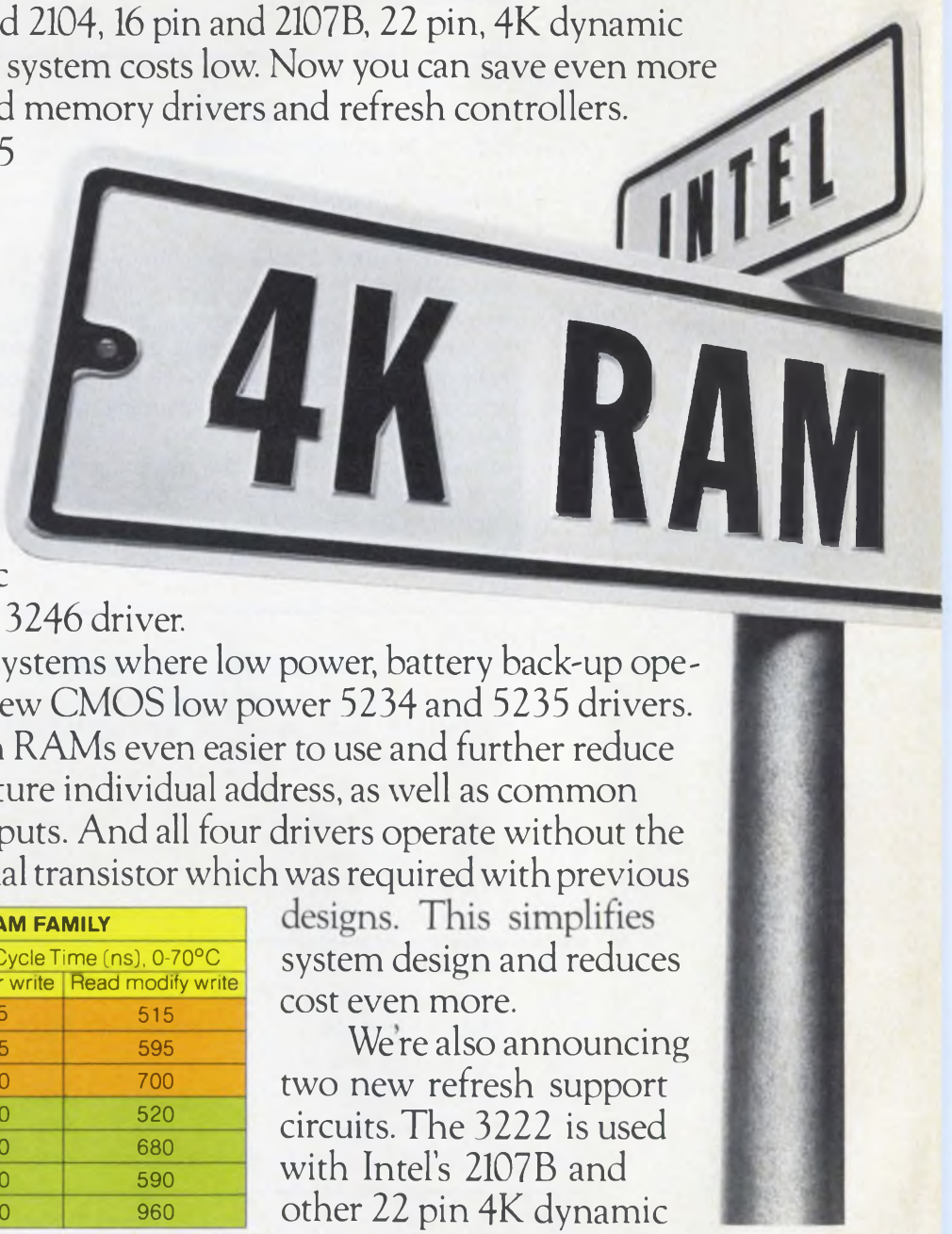
Intel is the way memory drivers and

Intel industry standard 2104, 16 pin and 2107B, 22 pin, 4K dynamic MOS RAMs help you keep system costs low. Now you can save even more with our new family of quad memory drivers and refresh controllers.



The new bipolar 3245 TTL to MOS driver is the first quad driver that does not require an extra 15 volt supply or an external transistor to generate and maintain the MOS clock level. The 3245 is a plug-in replacement for our 3235 and other MOS clock drivers. For ECL logic systems, choose the bipolar 3246 driver.

For CMOS and TTL logic systems where low power, battery back-up operation is required, use our new CMOS low power 5234 and 5235 drivers.

To make our 22 pin RAMs even easier to use and further reduce cost, all our new drivers feature individual address, as well as common refresh, clock and enable inputs. And all four drivers operate without the extra 15 volt supply or external transistor which was required with previous designs. This simplifies system design and reduces cost even more.

INTEL'S STANDARD 4K RAM FAMILY

Part Number	Pins	Max. Access Time (ns), 0-70°C	Min. Cycle Time (ns), 0-70°C	
			Read or write	Read modify write
D2104-2	16	250	375	515
D2104-4	16	300	425	595
D2104	16	350	500	700
2107B	22	200	400	520
2107B-2	22	220	470	680
2107B-4	22	270	470	590
2107B-6	22	350	800	960

We're also announcing two new refresh support circuits. The 3222 is used with Intel's 2107B and other 22 pin 4K dynamic

to go for 4K RAMs, refresh controllers.

RAMs, while the 3232 is designed for Intel's 2104 and other industry standard 16 pin 4K dynamic RAMs. Both of these new circuits operate from a single +5 volt supply, help you simplify system design, reduce power and reduce the number of discrete packages required.

Intel 16 pin and 22 pin 4K MOS RAMs are helping engineers cut system design costs. Now our new quad drivers and refresh controllers make Intel 4K RAMs even easier to use. Save dollars, save space, and eliminate extra power supplies and discrete components. Start saving now. To order contact our franchised distributors: Almac/Stroum, Component Specialties, Cramer, Elmar, Hamilton/Avnet, Industrial Components, Liberty, Pioneer, Sheridan or L.A. Varah.

16 PIN QUAD MOS DRIVERS FOR INTEL 2107B 22 PIN 4K RAMs
Note: Intel 16 pin 2104 4K RAMs are TTL compatible

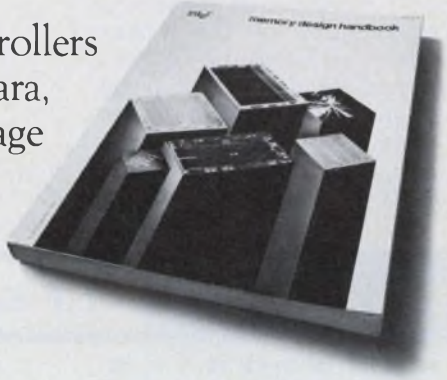
Part Number	Technology	Input Levels	Worse Case Delay & Rise Time 0-75°C	Power Supplies	Power Dissipation Channel
D3245	Schottky Bipolar	TTL	32ns	+5, +12V	75mW
D3246	Schottky Bipolar	ECL	30ns	−5.2, +5, +12V	110mW
D5234	CMOS	CMOS	100ns	+12V	3mW @ 0Hz, 39mW @ 1MHz
D5235	CMOS	TTL	125ns	+12V	
D5235-1	CMOS	TTL	95ns	+12V	

REFRESH CONTROLLERS FOR INTEL 16 & 22 PIN 4K RAMs

Part Number	Pins	Maximum Address Input to Output Delay 0-75°C	Power Supply	Used With
D3222	22	12ns	+5V	2107B
D3232*	24	8ns	+5V	2104

* Available 1st quarter 1976

For data sheets on the new drivers and refresh controllers write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051. For $5.00 we'll send you our new 288 page "Memory Design Handbook." This handbook contains applications notes and useful design information on our line of RAMs, ROMs, PROMs and support circuits.



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INFORMATION RETRIEVAL NUMBER 4

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Across the Desk

The cons and pros of ADC testing

Robert Havener's point in "Catch Missing Codes" (ED No. 16, Aug. 2, 1975, p. 58) that many manufacturers fail to do enough testing to ensure conformance to catalog specifications is well taken. However, the testing technique he suggests—and which, according to him, is in use at Analogic—also has some shortcomings.

First, an ADC tester of the type described by Havener cannot easily be used to check directly for integral linearity (or absolute linearity), a very important a/d converter specification.

Absolute, or integral, linearity error is a measure of how close each ADC code center is to the straight line through which all code centers would pass in a perfect converter. And, in any case, the indirect method (which is too time consuming for regular production use) it uses for checking integral linearity is not optimally precise.

Furthermore, Analog Devices uses a precision dc reference for the input to the unit under test, rather than feedback from the unit itself. This ensures that slowly changing errors are displayed and not compensated.

Second, we've found Mr. Havener's technique of displaying 16 code steps on a standard scope screen to be inadequate, if characterization of code widths and noise to better than 1/4-bit accuracy is desirable. The resolution of the display simply won't permit it.

Third, Mr. Havener's missing code detector can't check for codes that are two bits wide. This is as gross an error as missing codes and as likely to occur in successive-approximation converters. Analog Devices checks its a/d converters with what we call a dynamic cross-plot tester, which displays wide, narrow or missing codes with equal clarity.

One final note: Although Mr. Havener didn't caution his readers, he surely is aware that building test equipment capable of accurately testing ADCs of 12-bit or greater resolution is in itself no trivial task. It requires that great care be given to grounding, shielding, separating analog and digital leads, etc. Our dynamic cross-plot technique, plus other aspects of testing a/d's and d/a's are discussed in more detail in *Analog-Digital Conversion Handbook*, published in 1972, and available from Analog Devices.

Jeff Riskin
Manager of Converter Engineering
Analog Devices Inc.
Modular Instrumentation Div.
Route 1 Industrial Park
P.O. Box 280
Norwood, MA 02062

The author replies

It is important for users of a/d converters to understand how to test converters themselves. While the techniques described in my article are used in various stages of testing at Analogic, we also use high-speed, computer-controlled testers that make literally millions of measurements on every a/d converter, with standards traceable to a few parts per million relative to the Bureau of Standards definition of absolute accuracy. In addition our computerized test equipment is programmed to

(continued on page 8)

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, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

(continued from page 7)
perform a multiplicity of tests encompassing hysteresis, differential linearity, etc., and can plot out complete histograms of transfer functions.

The dynamic Cross-Plot Tester is the common test method described in my article, and I go on to indicate how to overcome the deficiencies of this basic technique.

With respect to absolute linearity, it is well known that properly designed DVMs have integral linearity well beyond that which can be achieved by other methods.

Mr. Riskin's comments about scope resolution make me wonder if he read my article thoroughly. The number of code steps to be displayed on the scope is controlled by switch S_1 in the diagrams. By expansion of the number of poles on the switch, any number (2, 4, 8, 16 . . . etc.) of steps can be displayed.

As for missing codes, quite clearly a code that is 2 bits wide is not missing. A unit with such codes may be out of spec, but that condition will be found either on checks for differential linearity or on histographic printouts. The method described in my article will check for the presence of all codes.

Robert W. Havener

Analogic Corp.
Audubon Rd.
Wakefield, MA 01880

A small gap noticed in Wescon coverage

I was very pleased to see an article covering our Wescon session on "Microprocessors in Medical Instrumentation" in your Sept. 13 issue. However, as chairman of that session (Session 24), I found it rather strange that you should so nicely cover three of the four papers in the session without even mentioning the fourth.

In addition to the three papers cited, there was an excellent paper on "The Microcomputer in Diagnostic Health Care and Patient Monitoring," by Radha Ramaswami of Xerox Corp. In this paper, she not only covered a very important area of application for microprocessors in the medical field, but also discussed the approach of using the microprocessor in a general-purpose microcomputer that can then be incorporated into an instrumentation system.

We find it difficult to understand why coverage of this paper was omitted.

Fred J. Weibell
Chief, BECC

Veterans Administration Hospital
Sepulveda, CA 91343

Editor's Note: The article was written before Wescon opened, and our reporter made three or four telephone calls to the author to elicit information. She was unavailable each time and did not return the calls. It's difficult to publish information when it isn't made available.

Misplaced Caption Dept.

"Now the way we go after this order . . ."

Sorry. That's Rembrandt's "The Night Watch," which hangs in The Rijksmuseum, Amsterdam.

A plug for digital control of microprocessors

I wish to comment on the article "Mating Microprocessors with Converters" (ED No. 18, Sept. 1, 1975, p. 76).

The full potential of microprocessors will be realized in digital control systems that use digital sensors and digital actuators, not in control systems employing analog inputs and outputs and conversion modules. To take advantage of the cost, power, weight and size benefits of microprocessor technology will require the use of digital sensors and digital actuators, such as stepping motors. Control-loop problems resulting from conversion errors are eliminated and noise and interface problems are greatly reduced.

Siltran presently offers position sensors with word lengths up to 12 bits and pressure sensors with word lengths up to 7 bits. All sensors are fully compatible with TTL or CMOS logic levels.

M. F. Hordeski
President

Siltran Digital
P.O. Box 437
Silverado, CA 92676

A double-cross

Two captions that appeared in the special computer issue, ED No. 22, Oct. 25, 1975, were placed under the wrong photos. The caption on Hewlett-Packard's 2644A Data Terminal, which appeared under the photo on p. 55, belongs with the photo on top of p. 91. The Omron 8025 caption on p. 91 belongs under the photo on p. 55.

Comments on 'Females' and 'The Shortcut'

I would like to comment on two of George Rostky's recent editorials. First, I doubt that anyone, not even Charlie, could confuse chipped beef on toast with French delicacies ("Look Men, Females," ED No. 20, Sept. 27, 1975, p. 49). Charlie would much more likely to be thinking of ways to make the same ingredients more appetizing. Innovation most often begins not with some pointless desire merely to be different, but with a value judgment: "This is ridiculous. There must be a better way." (Incidentally, such value judgments are often confused with arrogance, particularly when a well-established orthodoxy is called into question.)

"Necessity is the mother of invention" is another way of saying it, except that nowadays it's important to add: ". . . if there's time to think and freedom to act." One of the great benefits of a free market is precisely the freedom of action it affords.

(continued on page 19)

MEASUREMENT COMPUTATION NEWS
innovations from Hewlett-Packard

DECEMBER 1975

in this issue

New On-line/Off-line Mini DataStation saves computer time and data transmission costs

Program preparation, editing, tape copying, and tape-to-printer operations are now the domain of an off-line CRT terminal. HP's newest microprocessor-controlled 2644A Mini DataStation allows you to perform these and myriads of other operations normally requiring costly and often inconvenient connection to a computer.

220,000 bytes of local mass data storage has transformed the powerful HP 2640A CRT terminal into a new kind of terminal. The key to data storage is in the two fully-integrated cartridge tape transports using the newly developed shirt-pocket size version of the 3M data cartridge. The advantages over cassettes include reliability, assured inter-

(continued on third page)

HP-9815A: Big calculator features in a new small package

The new 9815 calculator combines keystroke calculating convenience, dedicated problem solving and an optional two-channel I/O to give you versatility and power in solving problems from the simple to the sophisticated.

A new AUTO-START capability and high-speed dual-track data cartridge capable of storing 96,384 bytes of data and programs are features that make the 9815A calculator a viable and easily customized choice for virtually any lab. Add the optional interface capabilities and you can easily extend powerful 9815 desk-top computing capabilities.

The 13-pound (5.9 kg) calculator features the Hewlett-Packard stack-oriented logic system simplifying keystroke calculations and giving you answers you can trust. The buffered keyboard contains 24 preprogrammed functions, 4 arithmetic keys plus keys for memory-stack manipulation.

The thermal printer prints up to 16 characters per line at 2.8 lines per second. In addition, there is an easy-to-read numeric display.

With the addition of the optional two-channel I/O structure, you can add 9800 Series peripheral devices, including the new 9871 printer/plotter, (see right column), 9862 plotter, tape readers or tape punches, or a digitizer.

The 9815 also mates with BCD instruments and devices with 8-bit parallel interfaces. The 9815 accommodates the Hewlett-Packard Interface Bus, (HP-IB) allowing you to control, gather, and process data from as many as 14 different HP-IB compatible test and measurement instruments.

The 9815 contains computer language functions for programming power and performance. The standard 9815 has 472 steps of program memory and 10 data storage registers. An option is available to expand the calculator's internal memory to 2,008 program steps.

Many standard problem solutions are available from the extensive library of pre-recorded programs in statistics, engineering, science and surveying.

For more information, check P on the HP Reply Card.

Prepare charts, graphs and text easily under program control with new printer

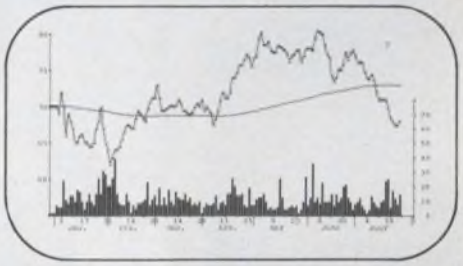
The new HP 9871A printer extends the output characteristics of the 9800 series desk-top programmable calculators including the new HP 9815A (see story on this page).

This new impact printer is a full-character, fixed carriage peripheral that can be used to fill out forms, create reports, draw charts and plot graphs using the bi-directional platen and carrier. It also features programmable horizontal and vertical tabulation.

In addition to the standard 96-character, upper/lower case print wheel, optional interchangeable wheels are available for ASCII character sets and European character sets.

The 9871 is a versatile printer, accommodating paper up to 15 inches (38 cm) wide and prints up to 132 columns at 10 characters per inch. Average printing speed is 30 cps. Six-part paper in single-sheet or continuous-feed form may also be used.

For more information on interfacing this new printer/plotter to your 9800 series calculator, check Q on the HP Reply Card.



Interchangeable printwheels are shown with new rugged 9871 output printer.

New On-line/Off-line Mini DataStation saves computer time and data transmission costs

(continued from first page)

changeability, and lower error rates. One cartridge contains the equivalent of 1000 feet of paper tape—enough for many hours of off-line work.

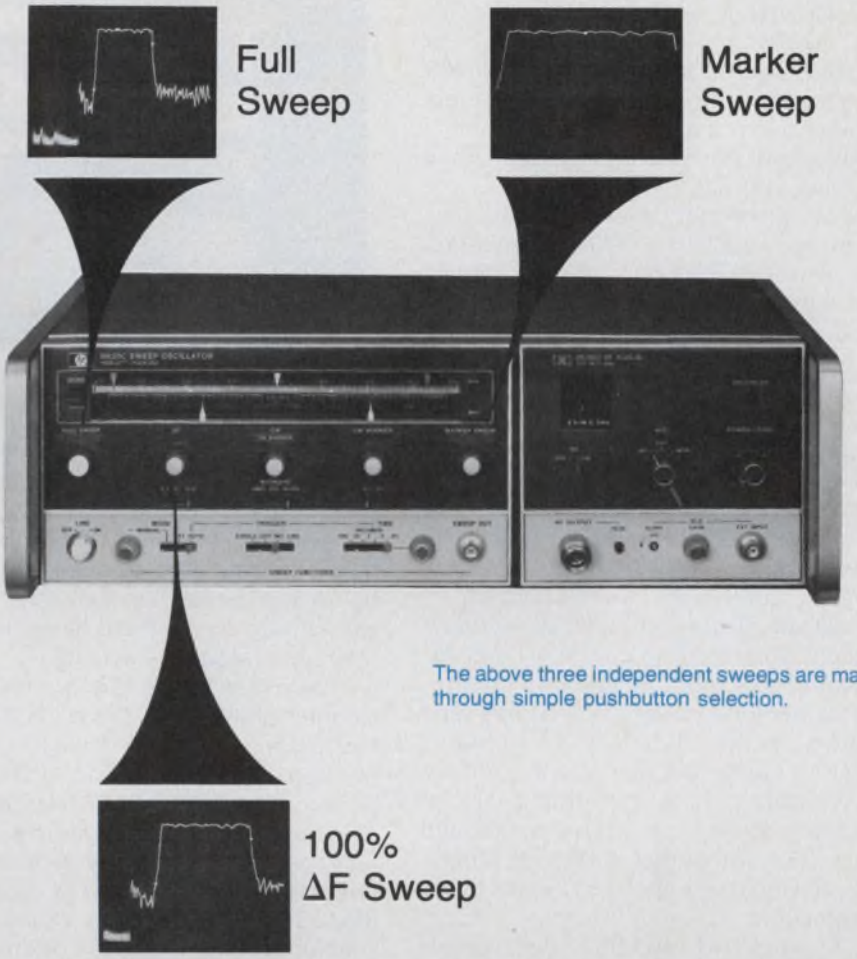
Here are some of the operations you can perform on the 2644:

- Enter data from the keyboard and view the data instantly on a high-resolution 7×9 dot enhanced display. Up to 4 different 128-character sets may be in the 2644.
- Store data on tape. Many hours of work at the keyboard can be stored on a single cartridge by pushing a single button—and selectively retrieved in seconds.
- If data entry requires a form, call any of up to 255 variable-length files stored on tape and retrieve the form you want at 60 ips search speed, usually within 10 seconds—with pushbutton ease.
- Edit the data, using the 2644's full editing capabilities, including character and line insert and delete, cursor sensing and positioning, and programmable protected fields.
- Batch-transmit stored data to the computer directly from the cartridge, at transfer rates up to 2400 baud.
- Move data among the 2644's functional units by pushbutton—between tapes, semiconductor memory, optional printer, and data communications interface.
- Expand terminal applications by using the 2644's dual tape unit so that one cartridge provides a write-protected input while the other provides a separate output.

The 2644 not only conserves computer resources and reduces communications line charges, it also improves the efficiency of data entry and provides a valuable backup during computer down-time.

To receive your copy of detailed specifications and performance information, check C on the HP Reply Card.

More markers, more sweeps, with new sweeper mainframe



The above three independent sweeps are made through simple pushbutton selection.

The new HP 8620C mainframe for HP's solid-state sweep oscillators offers highly useful new sweep modes plus up to three frequency markers for additional operating flexibility. Start with the FULL SWEEP mode: Just press the button and the RF plug-in's full band is swept. You have three frequency markers (select either "amplitude" or "intensity" markers) available to bracket and pinpoint portions of the full-band sweep. Then press the MARKER SWEEP button and the sweep now covers from the START marker to the STOP marker. In this mode, the CW marker is still available. Press the CW and ΔF buttons and you now have another independent sweep (in which the START and STOP markers can be used). The ΔF sweep, symmetrical around the CW frequency, can be as wide as 100% of the full band. This is 10 times greater than could be swept with the 8620C's predecessor (HP 8620A). Yet the 8620C still retains the narrow band ΔF and "CW Vernier" capabilities that permit very high frequency resolution and settability.

The 8620C mainframe offers two forms of frequency programming as options: BCD programming (Option 001) or through the HP Interface Bus (Option 011). Either form permits selection of 10,000 frequency points per band. RF plug-ins covering from 3 MHz to 18 GHz are available for the 8620C, including ultra wideband units spanning 10 to 2400 MHz and 2 to 18 GHz.

For more data, check N on the HP Reply Card.

New portable DMM has five full functions and 1 μV dc/10 μV ac sensitivity

HP's new 3465A digital multimeter lets you measure low-level voltage with 1 microvolt dc resolution and sensitivity. AC voltage resolution and sensitivity of 10 microvolts is provided on the 100 MV range. Your choice of ac lines or battery power make it attractive for use as a lightweight portable service tool, while serving your lab needs.

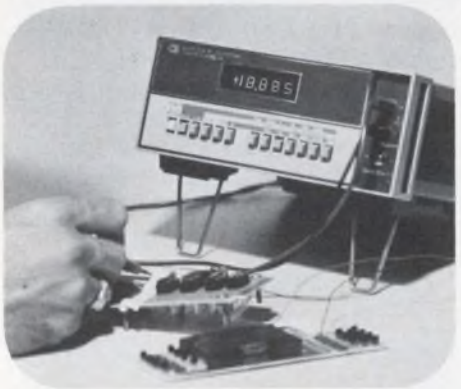
Full functional capability with high sensitivity make it a preferred measurement tool for troubleshooting in the lab or in the field. Its ease of use, low cost and unambiguous display, plus input protection, makes the HP 3465A especially attractive.

This new DMM gives you dc voltage accuracy of ±.02% of reading ±.01% of range on most often used ranges. The ac voltage accuracy is ±.15% of reading ±.05% of range for midband frequencies over the audio range. Ohms are measured from 10 milliohm sensitivity to 20 megohms with an accuracy of ±.02% of reading ±.01% of range for most ranges. Both ac and dc current measurements range from 10 mA sensitivity on the 100 μA to 2 A on the highest range. The dc current accuracy is typically ±.11% of reading ±.01% of range, and the ac accuracy at midband is ±.25% of reading ±.05% of range. There is a front panel 2A fuse for input protection.

The standard 3465A has rechargeable batteries. Option 001 is for AC operation only, Option 002 uses 4 Type D batteries.

For additional details, check D on the HP Reply Card.

Look at the front panel and you see what the 3465A can do for you. Look inside and you will see the latest technology with only seven adjustments for routine maintenance. Low cost to buy, and low cost to own were design considerations.



New synchronizer/counter improves usefulness of low cost signal generator

Now you can phase-lock the 8654A/B signal generator with the new HP 8655A synchronizer/counter for very low drift and 500 Hz resolution.

Tuned-circuit-type signal generators such as the HP 8654B are hard to beat for good spectral purity and non-harmonic signals more than 100 dB below the carrier. But they tend to exhibit turn-on drift and have only moderate frequency accuracy.

Now a new HP 8655A Synchronizer/Counter phase-locks the HP 8654A/B Generator to bring drift down to 0.1 ppm per hour. It can be locked to 500 Hz points across its 10-520 MHz range.

In the phase-locked mode, the excellent spectral purity of the generator is preserved as well as the FM capability (up to 100 kHz deviation). Operation is simple; after tuning to the desired frequency as indicated on the 6-digit LED display, a push of the LOCK button establishes phase lock to the displayed frequency.

The 8655A also serves as a versatile counter with excellent RFI performance, a very important consideration when used next to microvolt test signals. Less than 1.5 μVolt leakage is induced in a 2 turn-1 inch diameter loop at a 1 inch distance.

In the external count mode, frequencies from 1 kHz to 520 MHz may be measured to a sensitivity of 100 mV into 50 ohms. An internal crystal oscillator provides better than ±2 ppm accuracy within 3 months and over 15° to 35°C.

Provision is made to mechanically couple the synchronizer to the 8654A/B generator for excellent portability. The combination weighs 14 kg (31 lbs.) and is small in size.

To learn more, check O on the HP Reply Card.

Automate your process with a calculator-based multiprogrammer

Process engineers can now plug together and program their own automatic test and process control system quickly and economically. It's all made possible with a calculator-based HP Interface Bus (HP-IB) Multiprogrammer System designed for ease in communicating bi-directionally with your process instrumentation.

A basic system includes the controller, a desk-top programmable calculator (HP Models 9830, 9821, or 9820), connected via the HP-IB to a multiprogrammer interface unit, a 6940B multiprogrammer, and from 1 to 15 randomly-addressable I/O cards that plug into the 6940B mainframe.

Up to 15 extender mainframes, each holding 15 plug-in cards, can be combined permitting system expansion up to 240 I/O channels controlled by a single calculator.

Several different types of multiprogrammer input and output cards are available to interface with your process instruments. Input card functions include current monitoring, voltage monitoring, digital input, counting, and event sensing. Output functions cover stimulus and control including voltage, current, resistance, relay contacts, digital bit patterns, stepping motor control, time and frequency references. Cards may be added or changed as the functions of a real-time test and control system change.

To learn more, check J on the HP Reply Card.

HP-IB Multiprogrammer building-block components (center modules above), bring the power, economy, and ease of programming of HP desk-top programmable calculators to your automation job.

Programmable HP-25 has built-in power to solve technical problems

Preprogrammed to solve 72 scientific, engineering and mathematical functions, the HP-25 saves you time solving your difficult technical problems. In addition, it has 8 addressable memories, each capable of register arithmetic.

The HP-25's programming power includes a 49-step memory. Each step in this memory can accommodate multi-keystroke functions, because the keycodes of *all* prefixed functions—including the register arithmetic functions—merge. Thus, you gain extra capacity.

With the HP-25, you enter the keystrokes necessary to solve your repetitive problems only *once*. Thereafter, you just enter the variables and press the Run/Stop key for an almost instant answer you know is accurate.

You can add, change or skip steps. You can program the HP-25 to perform direct branches or conditional tests.

And it's the first hand-held to offer not only *fixed* and *scientific* but also *engineering* notation (i.e., exponent displayed as a multiple of $10^{\pm 3}$ as in giga and nano).

The RPN logic system with 4-register stack allows you to evaluate any expression without copying parenthesis or worrying about heirarchies or restructuring before entering.

For your copy of a descriptive brochure, check the HP Reply Card.

Short form catalog of power supplies for the lab or system

Hewlett-Packard power supplies are available in many types, sizes and ranges. Most DC supplies available from HP are described in a new 8-page illustrated catalog. Voltage and current ratings, performance specs, size and operating features are included.

Covered in this catalog are bench-type units for circuit testing and development, modular supplies to power systems, high-power supplies for industrial processes and many special purpose units ranging from bi-polar supply/amplifiers to digital power sources.

Available power options and ordering information are included.

This catalog is free of charge and may be obtained by checking S on the HP Reply Card.

To help you select the power supply most suitable for your application, this new catalog will be of valuable assistance.

Coaxial and Waveguide catalog and Microwave Measurement handbook

RF and microwave engineers will find plenty of use for HP's brand new 1975-76 edition of the *Coaxial & Waveguide Catalog*, 80 pages of product descriptions and specifications on over 300 microwave components. Product sections include Attenuators, Detectors, Couplers, Filters, Power sensors, Slotted lines, and many more.

The book is also intended as a *Microwave Measurement Handbook*. Over 20 pages are devoted to a technical summary of common measurements of impedance, attenuation, power, frequency, noise figure in both waveguide and coaxial systems.

Typical section titles listed below will interest design engineers, production test personnel, metrology labs, and others working on microwave measurements.

Microwave Measurement Matrix
Equipment Selection Matrix
Associated Instrumentation
Reference Literature for Microwave Engineers
Important Specifications for Attenuators
Waveguide Standard Data Chart

For your free copy, check R on the HP Reply Card.

Application Note describes dynamic measurement of microwave VCO's

The new Application Note 173-1, "Dynamic Measurement of Microwave VCO's with the 5345A Electronic Counter," describes a simple technique for determining the frequency-vs-time characteristics of fast-tuning VCO's to 18 GHz. This technique, centered about the 5345A Electronic Counter and its microwave plug-ins, is ideal for measuring VCO ringing and overshoot characteristics, risetime, settling time, and post-tuning drift.

Using the set-up described in AN 173-1, measurement resolution of microwave frequencies is better than 1 MHz, while resolution on the time axis is as fine as 5 nanoseconds. These values far exceed the capabilities of discriminators now used to make these measurements.

Of course, the technique is also applicable to sub-microwave VCO's. An accompanying application note AN 173, "Recent Advances in Pulsed RF and Microwave Frequency Measurements," discusses in detail the theory, techniques, and set-up considerations for this class of measurements.

For your copy of both of these Application Notes, check T on the HP Reply Card.

Several unique features of the 5345A Electronic Counter—external gating, frequency averaging, and the ability to accept plug-in microwave down-converters—are exploited to achieve an exciting new class of high-speed frequency measurements.

Display the external trigger as a *third* trace on new data domain oscilloscope

A new scope ideally suited for data-domain analysis and general purpose measurements including low-level signals of read/write heads, power supplies, electro-mechanical transducer outputs.

Special characteristics of the new Hewlett-Packard 1740A 100-MHz oscilloscope make it a logical first choice as companion instrumentation for today's data-domain analysis.

With the new third channel trigger, you can have a simultaneous display of the trigger waveform *plus* channel A and B traces. You can make accurate time measurements from the trigger signal to events on either or both channels.

In the data domain, you can combine the 1740A with HP's 1607A logic state analyzer offering a solution to digital troubleshooting with the combination of logic state and electrical analysis. Option 101 to the 1740A adds rear-panel inputs with internal switching circuits for convenient single push-button switching between the standard front panel inputs and the rear panel state display inputs without changing any cables. This single pushbutton switching capability is very useful when digital word-flow errors require analysis of electrical parameters to determine correcting measures.

5 mV/division at 100 MHz provides the detail needed to study ECL and other fast, low-level signals. A vertical magnifier provides 1 mV sensitivity on both channels to 40 MHz for measuring low-level signals without cascading problems. And, for maximum measuring flexibility, the 1740A has switch selectable 1 megohm or 50Ω inputs.

This scope with its new ideas simplifies both real-time and data-domain measurements.

For your copy of a technical data sheet, check B on the HP Reply Card.

8580B Component Test System and new application program for more effective stimulus-response testing

The HP 8580B Automatic Spectrum Analyzer is now available with a new component test option (Option 300) that makes major contributions to stimulus-response testing. These contributions include the capability for swept IM measurements for amplifiers and mixers, conversion loss for mixers, and for high dynamic range (120 dB) measurements. These measurements are difficult, if not impossible, to make manually.

The 8580B Option 300 adds to the base system an additional source control unit which can multiplex up to three sources plus CTEST, a microwave application program that provides powerful and flexible measurement capabilities.

Difficult test measurements can be made quickly and easily using CTEST, or programs can be easily generated by the customer in high level BASIC or FORTRAN with the TODS-II Disc Operating System.

The HP 8580B with Option 300 is capable of making the following measurements:

- VSWR
- Return Loss
- Frequency
- Power
- Isolation
- Conversion Loss/Gain
- Gain/Loss at equal frequencies
- IM and Harmonic Distortion
- Unwanted Mixing Products

The system is flexible enough to test a variety of devices such as active and passive components, subsystem modules and systems.

The Component Test System provides a practical solution to production testing needs. Its accuracy, speed, ease of operation and measurement versatility will provide an attractive return on investment through lower test costs, higher yield, and improved productivity.

For more information on the HP 8580B with Option 300, check M on the HP Reply Card.

Add a new dimension to your plotted graphics with a time-share plotter

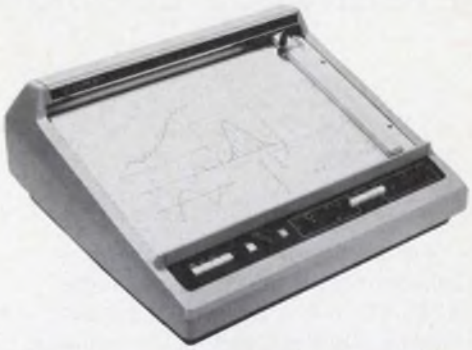
Using a highly efficient data transfer format, the HP 7203A high speed X-Y plotter can plot up to seven vectors per second in *any* direction.

Each data coordinate is expressed with a binary number and represented by the bit pattern of two successive ASCII characters. Thus, only 4 characters are required to define any move. ASCII characters are accepted at 10 *or* 30 cps through a standard RS232C compatible interface.

Operating in parallel with data communications terminals, graphs can be plotted on any size paper up to 27.9 × 43.2 cm (11 × 17 in).

Paper is held by an electrostatic paper holdown. Front panel controls allow adjustment of graph limits to fit a plot to any preprinted grid. Four colors of ink are available in disposable pens. Pens are changed quickly and easily so that plots may be superimposed in color for comparison.

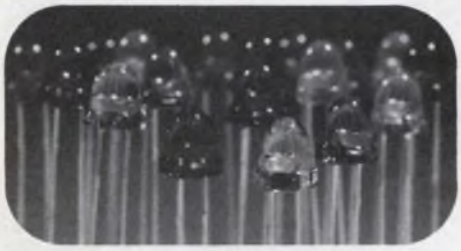
For more information, check K on the HP Reply Card.



Add a fast digital X-Y plotter to your communications terminal and display your data in easy-to-understand charts and graphs.

HEWLETT-PACKARD COMPONENT NEWS

New low-profile lamps in three colors



New low profile LEDs in three colors, narrow or wide beam, ideal for compact applications.

HP introduces a new low-profile configuration of solid state lamps: 5.8 mm (0.23 in) nominal. These high-effiency red, yellow and green LED lamps are packaged in a T-1¾ outline and are available in diffused and non-diffused types providing you with the choice of wide or narrow viewing angles.

These lamps are high intensity, IC compatible, have general purpose leads and operate at low current levels.

Models available are as follows:

	Viewing Angle	
Color	Wide	Narrow
Yellow	5082-4590/92	5082-4595/97
Hi-Efficiency Red	5082-4690/93	5082-4694/95
Red	5082-4790/91	—
Green	5082-4990/92	5082-4995/97

For more information, check R on the HP Reply Card.

New microwave high Q varactor offers maximum stability even in harsh environments

Hewlett-Packard 5082-1300 series tuning varactors are manufactured using a diffused junction mesa structure. Low surface leakage is insured in that the diode is passivated with silicon nitride and silicon dioxide.

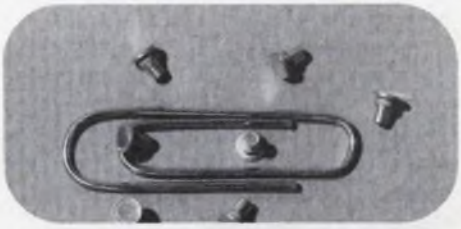
These varactors are optimized for high Q with high tuning ratio. Various package styles, as well as chips are available.

Designed for applications requiring a high Q with high tuning ratio, the devices are also suitable for use with transistor, Gunn or IMPATT oscillators.

For a technical data sheet with specifications, check H on the HP Reply Card.

Applications for these new varactors include tunable filters, voltage tuned oscillators and AFC loops.

New high power, high efficiency silicon double drift IMPATT diodes for CW power sources



New IMPATT diodes have the reliability to exceed the requirements of MIL-S-19500.

Two new double drift silicon IMPATT (Impact Ionization Avalanche Transit Time) diodes are now available with output of 3W from 5.9 to 8.4 GHz.

Double drift IMPATT diodes offer advantages of higher power and efficiency, lower junction capacitance per unit area, and lower fm noise, as compared to single drift IMPATT diodes.

Because of their high output power, efficiency, and reliability, these devices are ideally suited for use as the active element in C-band oscillators and amplifiers in point-to-point telecommunications links.

For details, check G on the HP Reply Card.

New selective level measuring set for faster, more accurate management of Frequency Division Multiplex system

New selective level measuring set for attended or unattended FDM system surveillance.

HP introduces a new concept in selective level measuring sets, the 3745A/B. It is a powerful new tool specifically designed for surveillance, maintenance and commissioning of Frequency Division Multiplex (FDM) Carrier Systems. Ability to tune in terms of an FDM Plan numbering scheme and make highly-accurate measurements using dedicated filters, distinguishes the 3745A/B from a traditional SLMS.

Measurement capability includes a frequency range from 1 kHz to 25 MHz and true rms measurements from +15 dBm to −125 dBm, depending upon the filter selected. A resolution of 0.01 dB and purpose-designed, flat-topped filters give accurate measurements of channel powers, group powers and pilot levels. The narrow-band pilot filter can be used for other single-tone measurements.

A micro-processor controls all instrument functions, including receiver tuning via a synthesized local oscillator. The SLMS can be operated from the keyboard or remotely, using a suitable calculator or computer, via the Hewlett-Packard Interface Bus (HP-IB).

There are two versions of SLMS, the 3745A and 3745B. The 3745A contains information on CCITT Recommended FDM Plans, and the 3745B contains information on BELL FDM Plans.

For a data sheet on the 3745A (CCITT), check E on the HP Reply Card.
For information on the 3745B (BELL), check F on the HP Reply Card.

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Europe-P.O. Box 349, CH-1217 Meyrin 1, Geneva, Switzerland, Ph. (022) 41 54 00.
Canada-6877 Goreway Drive, Mississauga, Ontario, L4V 1L9, Ph. (416) 678-9430.
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BIGGEST
WORLD'S LARGEST EXCLUSIVE MANUFACTURER

Thousands of PEP Scan Converters are at work on hundreds of different OEM and single system applications. PEP "image computers" are being used in industrial process controls. At research laboratories. For medical electronics. In the fields of X-Ray and Ultra Sound. PEP has solved the largest range of image storage problems. And PEP has the largest staff of specialists exclusively dedicated to the design, manufacture, sales and service of scan converters.

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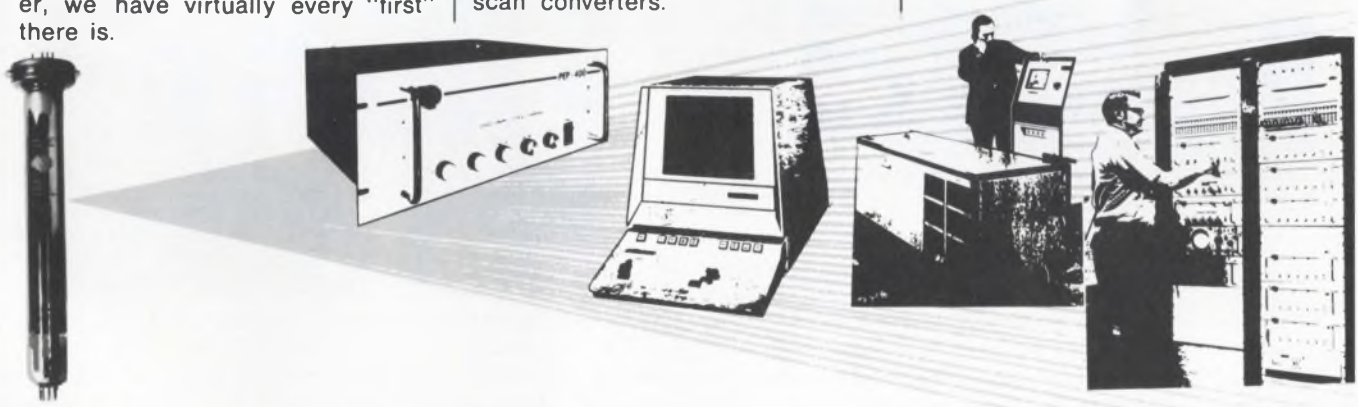
IN PERFORMANCE AND TECHNOLOGY

PEP's Lithocon II has made possible the practical world of electronic imaging. It accepts millions of bits of information, manipulates it, and then puts the information out again in a form specially processed for television and visual display. During the past seven years our constant refinement and practical experience in image processing has resulted in the best performing, most technically advanced equipment available anywhere.



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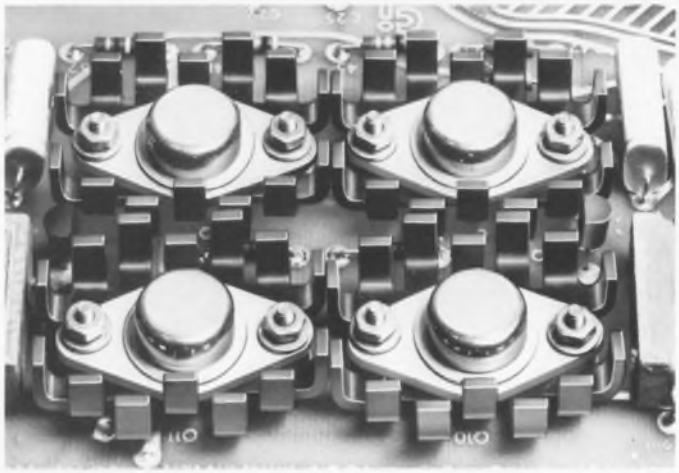
PRINCETON ELECTRONIC PRODUCTS, INC.

INFORMATION RETRIEVAL NUMBER 161

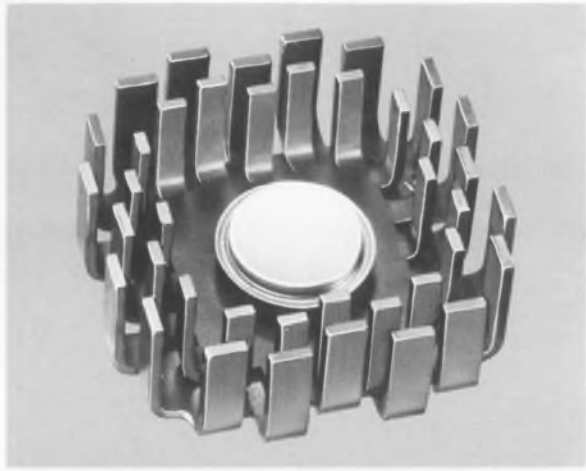
These semiconductor cooling ideas improve circuit performance and reliability, cut costs.

No. 7 of a Series

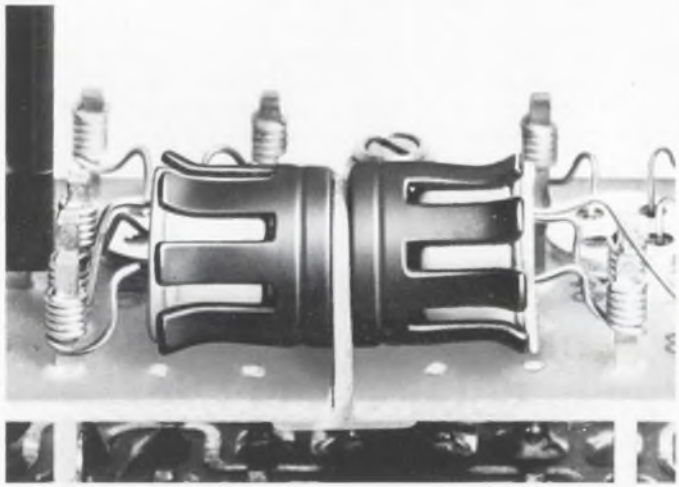
Engineers use Staggered Finger heat dissipators, Thermal Links, Fan Tops, and other IERC thermal management devices to solve a wide range of circuit design and packaging problems dealing with power, reliability, switching speeds, circuit density, stability, reproducibility, and cost. Here are four ideas that may suggest new ways you can put IERC dissipators to work for you.



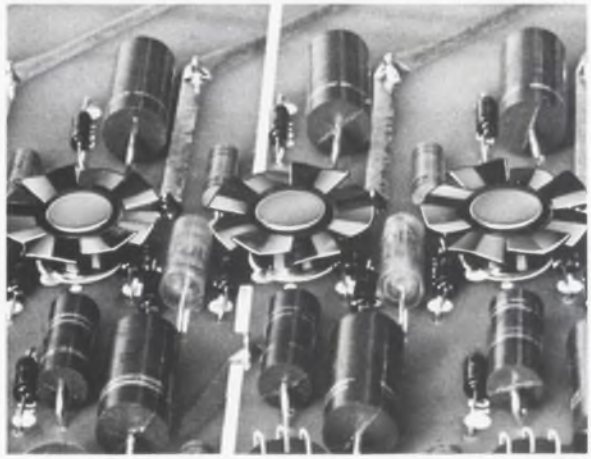
More power, higher reliability from the same TO-66s is a paradoxical requirement, but designer met it in this amplifier circuit with LB Series Staggered Finger dissipators. Nominal case rise above ambient of 90°C for bare case TO-66s permits 3 watts dissipation per device. Adding LB s doubled transistor life by giving 10°C temperature drop while increasing power to 5.5 watts per device.



Design-to-cost criteria were missed in a touchy servo amplifier because 4 parallel devices required too much testing and matching. Designers went to single TO-6 cooled by nested HP1 and HP3 Staggered Finger dissipators. At 100°C case rise above ambient, the single TO-6 dissipates 36 watts, plenty for the application.



Erratic flip-flop in high-G environment posed problem until IERC Thermal Links came to the rescue. Thermal Links held the TO-5s firm, increased their thermal mass, and linked the two cases to a common heat sink. Resulting lowered junction temperature permitted more stable operation and higher reliability while thermal matching assured a balanced circuit.



Faster switching speeds and lower junction temperatures at the same power levels without spending a bundle was called for after bread board testing of this circuit. Adding IERC Fan Top dissipators to the TO-5s held junction temperatures well below maximums and substantially improved rise and fall times. And the press-on Fan Tops cost just pennies.

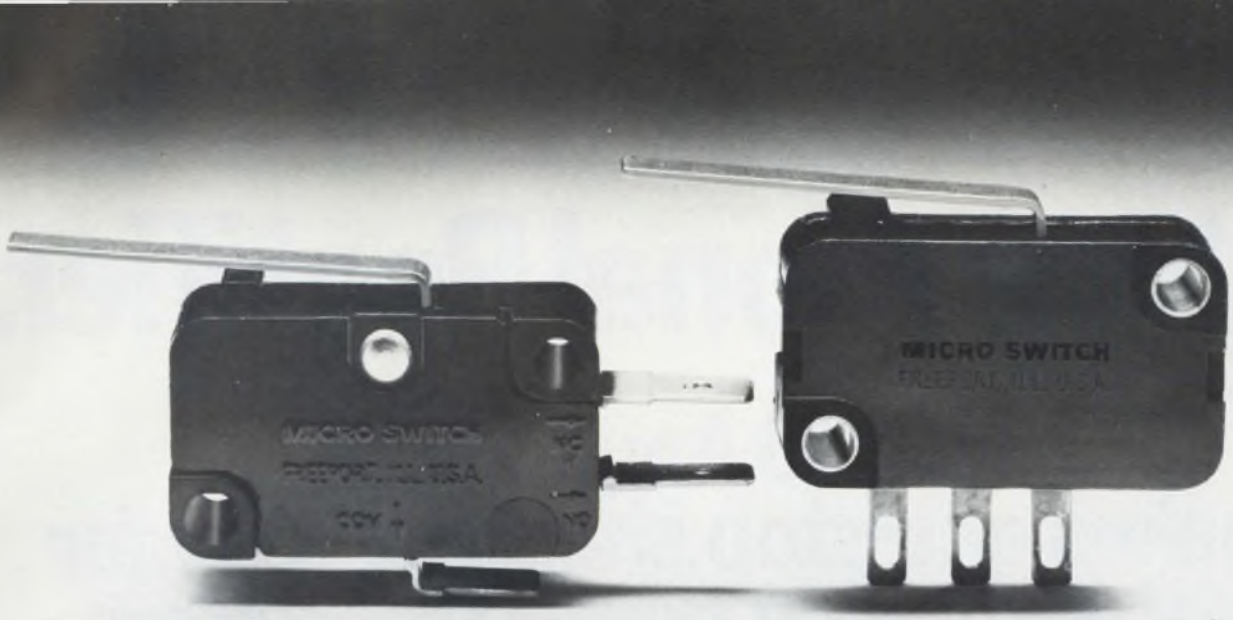
For more information
on heat sinks and dissipators for milliwatts to kilowatts, send for the IERC Short Form Catalog today. It covers the most complete line of thermal problem solving devices available anywhere.

IERC DCA

Heat Sinks/Dissipators

INTERNATIONAL ELECTRONIC RESEARCH CORPORATION / A SUBSIDIARY OF DYNAMICS CORPORATION OF AMERICA / 135 WEST MAGNOLIA AVENUE, BURBANK, CALIFORNIA 91502

INFORMATION RETRIEVAL NUMBER 162



One of these is a new solid state switch. It's important that you can't tell which one.

The switch on the left is the V3. A mechanically-actuated snap-action switch the size of a postage stamp. It was an industry first when MICRO SWITCH introduced it in 1943. And it's gone on to become the industry standard, with hundreds of millions in use worldwide.

The switch on the right looks like the V3. Mounts like the V3. It's even actuated like the V3. And that's exactly where the similarities end. Because it's all solid state inside.

Designed around a Hall-effect integrated circuit perfected by MICRO SWITCH, the XL has been made to provide every benefit of true solid state design without the necessity of getting out of mechanical control.

Because the XL is all solid state, there are no contacts to bounce or become contaminated. And the Hall-effect integrated circuit has been performance tested through over 12 billion operations without a single failure. Unlike standard mechanical switch designs, the XL can also interface directly with other solid state components. Its 20MA output eliminates the need for amplifiers, in most applications. And you can order it with either current sinking or current sourcing outputs.

It needs very little force for actuation—down to 10 grams. Even less with a lever. And the choice of actuator styles is the same as for the V3: over 500 different actuators in all. Including simple pin plunger, straight lever, simulated roller or roller lever.

Power supply requirements are also flexible. 5 VDC or 6 to 16 VDC with built-in regulator, over a temperature range of −40°C to +100°C.

So the XL obviously offers some unique advantages. It's just one of a wide range of MICRO SWITCH solid state designs that do. Including a complete range of magnetically operated solid state position sensors, like the ones pictured here.

If you'd like more information on the XL, or any of the other MICRO SWITCH solid state switches, call your nearest MICRO SWITCH Branch Office or Authorized Distributor. Or write for literature.

We'll tell you the advantages of solid state design in your particular application.

And about a switch that looks very familiar. But works like nothing you've ever seen.

Products shown are actual size.

MICRO SWITCH
FREEPORT, ILLINOIS 61032
A DIVISION OF HONEYWELL

MICRO SWITCH products are available worldwide through Honeywell International.

CIRCLE 231 FOR DATA
CIRCLE 232 FOR SALESMAN CALL

International Rectifier.

New 10 Amp device makes one-stop shopping easy for fast-switching power transistors.

Now, IR is your source for a wide variety of 3, 5 and 10 Amp JEDEC fast-switching power transistors, to simplify your buying. These hard-glass passivated devices are the ones to use for better reliability and lower costs in line operated power supplies, whether you're chopping line voltages at 20 KHz or inverting and stepping down at high frequency.

Fast Switching Speed—Cooler Operation . . . the oscillographs show typical fall times in the one-microsecond and lower range. Gives extremely low switching losses for cooler operation and higher reliability.

Lower Leakage — High Temperature Stability . . . with ICEO in the microamp range, IR devices are about one-tenth the accepted leakage rates of others. Provides the higher stability important for high performance at elevated temperatures.

High Second Breakdown — High Reliability . . . high second breakdown helps provide a broad safe-operating area for an extra margin of safety.

Glass Passivation — Long Term Reliability . . . high reliability and long term stability is achieved by hard glass passivation. Also, if you're using chips to make your own circuits, IR's glass passivation gives you the most stable, easy to assemble chips you can start with, making your yields higher.

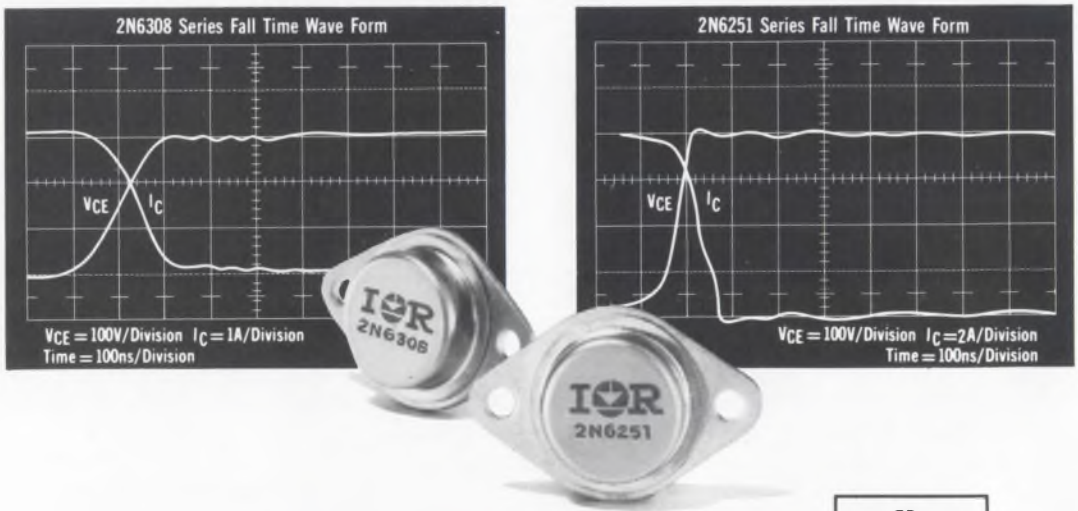
If you are paralleling devices, the tight gain, switching time and saturation voltage control of these transistors make the job easier. And through 100% testing of key parameters we can provide even closer matching if necessary.

JEDEC types listed are immediately available, so contact your local IR salesman, rep or distributor today.

International Rectifier, 233 Kansas Street, El Segundo, California 90245. (213) 678-8261.

New International Rectifier Fast Switching Power Transistors

IR Part No	$V_{CEO(sus)}$ (Max V)	I_C Peak (A)	h_{FE} (min/max)	@ I_C(A)	$V_{CE(sat)}$ (Max V)	@ I_C(A)	P_d (W)	t_r/t_f (μs)
2N6306	250	16	15/75	3.0	0.8	3.0	125	.6/.4
2N6307	300	16	15/75	3.0	1.0	3.0	125	.6/.4
2N6308	350	16	12/60	3.0	1.5	3.0	125	.6/.4
2N6542	300	10	7/35	3.0	1.0	3.0	100	.7/.8
2N6543	400	10	7/35	3.0	1.0	3.0	100	.7/.8
2N6544	300	16	7/35	5.0	1.5	5.0	125	1/1
2N6545	400	16	7/35	5.0	1.5	5.0	125	1/1
2N6249	200	30	10/50	10.0	1.5	10.0	175	2/1
2N6250	275	30	8/50	10.0	1.5	10.0	175	2/1
2N6251	350	30	6/50	10.0	1.5	10.0	175	2/1



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INFORMATION RETRIEVAL NUMBER 163

DANA INTRODUCES THE SMART COUNTER.

Series 9000: World's First Microprocessing Timer/Counter.

The Dana Series 9000 is smart enough to make your work a lot easier.

Microprocessing controls provide all the features of a premium timer/counter, a reciprocating counter and a calculator. Plus interfacing options and operating capabilities never before available in one instrument. Like automatic measurement of rise/fall time and pulse width.

The Dana Series 9000 Microprocessing Timer/Counter goes so far beyond all other counters it takes a whole brochure just to explain its capabilities. Ask for it. It's the smart thing to do.

Dana Laboratories, Inc., 2401 Campus Drive, Irvine, California 92664.

OR PRODUCT DEMONSTRATION CIRCLE # 251

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Others measure by us.

General Electric's New "44 Series" CCTV Cameras Provide...

1" VIDICON PERFORMANCE AT 2/3" PRICES!

And that's only the beginning! General Electric's 4TE-44 camera systems feature:

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- Automatic Operation—NO External Controls!
- Automatic patented beam current regulation—NO image tube adjustment!
- Sensitivity of 0.05 FC faceplate is unmatched!
- Resolution of 600 TV Lines!
- Indoor, Outdoor models!

Put this CCTV innovation by General Electric to work. Use the Reader Service Card number below or contact General Electric Company, Imaging Systems Operation, Rm. 104-Bldg. 7, Electronics Park, Syracuse, N.Y. (315-456-3293).

GENERAL ELECTRIC

INFORMATION RETRIEVAL NUMBER 167

Two years of a wealth of incredible information on MICROPROCESSORS brought right up to date by Electronic Design

We sifted through the last two years of ED and found an incredible amount of practical information and advice on selecting micros . . . using them to your best advantage . . . improving them for better speed and broader application. We compiled it all into one convenient handbook — **MICROPROCESSORS: New Directions for Designers.** If you'd like to see a copy, circle the information retrieval number below and we'll send you one to read and use FREE for 15 days. At the end of time, just send in a check for $8.95, or return the book.

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(201) 843-0550
INFORMATION RETRIEVAL NUMBER 95

(continued from page 8)

"The Shortcut" (ED No. 21, Oct. 11, 1975, p. 55) may have been an attempt to illustrate the difference between finding "a better way" and sacrificing product integrity for the sake of expediency. But the term "shortcut" actually obliterates the distinction by emphasizing deviation from orthodoxy, as if the orthodoxy and the act of deviating from it were more significant than the nature of the new idea itself.

When new ideas fail, what is important is not that they were new but that their underlying *reasons* were inadequately recognized.

The same is true of *old* ideas that fail when used indiscriminately. (I say indiscriminately because the problem is quite different when an idea is used with the expectation that it *will* fail, as so often happens when loyalty to orthodoxy is given precedence over the integrity of the work.) Good maps and careful planning are indeed invaluable, even when you're traveling on a well-beaten path.

David W. Johnson
17062 Green St.
Huntington Beach, CA 92649

The prime test

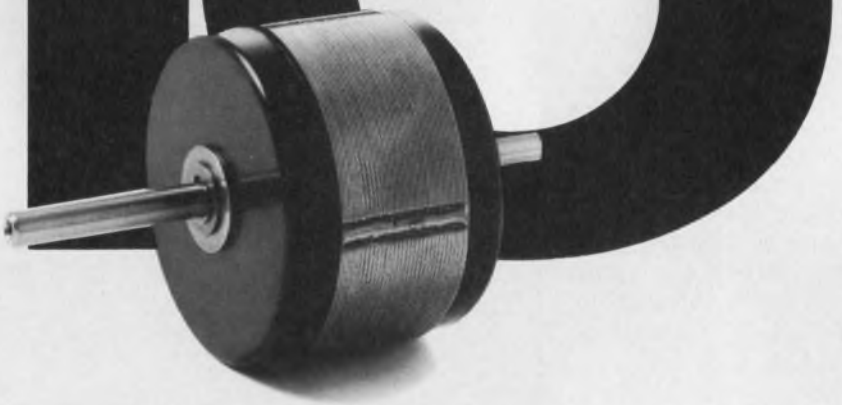
Dr. Jack Hubbs, president of E-H Research Labs, divulges an engineer's test of the hypothesis that all odd numbers are prime:

One? Yes. . . . Three? Yes. . . . Five? Yes. . . . Seven? Yes. . . . Nine? Well, experimental error. . . . Eleven? . . .

Vendor missing

Milton Ausman, 787 Mesa Way, Richmond, CA 94805, is looking for a vendor who has apparently disappeared. The company, John Griffin Co., used to be in St. Paul and made circuit-symbol stamps that were handy for making reproducible schematics on hatched paper. Can anybody help?

$13



Yet our new Econo-Line Stepper Motor is big enough for tough EDP jobs, and versatile enough to use wherever you might need it.

This is one time when 13 has to be considered a *lucky* number. Our new stepper motor costs only $13 each in 10,000 quantities. (We've equally remarkable prices for lesser quantities.)

And not only is the price tag on Kearfott's Econo-Line outstanding, but so is what's inside the motor.

This stepper motor takes the tough jobs in stride—for example, in printers, card punches, tape readers, paper drives. Plus any other application calling for a size 19 motor producing stepping torque up to 6 inch ounces at stepping rates of 200 pulses per second.

Its many attractive features include:

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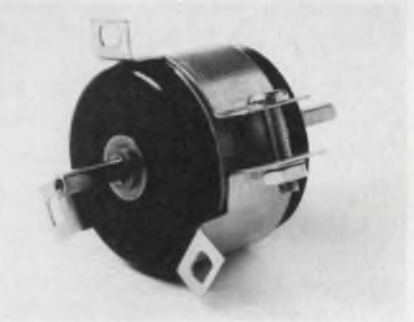
- ☐ Stepping angle _____ 15°
- ☐ Nominal voltage _____ 12Vdc
- ☐ Winding resistance _____ 5.8 ohms/phase

The Econo-Line also fits in a smaller space than that variable motor drive you may be paying more for right now. And, in keeping with its thrifty price, it is easily mounted in your product with a standard 27¢ capacitor clamp.

In these inflationary times, it takes more than good luck to get a good product from a good source at a good price. So, why not get all the details?

Write The Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, New Jersey 07424.



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INFORMATION RETRIEVAL NUMBER 8

INFORMATION RETRIEVAL NUMBER 9 ►

we got the bugs out of D.I.P. switches

The most common bug in dual in-line program (D.I.P.) switches has been the problem of open circuits.

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Call your local Licon rep or distributor for full details or call or write us for a catalog. Licon, A Division of Illinois Tool Works Inc., 6615 W. Irving Park Road, Chicago, Illinois 60634. Phone: (312) 282-4040. TWX 910-221-0275.

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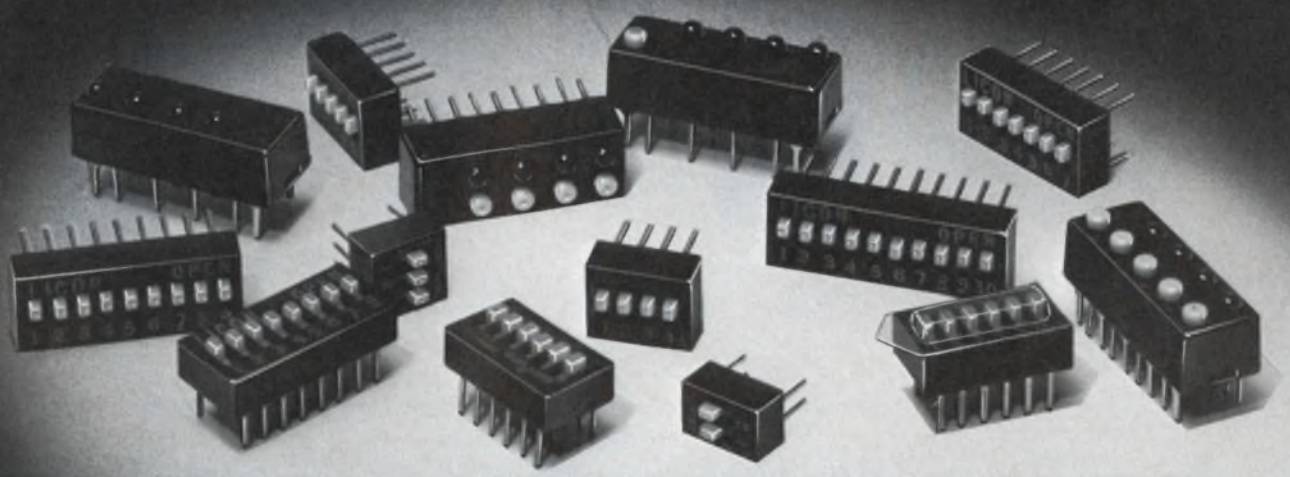

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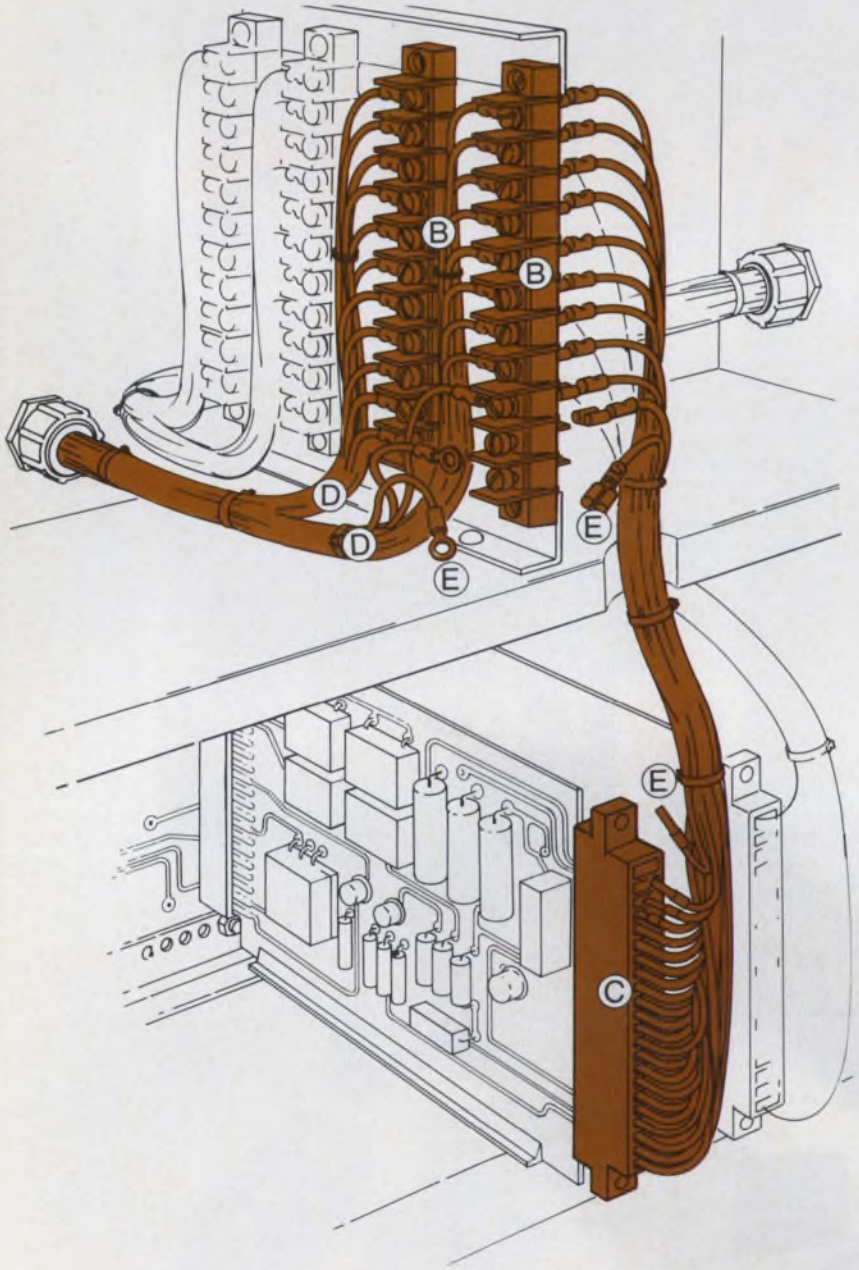
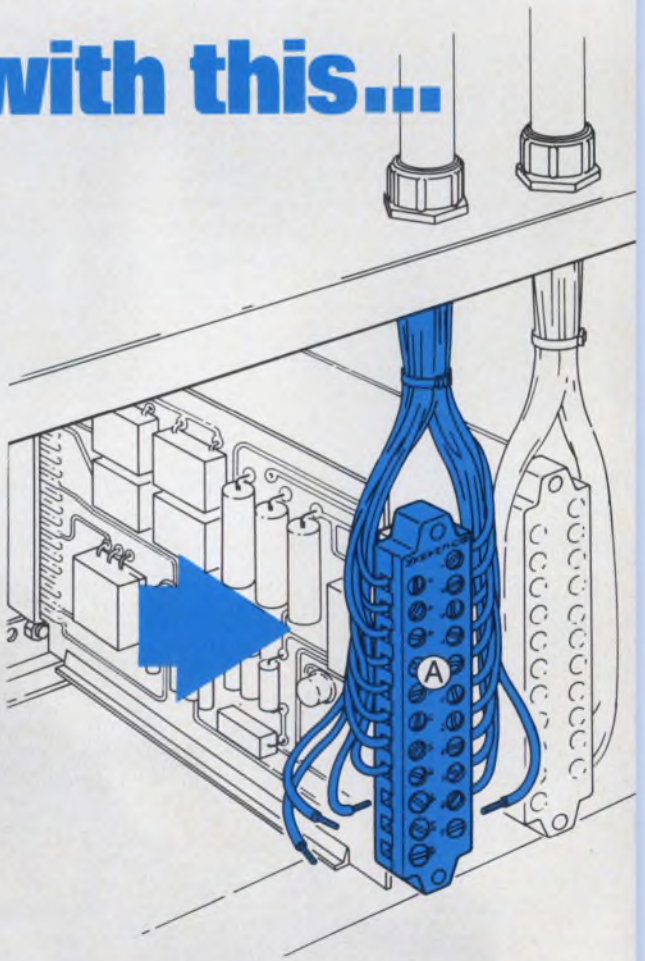
replace this...



with this...



Just one Buchanan Printed Circuit Board Connector (A) replaces the two barrier strips (B), the edge card connector (C), the double wiring (D), and the 110 costly terminations (E) shown at left. Result: LTIC (Lower Total Installed Cost)!

to the problem to the outside world!

with Buchanan® PCB Connectors

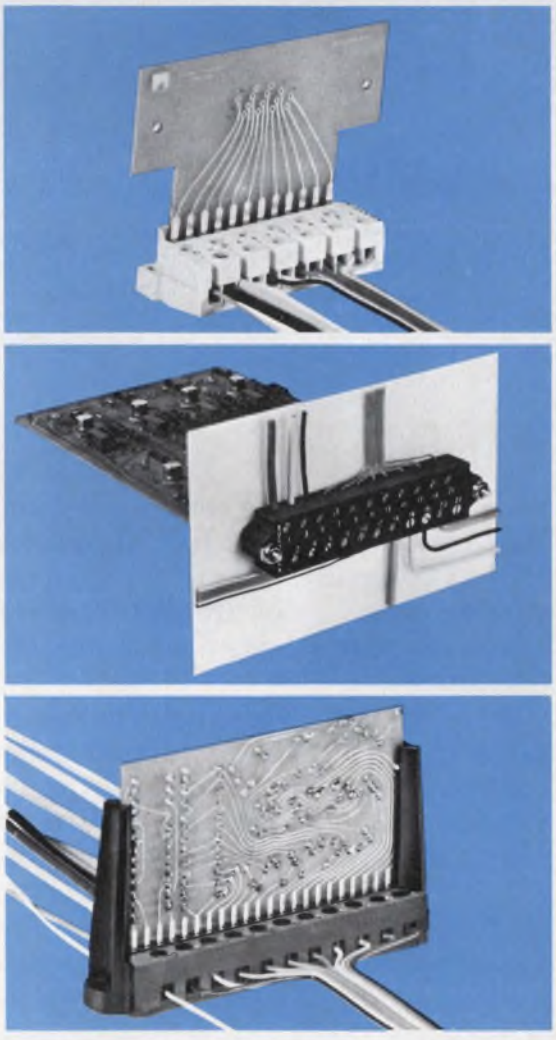
- **Accept unterminated wires from 12 through 30 AWG**
- **Save up to 5 connection points per circuit**
- **Eliminate barrier strips & terminal blocks**
- **Available for inside or through-the-panel wiring**
- **Save time, money and cabinet space**

If you're building control panels or other electrical/electronic equipment that uses printed circuit boards, here's a new PCB connector that's sure to give you LTIC (Lower Total Installed Cost)!

The new Buchanan connector eliminates hybrid interfaces between electronic circuitry and electrical connections. It replaces terminal blocks and barrier strips and the costly wiring between them and internal electronics. Actually saves you up to 5 separate connection points per circuit!

The unique screw terminals accommodate unterminated solid or stranded wires, #30 through #12 AWG. Models are available with .156″ or .200″ (.508 cm) centerlines; for up to 43 10-Amp circuits; and for inside panel or through-the-panel mounting. Many carry UL component recognition for field wiring.

For complete engineering and ordering information, use the Reader Service Card. Or, call one of our Factory Regional Offices shown below. They'll also be happy to talk to you about special configurations.



Models available for surface or through-the-panel mounting, with or without card guides and keys.

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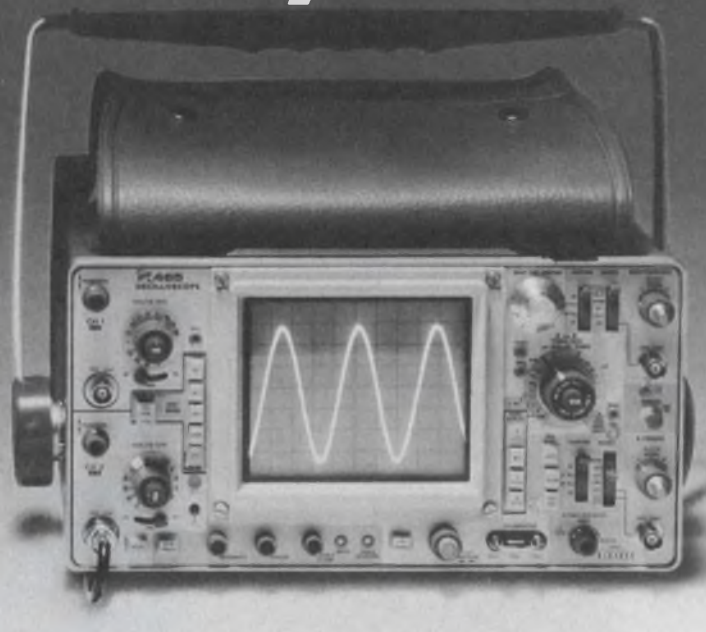

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INFORMATION RETRIEVAL NUMBER 12

News Scope

DECEMBER 6, 1975

FAA close to breakthrough in mid-air collision detector

The Federal Aviation Administration has awarded a contract for two experimental models of a mid-air collision system that—unlike all other systems under consideration—uses signals from transponders already on board the vast majority of aircraft in this country.

The new system could be the breakthrough that the Federal agency has been seeking in anti-collision equipment.

Invented by George B. Litchford of Litchford Electronics, Inc., Northport, NY, the system has already passed feasibility tests for the Air Force. The principal feature of the system, Litchford says, is that it operates by simply listening to aircraft transponder returns from ground radar-beacon interrogation.

"Anyone equipped with the system, which is comprised of a 1090-MHz receiver, a microcomputer and a display, can immediately 'see' any threats of mid-air collision from other planes," the inventor says.

"Before this system, we've never had any way to detect another airplane from your own, except for those systems which have been proposed and tested but which are of the cooperative type—they require costly special equipment in all planes in the system."

Such cooperative systems now under consideration by the FAA include those from McDonnell Douglas, RCA, Minneapolis-Honeywell and an in-house FAA development, the Direct Address Beacon System. For full protection, all planes must be equipped with special avionics.

The Litchford system makes use of the fact that almost all aircraft that are collision threats are already carrying transponders. Transponders are mandatory in all high-density air traffic areas.

"Since these planes are transmitting sharp pulses in reply to ground radar interrogations," Litchford points out, "it is only necessary to put in an intercept receiver and pick up those pulses, which give us information that can be processed in an on-board microcomputer, to provide the direction and velocity of the other aircraft."

An indication of aircraft altitude is transmitted by transponders in all planes with altitude encoders. These are carried by all airlines and are mandatory in the highest traffic density areas.

"If we intercept this information," Litchford says, "we can determine where other planes are, relative to our own plane, without imposing on the aviation community some odd-ball transponder that differs from the U.S. transponder, which also is an international standard.

"With my system, the first day it is installed, you'll be able to see everybody else carrying a transponder, whereas with a cooperative system, you can install it and not detect anybody for years, because no one else has it."

The FAA contract to Litchford Electronics calls for delivery of the two experimental models by January and complete evaluation by next June.

"This country has been looking for a collision-avoidance system for over 20 years," Litchford notes, "and we've had at least 10 different systems proposed, tested and not accepted."

The Litchford system makes use of the 700 ground radars in the FAA air traffic control network and—an important point—doesn't require vast FAA ground-station expenditures. The only modification to the ground radar is a simple kit to permit the radar to transmit a pulse when it passes through a North bearing.

When a pilot is flying with the Litchford system in a busy radar environment—for example, over New York City at 7000 feet—he can receive 30 ground radars because the system is purely passive.

But in areas where there are less than three radars interrogating the transponder, Litchford's system incorporated an on-board interrogator at 1030 MHz, which takes over and queries other aircraft when there are too few returns—that is, when insufficient interrogations from the ground are not providing enough information.

The system range, Litchford says, is about 20 miles, but a real collision threat does not occur until aircraft close to within 10 to five miles, he points out.

The type of display and amount of information in it would depend to a large extent upon the system cost, which Litchford estimates will range from about $1000 for a general-aviation model to $15,000 or $20,000 for an airline system.

CCD memories step up from 16 k to 64 k

Although 16-k CCD memories have just recently been introduced, 64-k CCD memories are already on their way.

"Our chip is five times denser than the existing chips from Intel and Fairchild," says Robert Bower, executive vice president of Mnemonics, Cupertino, CA.

Bower notes that while Intel and Fairchild use an overlapping gate two-phase approach, Mnemonics uses an offset design. The key advantage of the Mnemonics approach, he says, is that a single-gate electrode controls both the transfer and storage regions of each bit location. The other approach requires two separate gate electrodes.

Initially Mnemonics will only be making the chips for internal use.

"We are building a 1/4-to-2-Mbyte modular memory system," Bower says. "The system will be random access by block, with each block 4000 bits long. Average access time for the chip will be under

a millisecond, and for the system, just a few milliseconds."

Mnemonics plans to sell the systems as disc augmentation devices. They will be buffers or cache memories that interface to small moving-head disc memories in minicomputer systems.

Bower says the memory systems will be on the market in the first half of 1976, and the chips will be offered about six months later.

Green-light laser maps stretch of ocean floor

A patch of ocean floor near Key West, FL, has been successfully mapped through 10 meters of water by a green-light laser (5300 Å) carried in an aircraft. The plane was flying at 160 knots at altitudes of from 150 to 600 meters. The irregularities of the ocean bottom were recorded with a resolution of less than 20 cm (8 in.).

The new technique promises great savings in time and expense over the usual acoustic sounding techniques used in mapping the navigational channels and sand shoal movements in coastal waters, according to its developers at the National Aeronautics and Space Administration research center at Wallops Island, VA.

"The work is needed," says NASA experimenter Hongsuk H. Kim, "because some of our maps date back to the 18th century."

Theoretically the system can operate in 50 meters of water at night and from 10 to 20 meters during the day. The limitations are due to atmospheric light during the day and to sea state and water turbidity day and night—conditions that reflect and attenuate the laser beam.

The tests were made as part of a five-year research program on laser applications in hydrographic studies being carried out by NASA's Wallops Island facilities and the Naval Oceanographic Office. The Key West flights were carried out by NASA, the Navy and Computer Sciences Corp., El Segundo, CA, which provides technical support to the Wallops Island facility.

The laser used in the experiment was a neodymium-YAG Pockels cell, Q-switched, frequency-doubled instrument capable of providing a power output of 10 mJ in 8 ns at a maximum repetition rate of 50 times a second.

Attached to the laser was a waveform digitizer to record the returned signals. Ocean depth was calculated from the time differences of each pulse reflected first off the water's surface and then off the ocean floor. Depths can be displayed on a videoscope or recorded on film and magnetic tape.

While the present test version provides a straight-line profile, an advanced unit will soon be built by Avco Everett Research Laboratory, Everett, MA, that will have scanning capability. The Avco system will carry a minicomputer on the aircraft. The present system's data processing is handled on the ground after the flight.

16-k RAMs make debut in computer

The industry's first computer using 16-k RAMs has been introduced by Four-Phase Systems, Cupertino, CA.

The new processor, called the NP/80, can support a local data base of up to 270 megabytes. The data base can be accessed by up to 64 local displays through direct connection of Four-Phase System IV/70's. While communicating with the central mainframe at speeds up to 50-k baud, the NP/80 can also control a network of remote Four-Phase systems over multiple 9600-baud lines.

The NP/80 includes multiple DMA channels, software and hardware error recovery, firmware diagnostics, a memory relocation and protection system and communications control for up to six high-speed lines.

Dual register banks and separate program counters are provided for rapid context switching without save-and-restore overhead.

According to a company spokesman "The processor enables network users to geographically distribute their data base in a hierarchical form that closely parallels the organizational structure of most major corporations."

The NP/80 contains a 16-bit computer with 500 ns cycle time and up to 256-k bytes of MOS/LSI memory. The 16-k-bit n-channel silicon-gate RAM chips are designed and produced by Four-Phase to occupy a single printed-circuit board.

Monthly rental for the NP/80, with 16-k bytes of memory and communications support for three 9600-baud lines, is $312 on a 42-month lease.

First deliveries of the new system are scheduled for next spring.

CIRCLE NO. 319

A talking calculator is new aid for blind

An electronic calculator that displays braille and a calculator that talks have been announced by the American Foundation for the Blind in New York City.

The braille calculator, developed by the foundation's Engineering Dept., provides results in two modes, one a visible gas discharge display and the other a braille display. After a readout button is depressed, the digits and decimal points, as displayed on the visual readout, are sequentially translated to a braille cell. The signals are demultiplexed and decoded by a ROM and then multiplexed at a very slow rate and converted to four-dot braille information.

The calculator forms a braille digit by energizing electrical solenoids, forcing small dots or pins to protrude beyond the face of the braille cell. These are coded to represent the braille notation for each digit displayed. All the braille pins are de-energized momentarily when the calculator sequences to the next digit.

The talking calculator, developed by Telesensory Systems, Inc., Palo Alto, CA, receives inputs from a keyboard and provides answers from a 24-word tape over a self-contained speaker on an earphone.

As the user pushes a key, the loudspeaker repeats the number. When he pushes the readout button, the calculator reads out the display. The unit is built with a preprogrammed ROM whose digital format is converted to analog speech through a d/a converter.

The units will be available in February at the American Foundation for the Blind, 15 West 16th St., New York City 10011.

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Two-way 0°						
PSC 2-1 ZSC 2-1 ZMSC 2-1	0.1-400	25	0.4 above 3dB split	1	0.1	$ 9.95 (6-49) $24.95 (4-24) $34.95 (4-24)
PSC 2-2 ZSC 2-2 ZMSC 2-2	0.002-60	40	0.3 above 3dB split	1	0.1	$19.95 (6-49) $34.95 (4-24) $44.95 (4-24)
PSC 2-1W ZSC 2-1W ZMSC 2-1W	1-650	25	0.5 above 3dB split	3	0.20	$14.95 (6-49) $29.95 (6-49) $39.95 (6-49)
PSC 2-1-75*	0.25-300	25	0.4 above 3dB split	1	0.05	$11.95 (6-49)
MSC 2-1	0.1-450	30	0.4 above 3dB split	1	0.1	$16.95 (6-24)
Two-way 180°						
PSCJ 2-1** ZSCJ 2-1	1-200	33	0.6 above 3dB split	2.5	.15	$19.95 (5-49) $34.95 (4-24)
Two-way 90°						
PSCQ 2-90	55-90	30	average of coupled outputs less 3dB 0.3	3	1.0	$19.95 (5-49)

Model No.	Freq. range (MHz)	Isolation between outputs (dB) typical	Insertion loss (dB) (typical)	Unbalance φ (deg)	Unbalance Amp (dB)	Price (Quantity)
Three-way 0°						
PSC 3-1 ZSC 3-1 ZMSC 3-1	1-200	30	0.4 above 4.8 split	2	0.1	$19.95 (6-49) $34.95 (4-24) $44.95 (4-24)
PSC 3-2 ZSC 3-2 ZMSC 3-2	0.01-30	40	0.25 above 4.8 split	2	0.1	$29.95 (6-49) $44.95 (4-24) $54.95 (4-24)
Four-way 0°						
PSC 4-1 ZSC 4-1 ZMSC 4-1	0.1-200	30	0.5 above 6dB split	2	0.1	$26.95 (6-49) $41.95 (4-24) $51.95 (4-24)
ZSC 4-2 ZMSC 4-2	0.002-20	33	0.45 above 6dB split	2	0.1	$64.95 (4-24) $74.95 (4-24)
PSC 4-3 ZSC 4-3 ZMSC 4-3	0.25-250	30	0.5 above 6dB split	2	0.1	$23.95 (6-49) $38.95 (4-24) $48.95 (4-24)
Six-way 0°						
PSC 6-1	1-175	30	0.75 above 7.8dB split	4	0.2	$59.95 (1-5)
Eight-way 0°						
PSC 8-1	0.5-175	30	0.8 above 9dB split	3	0.2	$59.95 (1-5)

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INFORMATION RETRIEVAL NUMBER 13

News

INTERNATIONAL ELECTRON DEVICES MEETING

Power levels reported rising for lf to microwave elements

Under pressing demand from users for ever higher semiconductor power, solid-state device designers are coming up with new devices that show substantial power gains.

The devices, ranging from low-frequency industrial units to high-power microwave elements, were disclosed last week at the International Electron Devices Meeting in Washington, DC.

A new industrial power semiconductor with advantages over both SCRs and transistors was described by General Electric in a Session 16 paper entitled "The Field-Controlled Thyristor (FCT)—a New Electronic Component."

According to D. E. Houston, staff research physicist at the GE Research Center in Schenectady, the field-controlled unit—it can handle 20 A at 650 V—has a lower voltage drop than a power transistor, and it also has reverse blocking, which the transistor does not have.

"It's like a thyristor, in that it can be turned off and maintained in a forward blocking state," Houston said in an interview prior to the Washington meeting. "But unlike the thyristor, it's not regenerative; so it can't be inadvertently turned on by a voltage spike. This results in higher dv/dt and di/dt ratings than those of a conventional thyristor."

Houston points out that the new field-controlled thyristor can be thought of as a power rectifier, like a PIN diode, except that the GE device has a special type of grid structure.

"We've fabricated the device with a planar p-type grid, which can be reverse-biased to deplete the channels between the grids," he explained.

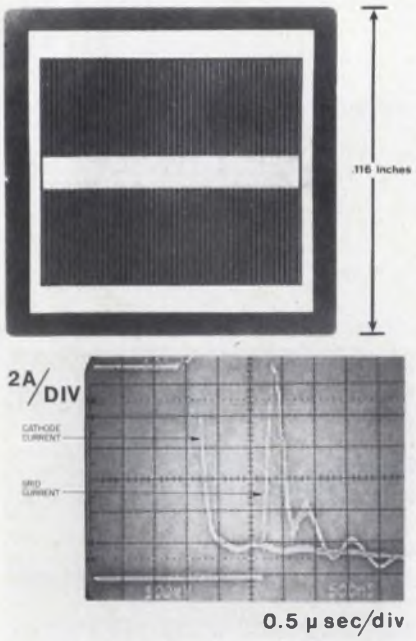
"And that makes a potential barrier which prevents any injection into the base region and gives us a forward blocking state."

The FCT planar grid is metallized. It can be reverse-biased, in which case it becomes a collector of holes and turns off the device. This, Houston insists, gives the special current-interrupt capabilities and the ability to provide both forward and reverse blocking.

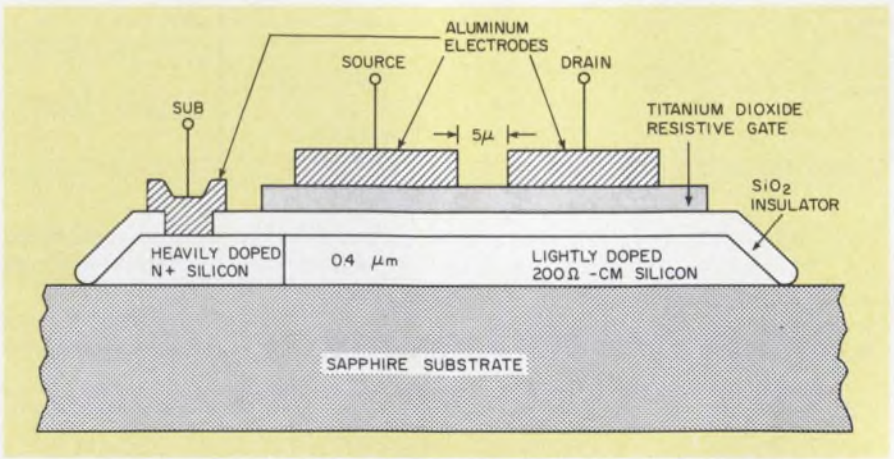
The FCT has two injection junctions and does not require any driving current to maintain it in an ON state, the way a transistor does. For a given voltage rating, the thyristor can handle higher working currents with lower forward voltage drops than a transistor with the same area.

The surge-handling capacity of the FCT is better than a transistor's, Houston says, having a

Jim McDermott
Eastern Editor



The cathode and grid structures of the General Electric FCT are highly interdigitated (top). Cathode current is interrupted by the grid control in 0.3 μs, as shown at bottom.



1. **A titanium dioxide resistive gate is the key element** in this Hughes MOS microwave switch. The rf is switched between the source and drain electrodes via a 1 to 2 accumulation layer beneath the silicon dioxide film.

capacity that is comparable to that of a PIN rectifier.

The FCT compares favorably with the conventional SCR and gate turn-off device, Houston points out. It is turned on simply by removal of the grid bias, and consequently it has a higher rate of rise of the load current than the usual thyristor.

New microwave switch

A new type of high-power silicon-on-sapphire device that can switch 100 W of rf at 3.5 GHz, using less than 1 μW of control power, was disclosed at the conference by the Hughes Research Center, Newport Beach, CA. The device, developed for radar phased arrays, requires but 1/50,000th of 50 mW of control power now dissipated by each of the thousands of PIN diodes in present phased arrays.

The Hughes device, described in a Session 27 paper, "The RIS Device—a Resistor-Insulator-Semiconductor Microwave Switch," is a three-terminal MOS structure that has a diode off/on ratio of greater than 1500 and an insertion loss of only 1.2 dB, according to Denis J. McGreivy, senior member of the Hughes technical staff and a co-author of the paper.

The RIS consumes drive power only during the switching transient, he points out. The key to its development was the creation of a new gate material—resistive titanium dioxide, which is rf sputter-deposited. The resistivity of the titanium dioxide, which is deposited in a layer about 500 Å thick, can be controlled from about 10 to 10^{12} Ω cm, McGreivy says.

"To get a device that would give zero or very low dc current in both ON and OFF states, we went to a MOS type of device," he explained in an interview, "using the titanium dioxide as a resistive gate material."

The MOS device developed (Fig. 1) has two aluminum electrodes—the source and drain—deposited on top of the titanium gate, which in turn is deposited over the silicon dioxide insulating film. The latter is lying over a 0.4 μm silicon film on the sapphire substrate.

Ohmic contact is made to the silicon film in the heavily doped n+ region. The source and drain electrodes are the microwave input and output terminals.

"In the 5-μm distance between the source and drain electrodes, we get an effective dc resistance on the order of 3000 Ω," McGreivy noted. "But the silicon oxide resistance is in the region of 10^{12} Ω.

"The rf is put into the source and taken from the drain. When there is a zero dc bias between the metal electrode and the substrate, the rf signal sees only the dc resistance between the electrodes plus a fringing capacitance of 1 pF."

If a positive dc bias is applied between the substrate (SUB) contact and either the source or drain, an accumulation layer is formed on one of the contacts. This layer spreads through the titanium and accumulates underneath the entire resistive gate.

The microwave signal sees the 3000-Ω dc resistance between source and drain and detours through the thin oxide of the silicon film to the accumulation layer, which has a resistance of 1 or 2 Ω. Thus the rf signal travels along the low conductivity path and then up and out again through the other electrode.

"So now," McGreivy pointed out, "we've made a switch which, in either the ON or OFF state, conducts essentially zero dc current because of the silicon oxide insulation. This insulation resistance also prevents any dc current from flowing between the substrate and metal rf input electrode." ■■

OIC performance is improved with use of silicon substrate

In optical IC technology, the Washington meeting was told, new developments are improving the efficiency, sensitivity and bandwidths of optical integrated systems. Silicon is being used instead of more exotic materials.

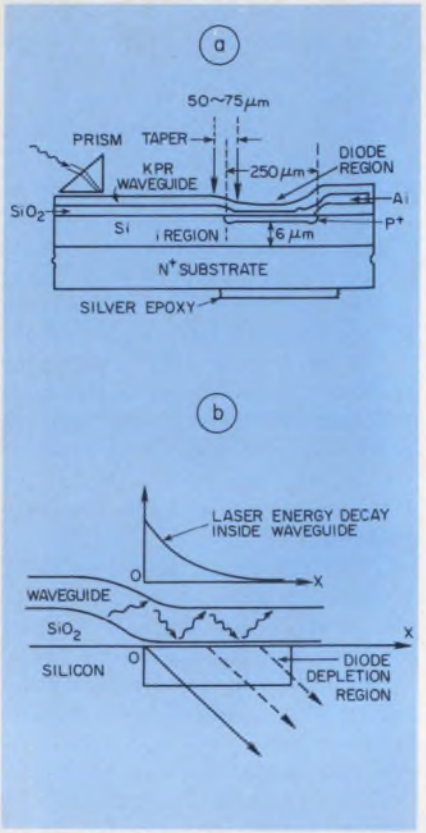
The integration of a silicon detector array into a silicon optical waveguide structure was reported in a Session 26 paper by Prof. J. T. Boyd and Prof. C. L. Chen of the University of Cincinnati Electrical Engineering Dept. The array gave a high measured value of quantum efficiency of 0.8 compared with a theoretical efficiency of 0.93, the authors said.

A silicon substrate was chosen for the array waveguide system, Boyd said in an interview, because it permits the fabrication of CCD array-addressing circuitry, signal-enhancement circuitry and signal-processing circuitry on the same substrate as the optical waveguide.

A further advantage of the silicon substrate, according to Boyd, is that silicon is well-suited for the formation of three-dimensional channel waveguides by preferential etching. Another advantage is that a thermally grown silicon dioxide layer, which supports a thin-film optical waveguide, has a low refractive index and a very smooth surface for waveguide deposition.

In the Cincinnati integrated waveguide photodiode structure, a row of masked p-type shallow diffusions were made in a silicon wafer having a high-resistivity epitaxial layer. The layer was grown on an n-type substrate to form the p-i-n photodiode array.

Each photodiode, Boyd reports, had a separately diffused guard ring that gives the junction a high breakdown voltage while maintaining a very thin p+ region for highest sensitivity. The substrate for a low-loss KRP photoresist waveguide was the thermally grown



2. **A 128-element photodiode array has been integrated,** at the University of Cincinnati, into a silicon waveguide structure (a). Laser energy from the prism is transferred from waveguide to diode by the tapered SiO_2 film (b).

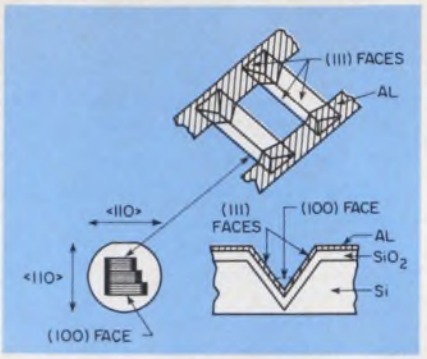
SiO_2 layer (Fig. 2).

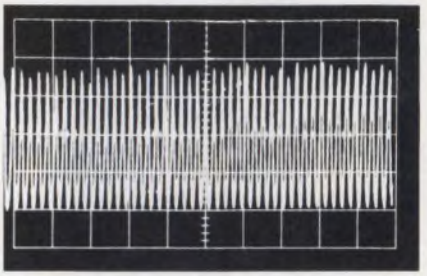
To minimize optical scattering of light and to obtain maximum transfer of energy into the detectors, the thickness of the SiO_2 layers was tapered, Boyd notes. Because the photodetector region is parallel to the waveguide surface, tapering of the SiO_2 layer to zero in the detector region produced maximum energy transfer through multiple refraction and through the evanescent field.

The taper of the SiO_2 region was achieved by undercutting during etching and prior to the p^+ diffusion, according to Boyd. The KPR waveguide was solution-deposited.

Optical waveguide arrays

Density of more than 1000 low-loss optical waveguides per inch was reported by the IBM Research Center, Yorktown Heights, NY. The researchers used preferential etching of grooves in silicon substrates.





3. **Multichannel arrays of optical waveguides,** by IBM, have integrated couplers (top). Outputs of the arrays are uniform within 5% (bottom) and the cross-talk is below −30 dB.

In a paper on "High Density Multichannel Optical Waveguides with Integrated Couplers," P. F. Heidrich, J. S. Harper, E. G. Lean and H. N. Yu, members of the IBM technical staff, noted in Session 26 that optical attenuation had been minimized by the thermal growing of an oxide layer over the wafer. The layer, about 1 μm thick, provides a low-index-of-refraction buffer layer.

For higher optical throughput, the reflectivity of the input and output surfaces were coated with a mirror-like layer of aluminum. In addition the grooves were filled with optical epoxy.

Preferential etching techniques have been used for fabricating other integrated optical structures in crystalline silicon and gallium arsenide. These devices include diffraction gratings, single-element channel waveguides and tapered couplers between thin-film waveguides and optical fibers.

The waveguides in the silicon grooves have a surface smoothness associated with crystalline planes, which minimizes surface scattering loss. IBM's efforts have extended the etching technique to the production of waveguide arrays having 50, 25 and 12.5-μm channel widths. ■■

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ANALOG DEVICES

INFORMATION RETRIEVAL NUMBER 15

Wireless power-transmission test aims at harnessing sun one day

For 75 years, engineers have tried to transmit power through the air without benefit of wires or other man-made conduits. Now a group of engineers in the Mojave Desert are doing it every few weeks via microwave signals.

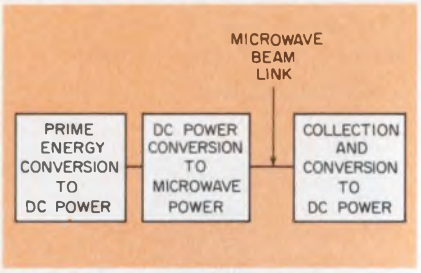
They are from the California Institute of Technology's Jet Propulsion Laboratory, in Pasadena, and Raytheon's Microwave and Power Tube Div., Waltham, MA. Their work is being sponsored by the National Aeronautics and Space Administration's Office of Applications and Office of Energy Programs.

The distance covered and the power transmitted in the Mojave experiments are both small (a little over 30 kW of dc output over 1.54 km), but the techniques for improving both are being defined.

John F. Mason
Associate Editor

The ultimate goal is to develop equipment capable of efficiently transmitting power captured by a solar-energy collector in space to a receiving station on earth. Such a proposal was first made in 1968 by a team consisting of Arthur D. Little, Raytheon, Grumman and Textron.

A more earthly application might be to beam power to a high-altitude, stationary, electrically powered, unmanned helicopter—say, at 50,000 feet—that would relay television signals for weeks or months at a time without having to land.



To transfer the electrical energy captured in space to earth, an electromagnetic beam link is created.

Point-to-point transmissions on earth are, of course, possible applications, but highly improbable, according to Raytheon's consulting scientist William C. Brown, who developed the rectifying antennas used in the current experiments.

"The attenuation and scattering through many miles of rain would be a problem," he says. "To replace high-power transmission lines, the power density in the beam would be far above safe exposure limits. The economics might also be questioned."

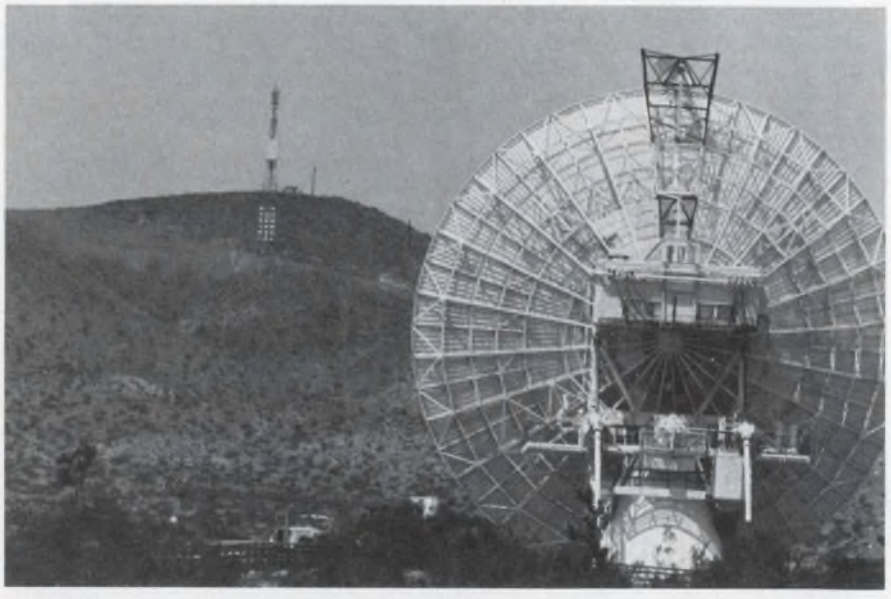
There could be isolated applications, Brown continues, that might be practical—for example, where power could be profitably transmitted over deep canyons or bodies of water.

But the main goal is to capture clean, nonpolluting energy from the sun. Earth-orbiting stations would collect solar energy, convert it to microwave radiation and beam it to receiving stations on earth.

"A typical satellite using a microwave beam at a 10-cm wavelength could provide 10,000 MW," says Peter E. Glaser, vice president of Arthur D. Little, Inc., Cambridge, MA. "A network of such satellites could generate enough power to meet a significant portion of the foreseeable U.S. energy demands."

The space station would require an energy-collecting area of at least 70 sq. km of solar photovoltaic cells, according to Raytheon's Brown. "The area needed for ground-based 'rectenna' arrays, as the antenna elements are called, measures some 40 to 59 km," he says.

The immediate goal of the current experiments is to test the



An 85-foot parabolic antenna and a 100-foot-tall collimation tower, located a mile apart, are used to transmit and receive electrical energy.

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INFORMATION RETRIEVAL NUMBER 16

high-power performance of a reception-conversion array rather than an over-all system. Existing transmitting equipment is being used, consisting of a klystron with a maximum output of 450 kW at 2.388 GHz, a 26-m-diameter (85-ft) parabolic reflector antenna, and a 30.5-m-tall (100-ft) collimation tower located approximately 1.54 km (1 mile) from the antenna.

The equipment is part of the Venus station, a research and development facility of NASA's Deep Space Network at Goldstone near Barstow, CA.

Thus far the Mojave Desert tests have shown, JPL says, that the present rectenna array concept should be adequate for a somewhat weather-dependent, yet highly efficient, receiving mechanization for a high-power microwave power transmission link.

To improve the system, a number of innovations are needed, JPL says: diodes with higher conversion-efficiency, a better array impedance match and simplified techniques for mass manufacturing and assembly.

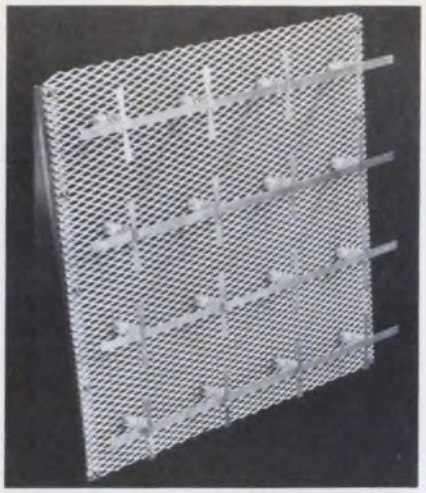
Collecting the power

The transmission of power via microwave differs from transmission of communication signals, in that a greater percentage of the power must be received. You can amplify weak communication signals but not power.

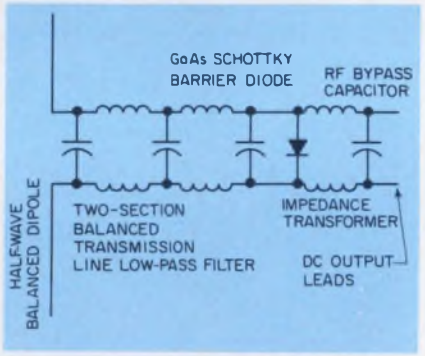
In the space station, a series of microwave generators would be combined in a subarray about 15 meters square, and the latter would form part of the transmitting antenna, according to Peter E. Glaser, vice president of Arthur D. Little, Inc., Cambridge, MA.

The generator design, Glaser says, is based on use of a crossed-field device such as an Amplitron, which has the potential of high efficiency, high reliability and very long life.

Each generator subarray must be provided with an automatic phasing system, so that the individual radiating elements of the antenna are in phase. These subarrays would be assembled into a slotted-waveguide phased-array transmitting antenna, about 1 km in diameter, to obtain a microwave beam. The distribution within the beam could be designed to range from uniform to Gaussian.



Receiving antenna of a microwave power link consists of dipole rectifiers separated one-half wavelength from each other.



Rectenna element equivalent circuit is used to calculate the antenna's electrical characteristics.

In the ground experiment microwave power is being received and rectified with a Schottky barrier diode detector. However, the diode operates at a power level of +39 dBm, and the output is dc. Although other power output forms, such as pulsating dc or even low-frequency ac (60 Hz), can be obtained, dc was selected for system simplicity at this time.

The function of the receiving system is to collect the incident rf and convert it to dc. This is done by building the receiving antenna in the form of a planar array of half-wave dipole rectenna elements over a ground plane facing the transmitter incident beam (see illustration). Each dipole has an integral low-pass filter, diode rectifier and rf-bypass capacitor.

The dipoles are dc-insulated from the ground plane and appear as rf absorbers in parallel to the incoming rf wave. Their dc outputs are in a parallel and series combination to produce the desired output voltage and current levels.

The size of the dipoles and their configurations are adjusted so that when they are in combination with the transformed dc load impedance the array provides a match for the incoming rf wave. The dipoles are 0.74 λ long; they are spaced 0.6 λ apart in a triangular lattice and are 0.2 λ from a ground plane.

The low-pass filter design represents a compromise between insertion loss at the fundamental and proper rejection at the harmonics. The harmonics must be trapped and phased properly to result in maximum rf-to-dc conversion (inverse Fourier Transform).

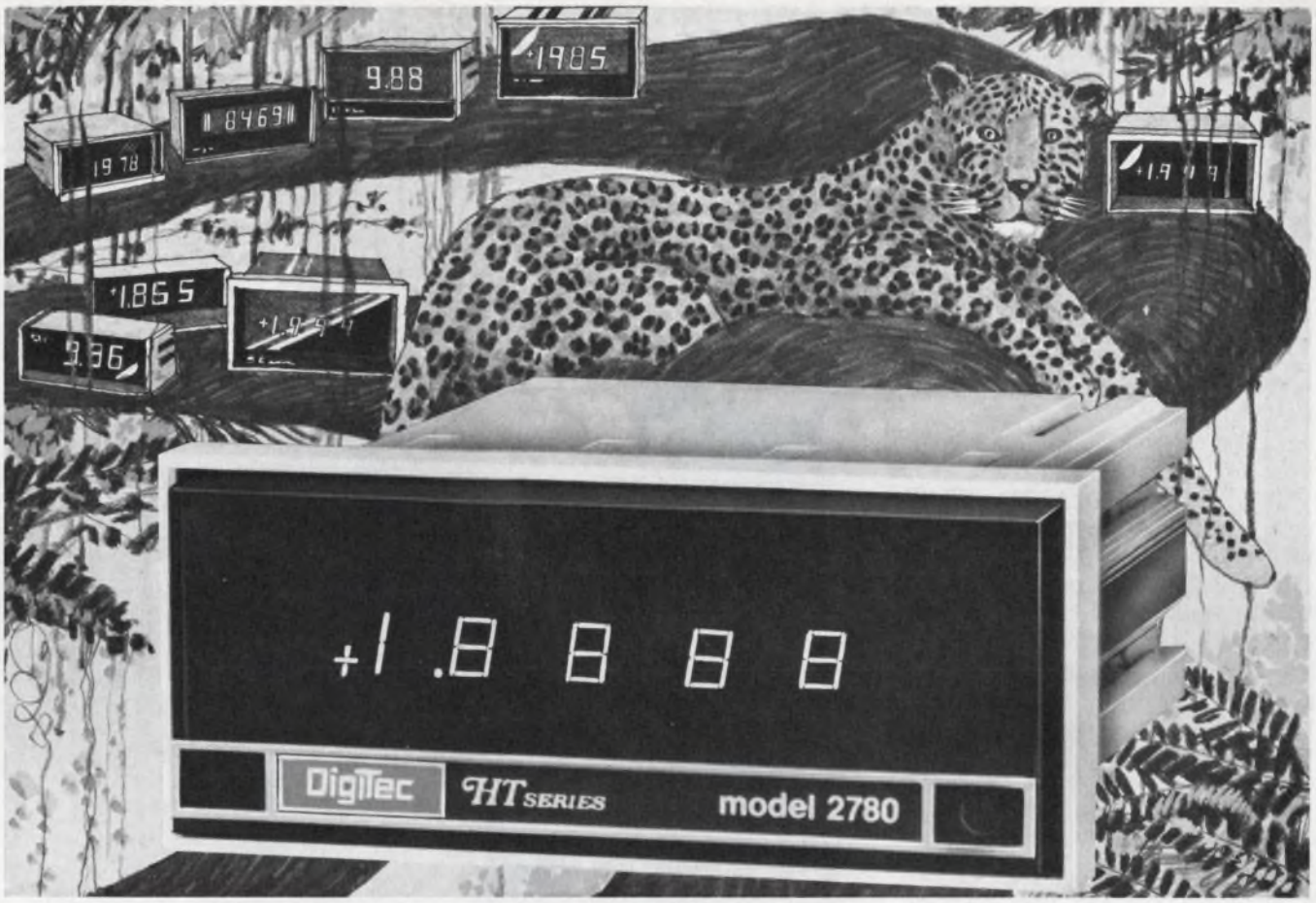
The rf-bypass capacitor in the rectenna performs the dual function of a smoothing filter for removing rf and harmonic ripple from the dc output and resonating the diode capacitance so that the proper impedance match between the diode and the low-pass filter is obtained.

Collection efficiency approaching 90 per cent in the 3-GHz region is expected ultimately for the rectenna, Brown says. The present efficiency of the rectennas at Goldstone is 82%. A principal reason for this optimism is the very high potential rectification efficiency of the GaAs Schottky barrier diode when its depletion layer is optimally designed for this application and when rectifier circuits using such improved diodes are also optimally designed.

The physical capture area of the array, including the interstices between subarrays, is 24.5 m^2 (263.5 ft^2). Each of the 17 subarrays is positioned normal to the beam from the Venus station antenna. All subarrays lie in the same plane.

The 17 separate dc load and instrumentation wires from each subarray are routed to a central load and instrumentation complex, located in and near the collimation tower support building.

Additional tests of the ground system are planned to determine performance vs frequency, incident polarization, treatment of the interstices and the effects of various environmental conditions, including rain, snow and angle-of-incidence variations. ■■



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Infrared device detects ice before it forms

A device with an infrared sensor detects icing conditions before ice has actually formed and turns on a heater to prevent its formation.

The unit was built by Environmental and Process Controls, Sterling Heights, MI, for use on the air intake of gas turbines in stationary outdoor installations, including those that drive gas or oil-line pumps, offshore oil-drilling pumps and electric power generators. When ice forms on the inlet vanes of these turbines, the efficiency of the turbine is reduced and the blades may be damaged. The new unit enables turbines to operate continuously with maximum power output at temperatures down to −120 F.

The ice detection system consists of an infrared dew-point-measuring sensor mounted on the turbine air intake and a remotely mounted electronic monitor connected to the sensor by cable.

The sensor uses infrared LEDs and phototransistors to identify the formation of moisture. First, one infrared diode and one phototransistor are focused on a thermocooler module reflective surface. At the same time another diode and transistor pair are focused on an identical uncooled reflective surface to provide compensating and reference photo-optics. The compensating photo-optics serve as a floating reference for an operational amplifier and also as a means of providing both temperature compensation and surface-contamination detection.

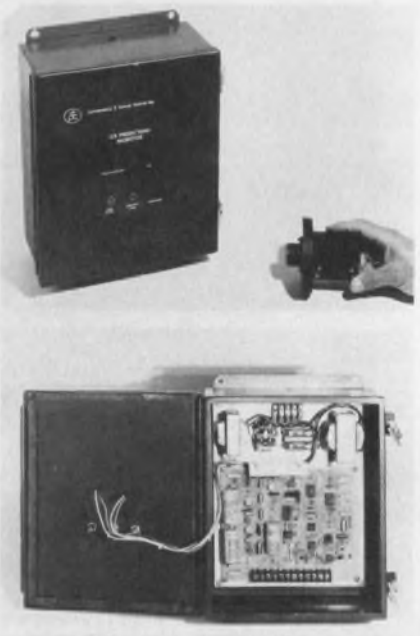
The electronic monitoring setup includes 10 operational amplifiers that control the power supply to the thermocooler, adjust the ambient temperature zero point, adjust dew point offset, and compare dew point and ambient temperature measurements.

The temperature-comparator operational amplifier also includes offset adjustments. In a typical operation, the relay that switches on the heater system is actuated when the dew point measures 4 degrees less than a freezing point setting of 41 F.

Independent monitor points on the comparator amplifier provide access for continuous dew point, ambient or surface temperature readings. LEDs continuously indicate amplifier state, a red diode showing ice warning and a green diode showing sensor assembly operation.

A switch provides self-testing and indicates anti-icing control performance.

The system consumes 6 W of power continuously and 15 W intermittent. Dew point and ambient temperature ranges are from −120 F to + 150 F. ■■



Infrared sensor (top) predicts ice formation on outdoor gas turbine installations and turns on a heater. The electronic control monitor (bottom) contains 10 op amps.

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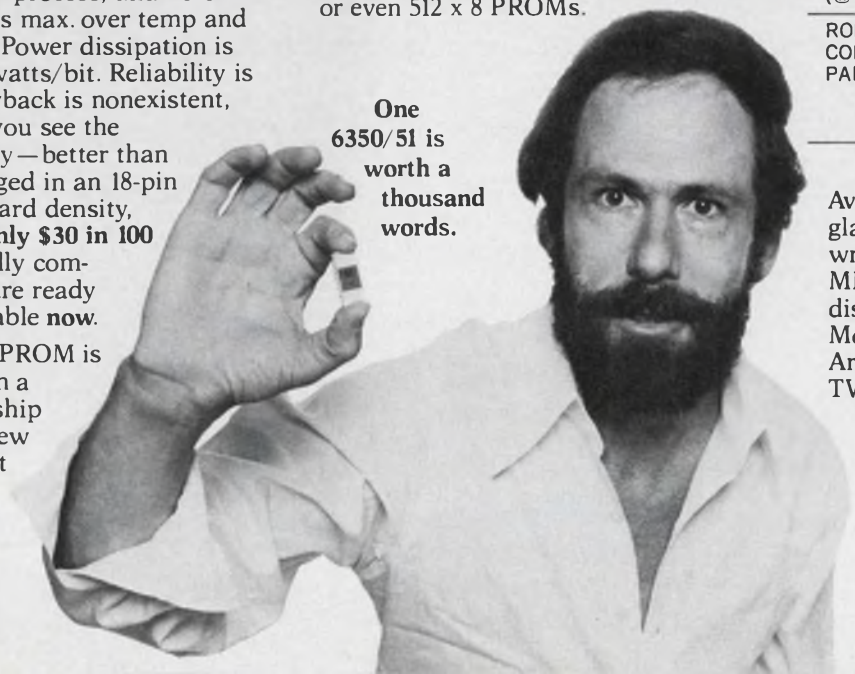

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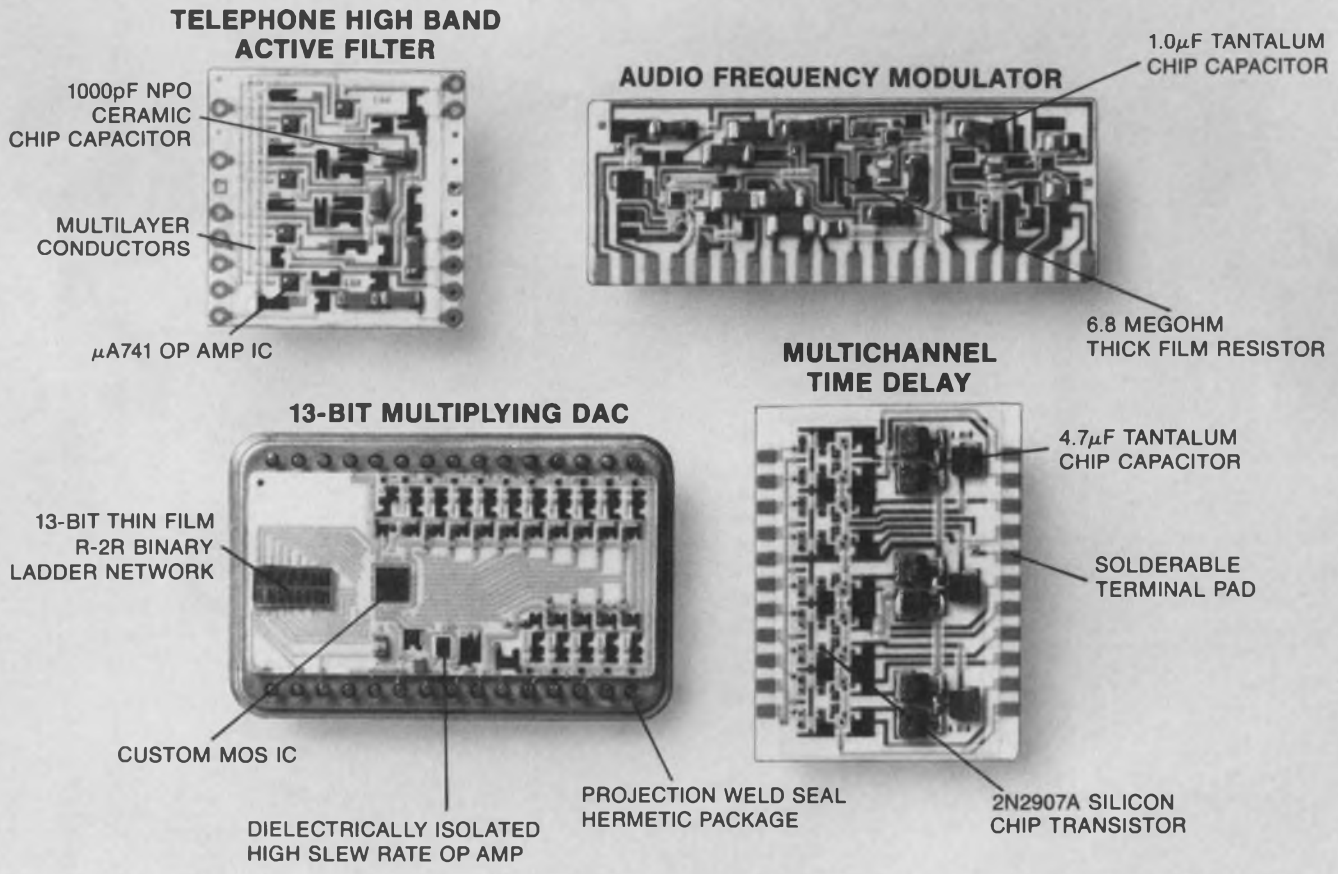

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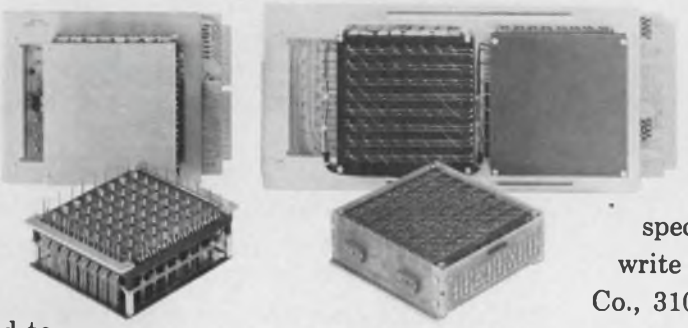

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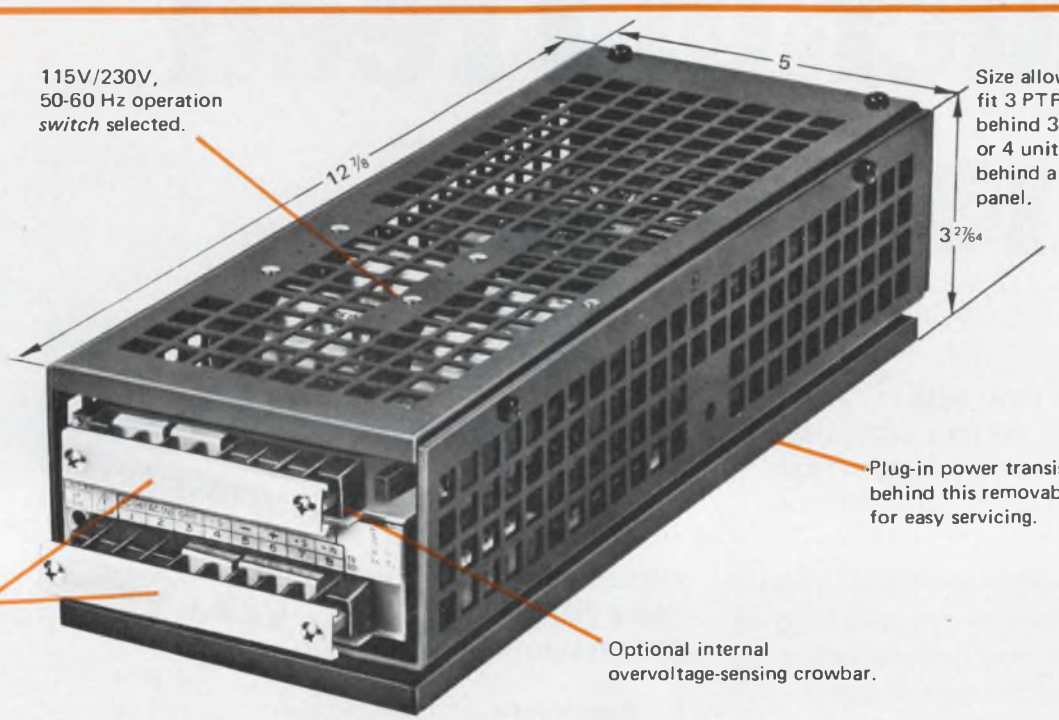

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For $273.00, you get a Kepco PTR . . . a fully-programmable, automatic crossover voltage and current stabilizer that functions with its self-contained, convection-cooled heat sink to produce *full output* to *+71°C* with *no derating*.

PTR's produce from 0–7 volts at 5.5 amperes to 0–100 volts at 0.6 amperes in six different models. All units have two control channels with plug-in I-C control amplifiers for excellent stabilization (0.005%) and temperature immunity (0.01%/°C).

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The PTR is a truly remarkable value—the features and performance of lab and systems-type power supplies in an inexpensive, value packed OEM module. Write for Catalog 146-1278 for the full details.

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INFORMATION RETRIEVAL NUMBER 22

Washington Report

Changes expected in weapons acquisition

According to a new report, the Defense Dept.'s procedures for acquiring major weapon systems could be improved. Prepared by an Acquisition Advisory Group established to review recommendations from the armed services, the report proposed 18 principal and 43 minor revisions to the process.

Just how many of these will be adopted by the Secretary of Defense won't be known until after an ongoing evaluation. Industry experts believe that certainly more decentralization of the acquisition process can be anticipated, which should benefit contractors by shortening the response time to their proposals.

Other proposed changes: Many programs that now must be reviewed by a top level defense council can be approved by the military service itself. Each service would also have the authority to initiate its own analyses of specific mission areas, such as antisubmarine warfare. It would then conduct studies and recommend solutions for any problems that may have emerged.

Competing proposals by the services would be reviewed by the Defense Dept.'s Weapons Systems Evaluation Group rather than the top level Defense Systems Acquisition Review Council.

Finally, a cost range would be used rather than a finite limit for a project—"between $90-million and $100-million," rather than a binding "93.5-million."

GAO notes rise in Citizen Band problems

A recent General Accounting Office report has told the Federal Communications Commission something it already knows—that Citizen Band radio problems are mounting and the entire situation may, in fact, be uncontrollable without some legislative help.

The GAO concurs with the FCC that legislation is needed to allow the FCC to assess fines against unlicensed operators and make it a crime to kill, assault or intimidate FCC personnel making station checks. As it now stands, the FCC can't levy a fine against an unlicensed user. The recourse is to turn the case over to the Justice Dept., which is reluctant to process small violations of Federal law and further clutter the court dockets. During fiscal year 1974 the FCC found that 2200 truckers out of 3400 violators it caught were unlicensed. In checks, the agency learned that 57% of the truckers were unlicensed.

The FCC reports that its agents are increasingly being subjected to

vocal and physical abuse. When violence occurs, the only recourse now is to go through local and state courts. A bill is in the Congressional hopper to remedy this situation, but there's been no action thus far.

Presidential science adviser planned

After a three-year absence, it's just a matter of time before there will again be a full-time science adviser to the President. Since being abolished by the Nixon Administration in 1973, that function has been an additional duty for the director of the National Science Foundation.

By a vote of 362 to 28, the House passed a bill that specifically authorizes a science adviser in the White House, and Senate passage is virtually assured. President Ford also supports the bill.

As passed by the House, the bill reaffirms the need and value of science and technology through a general policy statement; establishes an Office of Science and Technology, the director of which will be the principal adviser to the President; and sets up a special science and technology survey committee to analyze Federal science operations and to report back to the President and Congress within two years.

The office is to have a $2.1-million annual budget for operating expenses. The survey will cost an estimated $1-million.

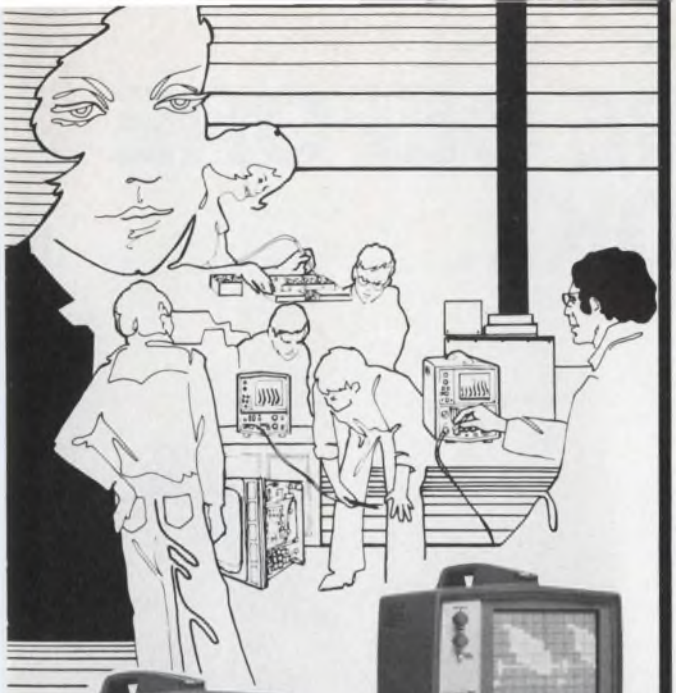
Antisecrecy measure passed in Senate

The Senate is trying to let the sunshine in to illuminate its own activities and those of more than 40 Government agencies, including regulatory bodies, such as the Federal Communications Commission.

By a 94-to-0 vote the upper chamber passed a bill providing for a "Government in the Sunshine Act." It would require legislative committees and regulatory agencies to stop holding most meetings in secret. It would prohibit secret contacts with commissioners and board meetings when a case is pending before a particular agency. Closed meetings by agencies could be held only to consider matters such as national security, personal privacy, trade secrets, committee personnel or an ongoing criminal investigation.

The new rules would force Congressional committees to meet in public, too, unless the committee members, meeting in public, voted otherwise. The real blockbuster and a point that could kill the legislation when it goes to the House is a provision that conference committees—those that hammer out the compromises between bills—would have to open their doors to the public unless the members voted otherwise.

Capital Capsules: NASA has selected **16 organizations to develop low-cost solar cells for residential and commercial use.** The project aims at production of cells for less than $500 a kilowatt hour. The present cost is between $20,000 and $25,000. . . . The Pentagon warns that the Soviet ground forces are getting four new weapons; **a tank, an armored fighting vehicle, a missile system mounted on an armored vehicle and an assault helicopter.** The Soviet navy is getting two new aircraft carriers. And the Air Force is modernizing its tactical air force. . . . **The Navy has given RCA an $8.4-million contract to design and build an integrated radio room for the Trident ballistic missile sub.** . . . The Electronic Industries Associations of the U.S. and Germany are going to work towards developing **a truly international system of nomenclature for solid-state devices, electron tubes and passive parts.**



T921

T912

T922

T935

T932

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T935—Dc to 35 MHz; dual-trace, dual time-base with delayed sweep	$1250**
T912—(Storage model) Dc to 10 MHz, dual-trace mono time-base	$1195**

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T900 Oscilloscopes are simple to use. All have a large, bright (8 x 10 cm) crt, beam finder, single knob trigger control, delay line to enable viewing of waveform leading edge, automatic selection of tv line or frame display and functionally color-coded control panels. Convenience is also enhanced by a full complement of accessories including 10X probes (included in price), optional scope stand, camera, rain jacket and more...T900 Oscilloscopes are easy to handle and fit into small spaces. They weigh only 15-18 lbs. and measure only 7″ x 10″ x 19″.

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T900 Oscilloscopes are warranted against defective materials and workmanship for one year. There are over 37 service centers and 50 field offices across the U.S. Whenever you need help in the selection, operation, application or servicing of T900 Oscilloscopes your local field engineer is available to help you...no extra charge...just extra value.

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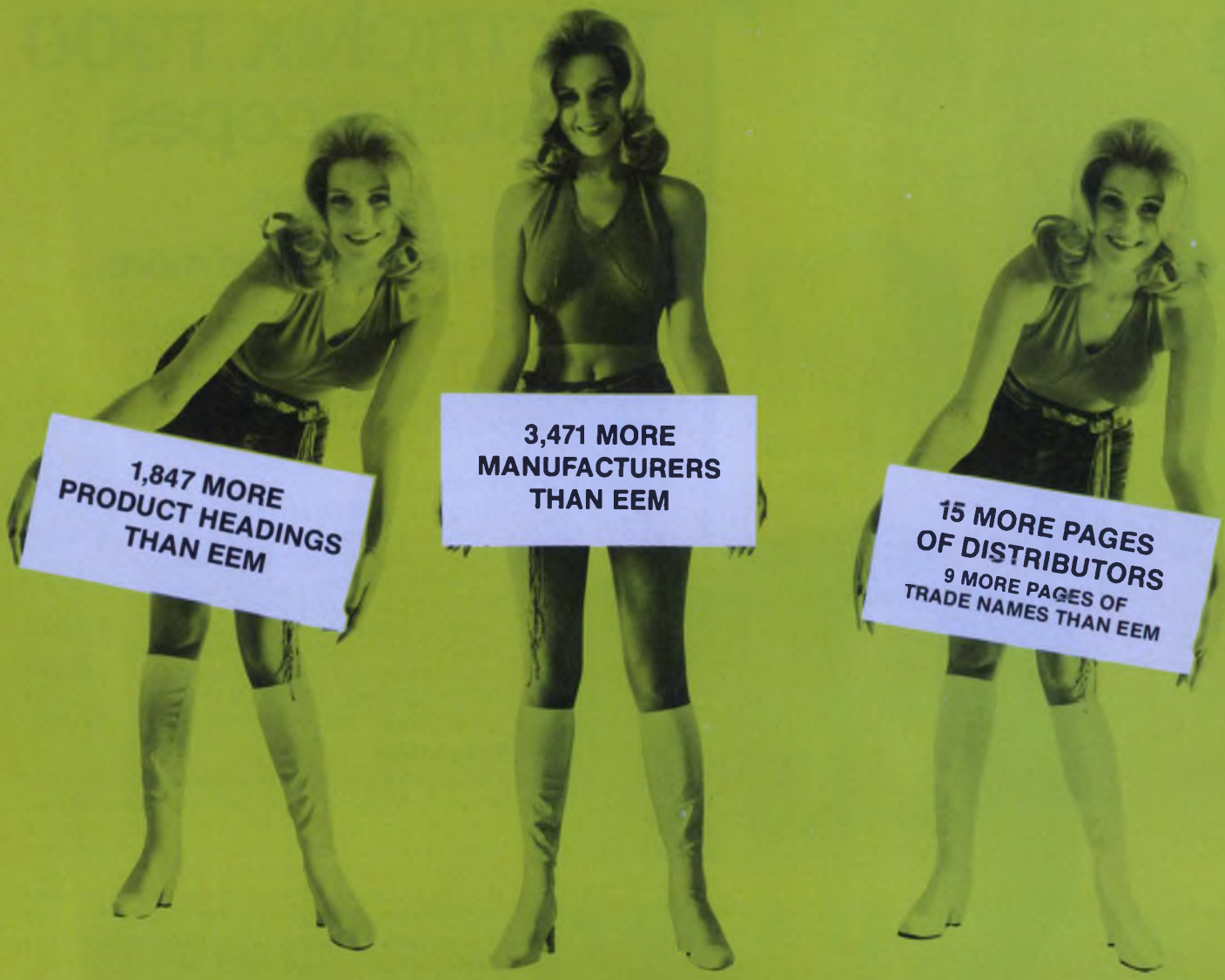

YOU'LL LOOK *FIRST* IN THE GOLD BOOK

Gold Book vs. EEM 1975/76 Comparison of Editorial Pages	EEM*	GOLD BOOK
Number of product headings in Product Directory	3335*	5182
Pages in Product Directory	255†	542
Pages in Trade Name Directory	24	33
Number of Manufacturers	3300*	6771
Pages in Manufacturers Directory	338	397
Pages in Distributors Directory-		
Geographic	19	17
Alphabetic	0	17

*Maximum estimates.

†Includes approximately 25 pages of cross reference from one volume to the other

SOURCE: ELECTRONIC DESIGN'S RESEARCH DEPT

Granted, our new ADM-3 is basic. Especially if you compare it with all the smart video terminals around (our ADM-1 or -2, for example). But the $995 unit price puts it into a different perspective.

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Here's what you get for $995. 12" diagonal screen. Full or half duplex operation at 11 selectable data rates. Bright, easy-to-read characters — 960 or 1920,* displayed in 12 or 24 rows of 80 letters. 59 data entry keys arranged like on a typewriter which keeps operator training short and basic, too. What's more, our ADM-3 is alert. It says "beep" when you come to the end of a line. The rest of the time, it just keeps cool and quiet.

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INFORMATION RETRIEVAL NUMBER 25

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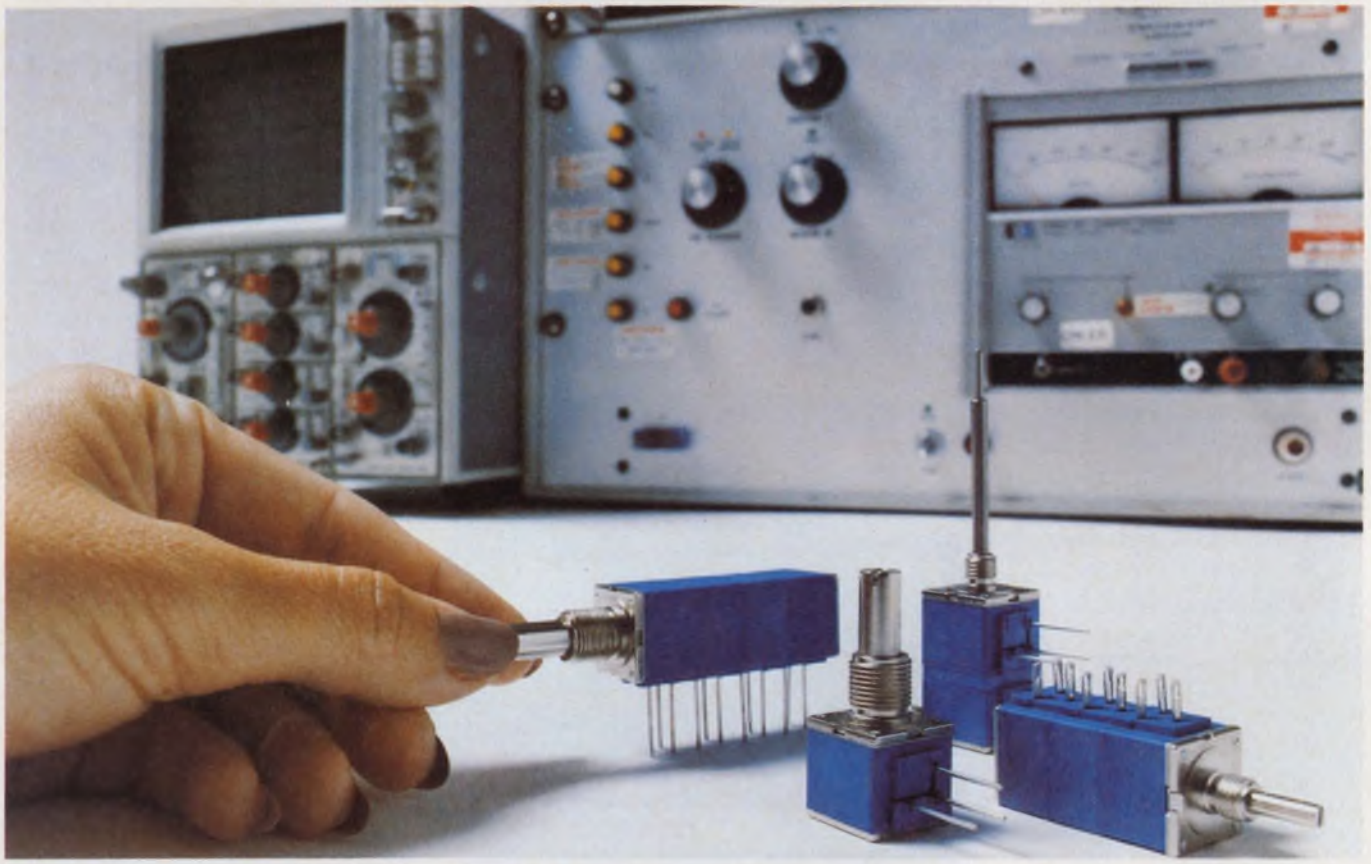


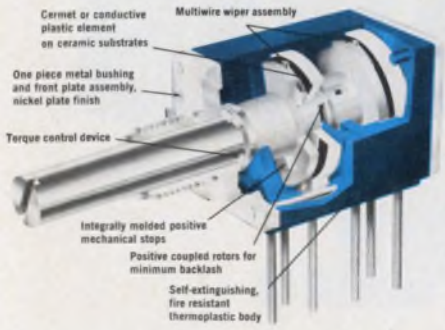
BOURNS announces an ADVANCED building-block potentiometer...

. . . with a velvety smooth control feel that will enhance the quality image of your equipment. It's BOURNS® new Model 80 Building-Block potentiometer.

The Model 80 incorporates a unique new shaft torque control device which enables us to produce an advanced modular potentiometer with a smooth, consistent high quality "feel" . . . regardless of the number of modules ganged on a single shaft (shaft torque only .3 to 2.0 oz.-in.).

MODULAR VERSATILITY, FACTORY ASSEMBLY

Bourns modular concept combines the design versatility of advanced building-block construction . . . with factory assembled reliability and quality control. All Model 80 potentiometers are built to your "prescription" by full-time production personnel, under the supervision and control of the industry's most respected quality assurance organization. High-volume assembly techniques, plus mass-produced modular components stock means fast delivery . . . at competitive prices.



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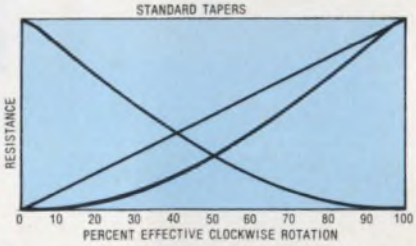
Bourns Model 80 is available with either cermet or conductive plastic elements in virtually all linear and non-linear tapers. Element types may be mixed in multiple section units. INDEPENDENT LINEARITY IS ±5% . . . offering more precise phasing of potentiometer output to panel calibration.

SUPER SETABILITY

A multifinger wiper and precise resistive ink formulations provide tight 1% CRV in both cermet and conductive plastic elements. This – combined with a smooth, no backlash feel — makes for easy, accurate operator settings.



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INFORMATION RETRIEVAL NUMBER 26

Where are high-level languages headed? 3 specialists in industry give views

The microprocessor industry has settled on a high-level language standard, even if by default. Intel's PL/M language—the sole entry for over two years—is setting the pattern for several compiler languages being developed by competing vendors.

However, most μP makers say they would prefer a somewhat different subset of IBM's PL/1, because of shortcomings in some versions of PL/M. Moreover other high-level languages, especially Fortran, could come from several sources within a year. Already Texas Instruments has announced just such an alternative with its 16-bit μP chip (see "Processor Family Debuts," ED No. 22, Oct. 25, 1975, p. 137).

ELECTRONIC DESIGN interviewed three experts on the current benefits of high-level languages and what the near future holds. Sharing their views are Phil Roybal, microprocessor marketing manager at National Semiconductor (Santa Clara, CA); Scott McPhillips, vice president at Microcomputer Technique (Reston, VA), and Paul Rosenfeld, software product manager at Intel (Santa Clara, CA).

By PHIL ROYBAL
Microprocessor Marketing Manager
National Semiconductor

The biggest plus of a high-level language is that it makes programming understandable to the engineer who isn't an expert in assembly language. It lets him write in a language that looks like English. However, most high-level languages, which have been around for about 15 years, were really designed for mathematics. In fact, Fortran stands for formula translation —it was an algebra language.

So they're super if what you want is an accounts-payable program or to do your homework. But they're not very good for what microprocessors spend most of their time doing—talking to the outside world in terms of bits and bytes.

In addition early PL/M versions have several shortcomings, such as the fact that arithmetic isn't signed. For example, in the comparison "if A > B, do this," the signs of A and B are not checked. If A is 5 and B is 3, it's obvious that A is greater than B. However, suppose A is −5, then A is less than B, but the language doesn't check for that. It's not overwhelming, but it's an annoyance.

A more serious shortcoming is the inability to manipulate individual bits and bit fields. Most present high-level languages suffer from this. But it's the single most important area for microprocessors.

There's another class of languages that really hasn't been touched on at all for micros, but

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I think will be. It's called POL, short for problem-oriented language. POLs are special-purpose languages that have commands for certain applications. For instance, a POL for civil engineers building dams, power stations and pipeline controllers might have commands like Open Valve or Measure Flow. These are part of the working vocabulary of the engineer.

By SCOTT McPHILLIPS
Vice President
Microcomputer Technique

We applied data and test programs to PL/M and concluded that you need about twice as much memory as you do with assembly language. On the other hand, in the actual coding phase of design—ignoring the software design—it'll save you about half the time.

But the PL/M version we used does suffer from several drawbacks. For example, it has several constructs—or instructions if you will—that are unique to the 8080; so it's not a general-purpose language because of that. Probably the largest disadvantage of PL/M as a program tool is the fact that it doesn't protect you from the vagaries of the machine. You're working with 8-bit quantities that only have a certain range; it has no ability to work with larger numbers. If you want to add up some 32-bit numbers, you have to do it 8 bits at a time, just as you would in assembly language.

Another disadvantage—one that really applies to any compiler language—is that the code generated is very difficult to understand. You can't always follow the assembly-language code generated by PL/M very well and could, therefore, have great trouble correcting the program. You might wind up with something in your computer that you don't understand.

Nevertheless the general language structures of PL/M are very good. They are much better than those in languages such as Fortran. The structures used to make decisions, loops and so on very closely parallel basic concepts

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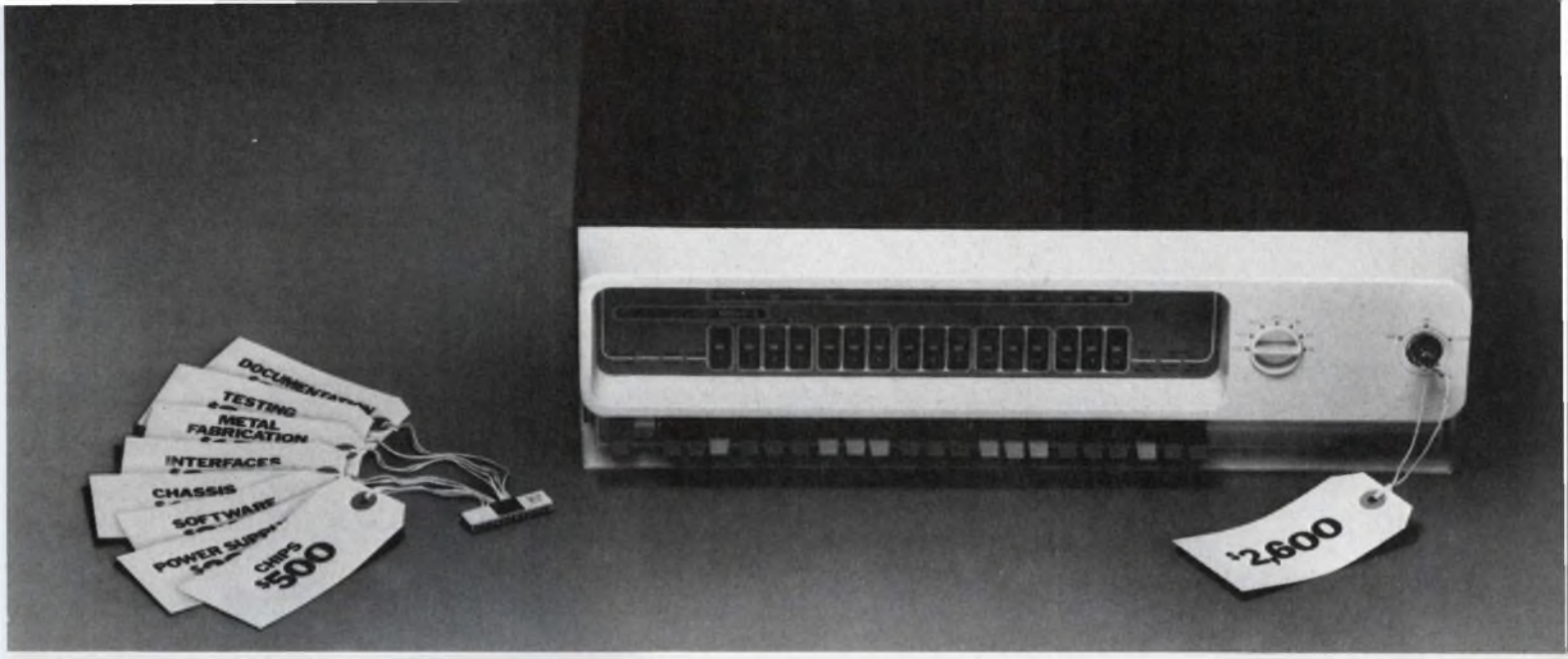

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DataGeneral

Nova 3: The biggest thing to ever hit the OEM market.

(continued from page 48)

advocated in a field called structured programming, or software engineering. A language like Fortran is so full of detail, you can't separate the big decisions from the semicolons and the dashes.

By PAUL ROSENFELD
Software Product Manager
Intel

High-level languages will dominate over assembly languages because they reduce programming costs, make software more reliable and simplify program documentation and maintenance. An assembly language requires a programmer to make numerous decisions on detail, such as the use of registers and memory, and when to save data in registers. It also requires him to write the basic program steps.

A high-level language like PL/M solves these problems but at the cost of a somewhat higher memory cost. However, memory costs are dropping while programming costs are rising. The tradeoff already favors high-level language in many cases, and in the future the extra memory will be an insignificant part of total programming costs in most cases.

PL/M has been used effectively for 2-1/2 years. It has resulted in an average reduction of 5:1 in programming costs. Also, the language has been continuously improved. A typical program using the current PL/M version requires 30 to 50% less code than one using the very first PL/M. And the amount of program-storage space available for large applications programs has been increased from 16-k to 65-k words. Intel has committed itself to further development of PL/M for future microprocessors.

It's simply not true, as some believe, that PL/M is too oriented to the 8080. PL/M consists of two parts: a so-called kernel of basic control structures that is machine-independent and another part that does depend on the machine. The latter is added to the kernel to specialize it to different μPs. To date, the second part has been developed for the 8008 and 8080. Specializing functions for μPs with entirely different architectures will be added, as needed, to the PL/M kernel.

Also, 8 and 16-bit processing are integral parts of the PL/M language. This capability includes both arithmetic functions and logic operations. Floating point could be added, but there is no need to. Instead a simple Call can be used to link the high-level program to any of several floating-point routines available in the Intel users' library. Double-precision operations are implemented with the 16-bit capability. Multiple-precision operations can be handled with Calls to subroutines available in the users' library or specially written subroutines in assembly language.

As programmers become familiar with PL/M, they can develop shortcuts that can often reduce subroutine length by as much as 2/3 or more. If they're careful and use the most efficient means, they can come up with a PL/M program that is almost as compact as one in assembly language.

Study predicts sixfold surge in μP use by 1980

The U.S. microprocessor market is expected to increase sixfold between 1974 and 1980, according to a study by Gnostic Concepts, a market-research organization (2710 Sand Hill Rd., Menlo Park, CA 94025. 415-854-4672). The annual dollar value of μP chips used in U.S. produced equipment will move from $13.5-million, or 400,000 circuits, this year to $83.5-million, or 5.2 million circuits by 1980, Gnostic Concepts says.

These figures don't include the additional support circuitry, memory and peripheral

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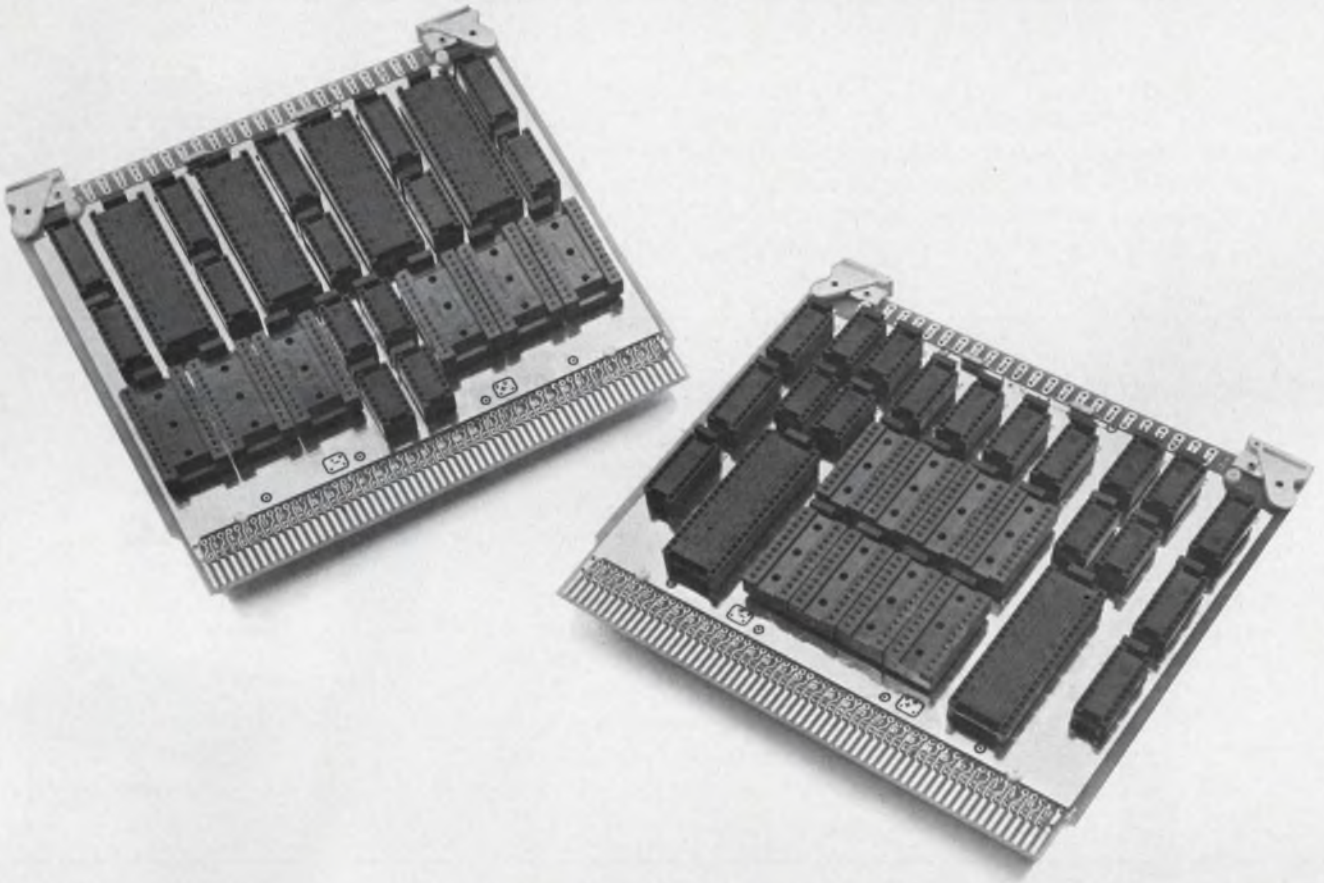
New socket cards for microprocessors.

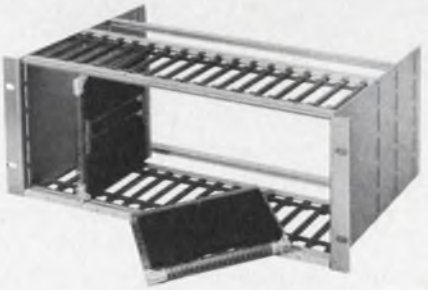


Instantly available, these two new cards are your answer to second-source problems. They enable you to change ICs and wiring for new pin patterns with great ease.

They are designed specifically for microprocessor applications, including controllers, random access memories, and erasable programmable memories. As such they are the newest in our line of 3D socket cards:

3D2017 Four 40-pin sockets, six 24-pin sockets, five 18-pin sockets, five 16-pin sockets, and four 14-pin sockets. $124.70.

3D2018 Two 40-pin sockets, eight 22-pin sockets, four 18-pin sockets, six 16-pin sockets, and eight 14-pin sockets. $140.70.



In addition, both cards provide a good ground plane for high-speed operation. They include a ceramic monolithic bypass capacitor at every socket, and provision for bypassing other voltages that may be required for chips. Power can be connected to various pins on LSI chips by means of solder tabs. And each card includes 22 built-in test points.

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INFORMATION RETRIEVAL NUMBER 29

(continued from page 50)

gear needed to form complete, stand-alone microcomputers. When these extras are included, dollar values increase eightfold, the researchers say, bringing the 1980 microcomputer market to well over $650-million.

Other findings of the study show an average μP-chip price drop from the present $31.19 to $15.99 in five years. The study also says most microprocessors will have cycle times of 1-to-3 μs by 1980.

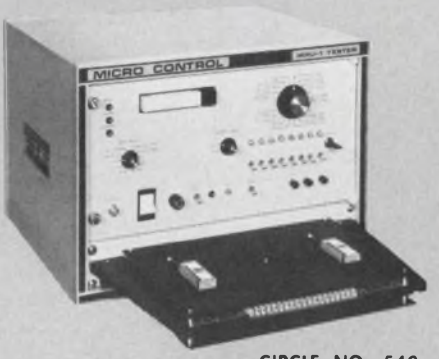
Furthermore, it adds, 4-bit μPs will dominate in business and consumer applications, whereas 8-bit units will prevail in communications, computer, industrial and instrumentation applications. On the other hand, Gnostic Concepts predicts, 12-bit μPs will amount to only a small percentage in all equipment sectors. But 16-bit microprocessors will pervade computer and government applications.

These and other findings are contained in the report "Digital Integrated Circuits."

Bench-top microprocessor tester does μP comparisons

A compact, bench-top microprocessor and software development system is offered by Micro Control Co. (1601 37th Ave. N.E., Minneapolis, MN 55421. 612-781-2612). The unit, designated the MPU-1, can compare the chip under test with a standard microprocessor chip. The test uses worst-case voltages and timing, including both fast and slow rep rates.

The system adapts to most μP chips and has complete panel controls for entering and displaying data, plus STEP mode for manually stepping through programs. The bench-top tester, complete with test programs and TTY software loader, costs $8500.



CIRCLE NO. 540

Bipolar processors advance to complete CPUs

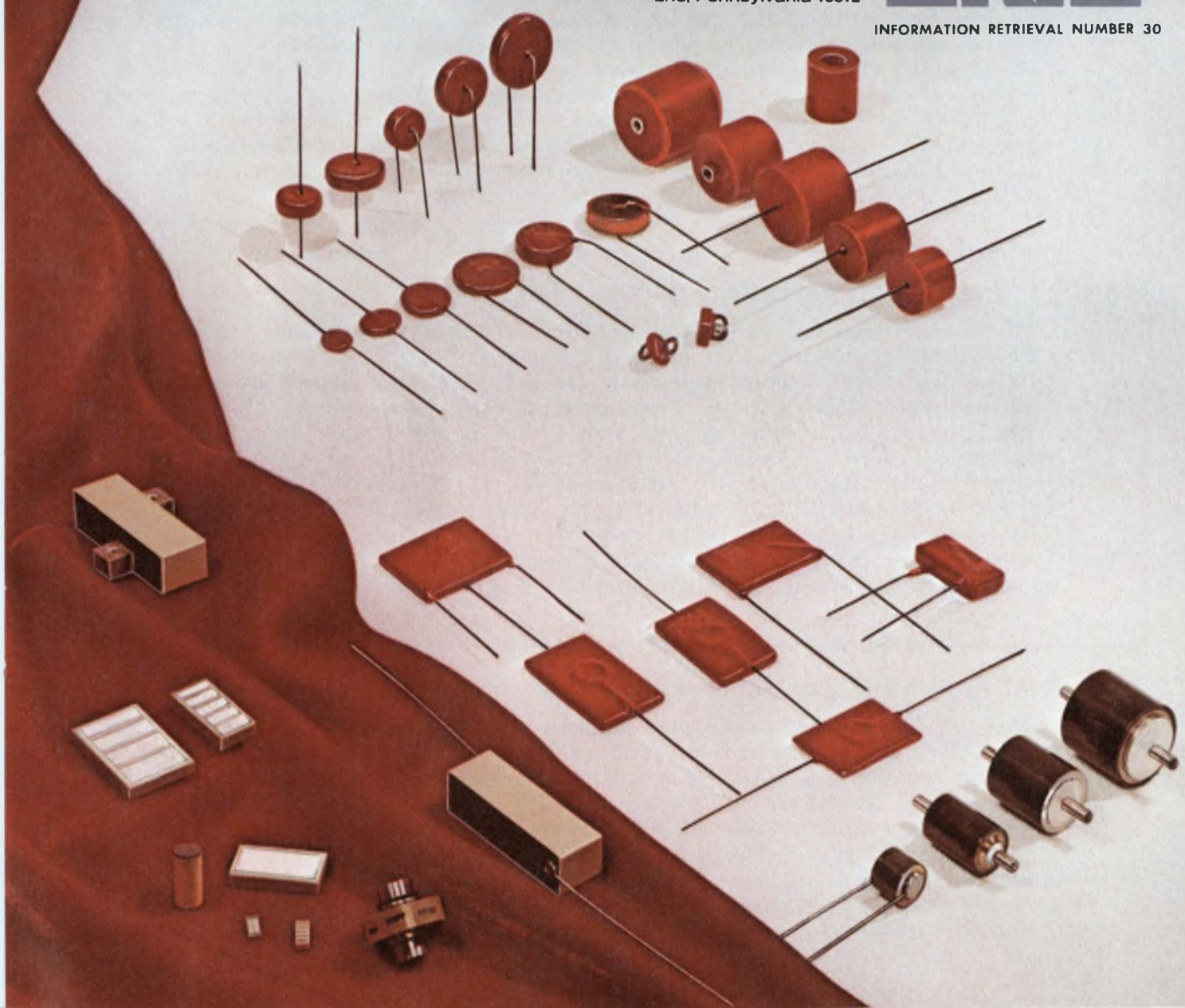
No longer are bipolar μPs just processor slices. The SMS 300 from Scientific Micro Systems (520 Clyde Ave., Mountain View, CA 94043. 415-964-5700) has emerged as the first available bipolar CPU chip, complete with fixed instruction set. Thus application programs for the SMS 300—unlike those for bipolar bit-slice units—can be developed without recourse to microprogramming techniques.

The 8-bit Schottky-TTL microprocessor executes complete instructions (including fetch, decode and execute operations) within 300 ns. Packaged in a 48-pin DIP, the chip contains eight scratch-pad registers, in addition to an arithmetic-logic unit. All inputs and outputs interface directly with other TTL circuits.

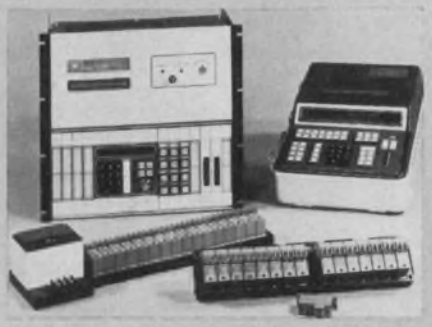
Actually Scientific Micro Systems has offered the SMS 300 (also called the Interpreter) since last January. But, the chip was part of the company's Microcontroller system. Now the Corning subsidiary has unbundled the Microcontroller, making the system available as components and modules, and in kit form.

A starter kit priced at $495 includes one SMS 300 Interpreter, six SMS 82S115 512 × 8-bit PROMs, and four SMS 360 input/output components called Interface Vector bytes. The latter are 8-bit I/O registers, one with three-state outputs and the other with open-collector input. Each interface circuit is housed in a 24-pin package.

CIRCLE NO. 541



μC system extends capabilities of industrial controllers



Features often associated with minicomputers combine with the ease-of-use of other programmable controllers in the Eptak industrial control system from Eagle Signal (736 Federal St., Davenport, IA 52803. 319-326-8113). Based on the 8080 μP, Eptak offers a lower-priced alternative to most minis for applications ranging from the control of a single machine to the supervision of a complex process.

The Eptak family consists of a programmable logic controller, process controller and a dedicated machine controller. The first is available now, while the latter two models will be next year. Basic system components for each member of the modular family include a central processor, I/O unit and programming equipment.

The new family performs arithmetic computations, provides analog interfaces (a/d input, d/a output and thermocouple) and allows the use of three types of memory: semiconductor RAM, UV-erasable PROM and core. Furthermore units can interface with a complete line of peripherals, including computers, video terminals and printers.

And they permit the use of four different languages for the development of application programs. The four consist of high-level and assembly languages, a control language based on solid-state logic expressions and a relay-diagram language.

Costs depend on the configuration selected. For example, a unit price of $6500 (in quantities of 10 or fewer) covers the following: central processor and power supply with 80 120-V inputs, 40 120-V outputs and standard 500-ft remote I/O; eight 4-to-20-mA analog inputs; 64 internal timer or counter functions in any mix; 12 256-step shift registers; add, subtract and compare functions; and 2048 words of RAM or UV-PROM memory. The price includes a 20-h internal battery backup supply.

CIRCLE NO. 542

CMOS μP and support get official part numbers

RCA Corp. (Route 202, Somerville, NJ 08876. 201-722-3200) has officially announced its CDP1800 microprocessor family (formerly known as COSMAC). The family includes the CDP1801 CMOS 8-bit microprocessor, the "Microkit" hardware support kit, microprocessor manuals and software development packages.

The CDP1801 architecture permits simple, fast, mostly 1-byte instructions, all executed in a single instruction cycle. The sixteen 16-bit registers on-chip can be used as program counters, data pointers or for data storage. The Microkit is a hardware support kit that contains the CPU, 1-k word of RAM, 512 words of ROM, space for additional memory and user-designed interface cards.

The CDP1800 family is now available from stock, with the CDP1801 full-voltage (15 V) chips available at $56 and the CDP1801C 5-V chips at $40, both in quantities of 1 to 99.

CIRCLE NO. 543

Cut cost of floppy-disc controller with μP I/O circuit

Rockwell International Corp. (3310 Miraloma Ave., P.O. Box 3669, Anaheim, CA 92803. 714-632-1650) has introduced a floppy-disc controller I/O circuit as part of its PPS-8 microprocessor system. With the circuit, the firm estimates costs of IBM-compatible disc controllers can be cut by as much as 80%.

Rockwell says that IBM-compatible floppy-disc control systems made with Rockwell components now can be manufactured for about $200 each in lots of 1000, compared with $1000 or more for other controllers in similar quantities. The floppy-disc controller chip, No. 10936, costs $125 each in 1 to 24 quantities and drops to $80 in 100 to 199. The circuit is available from stock.

CIRCLE NO. 544

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INFORMATION RETRIEVAL NUMBER 31


IBM

IBM's new 5100 Portable Computer

A compact problem-solving aid for engineers, statisticians, scientists and financial and business analysts.

Now you can have a computer right on your desk. Exactly where you need it. When you need it.

The new IBM 5100 Portable Computer incorporates the latest in semi-conductor technology. It features a typewriter-like keyboard and numeric key-pad for simplified data entry, a 1024 character display screen, an integrated magnetic tape drive, and 16K characters of memory.

Options available with the 5100 include a bi-directional 80-characters per second printer, a second magnetic tape drive, and additional memory up to a maximum of 64K characters. Also available is a communications feature which allows the 5100 to be used as a terminal.

The IBM 5100 comes with either APL or BASIC language or both.

Over 100 often-used analytical routines in mathematical, statistical and financial calculations are available for such functions as forecasting, modeling, matrix arithmetic, engineering and design calculations, regression and correlation analysis, return on investment and cash flow analysis.

In addition, the 5100 features a self-study training package that makes it easy to learn and easy to use without taking any classes or relying on specially trained experts.

If you'd like to find out more about IBM's new 5100 Portable Computer and arrange for a demonstration right at your desk, call your IBM General Systems Division office or fill out this coupon.

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INFORMATION RETRIEVAL NUMBER 32

HiNIL Interface

Prevent CMOS latch-ups and failures with a high noise immunity logic I/O.

CMOS systems are subject to latch-ups and failures in the field because of high voltage transients, static charge and improper field maintenance procedures. Moreover, due to their increased output impedance, CMOS is more susceptible to transient errors than corresponding bipolar logic.

A simple solution to these problems is to use Teledyne's bipolar High Noise Immunity Logic (HiNIL) as the system I/O interface. The I/O design approach shown in Figure 1 has solved these problems in applications such as business equipment, industrial controls and electronic games. The HiNIL interfaces protect the delicate CMOS inputs with a rugged bipolar "front end" not susceptible to CMOS failure modes. Also system noise immunity is maximized, and the HiNIL output devices provide direct, high current logic drive of relays, displays and long lines.

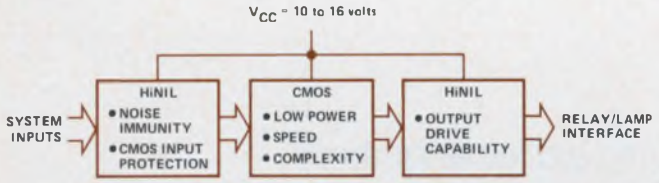

Figure 1. HiNIL input interface protects CMOS inputs while HiNIL outputs directly drive long lines and peripheral devices

The two families are directly compatible at the 10 to 16 volts V_{cc} range. The designer can take full advantage both of HiNIL's capabilities and of CMOS' low power dissipation, supply voltage flexibility and improved noise margin at higher supply voltages.

Parasitic SCR latch-up is an all too common CMOS malfunction. Large noise transients and DC input levels below ground or above V_{cc} could force CMOS input diodes into forward conduction, causing SCR action in the four-layer diodes formed by the diode and parasitic p-n substrate junctions. This condition leads to device latch-up, increased I_{cc} current and, when current is not limited, to gate destruction. Maximum protection can be obtained by using

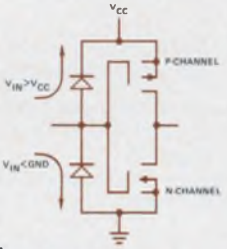

Figure 2A. CMOS latch-up causes

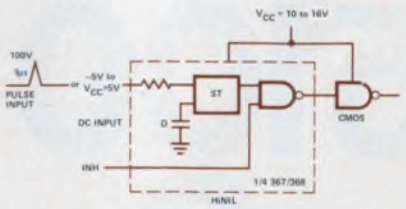

Figure 2B. HiNIL input protection

HiNIL Schmitt triggers. They prevent latch-up at DC input levels from −5 volts to V_{cc} +5 volts and suppress 100 volts transients as wide as 1μsec (Figure 2).

HiNIL inputs on plug-in cards will protect a CMOS system from problems associated with "on power" fault isolation, a widely used TTL system maintenance method. Plugging CMOS into powered connectors has led to latch-up failures because it allows inputs to see logic "1" signals before V_{cc} rises on the card. The failure is frequently catastrophic if input current is not limited.

HiNIL's lower output impedance and DC noise margin of 3.5 volts ignore large voltage noise transients that can cause CMOS logic errors. Also, static charges large enough to rupture CMOS oxide regions are often generated in dry environments by movement of materials and users. A HiNIL input gives more immunity to static and maximizes noise protection.

Examples of HiNIL Interface Devices

301 Dual 5-Input Power Gate 302 Quad Power NAND Gate (OC)	65mA relay or lamp driver
323 Quad NAND Gate (OC) 332 Hex Inverter (OC) 334 Strobed Hex Inverter (OC)	Input noise protection plus open-collector pullup to other logic levels
350 8-Bit Multiplexer 351 Dual 4-Bit Multiplexer	Drive longer lines than TTL with 10X noise immunity (I_{OH} = 12mA)
361 Dual Input Interface 362 Dual Output Interface 363 Quad Output Interface	361 directly connects HiNIL to DTL/RTL/TTL 362 and 363 connect DTL/RTL/TTL to HiNIL
367 Quad Schmitt Trigger 368 Quad Schmitt Trigger (OC)	Suppress 100V/1μs spikes, protect CMOS decode switches, etc
380 BCD to Decade Decoder 381 BCD to Decade Decoder (OC) 382 BCD to Decade Decoder 383 BCD to 7-Segment Decoder	Provide decode/drive for lamps, LEDs, gas discharge displays, etc
390 Interface Buffer Series	250mA HiNIL driver series will be available soon

HiNIL reliability insurance costs little since the I/O circuits—unlike filters and shielding—generally replace other logic and drive circuits. So, don't wait until your new CMOS system runs into costly problems in the field. We'll show you how to build foolproof low-power systems. Call or write today for HiNIL application notes and specifications.

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Editorial

Wanted: S.O.B.s

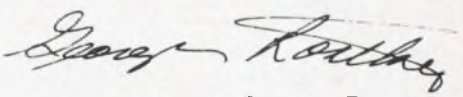
I was having a beer the other day with Jack, the press liaison man for a leading semiconductor house. "Your guy, Ted," he said (but I just changed the name because it could have been any of our editors), "visited us the other day and really roughed up some of our executives.

"Sure he asked all the questions they expected but then he started sneaking in those tough questions they didn't want to answer. He asked about characteristics we didn't measure. He asked us to define 'typical.' He asked us exactly how we measured some parameters that no two manufacturers seem to measure the same way. He was loaded with unkind questions.

"When we described some of our products with some of the exaggeration that's common in our business, he sort of smiled a bit as if he appreciated the humor. He had us all laughing at his jokes—even the bad ones—but he made us squirm a bit when he was digging for technical information. When we later saw his article, we could tell that we weren't the only ones he had grilled. Later, our chief engineer said to me: 'That fellow's a nice guy but he's a tough S.O.B.'"

When I heard Jack's story, I must confess, I glowed. Editors are supposed to know the industry they serve and they're supposed to be able to separate truth from hyperbole. But they can't know every technology as well as can the experts in that technology. So they've got to learn to ask lots of very sharp questions. They've got to develop finely honed ears so they can distinguish fact from the stuff that comes from the end of a horse that doesn't eat. When an editor develops that facility, some people, with admiration and respect, will call him an S.O.B.

Electronic Design can use some more S.O.B.s like Ted. We need one in San Francisco's Bay Area (in the heart of Silicon Valley) and another in our home office in New Jersey. If you're interested, or know somebody who might be, let us know. And if you're a nice guy (or gal) don't worry, we can train you.



GEORGE ROSTKY
Editor-in-Chief

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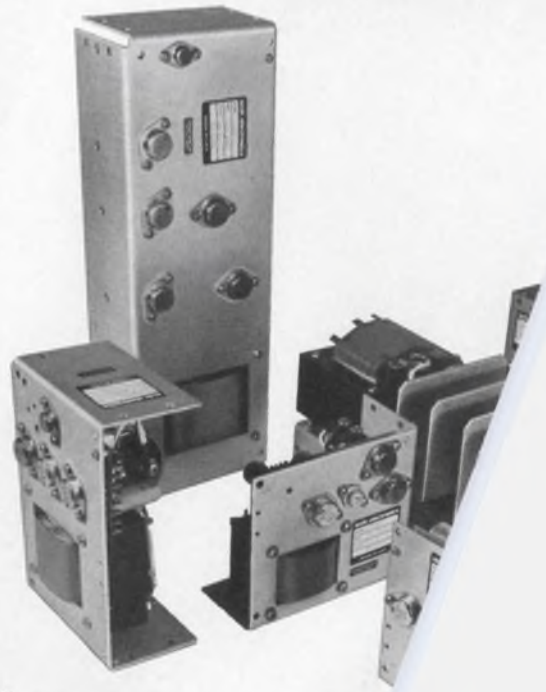
INTRODUCING THE EC SERIES -A NEW LINE OF LOW COST POWER S

The EC series is ACDC's new line of power supplies designed for OEM applications. No bells and whistles, no fancy frills or extras. Just solid, reliable power supplies designed and built by ACDC Electronics . . . a name synonymous with quality.

The EC series is mechanically and electrically interchangeable in form, fit and function with other open frame power supplies that meet accepted industry standard. There are over 50 models to choose from in a wide range of voltages and currents so you can order the exact power supply for your application. Power supplies with a maximum of reliability at minimum cost.



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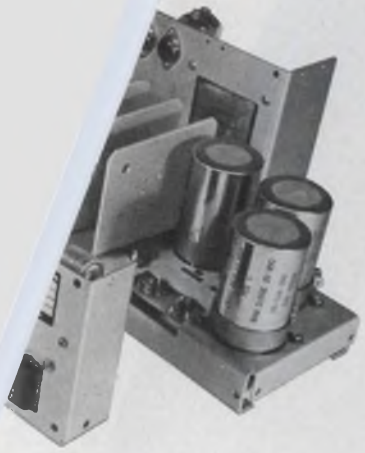
SINGLE OUTPUT POWER SUPPLIES

Nominal Output Voltage	Max. Current (amps)	Model Number	Price 1	Price 100	Price 250
2 V.	3.0	EC2N3	$ 31.00	$ 24.95	$ 22.95
	6.0	EC2N6	51.00	41.50	39.00
	9.5	EC2N9.5	63.00	51.00	48.50
	12.0	EC2N12	80.00	65.50	62.00
	17.0	EC2N17	101.00	82.00	78.00
	25.0	EC2N25	137.00	112.00	106.00
5 V.	3.0	EC5N3	31.00	24.95	22.95
	6.0	EC5N6	51.00	41.50	39.00
	9.5	EC5N9.5	63.00	51.00	48.50
	12.0	EC5N12	80.00	65.50	62.00
	17.0	EC5N17	101.00	82.00	78.00
	25.0	EC5N25	137.00	112.00	106.00
6 V.	2.6	EC6N2.6	31.00	24.95	22.95
	5.4	EC6N5.4	51.00	41.50	39.00
	8.5	EC6N8.5	63.00	51.00	48.50
	11.0	EC6N11	80.00	65.50	62.00
	15.0	EC6N15	101.00	82.00	78.00
	23.0	EC6N23	137.00	112.00	106.00
12 V.	2.2	EC12N2.2	31.00	24.95	22.95
	3.5	EC12N3.5	51.00	41.50	39.00
	6.0	EC12N6	63.00	51.00	48.50
	7.5	EC12N7.5	80.00	65.50	62.00
	11.0	EC12N10	101.00	82.00	78.00
	16.0	EC12N16	137.00	112.00	106.00
15 V.	1.8	EC15N1.8	31.00	24.95	22.95
	3.0	EC15N3	51.00	41.50	39.00
	5.0	EC15N5	63.00	51.00	48.50
	6.5	EC15N6.5	80.00	65.50	62.00
	9.5	EC15N9.5	101.00	82.00	78.00
	14.0	EC15N14	137.00	112.00	106.00
20 V.	1.5	EC20N1.5	31.00	24.95	22.95
	2.5	EC20N2.5	51.00	41.50	39.00
	4.2	EC20N4.2	63.00	51.00	48.50
	5.3	EC20N5.3	80.00	65.50	62.00
	8.0	EC20N8	101.00	82.00	78.00
	11.0	EC20N11	137.00	112.00	106.00
24 V.	1.3	EC24N1.3	31.00	24.95	22.95
	2.4	EC24N2.4	51.00	41.50	39.00
	4.0	EC24N4	63.00	51.00	48.50
	5.0	EC24N5	80.00	65.50	62.00
	7.5	EC24N7.5	101.00	82.00	78.00
	10.0	EC24N10	137.00	112.00	106.00



DUAL OUTPUT POWER SUPPLIES

Nominal Output Voltage	Max. Current (amps)	Model Number	Price 1	Price 100	Price 250
±12/15	0.5	EC12D0.5	$ 45.00	$ 38.00	$ 35.00
±12/15	1.5	EC12D1.5	69.00	57.00	53.00
±12	3.0	EC12D3	89.00	72.00	67.00
±15	3.0	EC15D3	89.00	72.00	67.00
±12	5.0	EC12D5	122.00	99.00	92.00
±15	5.0	EC15D5	122.00	99.00	92.00

TRIPLE OUTPUT POWER SUPPLIES

Nominal Output Voltage	Max. Current (amps)	Model Number	Price 1	Price 100	Price 250
5V ±12/15	6.0 1.0	ET401	$113.00	$ 92.00	$ 85.00
5V ±12	12 3	ET601	165.00	135.00	125.00
5V ±15	12 3	ET602	165.00	135.00	125.00

OVERVOLTAGE PROTECTION OPTION

Rated output current of power supply	Price 1	Price 100	Price 250
0 to 12 Amps	$ 8.00	$ 7.50	$ 6.50
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FOCUS on Printed circuits

Don't be too discouraged if a printed-circuit manufacturer says your job can't be done. What one PC vendor feels is impossible or impractical to achieve, another vendor may consider routine.

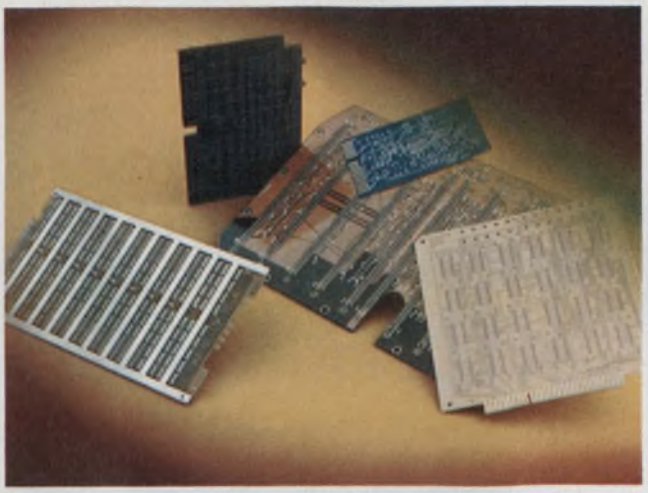
Your design may not be all that unusual. Circuit designers continually press the state of the art and many, but not all, board manufacturers find ways of meeting these demands.

Morris Grossman
Associate Editor

It's wise to remember that though PC technology is based upon a large body of common knowledge, every vendor has his own proprietary touches. Thus you should. check several PC sources before you conclude that your design requirements can't be met or that there is only one, expensive, way to do the job.

However, be sure that the vendors know exactly what you want. To avoid misunderstandings,

Additive processing for PC boards has the potential of becoming the most economical method, according to Photocircuits Div. of Kollmorgan Corp. High definition patterns are made without the use of resists.



Multilayer boards and plated-through holes are now routinely made, as illustrated by these TRW/Cinch Graphic boards.

A reflow solder machine at Buckbee-Mears Co. ensures dependable reflow and wicking when component pins are connected to solder pads.

you must give the vendor drawings and specs that are free of contradictions or errors and that contain all the essential information. Some of the common problem areas are these:

- Outdated and superfluous specs.
- Defective artwork—poor registration, pad tolerances not maintained.
- Contradictory hole-location data.
- Excessive number of different hole sizes.
- Mixing plated-through with nonplated-through holes.
- Inadequate base-material description and unclear copper-weight specs.

PC technology has been around a long time. It's a mature industry. But that's no reason why the PC specs must be ossified. Specifications need to be continually examined and rewritten. Far too many that originated many years ago still contain requirements intended for vacuum tubes and high voltages. When the specs are outdated, costs may climb.

Artwork often at fault

How about poorly executed artwork? A common problem is that pads, which locate clusters of fixed mounting pins—such as for IC packages, transformers or relays—have been sloppily positioned. If a PC vendor drills through the pad center holes and ignores a dimensioned drawing of the part, the part may not fit. But drilling in accordance with the dimensioned drawing may result in broken-out lands on the pads. Solution: Be precise.

A companion problem occurs when the PC holes must be located by X-Y coordinates to allow for drilling with numerically controlled (NC) machines.

Most PC vendors are set up to locate holes from the artwork, since this approach ensures placement of the hole in the center of the pads and also because most commercial PC drawing sets require this approach. Thus if your needs call for the X-Y coordinate approach, check first to see if the vendor is equipped to handle NC work economically, and then make doubly sure your artwork conforms to the hole-location dimensions.

Another complaint frequently reported by PC vendors is that the artwork registration between the component and soldering sides of double-

The advantages of additive PC processing include no copper undercutting and more efficient copper use.

Numerically controlled drills at the Bureau of Engraving, Inc., handle panel sizes to 25 × 25 in. Taped data automatically direct multispindle machines to accurately drill PC-board hole patterns.

sided boards is not adequately maintained. Misaligned pads break out when drilled through.

Don't specify many different hole sizes for your board. Each size needs a drill change; that takes time, costs money and may produce errors. Usually the number of hole sizes is more important from the standpoint of cost than the total number of holes drilled in the average board.

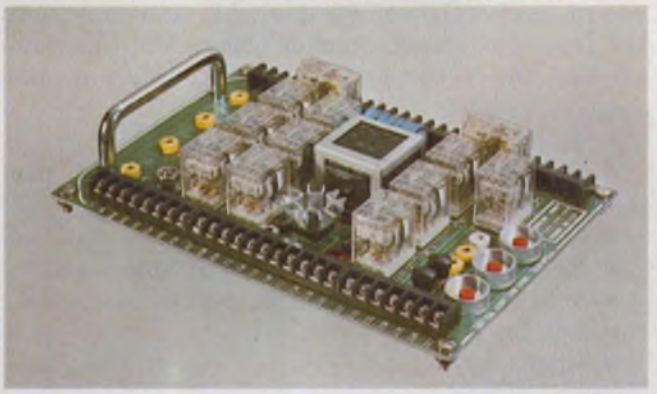
And don't specify both plated-through and nonplated-through holes on the same board. The double handling is costly. If some of the holes must be plated through, plate all of them. Understandably there are exceptions to this rule, such as when several large holes are needed for routing purposes or where components shouldn't be soldered into a hole.

Of course, the board base material should be thoroughly and unambiguously described. Identify the material by industrywide designations. If a specific laminator's part number is given, provide equivalent designations as well. Provide material thickness, any applicable military specs and the final board copper thickness or weight.

Copper weight specs are a common source of ambiguity when plated-through holes are used. The plating operation adds thickness to the copper on all parts of the board, and it's not always clear whether the spec refers to the final or initial copper thickness. Suppose you want a final weight of 2 oz/ft^2. From the PC vendor's point of view, it's better to start with a thinner copper layer—say, 1-oz of copper—and let the plating operation put on the additional ounce. But in any event, specify the final weight.

Which laminate?

The first decision the design engineer faces when specifying a PC board is: "What shall I use for laminate base material?" The more demanding the environment for the PC board, the more restricted the choice. Note the classification of NEMA-grade laminates against temperature in the table of substrate materials. Above 310 F, only G-7 and G-11 are permissible. The choice of permitted materials rapidly increases at lower temperatures.



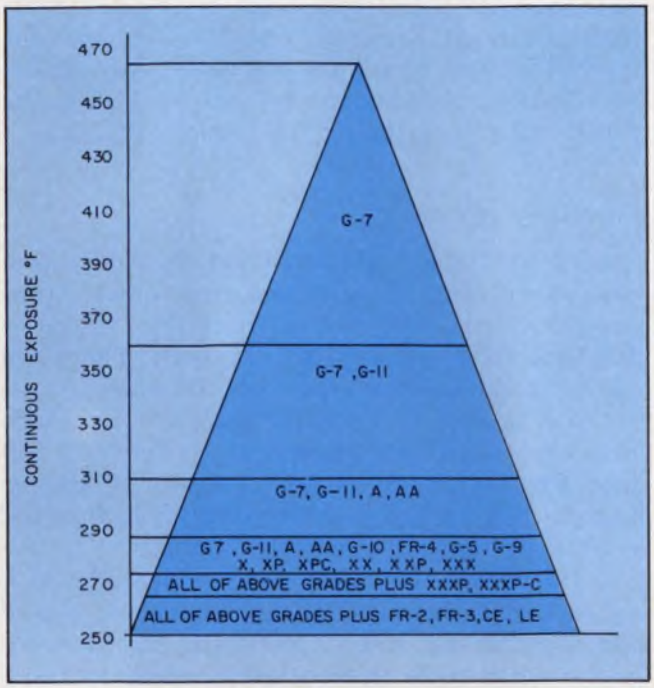
Many PC vendors provide a complete service. Like Dattilo Enterprises, they do everything from artwork to board assembly, and test to customer specs.

Paper phenolic base material is the lowest cost and most widely used, but glass epoxy, though considerably more expensive, is the type most often specified by the military and for demanding environments. Glass epoxies can cost three to five times as much as paper-phenolic grades.

In addition glass epoxy has a disadvantage: Carbide-steel tools must be used to cut or drill the material in production work. Holes punched in glass epoxy leave crazed edges, so glass boards are generally drilled, especially when the holes are to be plated-through. And drilling is a more expensive operation than punching.

Nevertheless, for dimensional stability and strength, glass epoxy is the usual choice. For many years, continuous-filament G-10 was the

Substrate temperature characteristics



From Institute of Printed Circuits—Printed Wiring Design Guide.

PC substrate materials

NEMA grade	Base material	Resin	Military	
			Specification	Type
X	Paper	Phenolic	MIL-P-79	PBM
XP	Paper	Phenolic	MIL-P-78	HSP
XPC	Paper	Phenolic	—	—
XX	Paper	Phenolic	MIL-P-3115	PBG
XXP	Paper	Phenolic	MIL-P-3115	PBE-P
XXX	Paper	Phenolic	MIL-P-3115	PBE
XXXP	Paper	Phenolic	MIL-P-3115	PBE-P
XXXPC	Paper	Phenolic	MIL-P-3115	PBE-P
CE	Cotton	Phenolic	MIL-P-15035	FBG
LE	Cotton	Phenolic	MIL-P-15035	FBE
A	Asb. paper	Phenolic	MIL-P-8059	PBA
AA	Asb. fabric	Phenolic	MIL-P-8059	FBA
G-2	Staple glass	Phenolic	—	—
G-5	Cont. glass	Melamine	MIL-P-15037	GMG
G-7	Cont. glass	Silicone	MIL-P-997	GSG
G-9	Cont. glass	Melamine	MIL-P-15037	GME
G-10	Cont. glass	Epoxy	MIL-P-18177	GEE
G-11	Cont. glass	Epoxy	MIL-P-18177	GEB
N-1	Nylon	Phenolic	MIL-P-15047	NPG
FR-2	Paper	Phenolic	MIL-P-3115	PBE-P
FR-3	Paper	Epoxy	MIL-P-3115	PEE
FR-4	Cont. glass	Epoxy	MIL-P-18177	GEE
FR-5	Cont. glass	Epoxy	—	—
GPO-1	Glass mat	Polyester	—	—

From Institute of Printed Circuits—Printed Wiring Design Guide.

most widely used glass epoxy, but it is being replaced by flame-retardant FR-4.

Between the cheapest and most expensive materials there are gradual variations of electrical, mechanical and chemical properties to fit almost any need. For example paper-phenolic grades XXXP and XXXPC differ mainly in insulation resistance and cold-punching characteristics. Another paper phenolic, FR-2, is similar in properties to XXXPC and also flame-retardant. The paper-epoxy FR-3 is flame-retardant and has higher flexural strength than XXPC, but it is nearly double the cost.

Putting more in less space

Circuit design engineers are forever pressuring PC manufacturers to squeeze more components onto the boards. But modern parts are no longer restricted to simple two-terminal resistors, capacitors and inductors. Most are multiterminal packages with many closely spaced connections (see layouts for DIP and T-100 can), and this makes it tough to squeeze the required interconnections onto the board.

Part of the solution is closer spacing and narrower conductor paths. But closely spaced conduction paths present reliability hazards and reduce production yields. Specks of dust in a resist coating can cause fine lines to be etched with interrupts or short-circuits. Correcting or avoiding such defects can be expensive especially on large, complex boards. Further, the defective board might pass unnoticed to the final assembly stage and lead to difficult-to-detect problems.

Of course, double-sided and multilayer boards allow higher component densities than do single-sided boards, but the board price increases faster than the density. Not only does the layout and fabrication of double-sided and multilayer boards cost more, but more costly laminate material must be used to provide the required dimensional stability.

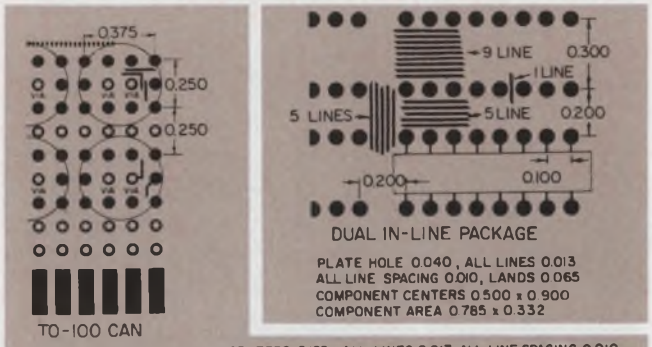
And a choice must be made between using plated-through and eyelet connections through the boards with double-sided and multilayer boards. Many manufacturers claim plated-through holes to be more reliable, less expensive and to facilitate wave solderings.

Another choice the engineer must make is between a few large boards or many small ones. In spite of compelling arguments for small boards—low-cost, throw-away packaging, modularity, easy fault isolation—PC experts, such as those at Lockheed Electronics Co., Los Angeles, report that the trend is to large boards.

Smaller boards need more connectors, wiring and cables. And systems built with small boards generally occupy more space, weigh more and leave less room on the board for such conveniences as built-in card extractors.

Fortunately the choices need no longer be influenced by the manufacturing problems of the recent past. PC manufacturers say there no long-

Typical line spacing on PC boards



From Institute of Printed Circuits—Printed Wiring Design Guide.

er is any reason to hesitate to use either multilayer boards or plated-through holes, which were formerly considered difficult to produce. Most manufacturing problems have been solved, and engineers can now concentrate on the cost tradeoffs.

Rules of thumb when buying

Cost comparisons aren't easy. Costs can depend upon such intangibles as vendor competition, economic conditions and even geographic location. But there are some rules of thumb to follow.

Where small boards in moderate quantities (100 to 500) may cost $2 to $6, larger designs run from $20 to $50 for single or double-sided units and $50 to $70 for multilayer.

Of course, it pays to order in quantity. A typical 4 × 6-in. board might cost $19 each in quantities of 10, or $5 in quantities of 100, and only $3.50 when 500 are ordered.

For a board with half the area, say 3 × 4 in., prices might drop only 10 to 20%—$17, $4.25 and $2.80. Not much of a saving. But double the 4 × 6 board to 6 × 8 in., and the price doesn't quite double. It may go up only 80%—$35, $8 and $5.50. Thus a large board gives you more real estate per dollar.

Reduce the number of different hole sizes—say, from eight to four—and you can save up to 5%. Knock off the request for rounded edges, and you save another 10¢ per board in the 500 quantities.

Don't ask for solder plating. Instead, accept simple etched copper with only a protective water-dip lacquer, and you can save as much as 20% more.

A double-sided board costs 2 to 2.5 times more than a single-sided, when both sides have about the same density. And for multilayer boards, one rule of thumb takes the cost of a two-sided board of the same area and density and multiplies it by the number of layers, plus 20% for bonding and checkout. Thus a 4 × 6, two-sided board that sells for $3.50 might cost about $16.80 in a four-layered version. But other opinions hold that for more than four layers, cost increments go down; so a 10-layer board might add only $10.50, to the four-layer cost, bringing the total to $27.30.

Choosing a vendor

Some PC vendors are small and serve only local companies. This is excellent for quick turnaround. Others serve the entire nation. If you've got time to shop for price, try both. There are plenty to choose from—perhaps too many.

Some vendors will provide samples of the circuit you design, if a large order is likely to follow. Or they might supply samples of similar boards they made for other companies. But you can't really judge a vendor by samples.

No vendor in his right mind will send you a board that reveals shoddy workmanship. You're not likely to get pitted, blistered, crazed (connected white spots on or below laminate surface) or measled (discrete white spots below laminate surface) boards, or boards that have peeling copper or bridging solder.

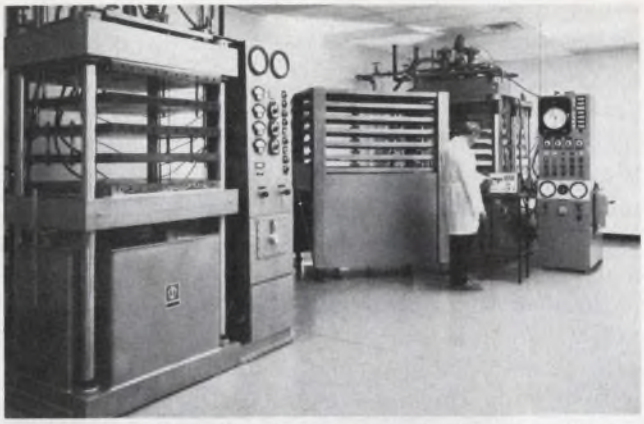
On the other hand, don't be overly critical and reject boards merely because the cosmetics don't please you. Slightly rough-edged lines, small copper blemishes or even somewhat over-tolerance holes are not good reasons for automatic rejection, if the board will reliably perform its intended function. A gold-plated board may look good, but obviously it will be expensive.

And even if samples are perfect, there is no assurance that ones you buy will be like the samples you evaluated.

This makes vendor selection a tough job. PC vendors sell a capability and service. It's therefore essential to check for process control, quality control, cleanliness and past performance. Does the vendor have a good reputation for keeping delivery promises? And does he deliver for the agreed-upon price?

Services vary widely. Some vendors can handle only conventional single or double-sided boards; others are more versatile and can do multilayer work and special work, not widely available. A few can work from schematic drawings and provide completely assembled boards; most, however, must have the finished scaled-up artwork and prefer to deliver only blank PC boards. A minority of vendors prefers to work from dimensioned mechanical drawings to extract X-Y coordinates for NC drilling. Also, by preparing their own artwork, some can adapt line widths and layout to take advantage of special processes.

In many large companies the design engineer must use in-house PC facilities. Some experts report that as many as two-thirds of the boards



Presses for bonding multilayer boards at Bureau of Engraving, Inc., are controlled by thermocouples that check the internal temperature of the laminates.

made in this country are built in-house. But there is still plenty of business for independent PC vendors. The two-thirds proportion appears high only because the large electronics companies make a tremendous number of boards; it doesn't mean that two-thirds of the companies make their own boards.

Any company can do as much or as little as it wants of its PC board production. A vendor can always be found to start at any point in the design/production cycle and to deliver at any stage. You can work with several vendors—one to do the artwork, another to provide blank PC boards, a third to assemble and perhaps a fourth to test.

A large company like IBM can start from scratch and even make its own laminate from raw bulk materials. And yet even IBM still buys many boards from outside vendors.

Most manufacturers, both in-house and independent, buy their laminates from companies like the 3M Co., Mica Corp., GE, Keystone Electronics, Shigoto Industries, Schjeldahl, Synthane, TME Corp., Woodrow Corp. and others.

Many circuit and system design companies have at least a prototype PC facility. And many can prepare their own artwork with supplies of masking film from a company like Ulano and tapes, stick-on component clusters and pads from Brady, Bishop Graphics, Circuit-Stik, Keuffel & Esser, Datak and Russel Industries.

PC technology advances, but gradually

What does the future hold?

Marvin A. Larson, a vice president with Bureau of Engraving, Inc., says: "The future of printed circuits will continue to be evolutionary. There is nothing on the present horizon that will revolutionize our industry. But there will be change, though it will be gradual."

Larson predicts that microthin foils will have a significant impact upon PC technology—but slowly. And additive-copper board production will have only a limited use—much as we see it today—especially as more of its negative aspects are realized, he says.

PC experts at Lockheed Electronics also foresee gradual changes. Their forecast for the next two to five years includes the following:

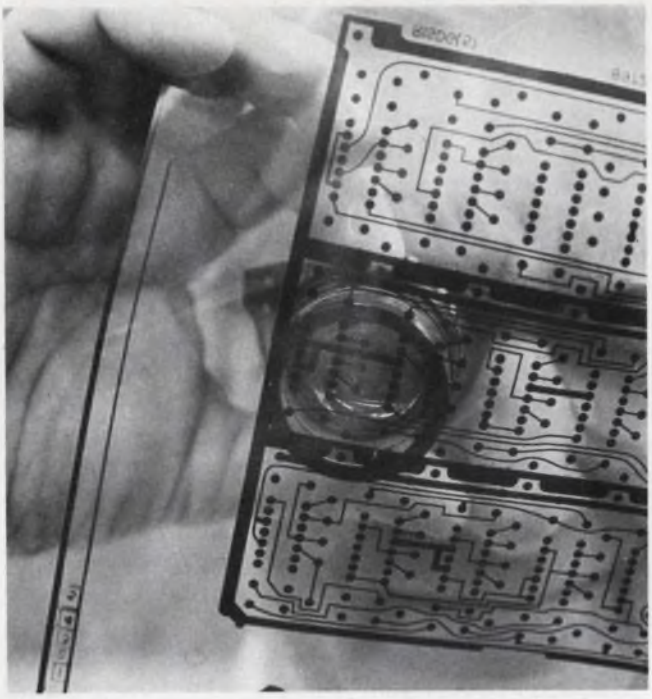
- Line widths as small as 0.003 to 0.005 in. will be developed and used commonly.
- Small holes from 0.013 to 0.015 in. will be frequently used for some IC devices.
- Very thin foils will increase in use and aid in the production of very narrow lines. Copper-plating thickness, now specified mostly at 0.001 in. maximum, may be reduced to as low as 0.0001 in.
- Gold-on-edge connectors will be eliminated. A plating material that is less costly and can be applied over the entire board will become common.
- Tin/lead etch resists will probably be replaced by nonmetallic resists, when the price of the nonmetallic drops.
- Dry-film photosensitive coatings can provide high resolution and will increase in use. Screen printing will be used only for boards with wide lines and spaces.
- Additive-copper processes will be used more as cost savings are proved and specs—in particular military specs—are changed to allow their use.

Lockheed seems more optimistic about the future of additive processes than Larson of Bureau Engraving, Inc., and most PC vendors seem to agree with Lockheed. Mike D'Ambrosio, general manager of the Photronics Div. of Control Systems Research, mentions two additional innovations he sees in PC technology:

1. Ultraviolet curing of screen inks and solder masking will be used increasingly instead of heat. The advantages include lower power costs, elimination of toxic fumes, less labor and better final quality.
2. Light-sensitive water-soluble emulsions, now being introduced, will produce finer lines at lower costs than the current dry film and wet resists.

D'Ambrosio expects screen-printing methods to remain constant, with only minor changes for the foreseeable future, and limited to line widths larger than 0.015 in. And he looks for photoprinting to be used for higher reso'utions.

Photocircuits, Div. of Kollmorgen Corp., is particularly bullish on additive PC methods. Recently the company announced its Photoform process, which it claims can produce high definition without the use of a resist. The company also believes that coated metal-core substrates, with conductive paths formed by additive methods, should prove a winning combination. Advantages



Phototechniques enable fine line resolution in PC-board manufacturing. Scott Graphics Positive II dry-process film can resolve over 500 line pairs/mm.

claimed include unbreakable, nonflammable boards with built-in heat sinks and low costs.

Additive processes for manufacturing PC boards are one of the few recent innovations in the industry. They now account for about 5% of the double-sided PC boards made in this country, and a rise to 20% by 1980 is predicted in a recent study, "Printed Circuit Technology and Market Assessment," by Darling & Alsobrook, Los Angeles. Though costs are still high, the study predicts that by 1978, savings in etchant, copper and manpower should overcome the high initial investment in equipment and the greater automation that the additive processes require.

Though 5-to-10-mil spacing and lines are realistically routine with additive methods, 3-mil lines are not far off. Additive is not subject to the dangers of overetching or underetching and is thus said to produce cleaner lines than subtractive methods. Additives can also automatically provide plated-through holes, while subtractive methods can damage the holes if the resist comes off.

While a fully additive method requires new capital equipment outlays, a semiadditive method may be used with equipment now common to conventional subtractive circuit manufacturing, and requires only a few extra steps. The method uses a plain insulating substrate. After holes for plating-through are drilled, the substrate is coated with a thin adhesive layer and then treated to render it catalytic to electroless metal deposition. A thin layer—typically 0.001-in. thick—of copper is then electrolessly deposited on the board surfaces and in the holes. A screen or photoresist pattern on this layer enables subsequent electroplate buildup of the conductor paths. The conductors are thereafter coated with etch-resistant metal. And after the screen or photoresist material is stripped away, the thin-layer copper background can be quickly etched away.

Because the etched material is very thin, not much copper is lost and very little undercutting can occur. Plated-through holes are produced with plating thickness equal to the surface conductors, and no discontinuities develop between the metal in the holes and the conductors.

While in semiadditive, most of the copper is applied by electroplating, in a purely additive process, electroplating is not practical, because the separate parts of a pattern are not electrically connected. Thus the full thickness of the conductors must be deposited by electroless methods, which may be slower and more expensive.

A major advantage that was initially attributed to additive processes was the promise of alleviating waste-disposal problems. But though additive techniques don't generate the etchant-disposal and copper-recovery problems of subtractive methods, depleted additive electroless baths must still be disposed of. An ideal solution would be a combination of additive and subtractive methods, where copper compounds that build up as a waste product in a subtractive process would be used to replenish the copper content of an additive electroless solution.

Many of the advantages claimed for additive processing are being challenged by subtractive methods that use clad foil of less than 1-oz/ft^2 weight. The principle advantage of thin-foil laminates is that they use the capital equipment and process technology already familiar to the majority of PC fabricators. However, for the long term, according to James A. Brewer, section head of research and development, Litton Industries, Beverly Hills, CA, both additive and subtractive methods will find an overlapping market.

William H. Tayor 3d, vice president of engineering at Excel Products explains: "With 1/4-oz/ft^2 foil, a subtractive-oriented shop can print line densities below the presently accepted threshold of 10-mil lines and spaces with no new capital investment. And even more important, learning-curve expenses and problems are minimal. Yet thin-foil techniques gain most of the pollution-reduction advantages of additive processing. This is an important consideration, because pollution abatement will be a major PC industry headache shortly.

R. E. Pritchard, executive director of the Institute of Printed Circuits, Evanston, IL, re-

ports: "Possibly the biggest impact on our industry in the next few years will be the EPA [Environmental Protection Administration]. The National Commission on Water Quality has recently estimated that the capital requirements for pollution-control equipment will be several times higher than the original investment in production equipment. Most companies are not prepared for such expenditures."

Battle lines are now forming. The institute is leading a contingent of companies in the demand for more "realistic" regulations. ■■

Available literature

Specifying and inspecting PC boards is more complicated than it seems. Following are some of the published standards and methods available to help designers.

From the Institute of Printed Circuits, 1717 Howard St., Evanston, IL 60202:

IPC Printed Wiring Design Guide, IPC Test Methods Manual and *IPC Assembly-Joining Handbook*, three looseleaf manuals that can be expanded and updated periodically. In addition the institute provides an extensive listing of individual specification and standards, such as *Acceptability of Printed Wiring Boards* (IPC-A-600B) and *Suggested Guidelines for Printed Wiring Board Repair and Modification* (IPC-R-700A).

From Martin Marietta Aerospace, MP-29, P.O. Box 5837, Orlando, FL 32805:

Workmanship Standards, containing colored photos of preferred acceptable and reject criteria for PC boards.

From N. V. Philips' Gloeilampenfabrieken, Publications Dept. Electronic Components and Materials Div., Eindhoven, the Netherlands:

Printed Circuit Boards, a guide to specifying and designing. It provides extensive coverage, from preparation of artwork to soldering, with many useful tables and color photos.

From Electrochemical Publications Ltd., 29 Barns St., Ayr, KA7 1XB, Scotland:

Printed Circuit Troubleshooting, H. R. Shemilt. A reference for pinpointing the cause of problems with suggested remedies, mostly in tabular form.

Need more information?

PC technology encompasses many diverse disciplines and services—artwork, photography, silk-screening, etching, plating—and also many sources of materials. Following is a partial list of companies in the field. Companies marked (v) are vendors of single, double-sided or multilayer boards, (p) provide PC production services, (m) provide production machinery, (c) provide chemicals, (b) provide PC-board materials and (s) provide silk-screen equipment. For a more extensive listing, consult ELECTRONIC DESIGN's GOLD BOOK.

AAI Corp., P.O. Box 6767, Baltimore, MD 21204. (301) 666-1400. (v) **Circle No. 401**

AD Ckts, Panorama Creek Dr., Rochester, NY 14625. (716) 381-2370. (p) **Circle No. 402**

Adv Circuitry, P.O. Box 2847, Commercial Station, Springfield, MO 65803. (417) 862-0751. (v) **Circle No. 403**

AEL, P.O. Box 552, Lansdale, PA 19446. (215) 822-2929. (p, v) **Circle No. 404**

Air Prods & Chem Inc., Specialty Gas Dept., P.O. Box 538, Allentown, PA 18105. (215) 395-8257. (c) **Circle No. 405**

Algorex Data Corp., 6901 Jericho Turnpike, Syosset, NY 11791. (516) 921-7600. (p) **Circle No. 406**

Allied Chemical Corp., Specialty Chem Div., P.O. Box 1087, Morristown, NJ 07950. (201) 455-5083. (c) **Circle No. 407**

American Screen Printing Equipment Co., 404 N. Noble St., Chicago, IL 60622. (312) 829-4004. (s) **Circle No. 408**

Amon Ra Inc., 149 E. Third St., Beaumont, CA 92223. (714) 845-4715. (v) **Circle No. 409**

Amphenol Cadre Div., Bunker Ramo Corp., P.O. Box 150, Endicott, NY 13760. (607) 754-4444. (p) **Circle No. 410**

Ansley Elecs Corp., 3208 Humboldt St., Los Angeles, CA 90031. (213) 223-2331. (v) **Circle No. 411**

ARF Prods Inc., 25596 75th St., Boulder, CO 80301. (301) 443-4844. (p) **Circle No. 412**

Artech Corp., 2816 Fallfax Dr., Falls Church, VA 22042. (703) 560-3292. (p, v) **Circle No. 413**

Astrocom Corp., 15012 Minnetonka Ind., Minnetonka, MN 55343. (612) 933-2208. (v) **Circle No. 414**

Attronics Corp., 530 Turnpike St., Rte. 114, North Andover, MA 01845. (617) 685-4336. (v) **Circle No. 415**

Autosplice Div., 222 E. 23 St., New York, NY 10010. (212) 674-4369. (v) **Circle No. 416**

Beco Inc., 740 Kesler Mill Rd., Salem, VA 24153. (703) 389-3053. (v) **Circle No. 417**

Bishop Graphics Inc., 20450 Plummer St., Chatsworth, CA 91311. (213) 993-1000. (b) **Circle No. 418**

Boston Digital Corp., 86 South St., Hopkinton, MA 01748. (617) 435-6871. (m) **Circle No. 419**

Buckbee-Mears Co., 245 E. 6th St., St. Paul, MN 55101. (612) 228-6371. (p, v) **Circle No. 420**

Bureau of Engraving Inc., 219 N. 2nd St., Minneapolis, MN 55401. (612) 339-8001. (v, p) **Circle No. 421**

Cambridge Thermionic, 445 Concord Ave., Cambridge, MA 02138. (617) 491-5400. (v, m) **Circle No. 422**

Casso-Solar Corp., 125-10 Queens Blvd., Kew Gardens, NY 10601. (212) 544-2424. (s, m) **Circle No. 423**

Cavitron Corp., 1290 Ave. of the Americas, New York, NY 10019. (212) 944-8430. (m) **Circle No. 424**

Center Line Specialties, Box 656, Boulder, CO 80302. (303) 443-9040. (p) **Circle No. 425**

Chemplast Inc., 115-150 Dey Rd., Wayne, NJ 07470. (201) 696-4700. (c) **Circle No. 426**

Christiansen Radio Inc., 1950 San Remod, Laguna Beach, CA 92651. (714) 497-1506. (v) **Circle No. 427**

Cincinnati Elecs Corp., 2630 Glendi-Milford, Cincinnati, OH 45241. (513) 563-6000. (p, v) **Circle No. 428**

Circuit Science Inc., 615 N. Country Rd. 18, Minneapolis, MN 55427. (612) 544-8635. (p, v) **Circle No. 429**

Circuit-Stik Inc., Centron Engrg Inc., 24015 Garnier St., Torrance, CA 90510. (213) 530-5530 (b) **Circle No. 430**

Colight Inc., 123 N. 3rd St., Minneapolis, MN 55401. (612) 333-8201. (m, s) **Circle No. 431**

Control Sys Research Inc., 1811 Main St., Pittsburgh, PA 15215. (412) 782-5300. (p, v) **Circle No. 432**

Custom Sys Assoc., 1427 N. W. Davis, Portland, OR 97209. (503) 224-7527. (p, v) **Circle No. 433**

Cyclo-Tronics, 3858 N. Cicero, Chicago, IL 60641. (312) 282-6141. (m) **Circle No. 434**

DAC, 725 Reddick Ave., Santa Barbara, CA 93103. (805) 963-3708. (m) **Circle No. 435**

Datak Corp., 65 71 St., Guttenberg, NJ 07093. (201) 869-2200. (b, c) **Circle No. 436**

Dattilo Enterprises, Inc., 9405 Doral Ct., Louisville, KY 40220. (502) 491-6262. (p, v) **Circle No. 437**

De Coursey Engrg., 11828 W. Jefferson, Culver City, CA 90230. (213) 397-9668. (v, p) **Circle No. 438**

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Defiance Circuit Corp., 12 Shepard St., Lawrence, MA 01843. (617) 688-1856. (p, v) **Circle No. 439**

Diablo Ind., 1713-B Junction, San Jose, CA 95112. (408) 288-6728. (p) **Circle No. 440**

Diceon Elecs Inc., 18522 Von Karman, Irvine, CA 92664. (714) 833-0870. (p, v) **Circle No. 441**

Digital Sys Inc., 232 E. Live Oak, Arcadia, CA 91006. (213) 445-6100. (m) **Circle No. 442**

Douglas Elecs, 718 Marina Blvd., San Leandro, CA 94577. (415) 483-8770. (p) **Circle No. 443**

Dow Chemical Co., 2020 Dow Center, Midland, MI 48640. (517) 636-1000. (c) **Circle No. 444**

DuPont De Nemours E. I., 1007 Market St., Wilmington, DE 19898. (302) 774-2421. (c, b) **Circle No. 445**

Dynell Elecs Corp., 75 Maxess Rd., Melville, NY 11746. (516) 694-0900. (v, p) **Circle No. 446**

Eastern Marking Machine, 30 Alabama Ave., Island Park, NY 11558. (516) 889-9090. (s) **Circle No. 447**

Eder Ind., 4865 S. 10 St., Milwaukee, WI 53221. (414) 482-2700. (p) **Circle No. 448**

EDI Inc., P.O. Box 66, Cairo, IL 62914. (618) 734-1694. (p, v) **Circle No. 449**

Electro-Science Labs Inc., 1601 Sherman Ave., Pennsauken, NJ 08110. (609) 663-7777. (c) **Circle No. 450**

Elecs Plastics, 21601 Parthenia, Canoga Park, CA 91304. (213) 882-1700. (v) **Circle No. 451**

Elgin Elecs, Walnut St., Waterford, PA 16441. (814) 796-2601. (p, v) **Circle No. 452**

Engineered Tech Prods Inc., 3421 U.S. Hwy 22, Somerville, NJ 08876. (201) 725-0330. (s) **Circle No. 453**

Enthone Inc., P.O. Box 1900, New Haven, CT 06508. (203) 934-8611. (c) **Circle No. 454**

Etchomatic Inc., 151 Newton St., Boston, MA 02154. (617) 893-2020. (b, s) **Circle No. 455**

Excel Prods Co., Inc., 700 Joyce Kilmer Ave., New Brunswick, NJ 08903. (201) 249-6600. (v) **Circle No. 456**

Fabri-Tek Inc., 5091 S. County Rd. 18, Minneapolis, MN 55436. (612) 935-8811. (p) **Circle No. 457**

Faul-Coradi Inc., 643 W. Onondaga St., Syracuse, NY 13204. (315) 475-2155. (p) **Circle No. 458**

Flexible Ckts, Paul Val Indl. Pk., Warrington, PA 18976. (215) 343-2300. (v) **Circle No. 459**

Flex-Link Prods Inc., 1923 First St., San Fernando, CA 91340. (213) 365-9355. (p) **Circle No. 460**

Garry Mfg. Co., 1010 Jersey Ave., New Brunswick, NJ 08901. (201) 545-2424. (b) **Circle No. 461**

GC Elecs, 400 S. Wyman St., Rockford, L 61101. (815) 968-9661. (v, c) **Circle No. 462**

General Automation, 11842 Vose St., North Hollywood, CA 91605. (213) 875-0618. (m) **Circle No. 465**

General Electric Co., Laminated & Insulating Matls Business, Coshocton, OH 43812. (614) 622-5310. (b) **Circle No. 464**

General Printed Ckts, Box 4013, Downey, CA 90241. (714) 997-3771. (v) **Circle No. 463**

General Research Inc., 309 S. Union St., Sparta, MI 49345. (616) 887-8221. (s) **Circle No. 466**

GT Schjeldahl Co., Electrical Prods Div., P.O. Box 170, Northfield, MN 55057. (507) 645-5633. (v) **Circle No. 467**

GTE Sylvania-Elec Components Grp., 100 First Ave., Waltham, MA 02154. (617) 890-9200. (p, v) **Circle No. 468**

Harshaw Chemical Co., Div. Kewanee Oil Co., 1945 E. 97 St., Cleveland, OH 44106. (216) 721-8300. (c) **Circle No. 469**

Hi-G Inc., 580 Spring St., Windsor Locks, CT 06096. (203) 623-2481. (v) **Circle No. 470**

Hughes Aircraft Co., Centinela & Teale St., Culver City, CA 90230. (213) 391-0711. (b) **Circle No. 471**

Hyde Park Elecs, 4547 Gateway Cir., Dayton, OH 45440. (513) 435-2121. (p, v) **Circle No. 472**

Hysol Div., Dexter Corp., 15051 E. Don Julian, City of Industry, CA 91744. (213) 968-6511. (c, v, s) **Circle No. 473**

IEC Elecs Corp., 319 Chestnut E., Rochester, NY 14445. (716) 586-7850. (p) **Circle No. 474**

Injectorall Elecs Corp., 98-100 Glen St., Glen Cove, NY 14445. (516) 671-6010. (m, c) **Circle No. 475**

Intl Elec Research, Sub Dynamics Corp. of America, 135 W. Magnolia, Burbank, CA 91502. (213) 849-2481. (v, p) **Circle No. 476**

Jaesic Ind. Co. Inc., 29830 Beck, Wixom, MI 48096. (313) 624-6411. (v) **Circle No. 477**

Kaimus & Associates, 2424 S. 25 Ave., Broadview, IL 60153. (312) 343-7004. (p) **Circle No. 478**

Kepro Ckts. System, 3630 Scarlet Oak St., St. Louis, MO 63122. (314) 225-5166. (c, b, m) **Circle No. 479**

Keystone Elecs. Corp., 43-49 Bleecker St., New York, NY 10012. (212) 475-4600. (b) **Circle No. 480**

Kinetic Sys. Corp., Maryknoll, Dr., Lockport, IL 60441. (815) 838-0005. (p) **Circle No. 481**

Lamart Corp., 16 Richmond St., Clifton, NJ 07015. (201) 772-6262. (b) **Circle No. 482**

Lehighton Elecs. Inc., RD 1, Lehighton, PA 18235. (717) 386-4156. (p, v) **Circle No. 483**

Lockheed Elec. Co., Data Prods Div., 6201 E. Randolph St., Los Angeles, CA 90040. (213) 722-6810. (p, v) **Circle No. 484**

Maine Elec., Rockwell Intl, River St., Lisbon, ME 04250. (207) 353-8611. (v) **Circle No. 485**

Matheson Gas Prods., P.O. Box 85, East Rutherford, NJ 07023. (201) 933-2400. (c) **Circle No. 486**

Mervap Coldlight Prods., 2654 S. La Cienega Ave., Los Angeles, CA 90034. (213) 870-2363. (m) **Circle No. 487**

Mica Corp., Box 2578, Culver City, CA 90230. (213) 559-4223. (b) **Circle No. 488**

3M Co., Indl. Elec. Div., 3M Center, St. Paul, MN 55101. (612) 733-1110. (b) **Circle No. 489**

New Hermes Engraving Machine Corp., 20 Cooper Square, New York, NY 10003. (212) 777-3080. (m) **Circle No. 490**

Norplex Div., UOP, Norplex Dr., La Crosse, WI 54601. (608) 784-6070 (b) **Circle No. 491**

Orbital Prod., Inc., 191 Factory Rd., Addison, IL 60101. (312) 543-7050. (v, p) **Circle No. 492**

Panob Corp., 18 Merritt, Port Chester, NY 10573. (914) 939-3066. (v) **Circle No. 493**

Paraplegics Mfg. Co., Inc., 303 N. York Rd., Bensenville, IL 60106. (312) 625-7741. (p) **Circle No. 494**

Parlex Corp., Box 488, Methuen, MA 01844. (617) 685-4341. (p, v) **Circle No. 495**

Pemco Inc., 820 Decatur N., Minneapolis, MN 55427. (612) 546-2431. (c) **Circle No. 496**

Perforated Prod., 68 Harvard, Brookline, MA 02146. (617) 232-6044. (v) **Circle No. 497**

Photocircuits Div., Kollmorgen Corp., 31 Sea Cliff Ave., Glen Cove, NY 11542. (516) 676-8000. (c, v) **Circle No. 498**

Polyscience Inc., Paul Valley Indl. Park, Warrington, PA 18976. (215) 343-6484. (c) **Circle No. 499**

Precision Electrical Mfg Co., 9628 6 Ave. N., Minneapolis, MN 55441. (612) 544-8655. (p) **Circle No. 500**

Precision Gas Prods., 681 Mill St., Rahway, NJ 07065. (201) 381-7600. (c) **Circle No. 501**

Printed Circuit Corp., 180 Elm St., Waltham, MA 02154. (617) 899-0380. (v) **Circle No. 502**

Rectico Inc., 20 Village Park Rd., Cedar Grove, NJ 07009. (201) 239-6464. (p) **Circle No. 503**

Relwood Ckts. Inc., 1117 Isabel St., Burbank, CA 91506. (213) 842-4859. (v) **Circle No. 504**

R K Electric Co. Inc., 11315 Williamson, Cincinnati, OH 45241. (513) 793-4060. (s) **Circle No. 505**

Rogers Corp., 77 Main St., Rogers, CT 06263. (203) 774-9605. (b) **Circle No. 506**

Rosemount Nashville, Inc., P.O. Box 107, Nashville, TN 37202. (615) 793-7561. (v) **Circle No. 507**

Rowe Engravers, 68-1 Union Ave., Clifton, NJ 07011. (201) 546-2776. (p, v) **Circle No. 508**

Sanders Assoc., Daniel Webster Highway S., Nashua, NH 03060. (603) 895-2817. (s) **Circle No. 509**

Scott Graphics, Inc., Holyoke, MA 01940. (413) 536-7800. (c, b) **Circle No. 510**

Sel-Rex Co., 75 River Rd., Nutley, NJ 07110. (201) 667-5200. (s) **Circle No. 511**

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Shigoto Ind. Ltd., 350 Fifth Ave., New York, NY 10001. (212) 695-0200. (v, b) **Circle No. 513**

Sibley Co., 23 Bridge St., Haddam, CT 06438. (203) 345-4523. (v) **Circle No. 514**

Spartanics Ltd., 3605 Edison Pl., Rolling Meadows, IL 60008. (312) 394-5700. (m) **Circle No. 515**

Stanford Applied Engrg., 340 Martin, Santa Clara, CA 95050. (498) 243-9200. (v) **Circle No. 516**

Sumitomo Bakelite Chemical Div., 345 Park Ave., New York, NY 10022. (212) 935-8888. (b) **Circle No. 517**

Superior Electric Co., 3000 Middle St., Bristol, CT 06010. (203) 582-9561. (m) **Circle No. 518**

Techniques, 236 Jackson St., Englewood, NJ 07631. (201) 569-5900. (v, p) **Circle No. 519**

Texas Instruments Inc., P.O. Box 5012, Mail Station 84, Dallas, TX 75222. (214) 238-2011. (v) **Circle No. 520**

TFE Inc., 100 Gilbane St., Warwick, RI 02886. (401) 738-7550. (c) **Circle No. 521**

Thermo-O-Lab Corp., Farmdale Hart Ave., North Hollywood, CA 91605. (213) 875-0105. (v) **Circle No. 522**

TME Corp., Salem Indl. Pk., Salem, NH 03079. (603) 893-1661. (b) **Circle No. 523**

Total System Concept., 3630 Scarlet Oak, St. Louis, MO 63122. (314) 225-5166. (m) **Circle No. 524**

Transene Co., Inc., Route 1. Rowley, MA 01969. (617) 948-2501. (c) **Circle No. 525**

Tran-Sil Prods., 2974 SW Temple, Salt Lake City, UT 84115. (801) 466-3636. (c) **Circle No. 526**

Tronic Corp., Div. Vacu-Blast Corp., Box 247, Belmont, CA 94002. (415) 593-1487. (m) **Circle No. 527**

TRW Cinch Div., 1500 Morse Ave., Elk Grove Village, IL 60007. (312) 439-8800. (v) **Circle No. 528**

Union Carbide, Chem-Plastics, 270 Park Ave., New York, NY 10017. (212) 551-2345. (c) **Circle No. 529**

Universal Scientific, 1312 S. 13 St., Vincennes, IN 47591. (812) 882-2970. (v) **Circle No. 530**

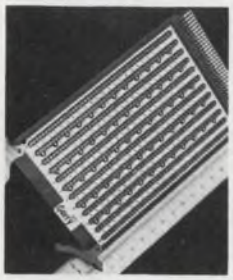
US Poymeric Armco Co., P.O. Box 671, Stamford, CT 06904. (203) 324-7545. (b) **Circle No. 531**

Vector Elec. Co., 12460 Gladstone Ave., Sylmar, CA 91342. (213) 365-9661. (v, b) **Circle No. 532**

Ventronics Inc., 346 Monroe Ave., Kenilworth, NJ 07033. (201) 272-9262. (v) **Circle No. 533**

Zagar Inc., 23922 Lakeland Blvd., Cleveland, OH 44132. (216) 731-0500. (m) **Circle No. 534**

IC PLUGGABLE PACKAGING ASSEMBLIES NOW AVAILABLE IN METRIC SIZES



Metric-sized IC pluggable packaging assemblies are now available from Garry Manufacturing Co., of New Brunswick, N.J. These meet the needs of European electronic manufacturers and of the machine tool industry.

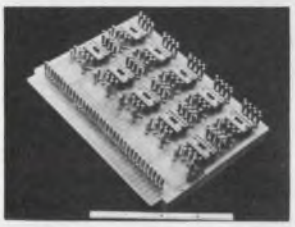
The new packaging assemblies can be obtained in many metric sizes, including: 100 mm x 160 mm.

The new metric boards offer large solder-plated ground and voltage plane area, and are offered with or without decoupling capacitors. Board is fabricated from glass epoxy 94V2.

Options include committed or non-committed power and ground planes. Contact pins in a variety of lengths permit one-, two-, or three-level wire wrapping. Pins are available in various thicknesses of gold over ductile nickel.

For complete information, use the Reader Service Card or contact Garry Manufacturing Co., 1010 Jersey Avenue, New Brunswick, N.J. Telephone 201-545-2424.

NEW SOLDERLESS BREADBOARDS FOR EXPERIMENT AND TEST

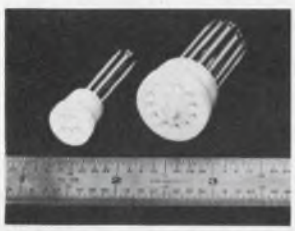


NEW BRUNSWICK, N.J. — A new series of plug-in breadboards is now available from Garry Manufacturing Company, of New Brunswick, N.J. Created to facilitate prototype design, experimentation, and testing of circuitry without the need for hardwiring, the new boards accommodate 14- or 16-pin DIPs and other packages, and are made in various sizes to accept from one up to as many as 50 integrated circuits.

Principal feature of the new boards is that they employ plug-in socket pins instead of the usual wire-wrappable or solderable connections. Thus, reliable yet temporary circuit interconnections can be quickly made and quickly changed during the course of design or test.

For complete information, use the Reader Service Card or contact Garry Manufacturing Co., 1010 Jersey Avenue, New Brunswick, N.J. Telephone 201-545-2424.

NEW TEST SOCKETS FOR TRANSISTORS



NEW BRUNSWICK, N.J. — A new line of test sockets, which accept the uncut leads of transistors, is now available from Garry Manufacturing Co., of New Brunswick, N.J. The new sockets have smoothly chamfered entry holes for fast insertion, and long, gold-over-nickel-plated beryllium copper elements that make reliable contact with the leads of the inserted components.

The sockets are available for three- to twelve-lead components, with pin circle diameters ranging from 0.200 inch to 0.510 inch. They are made in two basic versions: one to accept leads of 0.187 inch minimum length, the other for leads of 0.500 inch minimum length. Both accept leads ranging from 0.015 to 0.032 inch diameter. Contact resistance is 0.015 Ohm, maximum.

For complete information, use the Reader Service Card or contact Garry Manufacturing Co., 1010 Jersey Avenue, New Brunswick, N.J. Telephone 201-545-2424.

Improve your PC artwork techniques.

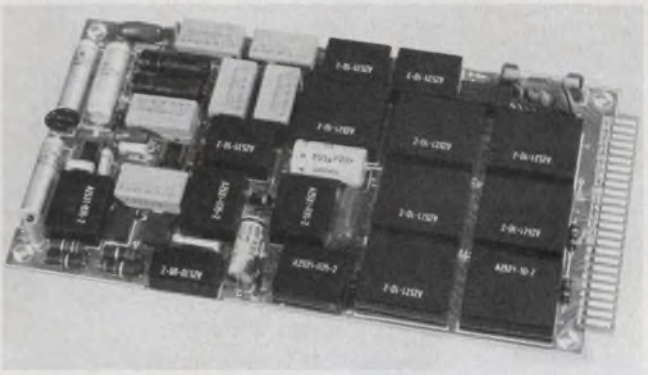
Even if you only supervise and check the work of others, you'll do a better job if you know the tricks of the trade.

You've completed your circuit design, you've got a schematic and detailed parts list. Now you're ready to implement the design on a printed-circuit (PC) board. The next stage—the circuit-board artwork—may present problems.

In some companies the work is farmed out to either a drafting department or some outside service, and the circuit designer only checks the final photomaster. In other companies, he may be required to supervise the artwork.

And in some companies, for some classes of design work—prototypes, one-of-a-kind designs, short runs, experimental work, etc.—the circuit engineer may be required to do his own artwork.

Because the artwork can be as important as the circuit design in the building of a successful system, here is a review of some "tricks of the trade."



PC boards need skillful artwork to achieve high packaging density and a properly functioning circuit.

Scale the artwork

Professional artwork is usually prepared on an enlarged scale for ease of viewing and sharpness of detail. When reduced to actual size, imperfections also are reduced. But don't become confused by scale terminology.

Artwork done to a 2:1 scale occupies four times the actual area. Thus, when you are told that the artwork is four-times actual size, 1 in. of artwork will be 0.5 in. on the finished board—a 2:1 scale reduction, not 4:1. Though 90% of all boards produced are made from 2:1 artwork, applications that require extra-fine detail often use 4:1 and some subminiature boards as high as 28:1.

The first step in laying out a PC board is to prepare the drawing table. Tape a sheet of grid paper to the table. In most cases, 10-squares/in. paper is best. Many components standardized for PC mounting have lead spacing on 0.1-in. centers. Make sure the paper lies flat, with no wrinkles.

Now place a sheet of clear Mylar over the grid paper. Do not tape it directly to the grid paper, because this will cause the paper to wrinkle. Always use a sheet that is large enough to cover the grid paper completely, and then tape the Mylar to the table. Of course, choose a size that is compatible with the size of the circuit board. The generally recommended Mylar thickness ranges from 0.005 to 0.0075-in.

The PC board size may be a standard one. You may have already built a breadboard or prototype and know fairly well how much space is needed. Or perhaps you have "played checkers" with paper or plastic cutouts of the components and have thus gained a pretty good idea of the parts layout.

Having decided on the board size, identify the corners of your circuit board by placing "corner marks" with strips of black drafting tape (Fig. 1). The inside edges of the corner marks correspond to the outside edges of the finished circuit board. Drafting tapes of various widths and a large variety of component pads are available from several companies. Strips of tape are used to form the circuit's conducting paths. The strips generally terminate on component pads, which define component-lead locations by the center of the hole in each pad. Of course, tape and pad dimensions must conform to the scale used.

Suppliers of tapes and pads include Bishop Graphics, Inc., W.H. Brady Co., Centron Engineering Co., Keuffel & Esser Co., Datak Corp. Most companies supply a catalog upon request.

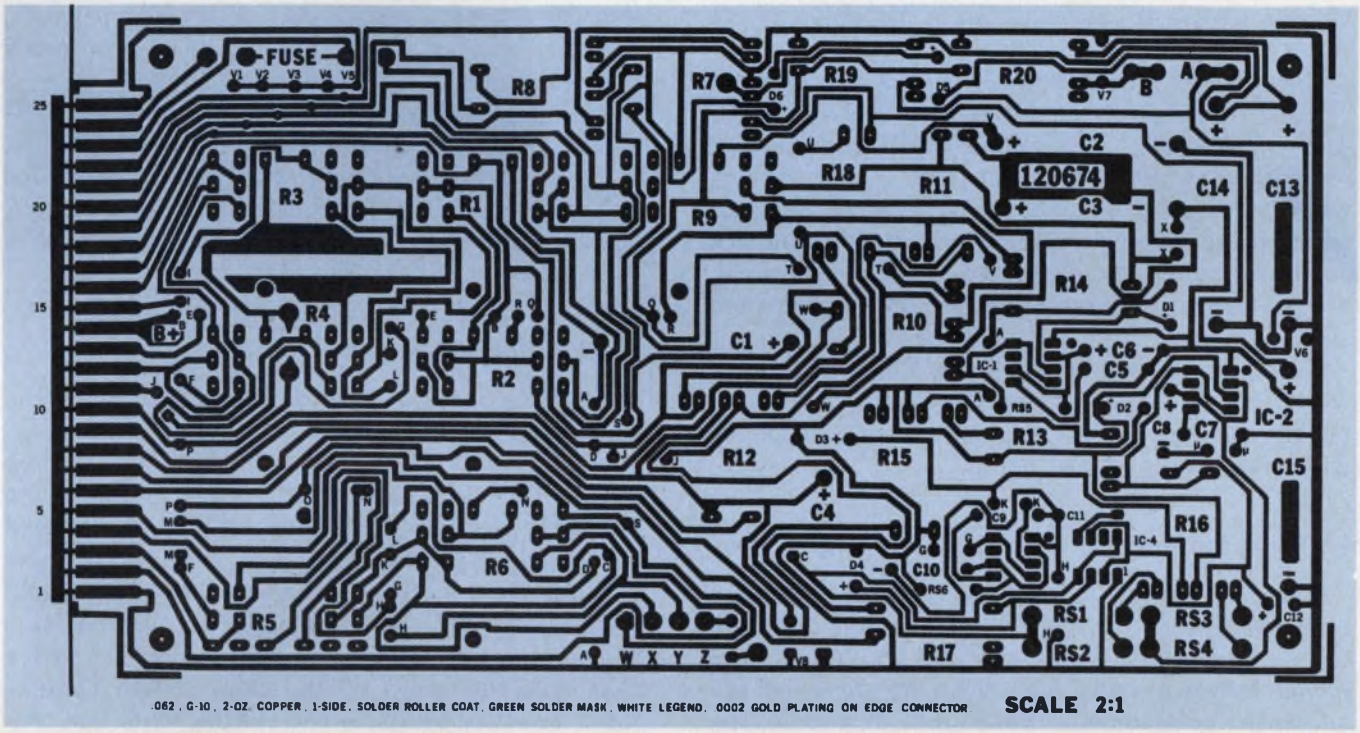
Donald P. Dattilo, President, Dattilo Enterprises, Inc., 9405 Doral Court, Louisville, KY 40220.

Before you can proceed, you must determine the dimensions of each component. Check the manufacturer's specifications carefully. If you aren't sure about any one dimension, find a second source to verify its accuracy. Check and double check. An error here can be disastrous. Measure a sample of the component with a quality dial micrometer.

Now make templates of the components to the scale you are using. These don't have to be fancy, but they should be accurate in all dimensions, certain that you don't box in leads or pins that you will need to get to later. This sounds obvious, but it happens even to the most experienced.

Let the jumpers fall where they may

Some people judge the quality of a circuit layout by the number of jumpers on it—the fewer the better. This is not necessarily true. If it takes jumpers to place a part, where important considerations dictate, use them. However, during assembly, jumpers are treated as components and they add to the labor cost. Don't overdo them.



1. **Printed-circuit artwork** is usually done on an enlarged scale and then photographically reduced to the correct size. Thoroughly marking the artwork with component designations helps in assembly and testing.

Pay attention to special component requirements. Make notes on the schematic, especially if you are farming out the work. For example: Mount tuning coils away from transformers; allow space for switch movement; keep output leads away from inputs.

Since the component templates are movable and sized to scale, you can see how any one component will locate in relation to any other component. When you decide upon a component site, hold the template firmly on the spot. And with a pointed tool, punch completely through both the template and the Mylar to mark the pin or lead.

Apply suitably sized pads to the Mylar, and align the punched hole in the Mylar with the hole in the pad. A trade trick is to use an Exacto knife, with the tip broken off about 1/16-in. from the point, to pick up and apply the stick-on

especially the pin or lead locations. Use scrap pieces of Mylar and drafting tape to make the templates. And use pads with small holes; this will help maintain pin-location accuracy.

But, remember, the templates should represent a bottom view. When you lay out a part on a circuit board, the bottom view is the reverse of the top view; thus right becomes left. It's very easy to make a mistake if you haven't provided some quick reference aids. It's wise to label the leads with their correct designation—on transistors, E, B, C; on ICs, pin 1, 2, 3, etc. Don't assume that you will remember later which lead is which.

Don't try to locate all the components on the Mylar in one step, with the intent of working out the connecting pattern later. Instead locate a few components at a time and complete the connection paths between them. Think ahead. It's easy to "paint" yourself into a corner. Make

Table 1. Recommended conductor width

2-oz. Copper	0.010	0.015	0.019	0.031	0.046	0.062	0.078	0.100	0.125	0.187	0.218
1-oz. Copper	0.015	0.026	0.032	0.062	0.078	0.100	0.112	0.125	0.156	0.203	0.312
Current	1-A	1.5-A	2-A	2.5-A	3-A	3.5-A	4-A	4.5-A	5-A	8-A	10-A

Maximum continuous current at 100 F.

pads. Trying to do it with your fingers is next to impossible.

Don't worry about punching holes in the Mylar. If you decide to move a part, the holes won't show up on the finished circuit board.

Recommended copper-path widths and spacing between conductors are shown in Tables 1 and 2. You may use wider copper paths and spacing for increased safety. A path that is too narrow will overheat. This can cause damage ranging from a raised etch pattern to an explosion. To meet minimum requirements for UL approval, the pattern must have at least 0.062 in. between all conductors.

But, remember, the widths of the tape strips, which represent the copper paths and the component pads on the Mylar, must be in accordance with the scale you are using.

Speeding the work

The application of drafting tape may seem to be a simple and obvious procedure, but here are some reminders: Don't merely lay down long strips between pads and then try to slice off unwanted portions with your knife. If you do, the connected pads will have slice marks that show up on the finished board. Instead, apply the tape and completely overlap the pads to be connected.

To remove excess tape at both ends of the run, don't cut down against the pad; instead pull the unwanted portion of the tape against the cutting edge at approximately a 70-degree angle. The result will be a clean cut, with no frayed edges. Of course, leave enough length to partially overlap the pads but don't cover the holes. Then apply pressure with the back, rounded end of the Exacto knife to make the tape stick firmly to the Mylar.

Advice on how to dispose of unwanted cut tape pieces may seem trivial, but professionals save 15 minutes of every hour with this simple procedure. If you pick up a piece of tape with one hand, don't try to pull it from your fingers with the other hand. The stuff is like fly paper. Use your mouth.

Here are a few more tricks:

- Don't stretch the tape when applying it. It will creep back to a shorter length and produce hair-line gaps between tape and the pads.
- Don't force an excessively sharp bend, when you apply tape in a curve. A little experience will show what's permissible. With sharp bends, the tape won't stay put regardless of how much you press on it.
- Don't route a section of tape along the outside edge of the board. Allow at least 1/32 in. between any conductor path and the outside edge. When the finished board is sheared to size, the shearing action may cause the copper path to separate from the board.

Choose compatible pads

Select a pad size that is compatible with the component's size and weight. But, remember, you are working to scale. The hole size in the stick-on pad is unimportant; it serves merely to locate the center of the hole that will be punched or drilled in the finished board. The final hole is usually larger than the hole in the stick-on pad.

The minimum length of material that remains around the hole after drilling should be greater than half the width of the copper path connecting it to other points in the circuit. This is measured from the outside edge of the hole to the outside edge of the pad. For mounting heavy components, such as transformers, provide extra pad area. For example, a transformer weighing 9 oz, with six 0.055-in.-diameter mounting pins, may be safely held in place with 0.2-in.-diameter pads. Unfortunately there are no fixed rules to help you select the proper sized pad. Reasonable mechanical considerations and experience are your best guides.

Normally, for manual parts assembly, the holes are 0.005-in. larger than the diameter of the lead or pin to be inserted; for automatic parts stuffing, the hole should be 0.010 to 0.025-in. larger. Automatic insertion equipment needs large target holes. For rectangular pins, observe the manufacturer's recommendations. But these specs usually don't consider the use of automatic inserters, so you may need to modify the given tolerance values.

Allow sufficient space between component pads to provide for bends in the leads. And when spacing the pads for components that attach with

fixed pins, make sure that the hole center-to-center spacing is accurate. Stick-on component pads are available for many standard components. Professional designers use TO-can and IC-package patterns regularly; however, patterns for some small transistors are often made up to allow flexibility in special placement problems.

Some experts say never trim a pad to provide greater conductor spacing. If you must, go ahead and do it, but don't go to extremes. Just make sure the pad still meets mechanical and electrical specifications.

Use of transfer letters requires skill

Transfer letters should be used to mark part numbers, jumper pads, dates and other identification on the etch side of the board. It's desirable to identify as many components as the density of the circuit allows. This will greatly simplify testing and the servicing of finished assemblies. Transfer letter sets and symbols are available in a large variety of sizes and styles.

The use of transfer letters requires some skill. But a few minutes of practice on a scrap of paper with a ballpoint pen that no longer writes should be enough. The trick lies in rubbing very lightly during the first pass over the letter to be transferred. Gradually increase the pressure for each successive pass until the letter is completely transferred. With practice, you'll be able to do this quickly without lifting the pen from the transfer sheet.

Transfer letters can be easily removed from Mylar. Hold an Exacto knife at a 45-degree angle and scrape in the direction of the slant of the knife. If there is a large area of lettering to be removed, use any clear industrial-grade lacquer thinner on a smooth rag. The thinner won't affect the Mylar sheet, but don't allow it to touch any of the pads or sections of drafting tape. It removes the black pigmentation.

There's another side to the board

If the circuit won't fit on one side of the circuit board, a two-sided circuit-board configuration can be used. Two methods are used.

One is a two-color method, such as offered by W.H. Brady Co. and Bishop Graphics, Inc. Bishop uses red and blue tapes and pads, and Brady amber and magenta. With these processes, both sides of a circuit board can be layed out on only one piece of Mylar. The second method requires two separate pieces of artwork, one for each side of the circuit board.

With the Bishop method, for example, the circuit paths for one side of the board are layed out with red tape and pads, and the other side with blue. But both patterns are done on the same Mylar sheet.

Table 2. Recommended spacing between conductors

Volts	Exposed copper	Copper covered with insulating coating
5	0.010	0.008
10	0.011	0.009
24	0.013	0.011
48	0.015	0.012
120	0.062	0.030
220	0.125	0.062
440	0.156	0.078
550	0.171	0.093

All voltages are dc at 100 F.

Points common to both sides are layed out in black. The colored tape materials are transparent and act as photographic filters to allow the process to "see" one side of the board at a time.

The most obvious advantage of the two-color method is that it takes less time to lay out one, rather than two, pieces of artwork. Another is the method's inherent ability to maintain perfect registration between the two sides.

But the colored tapes can't bend as much as conventional black drafting tape. Thus the layouts must almost be straight-line configurations. Also, the colored tapes are thinner and slicker, which makes them harder to work with. And colored lettering is available only in limited sizes and styles.

The critical factor when you work with two pieces of artwork is to maintain the registration between them. With the so-called flip method, this can be held to ±0.003 in. when a 2:1 scale is used.

To use the flip method, tape the first sheet of Mylar to the drafting table, as you did for a single-sided board. Place a second sheet of Mylar —slightly larger than the first—over the first sheet, and tape it securely to the table at the top only. This second sheet is now hinged at the top and able to be flipped like the page on a note pad. The top sheet is called the component side of the board.

Apply corner marks and start to lay out the bottom, or stationary, sheet first. When the upper sheet is needed, apply corner marks to it also, so they align with the marks on the stationary sheet.

Try to route all conductor paths so they terminate at component pads. Also, run the paths horizontally on one side of the board and vertically on the other side.

Don't place jumpers under component parts. Also, try to keep the jumpers straight; they may

travel in any direction, but they should not bend around components. Special bending requires additional labor, which increases cost.

As you complete a connection, mark the line on the schematic. This allows you to leave your drawing table without forgetting where you were; and it also makes it easier to decide which conductor paths should be run next. You need not lay out the etch pattern in the same sequence as the schematic is drawn. Quite often, it is better to jump around and take care of special situations and components.

If needed, you may use a felt-tip pen to mark the Mylar with temporary notes or identification. When no longer needed, the marks can easily be wiped off.

The component side of the board may be connected to the etch side with small eyelets, pin terminals staked in place, pieces of wire or component leads soldered to pads on both sides of the board. The easiest way is to specify plated-through holes. This process deposits a conductive metal plating on the inside walls of the hole. Be sure to specify all the hole sizes as "finished-hole sizes." This tells the board manufacturer that the drilled hole must be larger.

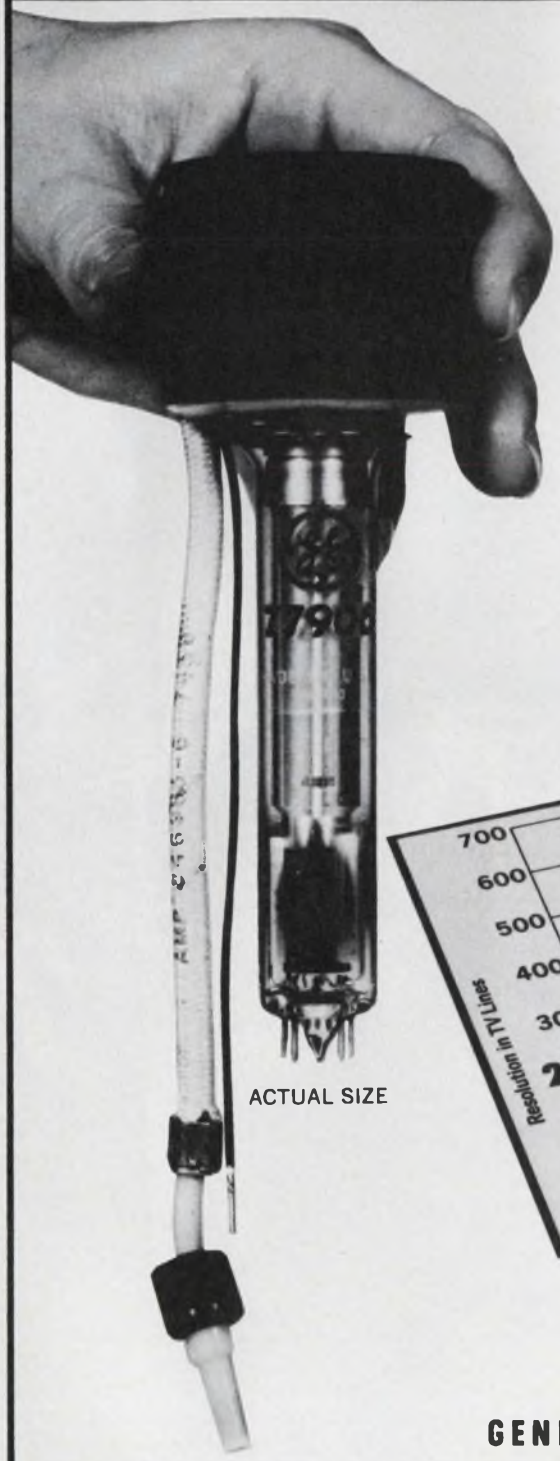
After you complete your layout, check it against an unmarked schematic drawing. Cross out each line in the schematic as you trace the pattern on the layout. Once you have confirmed that the layout is correct, go back and check each pad and drafting-tape path to make sure that they are firmly stuck to the Mylar.

Use a protective coating

Apply a clear acrylic spray, such as Krylon 1304, as a protective coating for the completed artwork. Spray it on with a side-to-side motion and with the can held 10 in. from the Mylar. Two thin but wet coats, applied 20 minutes apart, are much better than one thick coat. In addition to providing protection, the acrylic makes all cut marks and unused holes seem to disappear. But do not use this process on red and blue artwork; it will cause their colors to run together.

When the final coating has dried, the Mylar should be treated to prevent it from sticking to other surfaces. You can use a very thin coat of talcum powder, but this often results in a build-up of powder along the tape paths and pads. A better way is to use the acrylic spray again. But now spray from four feet away, and aim the spray about 14 in. above the Mylar. When done in this way, the spray dries to extremely fine powdery dust before it hits the artwork. Spread the spray over the entire surface with a circular motion. Don't apply too much spray dust; only a small amount is needed to remove any sticky feeling. ■■

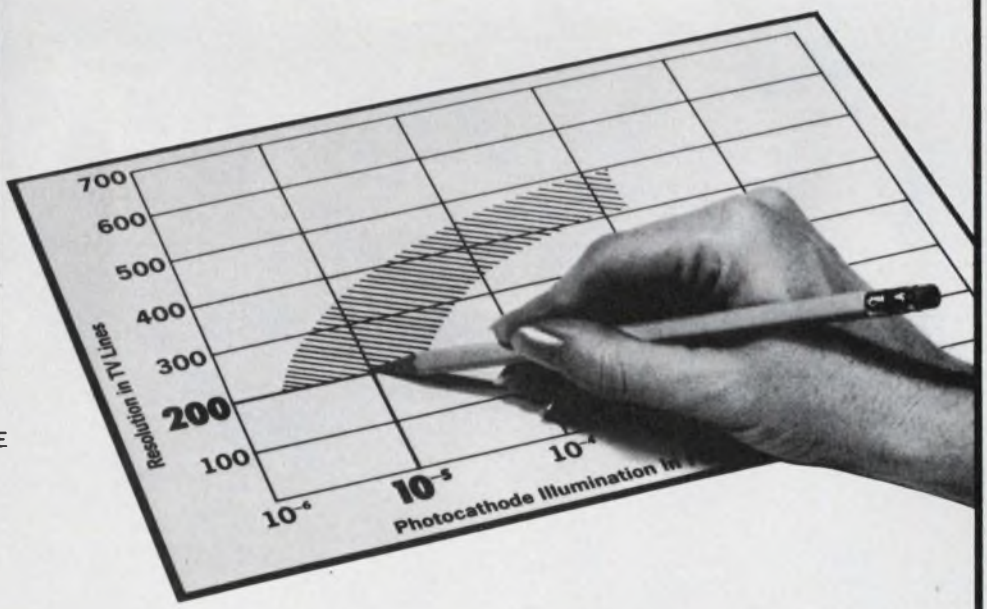
General Electric's Z-7906 provides 200 TVL at 10^{-5} Foot-candles!



ACTUAL SIZE

General Electric's new Z-7906 Miniature Intensified EPICON® facilitates design of compact, low-light-level CCTV cameras. The Z-7906 provides 200-TV lines at 10^{-5} foot-candles. This new EPICON® is ideal for low-light-level surveillance, pipe inspection, aerospace, military, underwater and other applications where space is at a premium.

Call GE's Microwave and Imaging Devices Products Section at (315) 456-3210 for more information and pricing, or write MIDPS Room 301, Building 7 Electronics Park, Syracuse, N.Y. 13201.



GENERAL ELECTRIC

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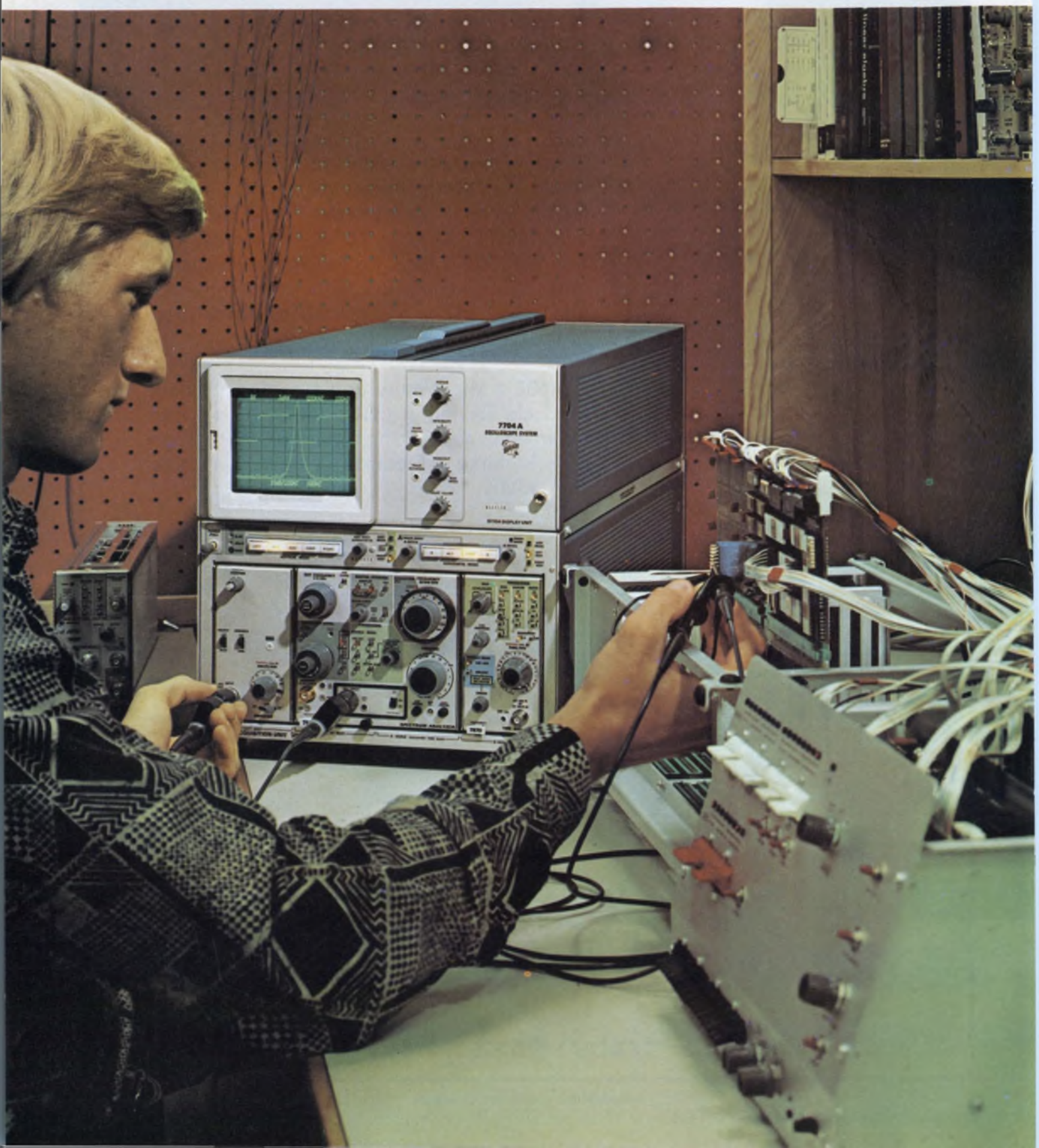

Measurement Flexibility

In today's research and development laboratory your work calls for measurements of many different types. For example, in integrated circuit development you most likely need a real time oscilloscope, a sampling oscilloscope, a digital multimeter and digital counters/timers. Or in communications R & D you probably use a spectrum analyzer in addition to all of or most of the instruments mentioned for the IC lab.

However, your space limitations, budget considerations and operator's convenience all demand that you get the maximum measurement flexibility from each instrument package.

The TEKTRONIX 7000 Series offers just such flexibility in a system of laboratory instruments. Its flexibility allows you to tailor the oscilloscope-based measurement system that most closely fits your needs. You select the measurement parameters—and the measurement techniques—you need, and combine them into interchangeable mainframe and plug-in packages.

Here are a few examples of 7000-Series flexibility:

BANDWIDTH RANGE—Whether your maximum bandwidth requirement is less than 100 MHz or up to 500 MHz (or even up to 1 GHz in some circumstances), there is a mainframe to match your needs. Eleven amplifier plug-ins and five time-base plug-ins (with sweep speeds to 0.5 ns per division) further help you tailor your system.

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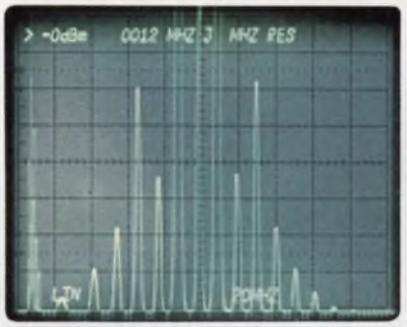

One more thing about 7000-Series flexibility: with a choice of more than 30 plug-ins and 17 mainframes in a continually evolving family, you can be assured of a long-lived oscilloscope system that will continue to accommodate your needs.

For a catalog describing all the 7000-Series instrument mainframes and their plug-ins, call your local Tektronix Field Engineer, or write Tektronix, Inc., P.O. Box 500, Beaverton, OR. 97077. In Europe, write Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

The 7000 Series . . . more than an oscilloscope

Microprocessor designer uses time domain plug-ins (7A16A/7B70) and spectrum analyzer plug-in (7L5) to give a combined display on 7704A mainframe. While the oscilloscope displays pulse characteristics, the spectrum analyzer identities clock jitter down to 10 Hz and measures system noise directly in dB.

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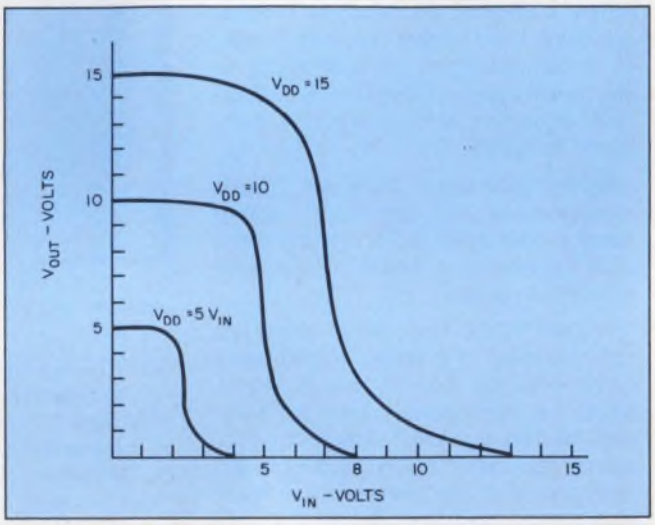
Avoid CMOS noise-sensitivity problems

by filtering power supplies, isolating high-frequency noise sources and controlling edge speeds.

Though the noise margin of complementary MOS is far greater than that of other popular logic families, designs employing CMOS sometimes require special care. There are noise-sensitivity problems peculiar to MOS technologies that must be avoided.

For example, CMOS-gate threshold tracks supply voltage. So multiple toggling of edge-sensitive flip-flops may occur if both power and clock signals are not relatively noise-free. Also, parasitic bipolar transistors—especially on transmission-gate inputs—may cause flip-flop data loss if these inputs become forward-biased because of signal overshoot or voltage-supply noise. Noise-related problems such as these can neutralize CMOS benefits, like low power consumption, loose power-supply regulation and high dc fanout.

Fortunately the problems can be overcome by these fairly simple solutions: adequate filtering of power supplies, isolation of high-frequency noise sources and control of signal rise and fall times at edge-sensitive inputs. In most cases, adherence to these basic guidelines ensures trouble-free operation.



1. **The threshold of a CMOS inverter** remains nearly centered between supply-voltage limits, regardless of the actual supply voltage.

Ideal transfer characteristics

The CMOS transfer characteristic (Fig. 1), with its output transition centered between its V_{DD}-to-V_{SS} signal swings, yields potentially the most ideal set of noise-rejection characteristics available in a logic family. Other popular technologies, such as TTL, rely on forward-biased silicon diodes to set gate-threshold levels. For TTL, two forward drops usually define the threshold at a level between 0.8 and 2.0 V, and the actual level depends heavily on temperature. In addition TTL thresholds are far from the center of their 0.2-to-3.0-V typical signal swing, yielding unbalanced voltage noise immunity at ONE and ZERO logic levels.

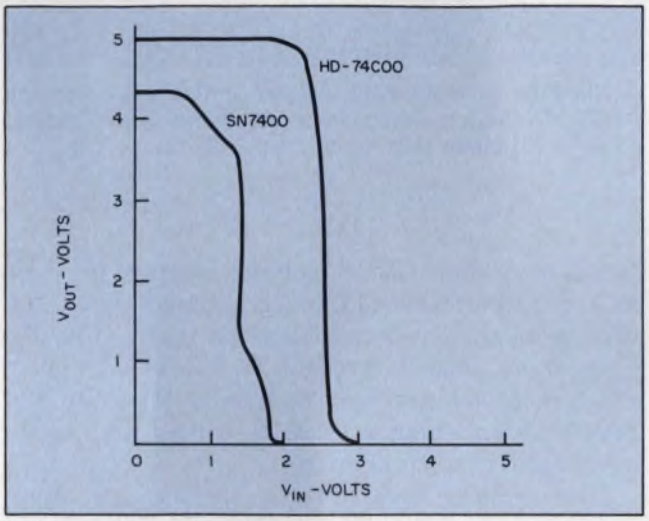
A simple CMOS inverter consists of a single complementary transistor pair. When transistor parameters and geometries are properly balanced, these devices represent nearly equal impedances when equivalent gate-to-source bias is applied. Ideally if the gate input is held midway between V_{DD} and V_{SS}, then the output would also be at the supply midpoint. Thus, operation anywhere within the permitted voltage-supply range results in nearly centered inverter or gate threshold, and therefore nearly equal ONE and ZERO-level noise margins.

In addition temperature variations don't have substantial effect on the CMOS inverter or logic gate threshold; temperature affects both the p and n-channel transistors in the same way. The voltage-divider effect of a complementary pair is relatively unchanged with temperature variations, even though absolute impedances vary substantially.

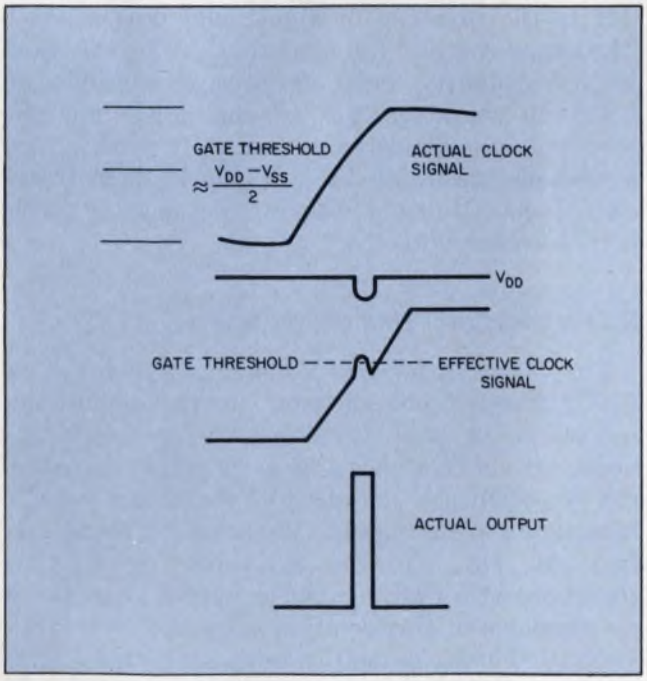
The V_{DD}-to-V_{SS} signal swings and centered gate thresholds of CMOS are indeed strong medicine when noise is the ailment. Typically, they provide the maximum dc noise margin possible for conventional logic circuits.

But like any medicine, you must heed directions on the label. In spite of the many strong

Ken Stephenson, Applications Engineer, Harris Semiconductor, P. O. Box 883, Melbourne, FL 32901.



2. **The improved transfer characteristics of CMOS** over TTL can be seen from a comparison of the TTL SN7400 and CMOS HD74C00, shown for $V_{DD} = V_{CC} = 5$ V.



3. **Noise on V_{DD} can cause multiple toggling** of an edge-sensitive flip-flop. CMOS gate thresholds track supply variations, and therefore add or subtract noise at signal transitions.

points of CMOS, there are some cases where these circuits are actually more sensitive to noise-related failures. Awareness of these areas and careful design will, however, preclude difficulties.

Let's take a look at some noise-margin definitions and see how they relate to CMOS specifications and performance. Logic ONE and ZERO-level worst-case noise margins are defined as the difference between respective worst-case input threshold levels and output ONE and ZERO levels (Fig. 2).

Even with worst-case specifications, CMOS noise immunity is still higher than that of TTL. However, noise immunity is specified differently by the two major CMOS lines, the 4000 series and 54C/74C. Manufacturers supplying the 4000 series specify the parameters V_{NL} and V_{NH}. The V_{NL} defines the noise immunity of a CMOS input in the low state. The value normally specified for noise positive-going from V_{SS} is 30% of the total supply voltage ($V_{DD} - V_{SS}$). For 5 and 10-V operation, 1.5 and 3.0-V noise levels are specified, respectively. V_{NH} defines the noise immunity for an input in the high state. Negative-going noise (negative from V_{DD}) equal to 30% of the supply voltage is specified in the same manner as for V_{NL}.

Specification pitfalls

The V_{NL} and V_{NH} specifications for the 4000 series have one feature that can present difficulties when worst-case design is a requirement. Worst-case output-voltage degradations are nearly equal to the 30% input offset. Any injection of additional noise into subsequent stages could yield undefined gate outputs.

Statistically a worst-case gate is rare, and there is little likelihood of plugging that gate into a socket with worst-case noise. Therefore the implication here is not that actual noise characteristics of the 4000 series are poor or that a system failure is likely, but simply that specifications do not guarantee substantial noise margins.

The low guaranteed noise margins described don't prevail across the board for 4000 series. They are primarily specified for the early vintage

single-stage gate and inverter/buffer functions. Those gate or logic functions that have two or more stages from input to output are generally specified to have higher dc noise margin.

The 54C/74C series specifies noise immunity across the board in a way that allows designs with higher guaranteed noise margins. For 5-V operation, inputs can deviate 1.5 V from supply, with outputs pulling to within 0.5 V of supply. At 10-V supply levels, inputs and outputs are specified within 2.0 and 1.0 V of supply, respectively. This specification guarantees a minimum ONE and ZERO-level noise margin of 1 V for both 5 and 10-V operation.

When driving low-power TTL, 74C outputs are guaranteed to be above 2.4 V or below 0.4 V with 360 μA source and sink currents, respectively. 74C inputs must be above 4 V or below 1 V to maintain these specified output drive levels.

Manufacturers indicate that the 54C/74C-type specification might become standard for other CMOS logic families. Most products in the 4000-series and 14500-series CMOS can meet the 54C/74C limits.

While considering noise immunity and assessing system noise rejection, you must look at more than the dc input/output drive levels. A properly designed system employing CMOS exclusively can exhibit excellent noise characteristics. But problems can arise when you mix other high-energy or high-frequency technologies without proper precaution or you don't give proper attention to the filtering of power distribution.

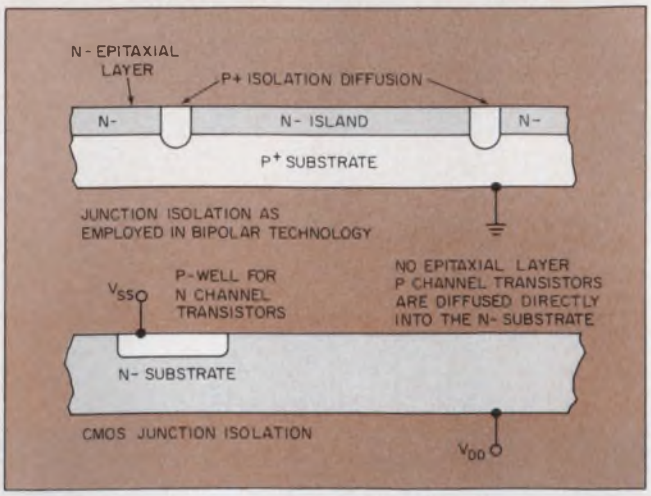
Hold that line

The output impedance of CMOS logic circuits is generally an order of magnitude greater than that of TTL, and it is this termination impedance that drives and must maintain signal levels against the barrage of noise. Signal lines driven by CMOS are therefore more vulnerable to coupled noise from high-energy sources.

The CMOS functions most affected by such noises are those clocked devices with memory capability, such as D-type flip-flops and shift registers. Noise glitches injected into combinational logic are, in many cases, filtered by the inherent gate delays and without harmful side effects. But such a glitch on a flip-flop clock input may cause a state change.

When using edge-sensitive devices in a system, particular attention must be paid to minimizing clock rise and fall times and providing adequate power-supply filtering. Noise on the clock line or on either V_{DD} or V_{SS} can cause multiple clocking. A clock with long rise and fall time is particularly vulnerable to such a failure.

Another key point to remember is that CMOS logic-gate thresholds track supply variations.



4. **Junction isolation differs significantly for bipolar and CMOS.** The latter, which uses less complex processing, employs a simpler technique.

Noise on either CMOS voltage supply (V_{DD} or V_{SS}) can therefore add to or subtract from the voltage of an edge-sensitive clock input (Fig. 3). Even if no noise is present on the clock line, a glitch in power that occurs when a slow rise and fall-time clock-input crosses threshold may cause an undesired state change.

Many CMOS data sheets specify maximum clock rise and fall times of 15 and 5 μs at 5 and 10-V operation, respectively. This is generally considered to be the maximum figure for reliable operation assuming noise-free power and signal lines. Most real system applications, however, won't tolerate such extended transition times, due to the presence of signal and power noise. The actual rise and fall time that can be tolerated when substantial noise is present depends on both the characteristics of the noise and the specified edge-sensitive device. It is, with a few exceptions, desirable to keep clock transistions very short. Multiple clocking because of noise then becomes unlikely.

Bipolar parasitics: They're everywhere

The isolation scheme commonly employed in CMOS does not provide true isolation of individual transistor or diffused interconnect elements under all circumstances. A satisfactory isolation can be obtained if the absolute maximum voltage limitations are observed. Violation of these ratings—by, say, allowing excessive forward-bias conditions at a CMOS input or output—results in a breakdown of the isolation scheme, due to activation of bipolar parasitics inherent to the CMOS structure. These parasitics can, in some cases, adversely influence circuit operation.

Junction isolation is most commonly used for CMOS. This method, however, differs greatly

from the scheme used in TTL. In CMOS, many transistor sources and drains and interconnects are diffused side-by-side at the substrate (Fig. 4). All junctions within this structure are intended to operate reverse-biased.

Parasitic bipolar transistors are always present in this CMOS structure, although they do not normally come into play unless maximum ratings are exceeded. Several chip-design techniques are used to minimize parasitic effects. The techniques include adequate spacing of critical diffusions and the use of guard bands to minimize gain and break up parasitic action.

The most common way to bring such parasitics into play is to cause an input or output junction to become forward-biased. Noise on power or signal lines is the most probable cause of a forward bias. Diffusions at CMOS inputs and outputs form junctions with both the n^- substrate material and the p^- wells that contain the n-channel transistors. The n^- substrate biases to V_{DD}, and the p^- wells bias to V_{SS}. Noise that is more positive than V_{DD} therefore causes the p^+ n^- junction to forward bias. Noise more negative than V_{SS} forward-biases the n^+p^- junction.

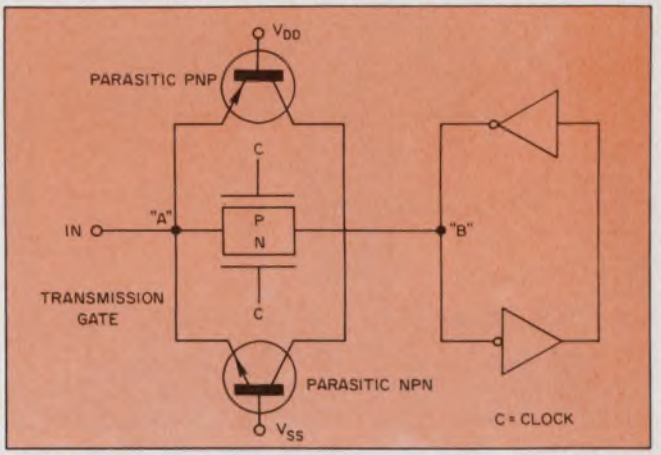
Note that voltage between pins is relative; noise on inputs or outputs should be considered with regard to supply noise. Supply noise adds directly to signal noise when the two occur simultaneously.

In general, the voltage required to activate bipolar parasitics decreases with increased operating temperatures. At 125 C, the actual forward bias required to bias a parasitic ON is between 0.4 and 0.5 V. Absolute ratings specified by various manufacturers set the maximum permissible forward bias at some level between 0 and 0.5 V.

The gain of a lateral bipolar parasitic varies inversely with junction spacings. Adjacent source-to-drain diffusions therefore produce the strongest parasitics, since the spacing is minimized. The CMOS configuration most sensitive to parasitic interference is probably the transmission gate, or bilateral switch. This sensitivity results from the use of the transmission gate in certain applications where the parasitic may have access to both device pin and internally stored data (Fig. 5).

Some counters, shift registers and simple flip-flop functions employ the transmission gate as part of the mechanism to load data. Noise at the transmission-gate input that is positive with respect to V_{DD} or negative with respect to V_{SS} may activate the high-gain drain-to-source parasitic. Direct access of this parasitic to the storage node may cause loss of data.

Activation of bipolar parasitics in CMOS circuits constitutes their most serious noise-sensitivity drawback. This is unfortunately true because signal and power-noise polarities and amplitudes frequently generate undesired forward-bias conditions.



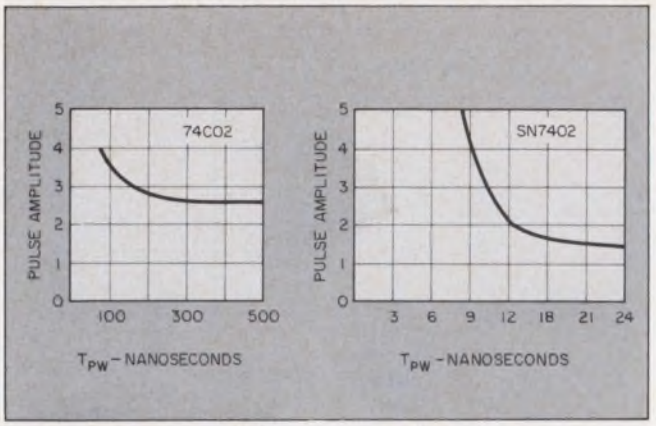
5. **Normal loading for a transmission gate** occurs when the clock signal equals V_{DD}. But if either bipolar parasitic base emitter becomes forward-biased, a lateral transistor will turn on. And latch "B" may be forced to an alternative state, thus losing data.

When noise on the power line is the culprit, the solutions are easy. Simply filter and control ground differences in power distribution. Anticipation of power distribution noise levels, though, isn't always possible. It's wise to provide an ample number of decoupling capacitors distributed throughout the PC board, rather than one filter only at the board's power input.

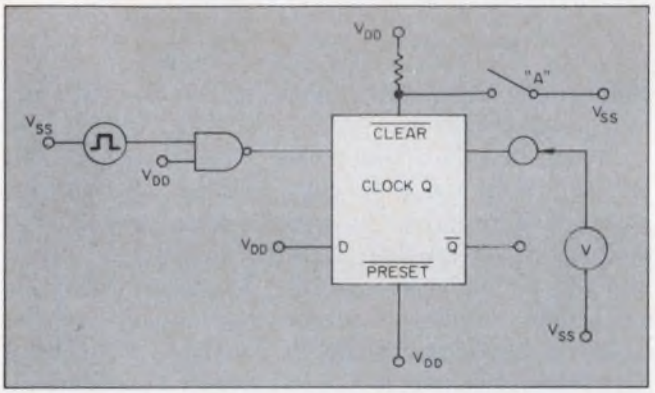
Large-signal overshoots generally don't present a problem in an all-CMOS system. Existing general-purpose CMOS is too slow to suffer transmission-line difficulties, because signal transition times aren't comparable in magnitude with line delays. Most signal noise in a CMOS system is coupled or related to poorly filtered power lines. Attention to the length of parallel signal lines, control of noise sources and adequate power-distribution filtering should curb excessive signal-line noise.

A comparison of CMOS vs TTL is difficult when it comes to ac noise immunity based on circuit speed. Significant differences in logic-gate threshold levels and the proliferation of TTL and CMOS manufacturers account for the problem. In general, though, CMOS ac noise immunity will be higher, if only because of the comparatively lower speed of present CMOS. The centered-gate threshold also enhances the CMOS ac noise margin. Actual ac noise immunity for the CMOS HD740C02 and its TTL counterpart, the SN7402, appears in Fig. 6.

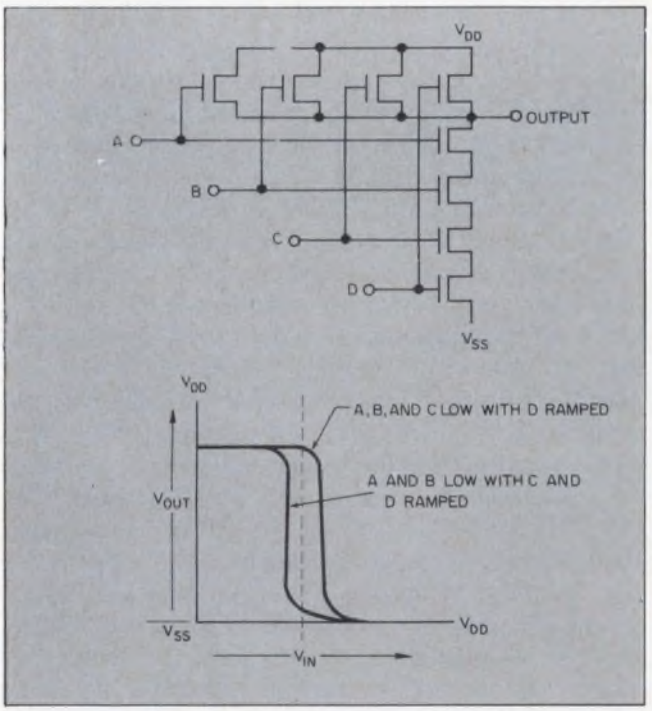
A common method to define ac noise characteristics employs a plot of noise pulse widths vs noise amplitude. In most cases, the noise sensitivity of a device that is sensitive to pulse width, such as a flip-flop, plays a key part in the definition of system-noise tolerance. The



6. **CMOS ac-noise immunity is generally higher** than that of TTL, as indicated by a comparison of the CMOS 74C02 with the TTL SN7402.



7. **A test setup measures ac noise immunity.** Before each reading, the flip-flop is initialized when switch A is closed. Then, for a given pulse width, pulse amplitude is increased to the minimum that will toggle Q to V_{DD}.



8. **A dual four-input CMOS NAND gate** illustrates how logic pattern sensitivity affects gate-threshold voltage.

minimum noise pulse amplitude vs width required to clock the worst-case noise-sensitive flip-flop is therefore a viable tool in assessment of system-noise tolerance. A test jig for noise measurement appears in Fig. 7.

Logic-pattern sensitivity

Gate threshold, and hence noise margin, for single-stage CMOS gate functions has a sensitivity to the input logic pattern. The position and shape of the vertical portion of the transfer characteristic depends on the voltage division between complementary-MOS transistors as the switching input or outputs traverse the linear region.

For example, consider the four-input NOR gate (Fig. 8). It consists of four n-channel transistors connected in parallel between the output and V_{SS}, and four p-channel transistors in series between V_{DD} and the output. If inputs A, B and C are held low and D is ramped through the active region, three dc-biased p-channel transistors and one ramped p-channel transistor will divide the supply voltage with one ramped n-channel unit. If A and B are held low, with C and D ramped, the voltage divider characteristic will be modified and the transfer characteristic shifted, as shown.

Usually the input pattern sensitivity appears only in devices that have single-level gate functions. Multilevel-function devices—such as decoders, some flip-flops and adders—have two or more gate or inverter functions that isolate inputs from outputs. These additional stages, in effect, perform a buffering function, even when buffering isn't their primary reason for inclusion.

The addition of buffer stages to functions that can be performed with a single logic level can eliminate pattern sensitivity. Additional gain provided by buffers also has the effect of sharpening the vertical portion of the transfer curve.

However, some penalty must be paid when buffer stages are added. Gate delay for a single-stage gate is primarily a function of input and output rise and fall times. There is very little inherent delay through the gate. The equivalent logic function performed with buffering will have added internal delays.

For heavy external capacitive loading, these internal delays may become insignificant compared with the total gate delay, resulting in speeds comparable to or possibly faster than an unbuffered gate. For light-to-moderate capacitive loading, these internal delays will exact a speed penalty because of small internal stage loading. ■■

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The direct measurements permit high-speed determination of a/d converter accuracy and resolution to 10 bits, although tests for resolution can be extended to 13 or more bits without loss of accuracy. Only some small hardware changes in the test set are needed.

Both accuracy and resolution affect the signal fidelity as a signal is translated from the analog to the digital domain. Lack of accuracy causes distortion of the digitized signal, while lack of resolution results in a small dynamic range or poor signal-to-noise ratios.

Traditionally parameters like dc accuracy and aperture error have been used to indicate the accuracy and resolution of the converter. However, these results are taken from special cases of input signal frequency. Tests such as dc, sample-rate, sample-rate/2, double-pulse and synchronous "ramp-walking" all depend on the input signal frequency. Efforts to make direct measurements of accuracy and signal-to-noise ratio at high speeds and high resolution, by use of nonsynchronous signals, are thwarted by lack of adequate instrumentation at reasonable prices.

Until recently, the inaccuracies of digital-to-analog conversion and measuring instruments have been limiting factors in the direct testing of high-speed a/d converters. But by using a digital processing system operating in the digital domain, you can eliminate the errors caused by d/a converters and their associated analog instrumentation. The only analog instruments needed are the signal source and the filter (Fig. 1).

The input signal should be as pure a sine wave as possible; for that reason, it is fed through a bandpass filter, which removes any harmonics and spurious signals. The test signal frequency is not locked to the encode frequency or any of its harmonics; as a result, the sample-to-sample variations in the sampled input signal or encoded output voltage of the a/d converter are unpredictable and nonrepeatable. Thus the measured results indicate the true linearity and resolution under normal a/d converter operating conditions.

Basically the test set feeds a filtered sine-wave signal to a converter under test, lets the converter encode up to 1024 samples of the waveform and stores the samples in a buffer memory. Next, the contents of the buffer are transferred into the main processor memory for analysis.

The best way to do the analysis is to use a discrete Fourier transform (DFT). Thus the first step in the analysis is to apply time-weighting to the data to reduce frequency side lobes. And unless the proper weighting function is provided, the main lobe energy spills over into many other frequency bins and makes noise measurements impossible.

To use the DFT, first determine the weighting function. For the method used in this article, this is the $\cos^2$ function without a pedestal. Thus the expression for the input data multiplied by the weighting function becomes

$$WD_n = D_n [0.5 - 0.5 \cos (2\pi n/N)], \quad (1)$$

where WD_n is the nth weighted data sample, D_n is the nth input data sample, and N is the total number of samples.

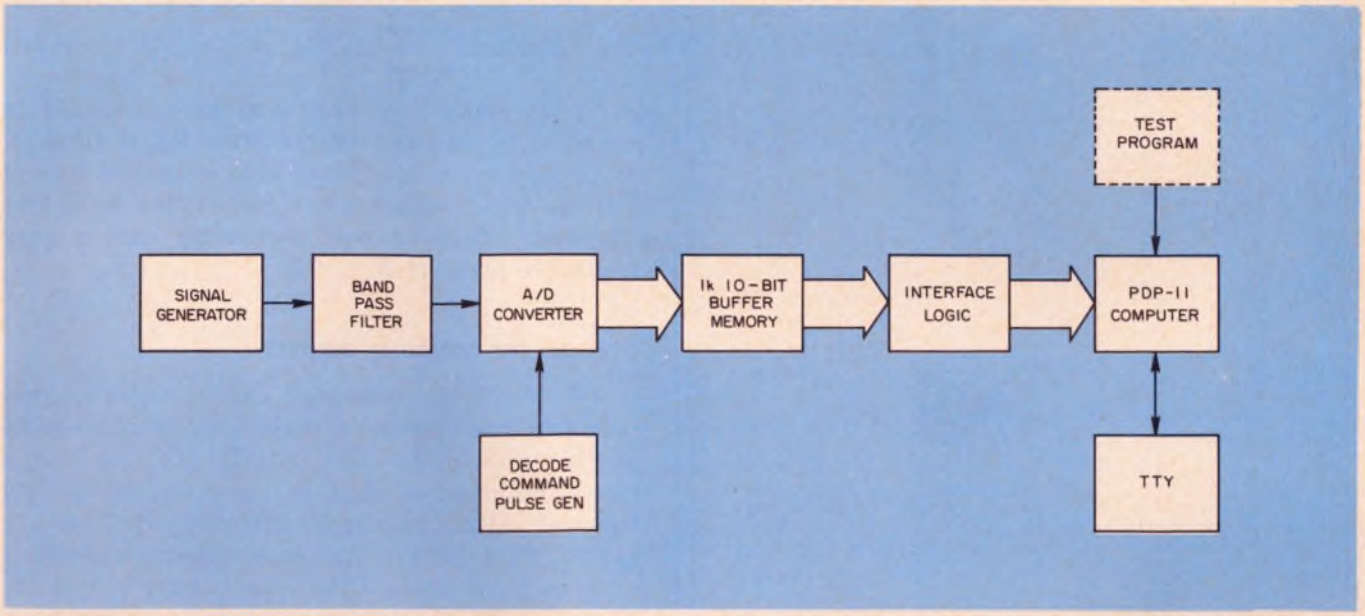
By weighting the inputs, you can compress the spillover energy (leakage) into a small band of frequencies centered on the carrier frequency. This eliminates contamination of a large portion of the over-all spectrum.

Next, the program must find the DFT of the sequence of weighted data samples for N/2 frequencies. To do that, the program must solve these two equations for the Kth frequency:

$$A_k = 1/N \sum_{N=1}^{N} WD_n \cos [2\pi k(n-1)/N] \quad (2)$$

$$B_k = 1/N \sum_{N=1}^{N} WD_n \sin [2\pi k(n-1)/N], \quad (3)$$

Bill Pratt, Senior Engineer, Computer Labs, 505 Edwardia Dr., Greensboro, NC 27409.



1. **Block diagram for the entire test bed** shows that only a single analog instrument—a signal source—is needed to test a/d converters. This system can operate at speeds up to 15 MHz.

where A_k and B_k represent the magnitudes of the cosine and sine parts of the Kth spectral line.

The total magnitude of the Kth spectral line is then expressed by the equation

$$Mag_k = \sqrt{A_k^2 + B_k^2}, \qquad (4)$$

which is used by the processor to determine linearity (accuracy) and signal-to-noise ratio (true resolution).

Program finds the linearity

You can measure the linearity of the a/d converter by observing the relative amplitude of the mth harmonic relative to the fundamental frequency (measured in dB). This can be expressed by

$$\text{Amplitude} = 20 \log (Mag_f/Mag_{mf}). \qquad (5)$$

In Eq. 5, Mag_f is the magnitude of the fundamental and Mag_{mf} the magnitude of the mth harmonic. Thus this equation provides a direct indication of linearity of the transfer function. If you want to find the maximum deviation from linear, combine the A and B components of Eq. 4 by adding them algebraically. This gives the peak amplitude of the summed signal. The program in Fig. 2 does not do this, however, since harmonic distortion alone is a good criterion.

True resolution of the a/d converter can be found by first establishing the residual noise floor in all frequency bins except those occupied by the input signal. The processor program can do this by squaring a magnitude of each frequency bin that doesn't contain the input signal, adding all N/2 squared magnitudes and then solving for the square root:

Basic program for high-speed A/D S/N test

```
10  P2=6.28319
20  DIM D(1024), S(1024), C(1024)
30  REM - COMPUTER COEFFICIENTS
40  FOR N=0 TO 1023
50  S(N)=SIN (P2*N/1024)
60  C(N)=COS(P2*N/1024)
70  NEXT N
80  REM - INPUT DATA
90  FOR N=0 TO 1023
100 INPUT # 1 : D(N)
110 NEXT N
120 REM - WEIGHT DATA
130 FOR N=0 TO 1023
140 W=0.5 - 0.5*COS(P2*(N+0.5)/1024)
150 D(N)=D(N)*W
160 NEXT N
170 REM - COMPUTE SPECTRUM
180 FOR K=0 TO 511
190 X=0
200 Y=0
210 FOR N=0 TO 1023
220 L=K*N
230 220 IF L 1024 THEN 250
240 L=L-1024\GO TO 230
250 X=X+D(N)*S(L)
260 Y=Y+D(N)*C(L)
270 NEXT N
280 X=X/1024\Y=Y/1024
290 X=2.83 * SQR (X↑2+Y↑2)
300 X=8.67*LOG(X)
310 PRINT K, X
320 NEXT K
330 END
```

2. **This short Basic program** is all that's needed to compute the different errors of the high-speed a/d converter under test.

$$\text{Noise} = \sqrt{\sum_{K=1}^{N/2} \text{Mag}^2 K}\,. \qquad (6)$$

At the same time Mag_{f-7} to Mag_{f+7} should be set equal to zero and deleted from Eq. 6. In practice, these seven frequency bins on either side of the sine-wave bin must be ignored; the main lobe widening effect of $\cos^2$ weighting causes only negligible error if $N \geq 256$.

Evaluate the computer outputs

An "ideal" a/d converter can be used to compare the true resolution and signal-to-noise ratio of the units under test. Ideally an a/d has a quantization error that is an equal-probability function, with a maximum error of $\pm q/2$ ($q = 1$ quanta or 1 LSB). The rms voltage associated with an equal-probability error signal is $q/\sqrt{12}$. Therefore this is the expected noise floor for an ideal a/d. Expressed in dB, relative to full scale, the equation becomes

$$S/N = 6n + 10.8 \text{ dB} \quad (n = \text{number of bits}), \qquad (7)$$

and the rms signal to rms noise ratio becomes

$$\text{sine wave } S/N \text{ (ideal)} = 6n + 1.8 \text{ dB}. \qquad (8)$$

However, the weighting function used to implement the test causes a loss of 1.8 dB. Thus the ideal case can be modified by subtraction of the 1.8 dB, which leaves, for the rms case,

$$S/N = 6n \text{ dB}.$$

For an ideal 10-bit converter, the measured result would be 60 dB. In practice, an a/d converter will measure less than this figure because of analog errors associated with the converter itself.

For example, a typical a/d converter with 10-bit accuracy has an over-all specification of 0.05% ±0.5 LSB. The first part of that spec (0.05%) is called the analog error and is caused by aberrations in the transfer function. The other half of the spec is the quantization error associated with any a/d converter, including the so-called ideal.

Since the rms contribution of the quantization noise is $q/\sqrt{12} = 0.29\ q$, and the rms contribution of the worst-case analog error is 0.5 q (assumming a square-wave error function), the worst case noise for an a/d converter that meets its accuracy (linearity) specification is

$$(0.29\ q)^2 + (0.5\ q)^2 = 0.58\ q,$$

which is approximately 6 dB worse than an ideal a/d converter.

Thus, an acceptable criterion for an n-bit a/d could be: Min $S/N = 6n - 6$ dB.

This is the minimum acceptable sine-wave signal-to-noise ratio for an n-bit a/d converter. However, note that $6n - 6$ can be written as $6(n - 1)$. Expressed another way, a converter with n-bit resolution and operated with worst-case tolerances would perform equally well or better than an ideal converter with $n - 1$ bits of resolution. ■■

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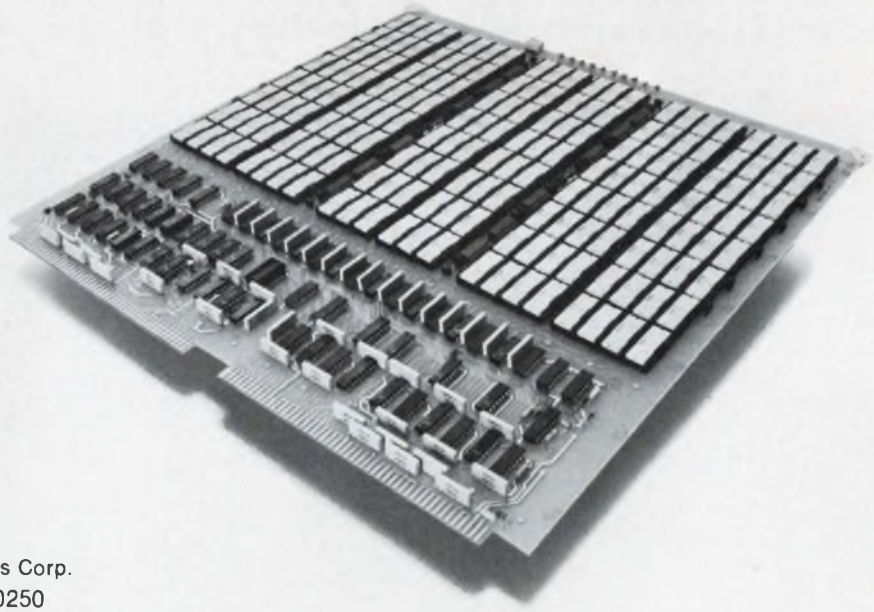

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INFORMATION RETRIEVAL NUMBER 42

Microvolt probe traces PC current paths to help locate those defective ICs

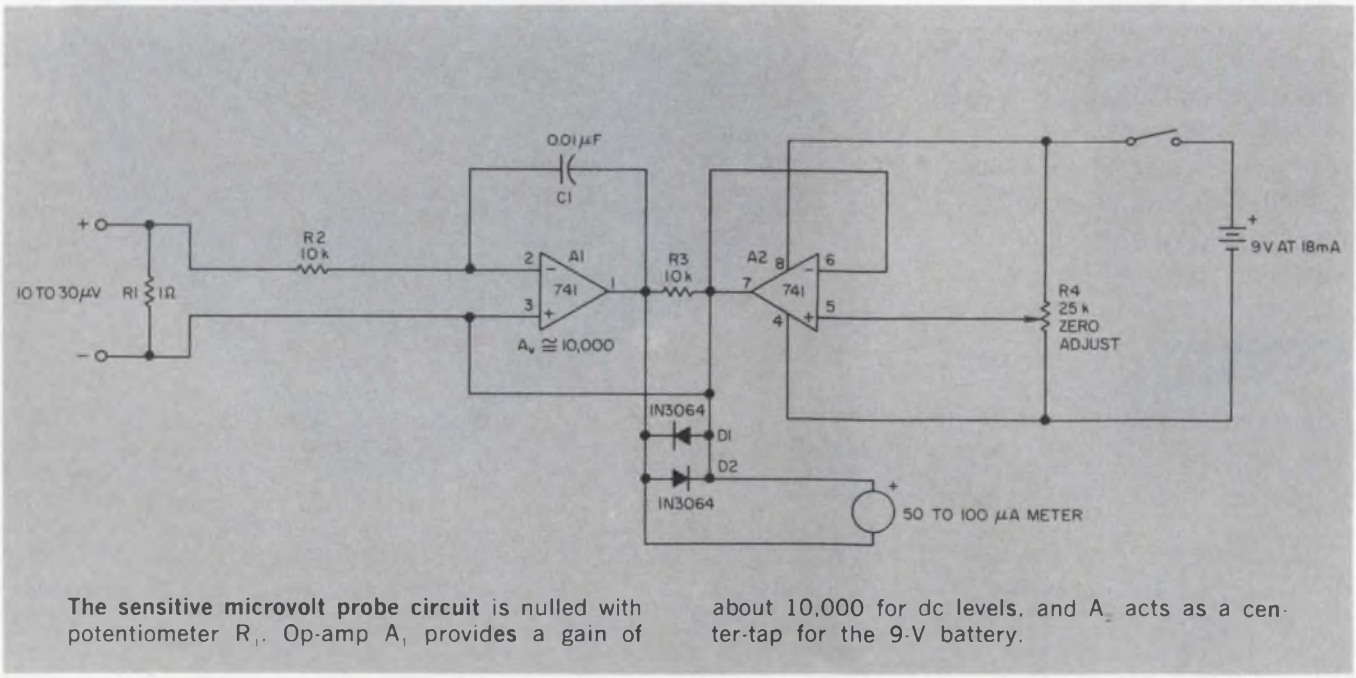
It's tough to find a defective IC chip on a PC board when the power-supply lead is routed to several chips in parallel. The usual procedure of cutting PC traces or unsoldering chips often causes additional damage. But a simple current tracer can eliminate the frustration and lead directly to the faulty IC that is loading down the power supply.

The tracer amplifies the small voltage drop caused by current flow along a fraction of an inch of PC wiring and drives an ordinary microammeter. Needle-point test probes are used to contact the edge of a PC trace and to follow the current to determine which branch the current takes.

One-half of a dual 741 op amp forms a dc amplifier with ac feedback to prevent oscillations and hum-pickup problems. It drives a 50-to-100-μA meter, such as is found in many VOMs. The other op amp provides a center tap for the 9-V battery supply and zero adjustment with R_4. Two diodes protect the meter. Resistor R_1 eliminates the necessity for shorting the probes when the meter is zeroed. The value of 1 Ω is large when compared with the resistance of the meter leads plus the bridged portion of PC wiring.

The effects of drift and thermal emf—though readily apparent, since microvolts are being measured—do not hinder the circuit's current-tracing ability. The absolute value of the readings is unimportant.

Roy A. McCarthy, Production Engineer, GYYR Div., Odetics, Inc., 1845 S. Manchester Ave., Anaheim, CA 92802. CIRCLE NO. 311



The sensitive microvolt probe circuit is nulled with potentiometer R_4. Op-amp A_1 provides a gain of about 10,000 for dc levels, and A_2 acts as a center-tap for the 9-V battery.

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The high quality Triplett 310 is a little all-in-one VOM. This made in the U.S.A. VOM gets around a lot for half fare. It packs most of the features you'd expect to find only on a meter twice the size and price. It fits in your shirtpocket easily. The small size and its versatility is a boon to field servicemen as well as circuit designers, technicians, electrical maintenance engineers, and the price is right for vocational and hobbyist use.

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INFORMATION RETRIEVAL NUMBER 43

CMOS switch inverts analog signal under control of digital logic

Circuit designers often need to invert an analog signal under direction of a logic signal. But logic-controlled converters generally suffer from voltage offset errors. A control circuit that uses a single CMOS IC to switch the inputs of an op amp can overcome this problem.

In the simplified schematic (Fig. 1) the inverter between the logic input and SW_2 symbolically indicates that SW_2 is open when SW_1 is closed, and vice versa. For a typical CMOS switch, the on-resistance, R_c, is about 300 Ω and the off-resistance, R_o, about 1000 MΩ with a ±7.5-V supply.

Assume the op amp is ideal. With SW_1 open and SW_2 closed, the circuit inverts. By superposition, the output voltage is

$$V_o = \frac{-V_{in}R_2}{R_1} + \frac{V_{in}R_c}{R_o + R_c}\left(\frac{R_2}{R_1} + 1\right). \quad (1)$$

Since

$$\frac{R_c}{R_o + R_c} < 3 \times 10^{-7}, \quad (2)$$

the second term in Eq. 1 can be neglected, and if $R_1 = R_2$, then $V_o = -V_{in}$.

When SW_1 is closed and SW_2 open, the circuit is noninverting, and now the output is

$$V_o = \frac{-V_{in}R_2}{R_1} + \frac{V_{in}R_o}{R_c + R_o}\left(\frac{R_2}{R_1} + 1\right). \quad (3)$$

Since

$$\frac{R_o}{R_c + R_o} = 1$$

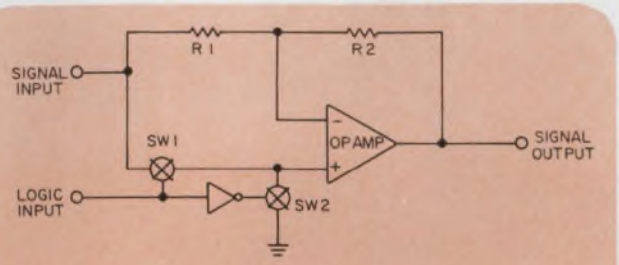
to within 0.001%, the second term can be simplified to $V_{in}\left(\frac{R_2}{R_1} + 1\right)$ and, now, $V_o = V_{in}$.

The required logic inverter is formed from the SWD section of the CD4016 IC and a 10-kΩ resistor (Fig. 2). The input signal can come from prior CMOS circuitry, also operating from ±7.5-V supplies, or from TTL logic if a logic-level translator is used (Fig. 3).

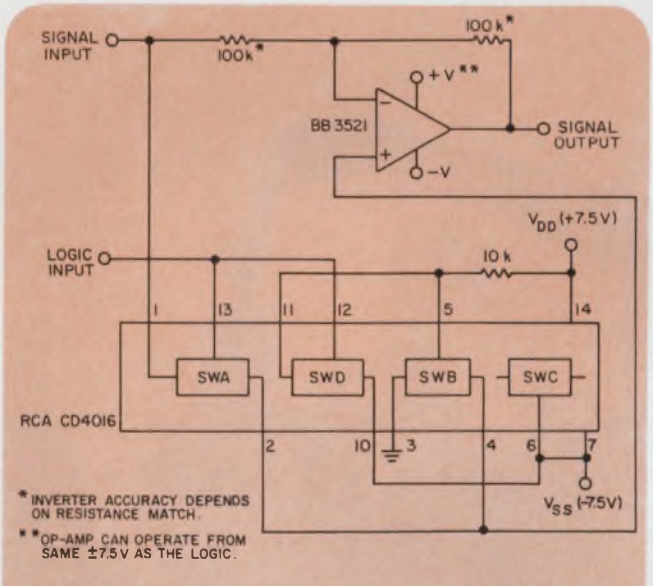
The input-voltage swing is limited by the CMOS logic. With the CD4000-series, this is about ±6 V when operated with ±7.5-V supplies. If higher voltage swing is required, a hybrid FET switch, such as the Siliconix DG182, can provide ±10 V.

Mark Stitt, Engineer, Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85734.

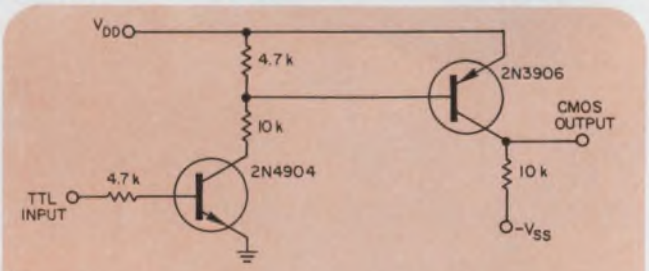
CIRCLE NO. 312



1. **Simplified analog-inverting-circuit** schematic represents the CMOS switches used by SW_1 and SW_2. When SW_1 is open, SW_2 is closed.



2. **In the analog inverter,** sections SWA and SWB of a CMOS switch control the signal inverting, and SWD and a 10-kΩ resistor act as a logic inverter.



3. **The CMOS switch can be driven from TTL** with this logic-level translator.

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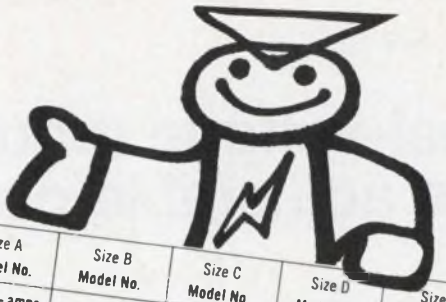


Size A Model No.	Size B Model No.	Size C Model No.	Size D Model No.	Size F Model No.
volts — amps	volts — amps	volts — amps	volts — amps	volts — amps
Q 5 — 3.0	Q 5 — 6.0	Q 5 — 9.0	Q 5 — 12.0	Q 5 — 18.0
Q 6 — 3.0	Q 6 — 6.0	Q 6 — 9.0	Q 6 — 12.0	Q 6 — 18.0
Q 12 — 1.7	Q 12 — 3.4	Q 12 — 5.7	Q 12 — 7.0	Q 12 — 10.8
Q 15 — 1.5	Q 15 — 3.0	Q 15 — 4.8	Q 15 — 6.3	Q 15 — 9.5
Q 18 — 1.3	Q 18 — 2.6	Q 18 — 4.0	Q 18 — 5.2	Q 18 — 7.8
Q 20 — 1.3	Q 20 — 2.6	Q 20 — 4.0	Q 20 — 5.2	Q 20 — 7.8
Q 24 — 1.2	Q 24 — 2.4	Q 24 — 3.3	Q 24 — 4.8	Q 24 — 7.2
Q 28 — 1.0	Q 28 — 2.0	Q 28 — 3.1	Q 28 — 4.2	Q 28 — 6.0
Dimensions: 4⅞ x 4 x 1⅝	Dimensions: 5⅝ x 4⅞ x 2½	Dimensions: 7 x 4⅞ x 2¾	Dimensions: 9 x 4⅞ x 2¾	Dimensions: 14 x 4⅞ x 2¾
Price: 1 — $32.00 100 — $26.00 250 — $24.00	Price: 1 — $54.00 100 — $44.00 250 — $41.00	Price: 1 — $67.00 100 — $54.00 250 — $51.00	Price: 1 — $87.00 100 — $70.00 250 — $66.00	Price: 1 — $113.00 100 — $ 91.00 250 — $ 85.00

Some open talk about open frame power supplies

Deltron inc.

Dual-voltage regulated power supply has adjustable outputs that track

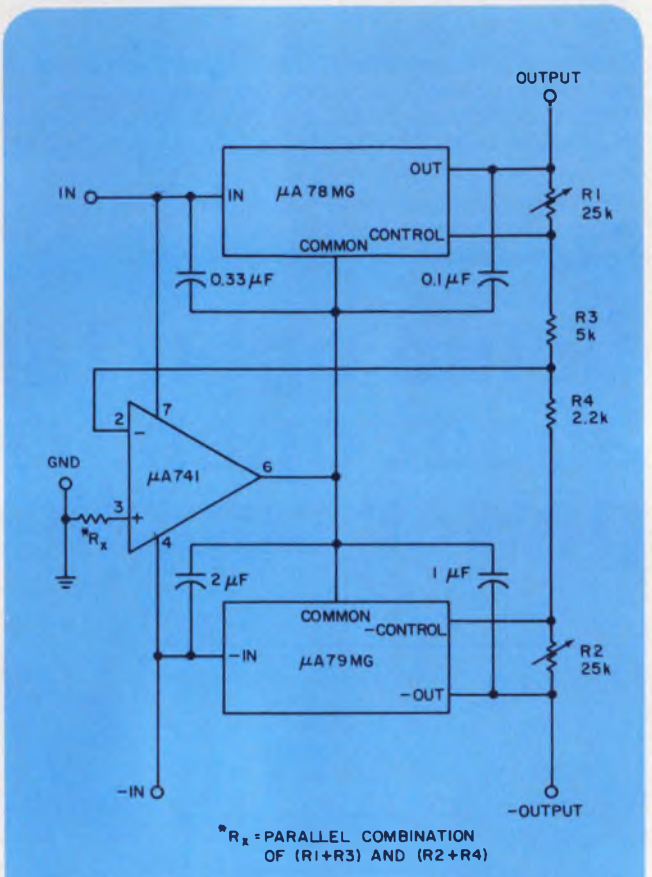
A comparator and a few external parts can transform two IC regulators into a dual-voltage regulator that tracks, has safe-area limiting, and protection against short-circuits and thermal overload. The combination can deliver currents to 500 mA, and the positive and negative outputs of the two integrated regulators can be adjusted independently with variable resistors, R_1 and R_2.

The component values in the figure provide output voltages from the positive regulator—the μA78MG—over a range of 5 to 30 V and from the negative—the μA79MG— from −2.2 to 27.2 V. But care must be taken not to exceed the maximum voltage ratings of the μA741.

To achieve tracking, the common terminals of the two regulators are both tied to the output of the μA741. Thus a decrease in, say, the positive output because of temperature or a line or load variation would cause a reduction in the μA741 inverting input voltage. This, in turn, would raise the potential of the common terminals of the two IC regulators to reduce the output of the negative regulator.

In this way changes in one of the outputs tend to produce a corresponding change in the common regulator terminals, to force the other output to track. Since each regulator has its own reference, there is no slaving. The outputs and degree of tracking are proportional to the ratio $(R_1 + R_3)/(R_2 + R_4)$.

Andy Adamian, Supervising Engineer, Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94040 CIRCLE No. 313



A tracking regulator for positive and negative voltages supplies independently adjustable voltages. and load currents to 500 mA.

IFD Winner of August 2, 1975

J. Brian Dance, Physics Dept., The University of Birmingham, P.O. Box 363, Birmingham B15 2TT, England. His idea "Ultrasonic Transmitter/Receiver Generates a 20-ft Beam That Detects Objects" has been voted the Most Valuable of Issue Award.

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A better answer

The new Slim-Line II audio connector line from Switchcraft, the leading supplier of audio and microphone connectors. A new money-saving interchangeable connector system provides the design flexibility equipment and instrument manufacturers need for quick and inexpensive model changes.

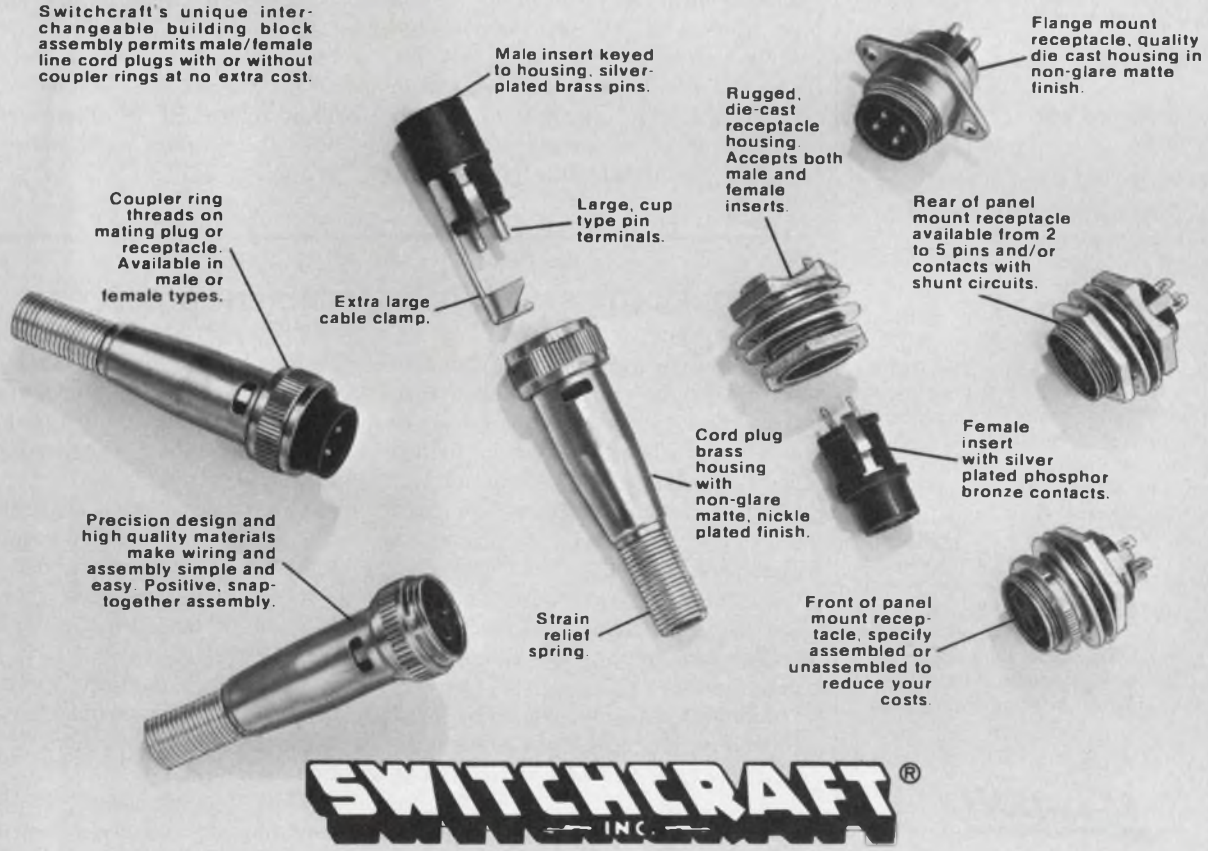
Before Switchcraft's interchangeable connector system, you could get connectors two ways. First you could buy male or female line cord plugs and receptacles completely assembled, and at times, packaged individually. (This required disassembly before installation and adds at least 10% to the price of the connector alone.) Secondly, you could specify a disassembled connector which required long delays in obtaining special part numbers and prices.

Now the people who brought you the Q-G (Quick Ground) Audio Connector bring you the best of two worlds. The first complete audio/microphone connector line that gives you economy and flexibility using a unique interchangeable connector system.

The Slim-Line II line cord plugs consist of only four parts for simple trouble-free installation, assembly and low cost. The receptacles consist of only two parts, plus mounting hardware.

The inserts available from 2 to 5 pins and/or contacts, plus a shunt circuit, can be assembled into any line cord plug or receptacle housing. Using Switchcraft's established listings of Slim-Line II connector components, manufacturers can choose any combination of components and assemble any type of male and/or female connector... without costly labor or component revision.

This is the new Slim-Line II audio connector line from Switchcraft, a dependable low cost connector line for instrumentation, recorders, microphones, computers, industrial controls, broadcast and telecommunication apparatus, and other equipment where a connector is required. For more information write for Engineering Specification Catalog C-520a to Switchcraft, Inc., 5555 N. Elston Avenue, Chicago, Illinois 60630.



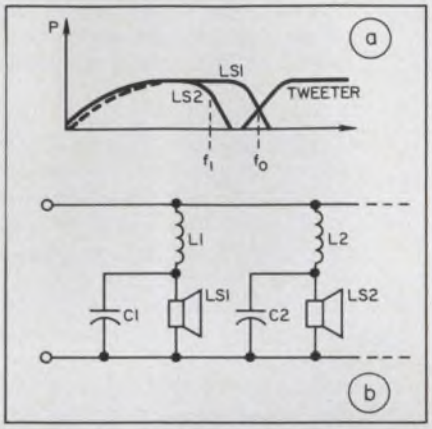
INFORMATION RETRIEVAL NUMBER 45

International Technology

Interference prevented in loudspeaker setup

Undesirable group radiation or interference effects that occur when identical loudspeakers are used in a single small cabinet are prevented by use of a method developed by Saba Schwarzwalder Apparate-Bau-Anstalt August Schwer Sohne GmbH of West Germany.

Where one high-frequency tweeter or midrange unit is used with more than one identical bass speaker, the bass speakers cannot, without interference, share the same load at the region of crossover with the middle or high range units. Although the bass units may share the same load over a part of their operating frequency range, all but one must be rolled off to zero well before the crossover range. According to the German designers, this roll-off should be about 12 dB per octave and should start at least an octave below the crossover point, as shown in Fig. a. The speaker circuit is in Fig. b.



Two identical low-frequency speakers are independently filtered.

The filter for LS1 (Fig. a) is a low-pass unit with a top cut-off of substantially f_0. The filter has a slope of 12 dB per octave and overlaps the curve of the high-pass filter for a tweeter. The filter for LS2 also acts as a low-pass filter but with a cut-off at f_1, which lies more than an octave lower than f_0. Thus only LS1 is effective at the overlap region, and there is no group effect.

Piezoelectric switch is environment proof

Many elevators and television sets are equipped with touch controls and proximity switches in which the user's finger brings about a change in the conductivity or capacitance of the sensor area and, by doing so, generates a switching signal.

Problems with these switches are that they can be inadvertently triggered and they are sensitive to moisture.

Siemens AG of Erlangen, West Germany, has developed a pushbutton in which the actuating area is designed as part of a rigid and hermetically sealed surface. Moisture and soiling are said to have no effect on the switching characteristics and inadvertent contact does not result in false operation because a definite minimum pressure is required for actuation of the pushbutton.

The piezoceramic transducer in the pushbutton switch responds to light finger pressure (about 150 g). The deformation that occurs is less than 0.5 μm and produces about 0.8 V.

The switch contains an RC low-pass filter to prevent false trigger action by vibrations of a particular amplitude and frequency.

The piezoceramic pushbutton does not pick up stray current and is particularly suitable for battery operated radios and TV sets.

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PLUS A COOL $1,000 CASH AND PRE-PAID AIR TRANSPORTATION FOR TWO

In addition to the cruise, the first prize winner gets $1,000 cash, plus air transportation for two to and from the cruise ship's point of departure.

PLUS FREE AD RERUNS FOR YOUR COMPANY

If your company has an ad in *Electronic Design's* Jan. 5, 1976 issue, and you are one of the top three reader or advertiser winners, you earn a free ad rerun* that can be worth up to several thousand dollars for your firm.

100 PRIZES IN ALL

READER PRIZES

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SEPARATE CONTEST FOR ADVERTISERS AND THEIR AGENCIES

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HERE'S ALL YOU HAVE TO DO TO ENTER

Examine the January 5, 1976 issue of *Electronic Design* with extra care. *Read the Rules.* Then:

(1) Select the ten ads you think will be best seen and read.

(2) List the ten ads by company name and inquiry number on the contest entry card.

(3) Fill in your name and address and mail before midnight Feb. 15, 1976.

*The top ten ads will also receive free reruns. Only one free rerun per company. The first three prize winners in the reader contest and the first three prize winners in the advertiser contest awarded reruns only if their companies have an ad in the Jan. 5, 1976 issue.

COMPLETE RULES AND ENTRY BLANKS IN JAN. 5 ISSUE

Ise introduces five new ways to make the competition turn green.

Your competition probably already thinks they're using the perfect display in whatever it is they make. Let them keep thinking it. While you prove them wrong with a new Itron display. They're designed to make the competition turn green. Which also happens to be the color of the segments.

All 17 of them on the 17-digit Itron.
All 5 on the FG-512A1.
Next comes an Alfa-Numerical Itron.
A Linear-Analog Itron. And a Digital Clock Itron.
Five ways to be heartless if you put a little heart into it.

itron®

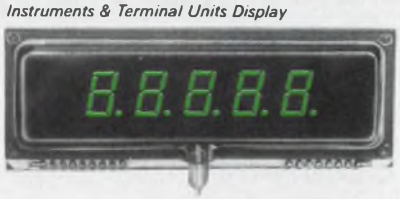
Alfa-Numerical Display

FG209M2
ef = 10V
ec = eb = 40Vp-p
ic = 10mAp-p
ib = 8mAp-p
Wd. 205mm
Lg. 40mm
Segment 9mm

Instruments & Large Calculator Display

FG179F2
ef = 7V
ec = eb = 35Vp-p
ic = 7mAp-p
ib = 5.5mAp-p
Wd. 170mm
Lg. 40mm
Segment 9.5mm

Instruments & Terminal Units Display



FG512A1
ef = 3.5V
ec = eb = 24Vp-p
ic = 4mAp-p
ib = 3mAp-p
Wd. 100mm
Lg. 40mm
Segment 12mm

Digital Clock Display

FG425A1
ef = 5.5V
ec = eb = 35Vp-p
ic = 8mAp-p
ib = 6.5mAp-p
Wd. 140mm
Lg. 59mm
Segment 25mm

Linear Analog Display

FG120S1
ef = 5.5V
ec = eb = 35Vp-p
ic = 4mAp-p
ib = 0.2mAp-p
Wd. 140mm
Lg. 40mm
Segment 8mm

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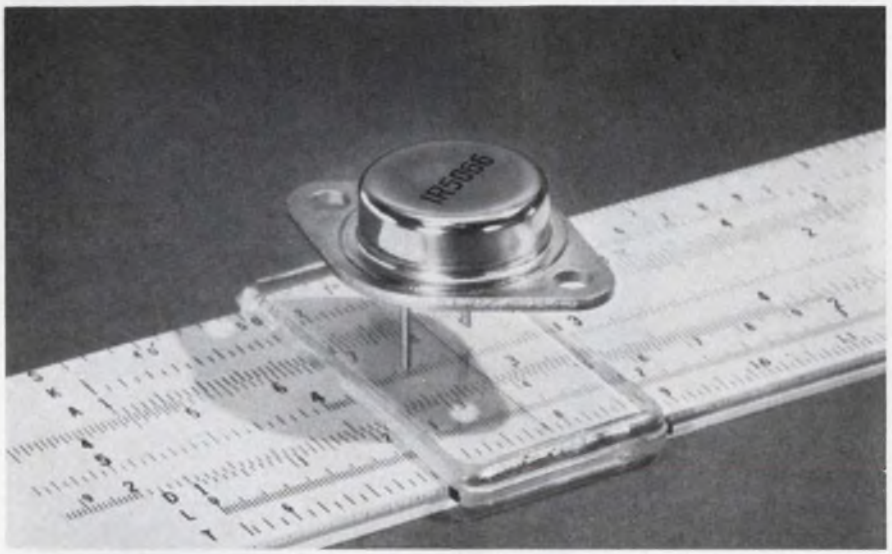
INFORMATION RETRIEVAL NUMBER 49

Power Darlington transistors challenge thyristors for high-power control



International Rectifier, 233 Kansas St., El Segundo, CA 90245. (213) 678-6281. P&A: See text.

Manufacturers of power semiconductors have long been trying to develop fast-switching monolithic control elements that don't require complex drive circuits. Now International Rectifier has taken a big leap forward with its IR5065 and 5066 monolithic power Darlington switching transistors, housed in TO-3 metal cases.

These transistors have collector-emitter sustaining voltages of over 900 V and can control peak currents of more than 20 A. Collector currents of up to 15 A, continuous, can also be handled. Storage times have also been kept low—only 20 μs max and less than 8 μs typical for the regular series and less than 5 μs max, for a premium series available soon.

There are two basic series of power Darlingtons: the 5065 units have 20-A I_C, 750-V $V_{CEO(SUS)}$ ratings, and the 5066 series has a 20-A, 900-V rating. According to Dave Cooper, vice president of engineering product development for International Rectifier, no other commercially available power transistor can handle such a tough combination of parameters.

The only other devices that can do the job, he continues, are thyristors (SCRs, triacs, etc.). They can handle the voltages and currents, but tend to cost about double that of the Darlingtons since they require much more complex control circuitry for turn off. All the transistors need are simple base-drive circuits that can handle the collector current divided by the gain (I_C/β).

Both series of power Darlingtons are rated for operation over a −65 to +165-C range and have a thermal resistance of 1 C/W, maximum. The sustaining voltages —the voltages fed back from the load during turn-off—are specified for a 1-mH load and a collector current of 4 A.

The transistors have maximum base currents of 2.2 A, continuous, and collector-emitter saturation voltages of only 1.6 V, maximum, when a collector current of 10 A flows. Dc current gain for both series at a collector current of 10 A and a V_{CE} of 5 V is guaranteed to be a minimum of 20. The gain drops to 12 if the collector current increases to 15 A for the 750-V series, and it falls to 10 for the 900-V units.

Rise, fall and storage times for the transistors are specified at a collector current of 10 A and a forward base current, I_{B1}, of 600 mA, or reverse base current, I_{B2}, of 1.2 A. For the 5065 series, the rise time is 3.6 μs, and for the 5066 series, 5 μs, maximum. Fall times are the same as the rise times.

Storage times, though, are short, says Cooper, and that, combined with a low saturation voltage, determines the power dissipation of the transistor. Maximum storage times are only 15 μs for the 750-V units and 20 μs for the 900-V devices. Power dissipation for the Darlingtons is specified at a low 125 W.

The transistors are made with the triple-diffused process to give high second breakdown voltages of 850 and 1000 V, respectively, for the 5065 series and the IR5066 series. Integrated on a single chip are the two transistors, two resistors and a diode. Hard glass passivation is used on the chip to ensure stability and improve reliability.

Applications for the power Darlingtons include auto ignition systems, ac/dc motor drives and off-line switching power supplies.

Prices for the transistors start at $18 each for 1 to 49 units and drop to $12 each in lots of 5000 for the IR5065 series. Similarly, prices for the IR5066 series are $22 and $14, respectively.

Delivery for the Darlingtons is from stock to eight weeks.

CIRCLE NO. 301

Pnp power transistors handle 100 V at 5 A

Semicoa, 333 McCormick Ave., Costa Mesa, CA 92626. (714) 979-1900. From $4 (1000-up); stock.

A series of 100-V, 5-A pnp transistors is intended for switching and wideband amplifier applications. The four units, the 2N6190 through 2N6193, are complements of the company's npn transistors, the 2N5336 through 2N5339. The pnp units have an emitter saturation voltage of only 1.2 V at 5 A and are rated for applications with frequencies up to 60 MHz. The transistors are housed in TO-39 packages that permit up to 10 W of heat dissipation.

CIRCLE NO. 303

Fast switching diodes available in kit form

Solid State Devices, 14830 Valley View Ave., La Mirada, CA 90638. (213) 421-9660. $98.75; stock.

A designer's kit of ion-implanted ultra-fast recovery rectifiers permits evaluation and prototype of fast-switching supply designs. The kit consists of twelve 50 V Epion devices, four each of the 20, 50 and 100-A units. The 20-A units are supplied in DO-4 cases, and the 50 and 100-A devices in DO-5. Performance characteristics include a forward voltage drop of less than 450 mV, rated at a maximum full-cycle average forward voltage drop halfwave at a temperature of 55 C and maximum reverse recovery time of 75 ns or less.

CIRCLE NO. 304

UV photodetectors claim to have top performance

EG&G, 35 Congress St., Salem, MA 01970. (617) 745-3200. From $29; stock.

The UV series of silicon photodetectors incorporates processing changes which are claimed to completely eliminate UV spectral instability. As a bonus, the series also boasts an anti-reflection coating that enhances the UV response by as much as 60%. The spectral range is from 200 to 1150 nm with an absolute responsivity of 180 mA/W at 250 nm. Noise equivalent power is as low as 7×10^{-14} W/Hz$^{1/2}$ at 250 nm for an active area size of 5.1 mm^2. The new series is claimed by the company to have the highest shunt resistance and lowest noise current per unit area of any commercially available detector. The responsivity is linear within 1% over a 7 to 12 decade range of light intensities. The UV series is available in four different package styles with active areas ranging from 5.1 to 314 mm^2. They are also available with compatible FET-input op amps (the HUV series) for use as photodetector/amplifiers.

CIRCLE NO. 305

Npn and pnp transistors have 800 MHz BW

AEG-Telefunken, 570 Sylvan Ave., Englewood Cliffs, NJ 07632. (201) 568-8570. From $1.05 (100-up); 6 to 8 wk.

A series of npn, rf transistors, types BF 362 and BF 363 and pnp types BF 679 and BF 680, have a gain-bandwidth product of 800 MHz, typical. The power gain is typically 12 dB; noise figure, 4 dB; and the reverse attenuation, 20 dB. The devices are housed in a flat plastic pack similar to the JEDEC TO-50 package.

CIRCLE NO. 306

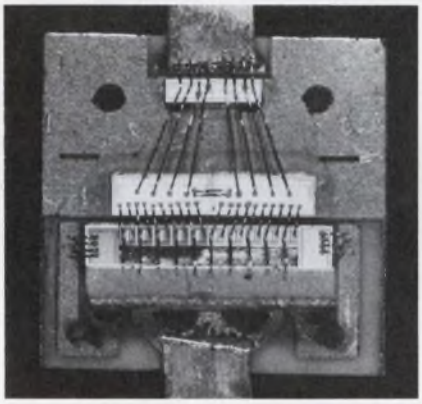
Schottky mixer diodes have low V_f's

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. From $5.95 to $62.40; stock.

Low forward-voltage equivalents of HP's Schottky mixer diode line have V_f's of 200 to 300 mV. A total of 23 devices are available, which include chips, beam lead and quad configurations. The diodes are closer to a 50-Ω impedance than standard Schottky mixer diodes, which results in a lower VSWR over the band. Noise figure of the diodes is typically less than 6 dB at 9 GHz for power levels ranging from −5 dBm to +5 dBm. Beam lead versions are the 5082-2229 series; microstrip quads are available as the 5082-2231 series (hermetic) and the 5082-2271 series (broadband); single chip microstrip packages are the 5082-2765 (hermetic) and the 5082-2774 (broadband), respectively.

CIRCLE NO. 307

Rf power transistors have internal matching



TRW RF Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260. (213) 679-4561. For the MRA 2023, 12 W unit: $200 (25-up); stock.

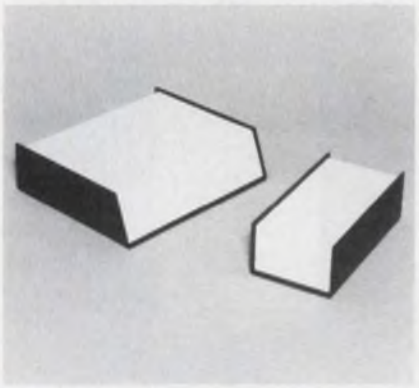
The MRA 2023 series of broadband, high gain transistors has internal impedance-matching circuitry. They are designed for 28-V operation and MRAL 2023 series is intended for 22-V operation. Both series are rated for broadband operation from 2 to 2.3 GHz. Units in the line offer power ratings of 1.5, 3, 6 and 12 W, with saturated output power typically 1 dB higher than the device rating for all units in broadband circuits.

CIRCLE NO. 308

Advertisement

ELECTRONIC PACKAGING

Versatile enclosures, economical too



Bud Radio, Inc., 4605 E. 355 St., Willoughby, O. 44094, (216) 946-3200. All aluminum.

Each is immediately available in two configurations at your Bud Distributor: the Slope (left), the Linear (right). Both offer an economical means for enclosing sub-systems and instrumentation. One-piece covers are easily removed. No visible fasteners on panel areas. All aluminum: covers, .057; base, ⅛". Rubber feet furnished. Black texture with smooth white enamel finish. For further information, phone —

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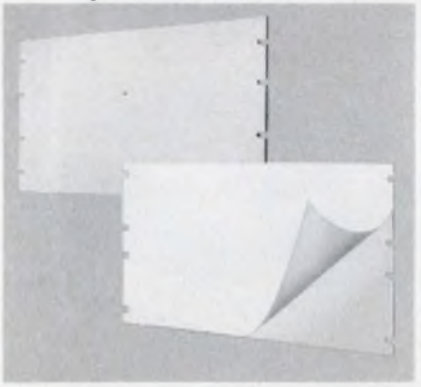

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1-800-321-1764, TOLL FREE
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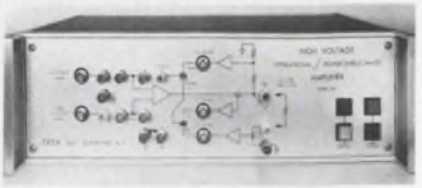
INSTRUMENTATION

An op amp with an output of ±10 kV? Yup!



Trek, Inc., 8460 Ridge Rd., Gasport, NY 14067. (716) 772-2427. $2285.

Model 606 high-voltage operational/transconductance amplifier has all the typical specs found in its little brother, the monolithic IC op amp, but features an output voltage range of ±10,000 V at a current of ±1.6 mA. In addition, with a flip of a switch, the unit becomes a precision transconductance amplifier capable of precise control of the output current. Like any other op amp, the 606 can be gain programmed with various input and feedback elements.

CIRCLE NO. 320

Dataloggers handle picoamp currents

Keithley Instruments, 28775 Aurora Rd., Cleveland, OH 44139. (216) 248-0400. 90 days.

System 70 embodies six basic Datalogger configurations, each centered around a particular DMM, electrometer, or nanovoltmeter. A 10-channel scanner precedes the measuring instrument in the circuit and an 18-column printer provides a record of time-of-day, channel, data, exponent if applicable, and, in most cases, engineering units. The number of input channels can be expanded, if necessary, in multiples of 10 channels. System 70/616/18, an electrometer-based datalogger, is said to be the first of its kind. It features current sensitivity from 10^{-13} A to 100 mA.

CIRCLE NO. 321

4-1/2-digit DMM uses line or battery pack

Data Precision, Audubon Rd., Wakefield, MA 01880. (617) 246-1600. $355.

Model 1455 is both a line-powered bench and battery-powered portable DMM. Featured are a 1/2-in-high seven-segment planar display, 100% overranging and 21 function/range operation. DC volts are measured from 100 μV to 1000 V; ac volts from 100 μV to 500 V rms; resistance from 100 mΩ to 20 MΩ; current, both ac and dc, from 1 μA to 2 A. Frequency response for ac current and voltage is from 30 Hz to 50 kHz. Basic accuracy on dc V is ±0.02% rdg ±0.01% fs, ±1 digit for six months.

CIRCLE NO. 322

Unit converts CRT to logic analyzer

Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. $3250 including probes; 10 wks.

Model LA 501 digital storage unit converts any CRT display into a logic analyzer. The unit displays up to 16 channels of data in timing diagram format, stores 4096 bits, provides variable storage and display format (4 channels × 1024 words through 16 channels × 256 words) and samples to 100 MHz. Other features include pre-trigger, center-trigger, and post-trigger modes, accommodates any logic family, choice of synchronous or asynchronous sampling of machine data.

CIRCLE NO. 323

Unit captures and displays four signals

Devices Limited, Hyde Way, Welwyn Garden City, Hertfordshire AL7 3AP, England.

This instrument offers four-channel digital display and tape-memory system with modular preamplifiers and signal processing facilities. Signals are displayed on a nonfade CRT with a graticule size of 20 × 15 cm. Slowly varying signals, difficult to interpret on an oscilloscope, can be presented as stationary images which can be frozen for an indefinite period and expanded five times for inspection of any portion of the waveform. Alternatively, a "wipe" facility is provided to momentarily hold a free-running signal. Input signals up to 1 kHz from levels as low as a few microvolts are digitally sampled and stored at up to 5000 samples per second at a sampling resolution better than 1 in 200 for each of the four channels.

CIRCLE NO. 324

Analyzer shows average & instantaneous waves

Spectral Dynamics, P.O. Box 671, San Diego, CA 92112. (714) 565-8211. $9950.

This 500-line real-time spectrum analyzer operates over a frequency range of 0.06 Hz to 50 kHz and contains a dual memory and built-in scope. Thus you can view on-line and averaged spectra on the same screen for direct, visual comparison. Two different averages may also be displayed and directly compared. Dynamic range of greater than 60 dB and the ability to average up to 1024 ensembles of data allows the unit to retrieve signals hidden by background noise.

CIRCLE NO. 325

INSTRUMENTATION

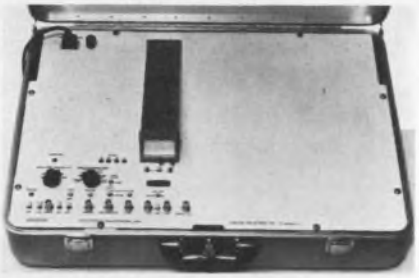
Function generators cover low frequencies

Philips Test & Measuring Instruments, 400 Crossways Park Dr., Woodbury, NY 11797. (516) 921-8880. PM5108, $600; PM5127, $795.

Two new low-frequency function generators offer a variety of outputs and features. The three-function PM5108 has a 1-Hz-to-1-MHz range with a 20-V output, while the four-function PM5127 covers the 0.1-Hz-to-1-MHz range, and has a 30-V output. PM5108 gives sine, triangular, and square waves and has six overlapping ranges. Accuracy is ±2% up to 100 kHz. Output impedance is 600 Ω. PM5127 offers sine, triangular and square waves with variable duty cycle in seven overlapping ranges. Accuracy is ±3%.

CIRCLE NO. 326

Spectrum analyzer fits in suitcase



Unigon Industries, 1 Park Ave., Mount Vernon, NY 10550. (914) 699-7545. $7500; 60 days.

Said to be the first FFT spectrum analyzer fully contained in an aluminum suitcase 17 × 21 × 7-1/2 in., the FFT MINI U512 weighs 30 pounds and fits under an airplane seat. The unit features a built-in CRT display, LED cursor, analysis range to 40 kHz, dynamic range of 60 dB, fully real time to 32 kHz, spectral averaging, transient capture, and hanning or flat weighting. FFT MINI U512 provides all digital real time FFT spectrum analysis in 12 ranges from dc to 10 Hz to dc to 40 kHz (resolution from 0.02 to 80 Hz).

CIRCLE NO. 327

3-1/2-digit DMM costs just $149.95

Sinclair Radionics, 375 Park Ave., New York, NY 10022. (212) 688-6623. $149.95, including ac adapter.

The DM2 multimeter measures ac and dc volts, ac and dc current and resistance in a total of 20 combinations—five functions each with four ranges—with a basic accuracy of 0.4%. Operation is by press-button selection, and contact is made by two clip probes on long leads. The unit features a 0.3-in. LED display and a violet screen to boost contrast in high ambient light conditions. Maximum reading is 1.999. The DM2 uses a MOS IC and dual-slope integration. Separate fuses for current and resistance ranges protect the unit against overload.

CIRCLE NO. 328

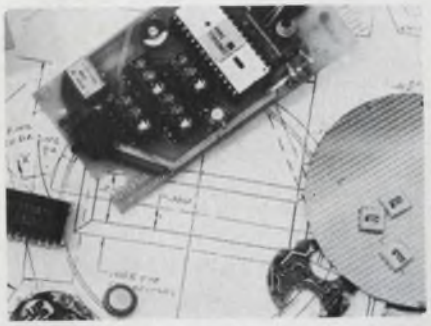
DPM monitors line voltage and frequency

Electro Industries, P.O. Box 3542, North New Hyde Park, NY 11040. (516) 621-6652. $195; stock-4 wks.

Power-line monitor Model LM 1600 is a solid-state digital panel meter that combines the functions normally provided by two distinct conventional line monitoring panel meters: monitoring ac line voltage and line frequency. The unit measures voltage up to 300 V and frequency up to 100 Hz with a resolution of 0.1 Hz. An optional terminal can be provided to change the time base from 10 to 1 s. This feature extends the range of frequency measurement to 999 Hz with a resolution of 1 Hz.

CIRCLE NO. 329

CMOS watch chips feature SPST action



Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $7.55 to $11.70 (100-999).

A family of fully integrated digital-wristwatch CMOS circuits offers single-pole-single-throw switching action. The ICM7200A is a single-chip LED 12-hour circuit with alphanumeric capability, providing hours, minutes, day, date and seconds readout. The ICM-7203A is a 24-hour version. The ICM7202A is a numeric 12-hour circuit that interfaces with existing seven-segment LED displays. The ICM7204A is a 24-hour version of the 7202A. All circuits operate with two SPST switches that can be connected either to V_{DD} or to the midpoint of the watch case's battery stack. Antibounce circuitry on the switch inputs can handle up to 31 ms of switch bounce.

CIRCLE NO. 330

Self-protected ICs drive 48-V relays

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. $3 (100); stock.

Two interface ICs can drive 48-V telephone relays without the need for external protection circuitry. The circuits are the DS-3686, a positive-voltage driver, and the DS3687, a driver for negative-voltage relays. Both convert standard bipolar and CMOS logic signals to the signals needed by telephone relays. Darlington-transistor outputs are rated at 65 V, and the devices can sink 300 mA from each of two channels. With both outputs ON, V_{CC} must provide 90 mW, typical.

CIRCLE NO. 331

4-decade counters employ CMOS/LSI

Hughes Microelectronic Products, 500 Superior Ave., Newport Beach, CA 92663. (714) 548-0671. $6 to $8.50 (1000); stock.

Two CMOS/LSI counters contain four synchronous decade counters and their associated storage latches. The TTL-compatible circuits consist of the HCTR6010, a 16-pin up-only counter, and the HCTR4010, a 24-pin up/down counter. Both counters feature multiplexed BCD outputs.

CIRCLE NO. 332

6-function watch chip tracks two time zones

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. $9.50 (100); factory stock.

The exact time in any two zones can be kept simultaneously by a new six-function CMOS watch circuit. The Model MM5880 provides all the control signals needed by a four-digit LED watch. The circuit provides hours, minutes, seconds, and month-with-date under control of a single pushbutton. A second pushbutton controls the display of seconds, minutes and hours in a different time zone. The circuits operate from any dc source supplying a voltage between 2.4 and 4 V.

CIRCLE NO. 333

12-bit DAC has $27 price tag

Analog Devices, Rte. 1, Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700.

A 12-bit digital-to-analog converter guarantees monotonicity over its entire operating temperature range and costs as low as $27 in quantities of a hundred. The AD563 comes in a 24-pin package that contains three chips; switch and control amplifier, thin-film resistor and reference. Maximum error at 25 C is 1/4 to 1/2 LSB. The gain tempco is as low as 10 ppm/°C max. Also the unit has a differential nonlinearity tempco of 1 ppm of FSR/°C.

CIRCLE NO. 334

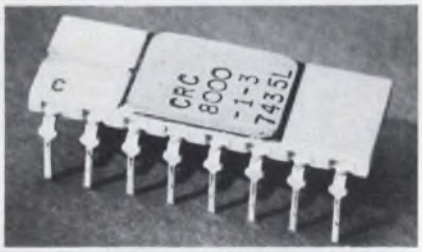
MOS/LSI test circuits span technologies

Mosfet Micro Labs, Inc., Penn Centre Plaza, Quakertown, PA 18951. (215) 536-2104.

A set of four MOS/LSI test circuits encompasses CMOS (metal gate), p-channel and silicon-gate technologies, as well as charge-coupled devices (three-phase polysilicon or tungsten). The test chips can be used by designers to learn about IC design, or as an alternative to high-priced custom MOS. Each of the test-circuit patterns are layered, and each layer is individually colored, ready for the mask maker to cut rubys. Also included with each set is a full explanation of each individual test pattern for manual probing. Test patterns allow evaluation of p and/or n transistors for gate and field threshold voltages, source/drain breakdown voltage, and transistor-gain characteristics. Individual test-circuit patterns cost $100 per process.

CIRCLE NO. 335

Convert binary data to dial pulses



Collins Radio Group, Rockwell, Newport Beach, CA 92663. (714) 833-4600. $9.95 (100).

The CRC-8000 ion-implanted, p-channel, MOS circuit converts binary-coded data into standard dial-pulse signals. Operation can be varied by changing an external clock frequency. With a 2-kHz clock input, the CRC-8000 accepts asynchronous binary data, stores it in a first-in-first-out memory, and generates a 10-pulse pair per second (60% break/40% make) dial pulse having a 650-ms minimum interdigit time. If a 4-kHz clock is used, the dial pulse frequency is 20 pps and the interdigit time is reduced to 325 ms minimum. A memory inhibit input signal can be used to delay the dial pulse output.

CIRCLE NO. 336

Dialight sees a need:

Need: A new computer-grade switch at a price you can afford.

LOW COST • COMPUTER GRADE QUALITY • DESIGN FLEXIBILITY • GOLD OR SILVER CONTACTS • CHOICE OF TERMINALS • MOMENTARY OR ALTERNATE SWITCHING ACTIONS • SPDT, DPDT • DESIGNED TO MEET UL SPECIFICATIONS • UNIFORM FRONT PANEL APPEARANCE AND REAR PROJECTION • MATCHING INDICATOR LIGHT • FRONT MOUNTING SNAP-IN BEZELS—4 SIZES/SHAPES TO CHOOSE FROM • REAR MOUNTING SWITCH WITH ANTI-ROTATION FEATURE • CHOICE OF OVER 200 CAP SHAPES, SIZES AND COLORS • CHOICE OF ENGRAVED, HOT STAMPED OR REPLACEABLE LEGENDS.

Dialight's low cost 554 series switches are available in a wide selection of rear panel and front bezel mounting types. Switches are available with silver or gold contacts for wide range of applications; operating life is 250,000 operations.

Fingertip grips permit easy cap removal . . . lamp replacement is from front of panel . . . no special tools needed.

Caps are available with or without underlying color filter in ⅝" and ¾" square, ⅝" x ¾" and ¾" x 1" rectangles. At Dialight it's your choice because we see your need.

DIALIGHT

Dialight, A North American Philips Company
203 Harrison Place, Brooklyn, N.Y. 11237
(212) 497-7600

INFORMATION RETRIEVAL NUMBER 57

INTEGRATED CIRCUITS

1-k S-TTL RAM accesses in 45 ns

Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $22.00 to $61.60 (100-999).

Static Schottky-TTL 1024 × 1-bit RAMs—the IM55S08 and IM-55S18—offer a typical access time of 45 ns. The IM55S08 provides open-collector output, and the IM-55S18 has three-state. Input current is 250 μA maximum for both memories. Maximum read and write cycle times are 70 ns for commercial temperature-range versions and 75 ns for military parts.

CIRCLE NO. 337

Transceiver offers full-duplex at 40-k baud

Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, CA 92705. (714) 540-9979. $9.50 (100); stock.

A universal transceiver LSI circuit handles asynchronous, full-duplex communications at speeds up to 40-k baud. Called the MP1013, the unit is a second source to General Instruments' AY-5-1013. Completely DTL/TTL-compatible, and requiring no interfacing circuits, the device accepts serial-bit characters from a terminal or computer, and receives and transmits the characters. Baud rate, number of data bits, parity mode, and the number of stop bits are programmed externally.

CIRCLE NO. 338

Dual-port register uses positive clock

Advanced Micro Devices, 901 Thompson Pl., Sunnyvale, CA 94086. (408) 732-2400. $2.16 to $12.96 (100).

A 4-bit register with quad two-input multiplexed parallel inputs and positive-going clock—the Am-25LS09—has a minimum clock frequency of 40 MHz, with a typical value of 65 MHz. The circuit is logically similar to the 74LS298 with the exception of the positive-going clock input. This eliminates the need for an additional external inverter package. The Am25LS09 is being second-sourced by Texas Instruments.

CIRCLE NO. 339

Data-acquisition module designed for wrapped-wire installation

Data Translation Inc., 109 Concord St., Framingham, MA 01701. (617) 879-3955. See text.

If you need 8 or 10-bit a/d converter precision in a low cost data-acquisition subsystem, Data Translation offers an answer with its Datax II series of modular data-acquisition systems. There are four models in the series—the DT820, 825, 830 and 835. Two models, the 820 and 825, offer 8-bit resolution and accuracy, while the 830 and 835 provide 10-bit. Prices start at $130 for quantities of 100.

A unique feature of these modules is their packaging. The entire system—an input multiplexer, differential amplifier, sample-and-hold amplifier, a/d converter and all system logic—is housed in one 3

× 4 × 0.4-in. module. And the module itself is designed for wrapped-wire applications with the pins extending from the bottom 0.025 in. square. instead of the typical 0.02-in.-diameter round pins usually found on circuit modules. The pins are on 0.1-in. centers, and there are two rows of 32 pins each.

The Datax modules are designed for 16 or eight input channels and can be expanded to 64 channels. Temperature coefficients are guaranteed at ±30 ppm/°C max. Channel acquisition time for the sample-and-hold circuit is 8 μs for the 8-bit and 12 μs for the 10-bit units, both for accuracies to 0.05%. Input impedances are greated than 100 MΩ, and input ranges of ±5, ±10 and 0 to 10 V are available.

Prices for the DT-series data-acquisition systems start at $130 for the DT820, 8-channel unit; $140 for the DT825, 16-channel; $140 for the 830 8-channel, and $150 for the 835 16-channel model. Delivery for the units is from two to four weeks.

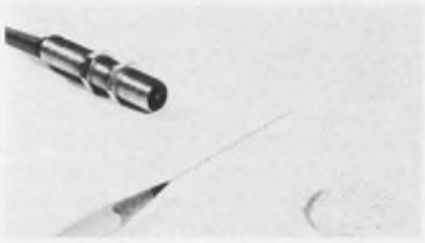
CIRCLE NO. 302

INFORMATION RETRIEVAL NUMBER 61

INFORMATION RETRIEVAL NUMBER 62

MODULES & SUBASSEMBLIES

Noncontact sensor has 6-ft range



Scientific Technology Inc., 1201 San Antonio Rd., Mountain View, CA 94043. (415) 965-0910. From $153.50; 2 to 4 wk.

The Model 2070-series Optaxial controls detect any visible object or material in its field of view. It reads code marks as small as 0.06 in. or color changes and can see or see through, as required by the application, transparent and translucent materials, liquids or clouds. Its range is up to 1.5 in. (38.1 mm) proximity mode and 6 ft (1.8 meters) with a 3 in. (8 mm) diameter retrotarget. The sealed sensor head of the 2070-series is 2.75 in. (57.15 mm) long and is housed in a threaded tube that has an outside diameter of 0.375 in. (9.53 mm) and may be remotely mounted up to 100 ft (30 meters) from the control electronics. The 2070-series units operate from any 2.5-W input from 21 V dc to 240 V ac. Output switching may be selected to meet any requirement. Standard plug-in control option modules include time delays, one-shots, latches, predetermined counts, etc.

CIRCLE NO. 340

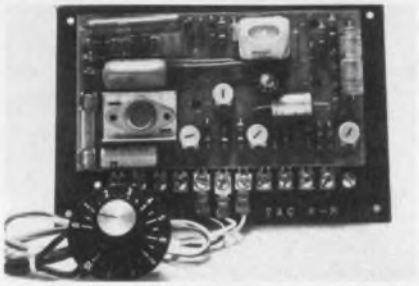
Mini 8-bit modular DAC fits 16-pin DIP

Cycon, Inc., 1240 Elko Dr., Sunnyvale, CA 94086. (408) 734-1575. $11 (100-up); stock.

The cyDAC 371-8, a miniature modular digital-to-analog converter, measures only 1.3 × 0.6 × 0.5 in. and plugs into a 16-pin IC socket. The DAC has an 8-bit TTL/DTL-compatible input, an internal reference source and is monotonic.

CIRCLE NO. 341

Variable speed drive has speed range of 20:1

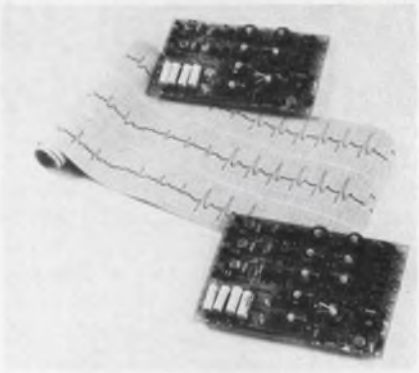


Mercer Controls Corp., 96 Mercer St., New York, NY 10012. (212) 966-5815. Under $100; stock.

The AC-25C open chassis variable speed controller is specifically designed for use with sub-fractional and fractional (up to 1/4 horsepower) ac motors. The control operates geared or ungeared permanent split-capacitor single-phase ac motors. Typical speed range for the AC-25C is 20 to 1, with 1% load regulation throughout the speed range. The unit also includes an ac tachometer for precise velocity feedback control.

CIRCLE NO. 342

Multichannel amplifiers built for high isolation



Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. From $149 (1 to 9); stock.

Multichannel isolation amplifiers, the two-channel 282J and three channel 283J, are built on 3 × 5.5 × 0.67 in. open circuit boards. Each isolator has dual, isolated regulated power outputs of ±6 V dc at ±10 mA and ±3 V dc at ±5 mA, designed for exciting external circuits and transducers. The isolators offer adjustable gain from 1 to 100 V/V, only 1.5 μV rms of input noise (1 kHz bandwidth), a low of 2.4 μA rms maximum ground leakage current (at 115 V ac, 60 Hz) and 160 dB of common-mode rejection (at dc). Both models use a floating guard to provide high common-mode rejection. The 160 dB CMR at dc degrades to only 135 dB at 60 Hz and a 5-kΩ source imbalance. Each channel will also withstand 220 V rms, continuously, applied directly across its differential input.

CIRCLE NO. 343

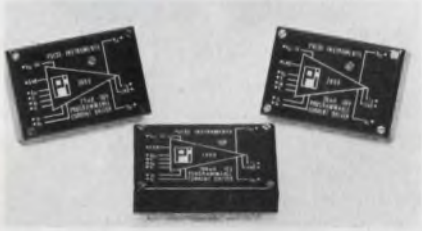
Stepping motor control operates from TTL levels

NEC Microsystems, 1150 N.W. 70th St., Fort Lauderdale, FL 33309. (305) 974-5400. $31.75 (1 to 24); stock to 8 wk.

The Type 2030 hybrid microcircuit controller for stepping motors includes TTL control logic, "predriver" circuitry. Because stepping motors vary in power driver requirements, the final driver transistors are not included in the 2030. Instead, the circuit was designed with sufficient capability to control many different types of driver transistors. Each of the four outputs will deliver a minimum of 40 mA and will operate with motor supply voltages of 40 V dc or less. The 2030 controller operates from standard TTL input logic levels. It controls bi-directional motors and operates 1 of 3 phase, 1 of 4 phase or 2 of 4 phase motors. The circuit is housed in a 1.9 × 0.775 × 0.23 in. 20-pin DIP like case.

CIRCLE NO. 344

High speed drivers deliver up to 100 mA



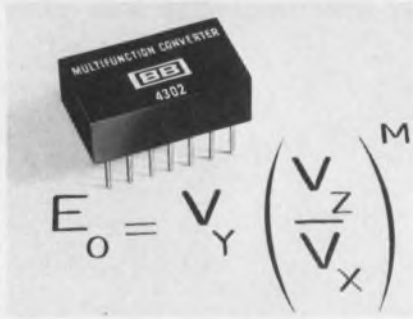
Pulse Instruments, P.O. Box 1655, San Pedro, CA 90733. (213) 541-3204. $80 (1 to 4); stock to 4 wk.

The PI-1000, PI-2000 and PI-3000 are programmable high-speed, high-voltage interface drivers. They can deliver 100 mA at 15 V, 50 mA at 40 V and 25 mA at 80 V, respectively. The output currents of these drivers can be programmed by means of reference voltages, currents or resistances. When used with matched 50 Ω systems, their respective output characteristics are: Rise/fall times, 3, 5 and 15 ns; max rep. rate, 50, 35 and 10 MHz; propagation delay, 10, 15 and 50 ns; and max output offset, ±10, +35/−30, +75/−65 V. The PI-1000, PI-2000 and PI-3000 can be operated from single power supplies of 10 to 20, 15 to 45 and 20 to 85 V, respectively.

CIRCLE NO. 345

MODULES & SUBASSEMBLIES

Multifunction converter squeezed into 14-pin DIP



Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734. (602) 294-1431. $32 (1 to 24); stock.

The Model 4302 multifunction converters multiply and divide with a typical accuracy of 0.25%. The general transfer function is $E_o = V_Y(V_Z/V_X)^m$, where V_X, V_Y, and V_Z refer to input voltages which are applied to produce E_o. The exponent, m, is resistor programmable and can be varied from 0.2 to 5. The unit is housed in a 14-pin DIP and has an output capability of ±10 V at 5 mA when driven from ±15 V dc. The unit is pin compatible with the company's 4301 and Bell & Howell's Model 435. Typical accuracies expressed as a percentage of output full scale are as follows: multiply or divide, ±0.25%; square, ±0.03%, square root, ±0.07%; sine, ±0.5%; cosine, ±0.8%; and arctangent, ±0.6%.

CIRCLE NO. 346

Synchro modules deliver 8, 10 or 12-bit data

Astrosystems, 6 Nevada Dr., Lake Success, NY 11040. (516) 328-1600. From $300 (1 to 9); stock.

The M series of modules handles the analog signals from synchros, resolvers and selsyns. It converts them to binary or BCD digital format. Accuracy and resolution of 8, 10 and 12 bits binary or 0.1° BCD are available. Units will accommodate all standard synchro frequencies and voltages. All converters contain an output register. Modules will track inputs at a maximum rate of 2000°/s and will respond to a 180° step input in less than 4 ms. The modules may be combined for two speed conversion.

CIRCLE NO. 347

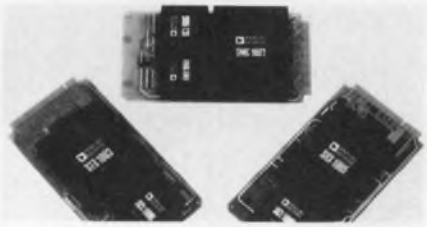
Deglitched d/a converter has 15-MHz update rate

Computer Labs, 1109 S. Chapman St., Greensboro, NC 27403. (919) 292-6427. From $900; 8 to 10 wk.

The TVDA "deglitched" d/a converters are available in 8 and 10-bit models. The TVDA-0815 and TVDA-1015 units include a deglitching circuit for suppressing transients in the analog output. Input word rates as high as 15 MHz are specified, thus making it possible to operate at either three times or four times the NTSC color burst frequency for video applications. Accuracies, including linearity, are specified to within ±0.05%. The converters are constructed on PC boards that measure 5.5 × 6 × 1 in.

CIRCLE NO. 348

Serdex subsystems include all parts

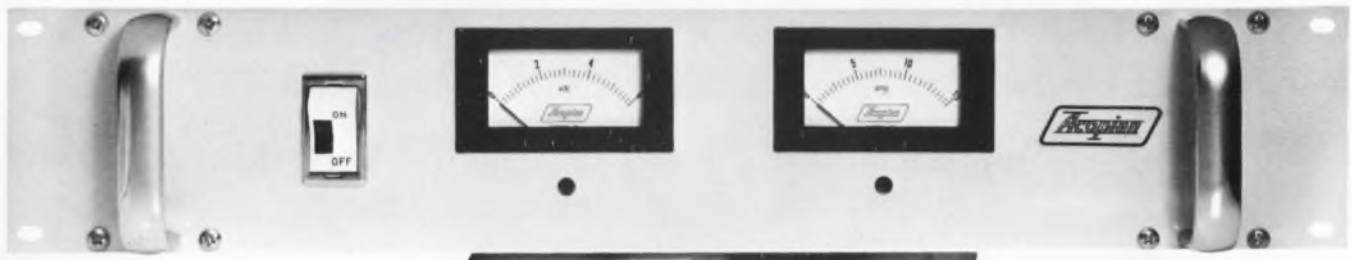


Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. From $395 (1 to 9); stock.

A series of Serdex subsystems-on-a-card simplifies interfacing between parallel digital data and asynchronous serial data networks. The Serdex units permit simple two-wire serial communications between equipment. The subsystems perform the complete transmit, receive and multiplex functions. Each subsystem is available on a 4.5 × 8-in. PC board and requires only 5-V-dc power for operation. The STX2603 subsystem converts parallel data into asynchronous serial ASCII and consists of a transmit module (STX1003), clock module (SCL1006), two additional shift registers, and all necessary interconnections and pull-up resistors. The STX2605 receive subsystem converts asynchronous serial ASCII into parallel digital data. It includes an SRX1005 receive module, an SCL1006 clock and all interconnects and pull-up resistors.

CIRCLE NO. 349

RACK MOUNT POWER SUPPLIES ...TO 60 AMPS



ALL MODELS U.L. RECOGNIZED

NOMINAL OUTPUT VOLTAGE	OUTPUT CURRENT AMPS	PRICE	MODEL	DIMENSIONS (INCHES) HEIGHT	DEPTH
5	20	$280	5PT20	3½	11
5	32	330	5PT32	5¼	12
5	60	525	5PT60	5¼	17
12	20	330	12PT20	5¼	12
12	45	550	12PT45	5¼	17
15	10	280	15PT10	3½	11
15	16	330	15PT16	5¼	12
15	31	590	15PT31	5¼	17

OPTIONS
Overvoltage protection—Add prefix "V" to model number and $25.00 to price of models with output current rating of 20 amps or less, $75.00 to price of other models.

Ammeter—Add suffix "A" to model number, $15.00 to price.
Voltmeter—Add suffix "F" to model number, $15.00 to price.
Handles—Add suffix "H" to model number, $10.00 to price.
Regulation, ±0.05% or better.
Ripple, 1 mv rms or better.
Many other models from 1 to 50 volts. Write for complete catalog.

Acopian Corp., Easton, Pa. 18042. Telephone: (215) 258-5441.

INFORMATION RETRIEVAL NUMBER 151

How far will the Guardian Angel go?

NO. 28 SOLENOID SWITCH

NO. 11 SOLENOID

She just spent a bundle to save you a bundle by slashing solenoid prices.

The money-saving "bundle" went for research and tooling.
The result: our new Uni-Guard® II molded bobbin and coil cover that gives you solenoids that cost up to 25% **less** . . . with at least 25% **longer** life. Plus QC termination for easier, faster, less expensive installation.

Uni-Guard II is available in a whole array of Guardian's most popular box frame and U-frame solenoids—from the No 2 right on up thru the No. 38. In AC and DC, push, pull and solenoid switch versions. All with the new, stronger, better looking molded assembly that saves you money. And meets tough new specs controlling flammability and out-gassing. (It's progress like this that **keeps** Guardian No. 1 in solenoids!)

WANT EVEN **LONGER** LIFE? GUARDIAN CAN DO! With the new line of long-life tubular solenoids that increase expected mechanical life for most tubulars from 1 million . . . to 100 million!

SEND FOR THE BOOK THAT TELLS IT ALL:
Guardian's 72 page solenoid catalog. Full of facts and specs to make selecting a solenoid a snap. Yours free for the asking.

GUARDIAN®

GUARDIAN ELECTRIC MANUFACTURING CO.
1572 West Carroll Ave., Chicago, Illinois 60607

INFORMATION RETRIEVAL NUMBER 152

RIGHT ON TARGET AGAIN

SGS ATES

Gala performance

TDA 2020=20 watts from a chip: hi-fi!

Meaning only 1 per cent distortion over the audio band for a typical output of twenty watts. All for a few hundred millivolts in. The single or split supply arrangement lets you eliminate costly and troublesome electrolytics.

The standard package allows easy assembly. Thanks to thermal shutdown the heatsink dimensions are not critical and the integral copper slug ensures efficient heat transfer.

No problems with loudspeaker connections either, because the output is short-circuit proof.

The TDA 2020 shares its versatile power op amp configuration with the lower-rated TDA 2010.

Two soloists, but a full symphony of applications.

SGS-ATES Semiconductor Corporation · **Newtonville, Mass.** 02160 · 435 Newtonville Avenue · Tel. 617-9691610 · Telex 922482 · **Stocking Distributors:** Edmar Electronics Co., **Des Plaines, ILL.** (312) 298-8580 · Energy Electronic Products, **Los Angeles, CA.** (213) 670-7880 · Esco Inc., **Dayton, OHIO.** (513) 226-1133 · KA Electronic Sales, **Dallas TX.** (214) 634-7870 · Radar Electric Co., **Seattle, WA.** (206) 282 2511 · Re-Call Electronics Inc., **Santa Clara, CA.** (408) 984-0400 · Rosyl Electronics, **Bayshore, NY.** (516) 586-1800 · Wilshire Electronics, **Burlington, MASS.** (617) 272-8200 · Zeus Components Inc., **Elmsford, NY.** (914) 592-4120 · **Burlington, MA.** (617) 273-0750 · **Pompano Beach, FLA.** (305) 942-4312 · Prelco Electronics Ltd., **Montreal 357, Quebec.** (514) 389-8051

Speech synthesizer talks in foreign languages

Federal Screw Works, 500 Stephenson Highway, Troy, MI 48084. (313) 588-2050. Under $2000 (100 up); 60 to 90 days.

The Votrax ML-I multilingual voice system is a small solid-state system that produces electronically synthesized speech; not only English, but other languages as well. The first foreign language available is German. Plans call for the development of several additional languages, such as Spanish, French, Italian and Japanese. The ML-I converts the output of a computer or other digital device into speech from a 300-b/s data-rate input in the form of standard ASCII characters. Inflection, speech rate and volume are controlled by the software.

CIRCLE NO. 350

Tape system mates with PDP-11 mini family

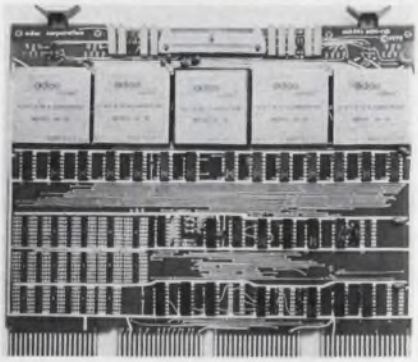
Digital Equipment Corp., Maynard, MA 01754. (617) 897-5111. See text.

A new nine-track, 75-ips magnetic tape subsystem is available in different configurations for PDP-11/70 and other PDP-11 family computers. The units feature a data density of 800 bpi NRZI and 1600-bpi phase-encoded. Up to eight tape drives can be tied to each subsystem controller. Called the TWU45 for PDP-11/70 computers, and TJU45 for other PDP-11 computers, both subsystems are priced at $26,500 for the first unit and $14,000 each for additional tape drives. Quantity discounts of controller-tape drive combinations are available. First deliveries are scheduled for July, 1975. The tape units employ a vacuum column for tape buffering and tension control. A servo-controlled single capstan and vacuum-type tape cleaner are used. Additional features include dual-gap, read-after-write magnetic head, data checking, error correction for a single track dropout, a transfer rate of 120,000 characters per second and a rewind speed of 250 in/s.

CIRCLE NO. 351

DATA PROCESSING

D/a converter system settles in 5 μs



ADAC Corp., 29b Cummings Park, Woburn, MA 01801. (617) 935-6668. $1350 fully loaded (unit qty); 4 wks.

Digital-to-analog converter systems, Models 600-11D and 600-8ED, which are compatible with the DEC PDP-11 and PDP-8E, F, M and A series of minicomputers, are high speed systems with fast settling time of 5 μs. The systems are contained on a 8-1/2 × 10-in. PC board, which can handle up to four, 12-bit d/a converters per card. The interfacing circuitry, power converter and cabling are included in the system.

CIRCLE NO. 352

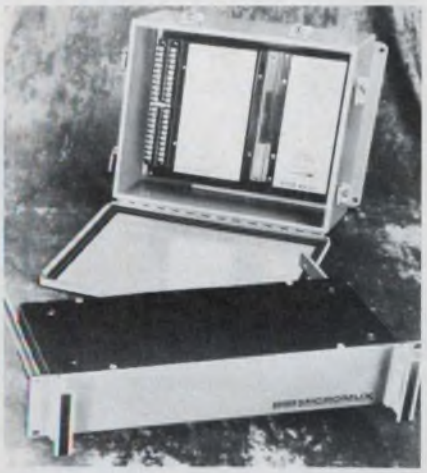
New PDP-8 uses second processor for math

Digital Equipment Corp., Maynard, MA 01754. (617) 897-5111. $5995; available April, 1976.

A parallel-processor version of the PDP-8/A, called the Super-8, performs fixed and floating-point computations with up to 17-digit accuracy and uses hardware to do it. The Super-8 continues to use the conventional PDP-8/A processor for other functions, such as input-output operations and system management. The new mini was designed for OEMs and end users who need fast Fortran IV, floating-point and extended-precision arithmetic at reasonable cost. It performs calculations faster than previous PDP-8 models. Sample instruction times include 10.5-μs fixed-point add, 30-μs floating-point add, and 37.5-μs floating-point multiply. It is completely compatible with previous models of the PDP-8 family.

CIRCLE NO. 353

Mux data system handles 16-channels on wire pair



Burr-Brown, P.O. Box 11400, Tucson, AZ 85734. (602) 294-1431. $2790 (one trans/rcvr pair).

Micromux consists of one or more remote transmitters located near sensors or contact closure points and a receiver. Each transmitter handles up to 16 data points, digitizes and multiplexes the information and transmits the data to a central receiver over a single wire pair. Power to the transmitter unit is also supplied over this same pair. One central receiver can handle up to four transmitters and thus monitor 64 points in a plant. And eight receivers can be connected to each communications interface of a computer for a total of 512 data points in a fully expanded system. The computer interface is a 2400-baud teleprinter port that uses a 20-mA current loop with ASCII coding. Signals can be transmitted up to 5000 ft.

CIRCLE NO. 354

Video terminal displays 16 lines, 1280 characters

Wintek Corp., 902 N. 9th St., Lafayette, IN 47904. (317) 742-6802. $850 (unit qty).

The Wintek Model B-R-B video terminal displays 1280 ASCII dot-matrix characters in 16 lines. The unit features selectable baud rates from 110 to 9600, an RS-232 serial-data interface, backspace capability, detachable keyboard, half and full-duplex operation and composite video output. Also, a board-only model for OEM and custom designs and a suitcase model are available.

CIRCLE NO. 355

Mixer-preamp spans multi-octave BW

Anaren Microwave, Inc., 185 Ainsley Dr., Syracuse, NY 13205. (315) 476-7901. $437 (100).

The Model 220060 combines an integrated balanced mixer with a preamplifier. The unit has a 400-MHz preamplified i-f output and provides low-noise rf coverage from 1.01 to 10.75 GHz. Internal filtering suppresses unwanted 200-MHz mixing products. Over-all case size measures 7.75 × 2.50 × 0.76 in.

CIRCLE NO. 356

Wideband amp has auto, remote leveling

Instruments for Industry Inc., 151 Toledo St., Farmingdale, NY 11735. (516) 694-1414. $3100.

The Model 5100 wideband amplifier, featuring automatic remote leveling, has a frequency range of 10 kHz to 250 MHz, rf output of 10 W and a gain of 40 dB. Designed to serve as a preamplifier, the 5100 can operate into any load from open circuit to virtually a dead short.

CIRCLE NO. 357

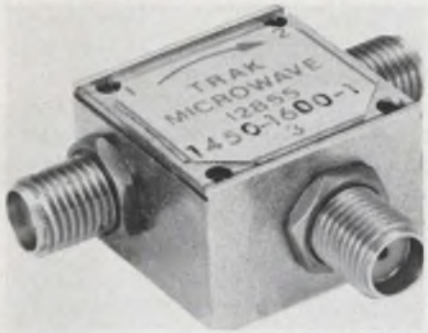
Amp modules seek CATV uses

Motorola Semiconductor, P.O. Box 20924, Phoenix, AZ 85036. (602) 244-3466.

Two amplifier modules can be used to form complete sections for 40-to-315-MHz CATV trunk and bridger stations. The MHW570 preamplifier offers 7.5-dB noise figure at 300 MHz. The MHW572 amplifier provides −57-dB 30-channel cross-modulation, −70-dB intermodulation and −80-dB triple-beat performance. Both units have 75-Ω input and output impedance and a minimum gain of 16-dB per block.

CIRCLE NO. 358

4-8 GHz circulators cut package size



Trak Microwave Corp., 4726 Eisenhower Blvd., Tampa, FL 33614. (813) 884-1411. $175 (Model 50A6001); stock.

Two 4-to-8-GHz circulators come in packages that measure only 0.75 × 0.75 × 0.5 in. and weigh 1.1 oz. The Model 50A6001 has 18-dB minimum isolation, 0.5-dB maximum insertion loss and 1.30 maximum VSWR. For Model 50B6001 minimum isolation is 17 dB, maximum insertion loss is 0.6 dB and maximum VSWR is 1.35. Both units operate from −45 to +95 C and no lumped circuit elements are employed.

CIRCLE NO. 359

Flange load works to 18 GHz

EMC Technology, Inc., 1971 Old Cuthbert Rd., Cherry Hill, NJ 08034. (609) 429-7800. $3.15 (100); stock to 4 wks.

A 50-Ω flange load has a maximum VSWR of 1.30 over the frequency range of dc to 18 GHz. The unit can handle powers up to 20 W and voltages up to 100 V. Operating temperatures extend from −55 to 125 C.

CIRCLE NO. 360

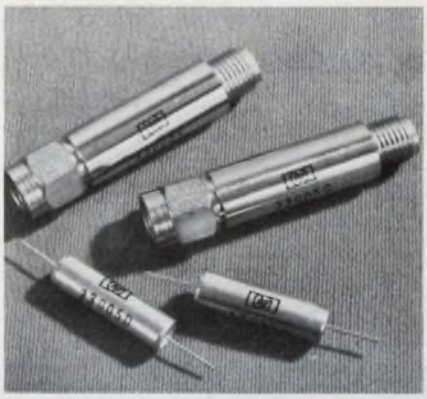
Broadband amp has low NF

Anzac Electronics, 39 Green St., Waltham, MA 02154. (617) 899-1900. $95; stock.

Model AM-102, 10-dB amplifier combines a noise figure of 5.5 dB with an output-power capability of +15 dBm. Operating over the 5-to-300-MHz frequency range, the unit has third-order intermodulation ratio of −60 dBm with 2-to-10-dBm signals at the output.

CIRCLE NO. 361

Module holds comb generator



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $205 to $265 (1-9); stock.

Two step-recovery diode modules are offered for comb-generation application. Model 33005C is a complete impulse-train generator with dc return and 3-mm connectors; Model 33005D is a cylindrical module with axial leads. Input frequency for both is 1000 ±50 MHz. Guaranteed output power at 18 GHz is −15 dBm with 0.5-W drive.

CIRCLE NO. 362

Low-noise amp aims for satcom use

LNR Communications, 180 Marcus Blvd., Hauppauge, NY 11787. (516) 273-7111. $10,000 to $15,005; 4-6 mos.

The NC4-91 low-noise amplifier, designed for unattended ground-based terminals for satellite communications, features a noise temperature of 80°K typical, and a gain of 50 dB over the 3.7-to-4.2-GHz band. The noncryogenic unit measures 12 × 8 × 4 in., and it is weatherproof. The self-contained unit includes power supply and solid-state pump source.

CIRCLE NO. 363

Transistor oscillator covers 8-12-GHz band

Watkins-Johnson Co., 440 Mount Hermon Rd., Scotts Valley, CA 95066. (408) 438-2100. $1825.

Model WJ-2835-25 varactor-tuned voltage-controlled oscillator produces a minimum power output of 5 mW across the 8-to-12-GHz frequency range. The unit operates over the full −54 to +71 C temperature range with a temperature coefficient of less than 30 ppm/°C. Voltage pushing is less than ±0.1%/V while pulling into a 2.0:1 VSWR. Harmonics are a minimum of 20 dB below the carrier.

CIRCLE NO. 364

10-mW laser costs $995

Hughes Electron Dynamics, Laser Products Div., 3100 W. Lomita Blvd., Torrance, CA 90509. (213) 534-2121.

A 10-mW helium-neon laser system, priced at $995 in single quantity, is said to be the lowest-priced 10-mW system available. With a 60-day delivery, the Model 3035H consists of separately packaged laser head and power supply. The 23-1/2-in. laser head has a cw output at 632.8 mm (TEM_{00} mode) and features a near-hemispheric cavity to enhance beam stability and speed warm-up. The regulated power supply is available for ac operation at 100 V, 115 or 230 V.

CIRCLE NO. 365

Dual-polarized horns span 2 to 18 GHz

ESL Inc., 495 Java Dr., Sunnyvale, CA 94086. (408) 734-2244.

Horn antennas feature dual-linear, dual-circular and diversity-polarized operation over the 2-to-18-GHz frequency range. Phase imbalance between ports is less than 10 degrees to 12 GHz and 17 degrees to 18 GHz. Gain imbalance port-to-port (and gain spread, horn-to-horn) is less than 0.8 dB to 12 GHz and 1.3 dB to 18 GHz. Over the entire 2-to-18-GHz band, VSWR is less than 2.5:1, isolation between ports is 28 dB minimum, and gain varies linearly from 5 to 18 dBi.

CIRCLE NO. 366

Synthesizer outputs frequencies to 18 GHz

Syntest, 169 Millham St., Marlboro, MA 01752. (617) 481-7827. $3450 (typical); 60 days.

The SI-203 microwave synthesizer covers any 10% band from 500 MHz to 18 GHz. Basic resolution is 100 Hz at 100 MHz. The resolution of the output signal is 100 Hz times the multiple used for phase lock. For example, a 2-GHz unit using a $\times 20$ multiple has a resolution of 2 kHz. Power output ranges from 5 mW at 18 GHz to 750 mW at 1 GHz depending on rf head. Inband spurious outputs are greater than 90 dbc. Second harmonic is typically 30 dbc. Frequency stability from -10 to $+50$ C is 1×10^{-8}.

CIRCLE NO. 367

Noise source checks μwave relay systems

Scientific Atlanta, 3845 Pleasantdale Rd., Atlanta, GA 30340. (404) 449-2000. $2070; 8 wks.

The Model 4643 baseband noise transmitter provides a simple noise-load source for quick performance checks of microwave relay systems. Frequency range is 12 kHz to 12.4 MHz, with output power 0 to -29 dBm. The baseband noise transmitter features automatic level control to maintain constant noise power output. The compact unit weighs 16 lb and operates from standard 110/220-V supplies.

CIRCLE NO. 368

Impatts operate at X-band and at mm waves

Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, CA 92705. (714) 540-9979. $675-$7500, 12 to 16 wks.

A line of silicon Impatt oscillators covers the 40-to-90-GHz range, and GaAs versions operate in X-band. The series of silicon double-drift diodes, mounted in waveguide cavities, provides mechanical tuning over $\pm 0.5\%$ of the specified frequency. Output power ranges from 20 to 200 mW, depending on the type. Typical operating voltage is from 14 to 28 V, with maximum operating current from 200 to 250 mA. Frequency pushing is +5 MHz/mA, and maximum load VSWR is 1.3:1 for all phases. The GaAs Impatts are furnished with a fixed frequency from 8 to 11.5 GHz, mechanically tunable over a 1% range. Output power is as high as 1.5 W, with typical conversion efficiency of 12%. The units can operate into any load VSWR. The GaAs devices operate with voltage from 55 to 70 V, with maximum operating current of 250 mA. Frequency pushing is -2 MHz/mA.

CIRCLE NO. 369

VOR zero-phase meter has 0.01° resolution

Rohde & Schwarz, 14 Gloria Lane, Fairfield, NJ 07006. (201) 575-0750. $3250; 30 days.

A vhf-omnidirectional-range zero-phase meter—Model POR—measures the phase difference between variable and reference-phase components of a VOR signal with a resolution of 0.01°. It can also check the standard deviation of the VOR subcarrier.

CIRCLE NO. 370

Blue 'neon' lamp completes spectrum

Littelfuse Inc., 800 E. Northwest Highway, Des Plaines, IL 60016. (312) 824-1188. Under $0.75.

Standard neon lamps emit light only in orange, red and yellow portions of the color spectrum. The blue "neon" lamps, which follow the recent addition of green "neons" to the line, now complete the color spectrum. Offered in 960, 970 and 980 Series, the lamps produce a highly visible blue light when used with a blue, white or colorless lens. The units have a built-in 30-kΩ resistor for operation at 125 V and a 100-kΩ resistor for 250-V applications. The lamp is rated at 1/3 W and has a life expectancy of 10,000 h.

CIRCLE NO. 371

Resolver provides 15° steps with 10 s accuracy

Magnetico, Inc., 182 Morris Ave., Holtsville, NY 11742. (516) 654-1166. $125 (25 up).

A new 400-Hz resolver standard operates from 26 V, 400 Hz and provides isolated outputs of 11.8-V-rms sine and cosine voltages in 15-degree increments, accurate to 10 arc-seconds. It can be used to provide built-in equipment checks without costly external precision equipment. Its size is only 2-3/4 × 2-3/4 × 1-17/32 in.

CIRCLE NO. 372

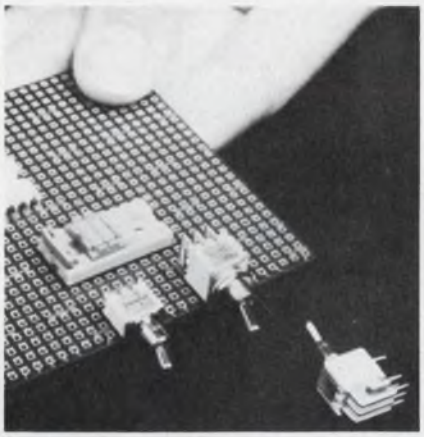
Liquid-crystal display is CMOS-compatible

Liquid Xtal Displays, Inc., 24500 Highpoint Rd., Cleveland, OH 44122. (216) 831-8100. $8.00: 6-digit, 0.5-in. (2500 up).

The new Felix product line includes 14 different field-effect liquid crystal displays. The line includes 3-1/2, 4 and 4-1/2-digit arrays in three sizes—0.5, 0.7 and 1-in. heights. A 6-digit instrument and timer display comes in two sizes with 0.5 and 0.7-in. heights. The display's DIP substrate clips can be plugged in or directly soldered. The displays are CMOS-compatible and offer 50,000 h of life. Units with voltage ranges of either 3 to 6 or 9 to 18 V are available.

CIRCLE NO. 373

PC toggle switch mounts at right angles

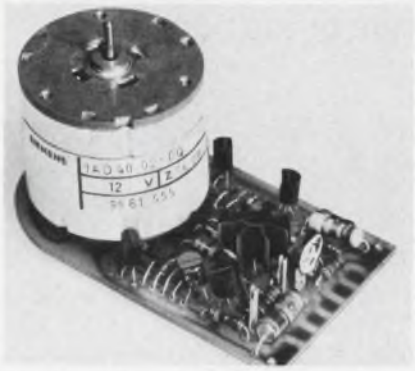


Alco Electronic Products Inc., 1551 Osgood St., North Andover, MA 01845. (617) 685-4371. $0.92 (1000 up); stock to 90 days.

TT Series right-angle PC-mounted switches in double-pole versions occupy 60% less volume than comparable miniature right-angle switches, according to Alco. This is the first subminiature toggle switch that fits easily between PC boards placed on 1/2-in. centers. All terminals and mounting pins fall into 0.1-in. X and Y grids. The switch line is offered with options of plain or threaded bushing and a choice of five toggle levers, in either SPDT or DPDT case styles. They are normally stocked with gold terminals and contacts, primarily for dry or low current applications.

CIRCLE NO. 374

Brushless dc motor includes electronics



Siemens Corp., 186 Wood Ave. S., Iselin, NJ 08830. (201) 494-1000. $30 (1000 up).

Brushless dc motor package, Model 1AD4002-0QQ99-AF, includes the motor integral with electronics. The motor can run without service for a minimum of 10,000 h with a continuous torque capability of 0.35 oz-in. and a speed-adjustment range of 2200 to 3300 rpm. Speed regulation over the entire torque range is 1%. The housing measures 1.57-in. dia × 1.49-in. long. It operates from 12 ±5% V dc. A key feature of this motor is very low torque ripple, which makes it particularly suitable for cassette drives, tape recorders and turntables.

CIRCLE NO. 375

PROM programmer can copy another PROM

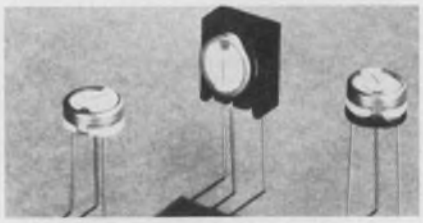
Technitrol, Inc., 1952 E. Allegheny Ave., Philadelphia, PA 19134. (215) 426-9105. $850.

Technitrol Model 107, a new PROM programmer/copier/reader/verifier, can be used to program EARMOS, copy previously written PROMs, read data from addresses sequenced by a machine or randomly selected by an operator and verify data while writing or reading. The unit is 12 × 14 × 6 in., weighs less than 8 lb and operates with eight data bits and eight address bits.

CIRCLE NO. 376

COMPONENTS

Cermet trimmers offer side or top adjustment



Allen-Bradley, 1201 S. Second St., Milwaukee, WI 53226. (414) 671-2000. $1.12 to $1.68 (1000 up).

A new 1/4-in. dia, single-turn, cermet trimmer, the Type A, is furnished with TO-5 or 0.1-in. grid-terminal spacings for top or side adjustment. The trimmer has a multifingered wiper for better adjustability and tis temperature coefficient is 100 ppm/°C. Power rating is 0.5 W at 85 C. Standard values are in the range of 10 Ω to 2 MΩ with ±10% tolerance. End resistance is less than 2 Ω at both ends of rotation. Contact resistance variation is typically less than 1% or 1 Ω.

CIRCLE NO. 377

Electronic counter presettable to 999

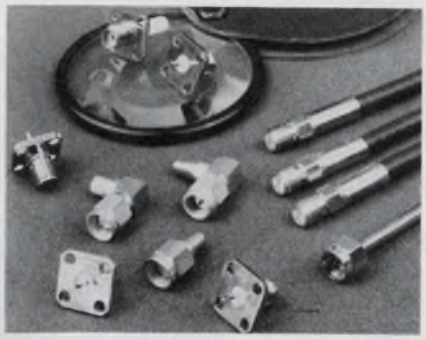
Micro Switch, 11 W. Spring St., Freeport, IL 51032. (815) 232-1122. $150 (OEM qty).

A predetermined electronic counter, the FE-STR1000, works at up to 300 counts/s. The count may be preset from one through 999. Once the preset count is reached, a follow-on operation such as routing or packaging is triggered before the unit resets itself for a new input series. The module will operate electromechanical or solid-state relays. Features include LED input and output indicators; top and front-count windows; instant-access count selector thumbwheels; sensitivity adjustment; and a light-operate/dark-operate selector switch for photoelectric actuation.

CIRCLE NO. 378

PACKAGING & MATERIALS

SMA steel connectors operate over 0 to 18 GHz



Amphenol, Bunker Ramo Corp., 33 E. Franklin St., Danbury, CT 06810. (203) 743-9272. Typical $0.80 (1000-up); stock.

The 901 series of SMA stainless steel subminiature coaxial connectors duplicates in form, fit and function the most popular types in use today. The 50-Ω high frequency connectors are fully intermateable and interchangeable with currently available SMA connectors. All shell and body parts of the connectors are type 303 stainless steel and are designed for operation in the 0-to-18-GHz range. The subminiature (3 mm) connectors meet all MIL-C-39012 requirements. The connectors include a solder-type straight plug for copper-jacketed 0.141-in. diameter semi-rigid coaxial cable, plus both solder and crimp plugs and jacks for the popular flexible cables; RG-174, 188A and 316/U cable and several flange-mounted receptacles.

CIRCLE NO. 381

Conductive adhesive has 50 Ω/cm resistance

Emerson & Cuming, Canton, MA 02021. (617) 828-3300. $7/lb. (10 lb. lots); stock.

Eccobond 60 C is a one-part conductive adhesive which has a bulk resistivity of about 50 Ω/cm. The resistance through a thin film of the material is less than 1 Ω. It is supplied as a paste, with no mixing required. Coatings of Eccobond 60 C no greater than about 0.125 in. (0.3 cm) should be cured before any more is applied. Once cured the adhesive can be used at temperatures from −65 to +350 F (−50 to +177 C).

CIRCLE NO. 382

PACKAGING & MATERIALS

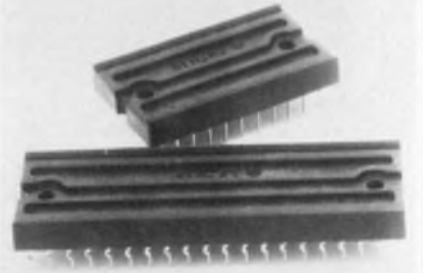
Kit of epoxy adhesives contains 17 types

Tra-Con, 55 North Street, Medford, MA 02155. (617) 391-5550. $25; stock.

The Epoxylab kit is a 51-piece assortment of 17 different high-performance epoxy adhesive systems. Each epoxy adhesive system comes in its own individual ready-to-use package, which contains the exact amount of resin and hardener.

CIRCLE NO. 383

LSI IC sockets come in 24 and 40-pin sizes



Augat, P.O. Box 779, 33 Perry Ave., Attleboro, MA 02703. (617) 222-2202. From $0.25 to $1.30; stock.

Two LSI contact sockets, the 324-AG (24 contact) and 340-AG (40 contact) series, use beryllium copper contacts. The sockets offer closed, tapered entry insulator design with large contact openings for quick LSI pin insertion and full seating. There is a 0.02-in. standoff between the insulator and the PC board for proper circuit clearance and flux cleaning. A 0.005-in.-thick polyester wafer is provided on the bottom of each socket to prevent IC leads from shorting to PC traces.

CIRCLE NO. 384

Copper-clad laminate permits clean punching

Norplex Div. of Universal Oil Products, 1300 Norplex Dr., La-Crosse, WI 54601. (608) 784-6070. Approx. $1.30/sq. ft.; stock.

The NP-424, copper-clad laminate punches cleanly for through-hole plating. It satisfies the need for a glass epoxy such as G-10 or G-10FR at a lower cost. NP-424 meets the UL 94-V-0 flammability rating, will withstand over 20 seconds of 500-F solder float and will maintain peel strength of 9 lb./in. NP-424 is available in single and double-sided copper in a variety of thicknesses, copper weight and sheet sizes.

CIRCLE NO. 385

Flame-retardant resin machines easily

Emerson & Cuming, 60 Walpole St., Canton, MA 02021. (617) 828-3300. $2/lb.; stock.

Stycast 2651-40 FR flame retardant casting resin provides the same versatility in application as the original Stycast 2651-40. For example, the viscosity of the resin is only 40,000 cps prior to addition of catalyst, a value which can be further reduced by raising the temperature to 100 F (38 C). Although the resin is normally black, it can be color coded per customer's specification. The cured resin is easily machined with carbide tools and meets the UL specification requirements of UL94, classification 94VE.

CIRCLE NO. 386

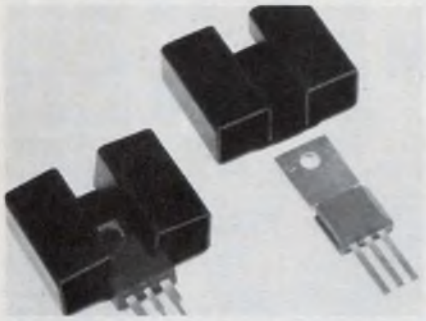
Knob display shows 10 different families

Alco Electronic Products, 1551 Osgood St., North Andover, MA 01845. (617) 685-4371. $12.47; stock.

A product display board contains 10 knob families of machined aluminum knobs. All data, including part numbers, choice of anodized finishes, knob diameters and knob types stocked for 1/8 or 1/4-in. shafts, are given on the chart. The boards are available to design engineers at a cost of $12.47, which is refundable on a first order for 500 knobs or more.

CIRCLE NO. 387

Low cost heat sink fits T-202 and 220 packages

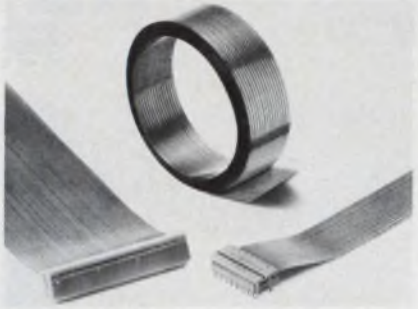


Fab-Tek, 17 Sugar Hollow Rd., Danbury, CT 06810. (203) 743-3312. See text; 2 wk.

The Models 106AB and 106BB heat sinks are designed for the JEDEC T-202 and TO-220AB plastic packages. Model 106AB fits the T-202 and can dissipate 3 W with a 67-C rise. Model 106BB fits both T-202 and TO-220AB and dissipates 4 W with a 58-C rise. Both sizes are available unfinished, gold chromate or black anodized. The unfinished 106A costs $0.037; the unfinished 106B, $0.056, both in 1000-piece lots.

CIRCLE NO. 388

Flat conductor cable made for flexing

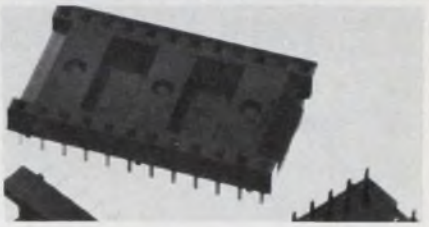


Ansley Electronics, 3208 Humboldt St., Los Angeles, CA 90031. (213) 223-2331. From $0.016/conductor ft.; stock.

The 175 series of flat conductor cable is designed for maximum flex life. The cable combines a tough Mylar insulation with conductors on 0.05-in. centers. Cable thickness is 0.01 in. and has a flex life of over 10-million cycles. The cable is available in 10, 14, 16, 20, 24, 26, 34, 40 and 50-conductor widths. Cable specifications include a 90-V, 0.5-A rating and a maximum operating temperature of 80 C.

CIRCLE NO. 389

Low profile DIP sockets have no wicking problem



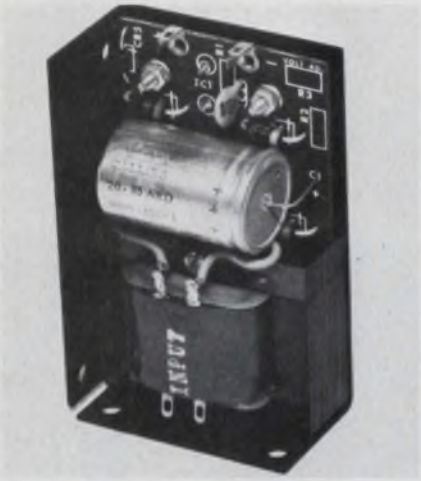
Scanbe Manufacturing, 3445 Fletcher Ave., El Monte, CA 91731. (213) 579-2300. From $0.136 (large qty.); stock.

A low profile DIP socket series, the US-2, completely eliminates the problems of solder wicking, intermittent short-circuits and corrosion due to flux entrapment. Nominal insertion force of the US-2 was 195 g per contact while the withdrawal force was 28 g after conditioning. Contact resistance after conditioning was 15.2 mΩ. Contact material is copper alloy CA-770 with a 100-microinch gold inlay on the contact surfaces. Sockets are available with from 8 to 40 pins.

CIRCLE NO. 390

POWER SOURCES

Open-frame unit sells for less than $20



Xentek Inc., 1550 Linda Vista Dr., San Marcos, CA 92069. (714) 744-3346. $18.95.

Seven models of regulated, single-output power supplies provide 5 to 24 V dc with 7-W output. Open frame and weighing only a fraction over a pound, the X17 series is only 4 × 2.38 × 1.69 in. The units have thermal cutout protection, current limiting, short-circuit and reverse-voltage protection and may be ordered with optional voltage adjustment. Load and line regulation are better than 1% and ripple is less than 0.1%.

CIRCLE NO. 391

Modular switchers cost less than $0.90/W

Control Data, 7801 Computer Ave. S., Minneapolis, MN 55435. (612) 830-5800. Less than $0.90 per watt.

A standard line of switching power supplies is based on a modular design approach and is expressly built for applications where 300 or 600-W modules plug into a bulk module. Parallel operation, low noise and compact packaging are main features, combined with a less-than-90¢-per-watt selling price. Typical thermal related problems are overcome via derating of components and innovative packaging. Heat generating components are separated from temperature limited components, with the power devices capable of operating at a maximum of 100 C. Full output power is guaranteed up to 50 C.

CIRCLE NO. 392

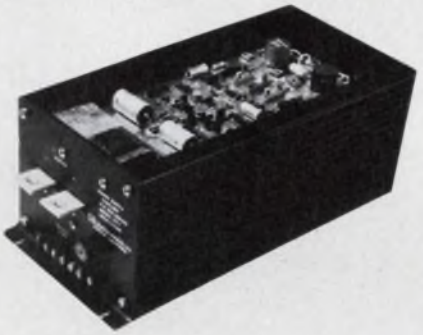
Regulated dc/dc sources come in DIP-like package

Reliability, Inc., 5325 Glenmont, Houston, TX 77036. (713) 666-3261. $38.20; stock-4 wks.

This series of regulated, dual-output dc/dc power sources are additions to the company's V-PAC Series. Depending upon the type, the new sources provide the designer with dual 15-V regulated outputs, positive and negative, from either 5-V (V5R 15-15) or 12-V (V12R 15-15) input. Maximum output current is 65 mA, with output ripple only 30 mV pk-pk over a bandwidth of 20 Hz to 20 MHz. Line and load regulation are 0.3%, and output voltage tolerance is ±5%. Efficiency is at least 50% at full load. V-PAC sources are packaged in a 24-pin DIP-like package and occupy only 0.3 cubic inch.

CIRCLE NO. 393

High efficiency marks modular OEM supplies



Electro-Module, Inc., 2855 Metropolitan Pl., Pomona, CA 91766. (714) 593-3565. Under $600; stock-30 days.

DLR (direct line rectification) series of modular dc switching supplies features an efficiency of up to 85%. Models available include: 4.2 to 6 V dc (500, 600 and 750 W); 6 to 11 V dc (500, 600 and 750 W); 16 to 23 V dc (500, 600 and 750 W) and 22 to 30 V dc (500, 600 and 750 W). All models have 80% to 85% efficiency. Key specs include: Input voltage of 115/230 V ac, single phase, 47 to 1000 Hz; output ripple and noise (max) of 2% pk-pk, 0.5% rms; transient response time of 0.5 ms. Protection includes current limit and overvoltage. Full-rated temperature range is −20 to 40 C.

CIRCLE NO. 394

"Electronic Design has in getting the

Richard D. Vance
President
AD-VANCE MAGNETICS, INC.

done one Hell of a job the GOLD BOOK to places it should be'

"The majority of our new business or new bids can be attributed to the GOLD BOOK," says Richard D. Vance, President, Ad-Vance Magnetics, Inc., Rochester, Indiana. Ad-Vance describes itself as the industry's largest, oldest, most experienced independent firm exclusively manufacturing magnetic shielding. Mr. Vance continues:

> **"We're an old company with a new name, so not too well known in the field. Our two-page spread in the GOLD BOOK has made us much better known.**
>
> **"The GOLD BOOK gave us opportunities to bid from firms who had never heard of us before they saw our GOLD BOOK ad. For example, just today we got to bid on 1,000 CRT magnetic shields for a midwest firm who found us in the GOLD BOOK.**
>
> **"Engineers don't hesitate to tell us they saw our ad in the GOLD BOOK when they call. I do a lot of sales work in the field, and I run into the GOLD BOOK almost everywhere our magnetic shielding has an application, both in purchasing and engineering. You've done one hell of a job in getting the GOLD BOOK to the places it should be."**

Ad-Vance states that over 90% of past and present magnetic shield designs have been fabricated in the Ad-Vance plant during the past 20 years. Its magnetic shielding is used off-planet in spacecraft and satellites, and worldwide in precision industrial, laboratory, military and consumer applications.

Because the GOLD BOOK goes primarily to *Electronic Design's* audience of specifiers, Ad-Vance gets the benefit of 78,000 engineers, engineering managers, purchasing agents and distributors throughout the U.S.A., not to mention 13,000 overseas. These are the men who are ready to talk shielding—the men who have the authority to *buy*.

ELECTRONIC DESIGN'S GOLD BOOK IS WORKING ...IT'S WORKING FOR READERS...AND IT'S WORKING FOR ADVERTISERS, TOO.

Application Notes

Gas-mixture technology

"Gas Mixtures—Facts and Fables" is a compact 23-page study of the technique and analysis of compressed-gas mixtures in cylinders, with chapters devoted to calibration, accuracy, impurities, sampling, storage and handling. Matheson Gas Products, East Rutherford, NJ

CIRCLE NO. 545

Cascadable amplifiers

Thin-film cascadable amplifiers are featured in a 28-page application note. The booklet is loaded with graphs, tables and photographs. Watkins-Johnson, Palo Alto, CA

CIRCLE NO. 546

Dual-delayed sweep

Especially for brief time intervals, such as cable length comparisons and computer-clock phasing adjustments, measurement is both easier and accurate by use of an oscilloscope with dual-delayed sweep. How and why this is so is spelled out in "Dual-Delayed Sweep for Precise Time Interval Measurements." Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 547

Freq response analyzer

Ways to use a frequency response analyzer are shown in an eight-page application note. EMR Telemetry, Sarasota, FL

CIRCLE NO. 548

High-speed a/d converter

"Low Cost, High Speed Analog-to-Digital Conversion with the DAC-08" describes three practical a/d designs, with total conversion times of 1, 2 and 4 μs. A discussion of basic successive approximation is given, followed by circuit designs and a PC-board layout for the 1-μs version. Precision Monolithics, Santa Clara, CA

CIRCLE NO. 549

Low-noise ac amplifiers

"Your Easy Guide to Low-Noise ac Amplifiers" provides illustrated explanations of some of the terms used to describe and specify these amplifiers. The guide includes a two-page selection chart. Ortec, Oak Ridge, TN

CIRCLE NO. 550

Light pens

Principals of operation, system basics and performance of light pens are described in a literature package. Data on luminous intensity sensitivity, spectral response and phosphor emission characteristics are discussed. Information Control, Los Angeles, CA

CIRCLE NO. 551

Synchro conversion

Application and specification information for solid-state synchro converters are given in a 24-page brochure. Natel Engineering, Canoga Park, CA

CIRCLE NO. 552

Clad-gold inlays

Have you a question on gold-clad inlays, compared with gold plating, as a cost saver in producing electronic connectors? You'll probably find it answered in a 12-page brochure. Technical Materials, Lincoln, RI

CIRCLE NO. 553

Voiceband testing

"The Simplicity of Modern Voiceband Testing" describes transmission level, circuit noise, echo return loss and singing point, battery voltage, ac induction, loop and leakage resistance, cable capacitance and loop current. Wiltron, Palo Alto, CA

CIRCLE NO. 554

Cathode ray tubes

Covering only the most common applications, "CRTs . . . A Question of Choice" includes data on waveform monitors, photography, data display, radar, flying spot scanning and domestic TV. Clinton Electronics, Rockford, IL

CIRCLE NO. 555

Bulletin Board

A series of drivers that may be called by Fortran programs for the BP-721 graphics display interface has been introduced by **Megatek.**

CIRCLE NO. 556

A 15% improvement in total throughput speed for all **Gould computer output microfilm systems** has been announced.

CIRCLE NO. 557

Redactron's communicating typewriters can now be equipped with **two options: unattended remote power turn-on and modem switch.**

CIRCLE NO. 558

Solid Power Corp. has announced JAN/JANTX qualification approval of its **2N3715, 2N3716 and 2N5241 power transistors.**

CIRCLE NO. 559

The Magnetic Media Group at the National Bureau of Standards has provided its first **calibration service** for medium-density magnetic disc surfaces.

CIRCLE NO. 560

Doric Scientific has announced an across-the-board price reduction of up to 20% on its **DS-350 and DS-330 0.1° resolution digital thermocouple indicators.**

CIRCLE NO. 561

The Digital Systems Div. of Texas Instruments has reduced memory prices for the **Model 960B and 980B minicomputers** by up to 38%.

CIRCLE NO. 562

Industrial Reproductions, a subsidiary of Buckbee-Mears, has dropped prices 20 to 25% for **screens used in the production of thick-film hybrid circuits.**

CIRCLE NO. 563

Rohde & Schwarz has cut the price 18% on its **rubidium frequency standard XSRM.**

CIRCLE NO. 591

Tektronix has announced a $50 reduction in the monthly lease price on the **4023 alphanumeric terminal.** Also, the Rulings Character Set option is now standard on all 4023s at no charge.

CIRCLE NO. 592

Agreement has been reached between **National Semiconductor** and Advanced Memory Systems, by which **AMS will second-source two of National's 4096-bit RAMs.**

CIRCLE NO. 593

Rogers Corp. is offering its **Quik/Bus bars** with a new insulation system that develops 350 pF per sq. in. capacitance.

CIRCLE NO. 594

American Videonetics dropped prices 23% on its **Datacord DI 112 tape memories.**

CIRCLE NO. 595

RCA Solid-State Div. has introduced 30 **SK-series ICs and power devices** as semiconductor replacement types.

CIRCLE NO. 596

New Literature

Audio magnetic heads

A 96-page book features answers to frequently asked questions about magnetic head design, head applications and circuit considerations for typical audio applications. Nortronics, Minneapolis, MN

CIRCLE NO. 597

Switches

Standard toggle and pushbutton switch packages that meet custom specifications are covered in a 12-page catalog. Specifications, photos and diagrams are included. Machine Components, Plainview, NY

CIRCLE NO. 598

Vidicons

"Vidicon 7735" details parameters of GE's Vidicon camera tube for educational, industrial and other CCTV applications. The four-page publication presents specifications, maximum and typical ratings, a close-up photograph and drawings. General Electric, Tube Products Dept., Owensboro, KY

CIRCLE NO. 599

Gate-turn-off SCRs

Two bulletins describe 18 8.5-A gate-turn-off (GTO) SCRs, grouped in three series designated G5001, G5002 and G5003. RCA Solid State Div., Somerville, NJ

CIRCLE NO. 600

Rf semiconductors

Hf, uhf, vhf, single sideband and microwave discrete transistors and amplifier modules; amplifier and transistor products for mobile radio; and hybrid amplifiers and discrete transistors for CATV applications are covered in a 16-page catalog. Electrical and mechanical specifications, photographs and package dimensional drawings are included. TRW RF Semiconductors, Lawndale, CA

CIRCLE NO. 564

Alloy tubing

"Super Alloy Tubing," an 18-page catalog, describes small-diameter tubing cold drawn from alloys for service up to 1650 F. Superior Tube Co., Norristown, PA

CIRCLE NO. 565

Radio Shack catalog

A 164-page catalog has 100 full-color pages and describes electronics for home entertainment, hobbyists and experimenters. Radio Shack, Fort Worth, TX

CIRCLE NO. 566

Oscillators

High-performance miniature hybrid oscillators are described in a 38-page catalog. Technical data, performance curves and selection criteria are included. Greenray Industries, Mechanicsburg, PA

CIRCLE NO. 567

Lock-in amplifiers

A 44-page catalog describes the company's lock-in amplifiers, preamplifiers and accessory equipment. Princeton Applied Research, Princeton, NJ

CIRCLE NO. 568

Multiprogrammer

An eight-page brochure describes a do-it-yourself automatic test and process control system that manages up to 240 individually controlled I/O functions with a single programmable desktop calculator. "HP Interface Bus Kit for 6940B Multiprogrammer" is illustrated with photos and diagrams. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 569

Precision tools

A 40-page precision tool catalog is sectioned into 10 categories: adjusting tools, cleaning equipment, drivers, screw and nut, gauges, tool kits, production assembly and service tools, pliers, soldering equipment, telecommunication tools, and wrenches. Jonard Industries, Tuckahoe, NY

CIRCLE NO. 570

Overvoltage protection

Protection of electronic equipment against surge and interference voltages is the subject of a four-page bulletin. Cerberus, Ltd., Mannedorf, Switzerland

CIRCLE NO. 571

Quartz products

Thirty-six pages feature high-purity quartz products. Nearly 1000 standard diffusion tubes, boats, carriers, reactor tubes, bell jars, joints, raw materials, accessories and miscellaneous items are included. Quartz International, Santa Clara, CA

CIRCLE NO. 572

NEW LITERATURE

Power supplies

Twenty-one modular line operated power supplies and 37 dc-to-dc converter modules are covered in a 20-page catalog. A tabular selection guide categorizes units according to output voltage and current and lists regulation, tempco, size and price. Datel, Canton, MA

CIRCLE NO. 573

Limit switches

Operating principles, advantages and applications data on solid-state camless limit switches are given in a 12-page brochure. Astrosystems, Lake Success, NY

CIRCLE NO. 574

Ultra-miniature indicators

The characteristics and performance of incandescent, neon and light-emitting diode lights are covered in a 20-page catalog. Dialight, Brooklyn, NY

CIRCLE NO. 575

Industrial control timers

The design, operation and application of reset and repeat-cycle industrial control timers are described in a 56-page training manual. Design exercises with solutions are included so the reader can test his mastery of the material. Eagle Signal Industrial Controls Div., Davenport, IA

CIRCLE NO. 576

Function modules

Voltsensors, instrumentation amplifiers, function modules and power supplies are featured in a 56-page catalog. Two introductory discount coupons are included—one entitles the customer to a 30% discount on the first order and a free personalized clipboard folder. The other enables the customer to buy any two power supplies and get a third one free. Calex, Pleasant Hill, CA

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Ni-Resist cast irons

Engineering properties and applications of the Ni-Resist austenitic cast irons are described in a 52-page catalog. The International Nickel Co., New York, NY

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Telecommunications

"Telecommunications from the Terminal Users Viewpoint" starts with the definition of the term "modem" and proceeds through large interactive time-shared computer networks using multiplexers, concentrators and front-end processors. Diagnostics, monitoring and test equipment are described. Moxon Electronics, Anaheim, CA

CIRCLE NO. 579

Wood miter grooving

A two-color illustrated data sheet features Myterwood, a wood-veneer miter grooving process used to make finished enclosures. Kell-Groove Corp., Somerville, NJ

CIRCLE NO. 580

Thyristors/rectifiers

More than 500 thyristors and rectifiers are described in a 40-page catalog. Data are given for both commercial and developmental types. Application information is also included. RCA Solid State Div., Somerville, NJ

CIRCLE NO. 581

Miniature lamps

Data on hundreds of lamps, including 61 new lamps, are included in a 40-page catalog. General Electric, Cleveland, OH

CIRCLE NO. 582

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.

Solid State Scientific. Microprocessors, memories, digital watch modules, telecommunications, automotive, mobile communications and avionics.

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Raytheon. Energy services, major appliances, and military, commercial and marine electronics.

CIRCLE NO. 584

The Foxboro Co. Instruments and systems for process management and control.

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Philip A. Hunt Chemical. Chemicals used in image-forming processes.

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quick ads

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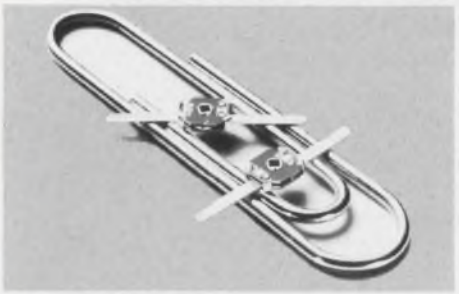

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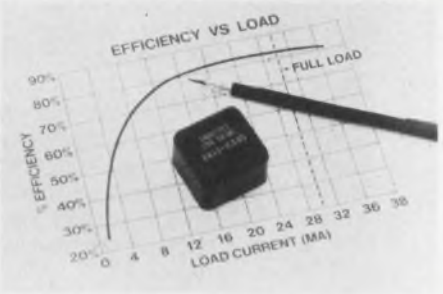
THIN-TRIM CAPACITORS 601



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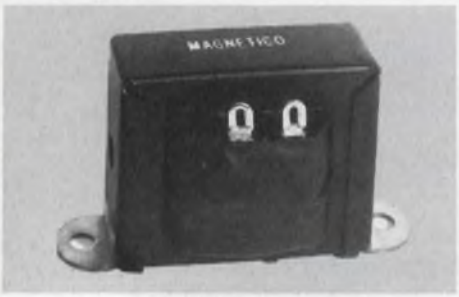

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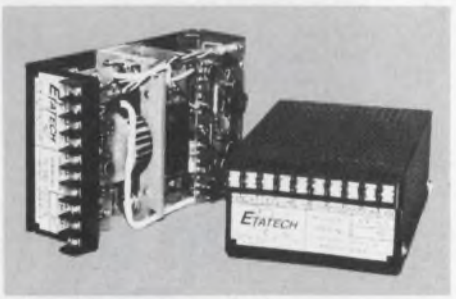

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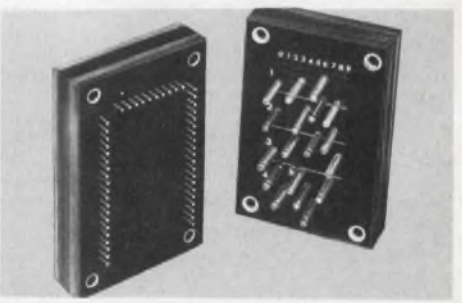

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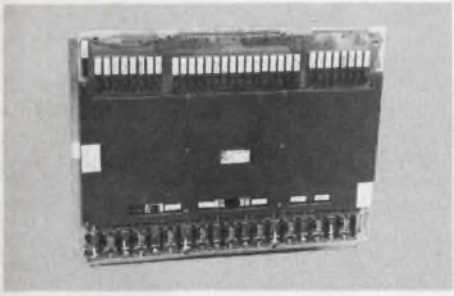

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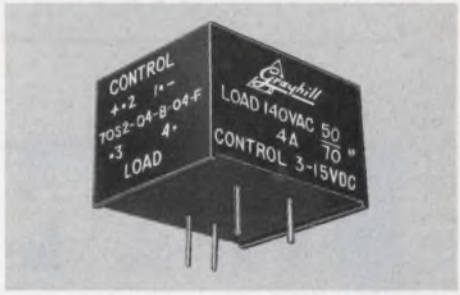

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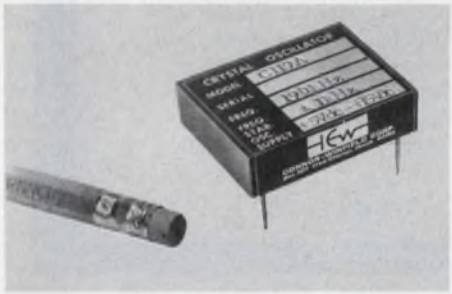

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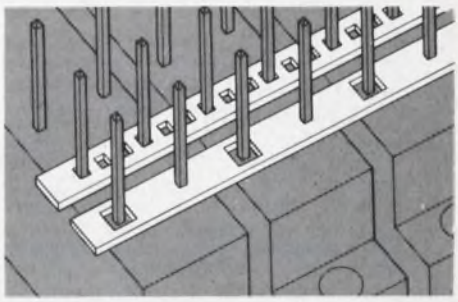

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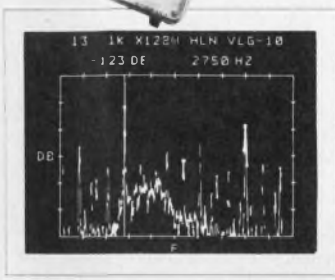

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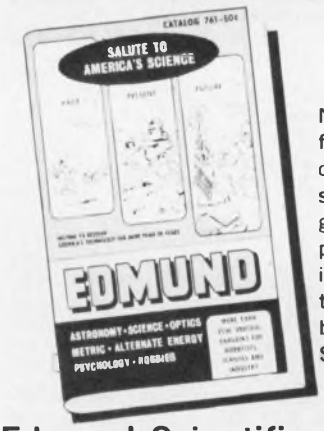

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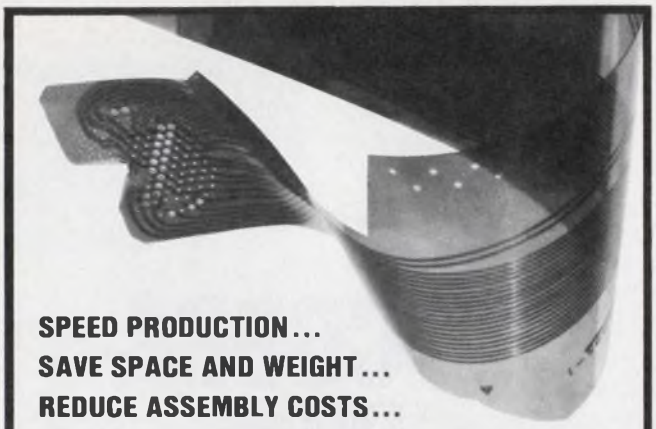

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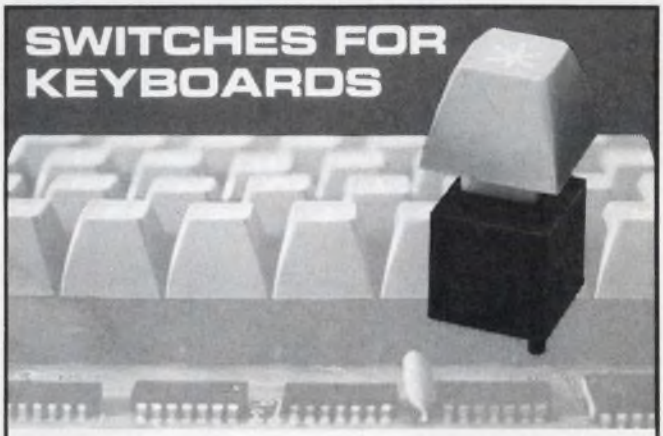

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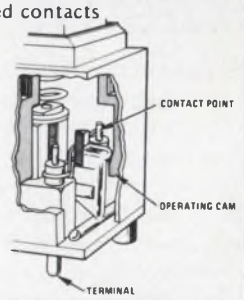

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Product Index

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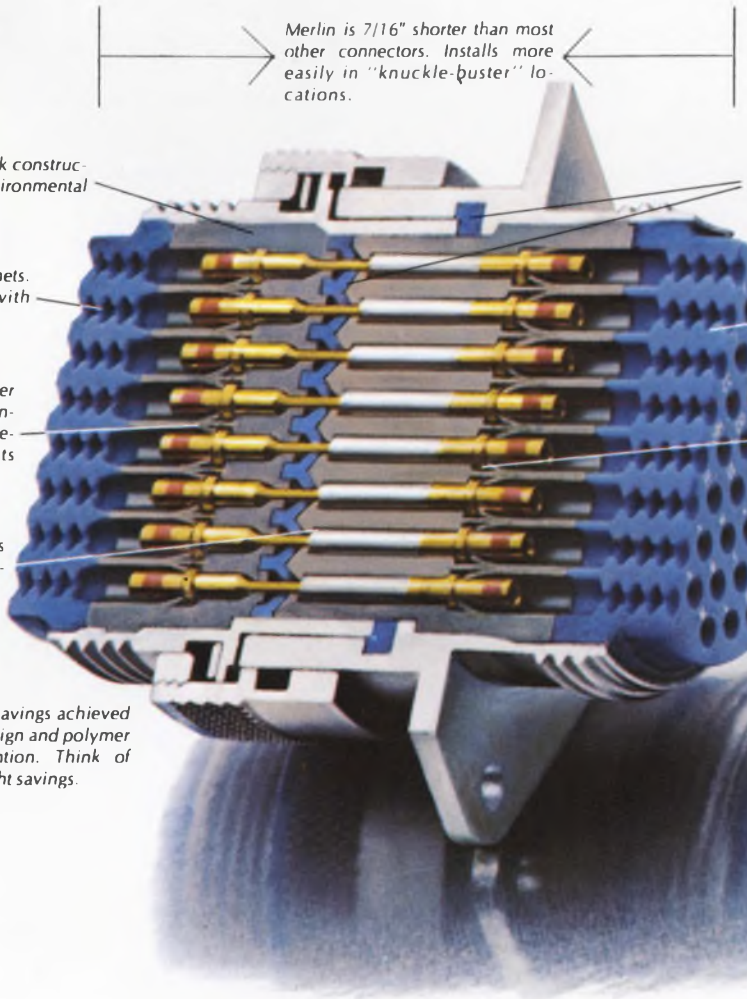

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The paper details how RCA's comprehensive specifications help designers match device to application. Typical RCA specs and test circuits are shown. You'll see how a 4-step testing routine and real-time indication tests assure product quality and long-term reliability.

Designing for the environment

Curves and data in the paper reveal the effects of environmental extremes on various packaging systems such as plastic, frit seal and the new Gold CHIP. They show accelerated life and thermal cycling tests with high MTTF figures. An important section compares predictable life data of TTL vs. COS/MOS: under the same ambient temperature, COS/MOS would have a better failure rate by a factor exceeding 20.

There's much more in this important document, ST-6418. We want you to have it, free. Contact your local RCA Solid State distributor. Or RCA.

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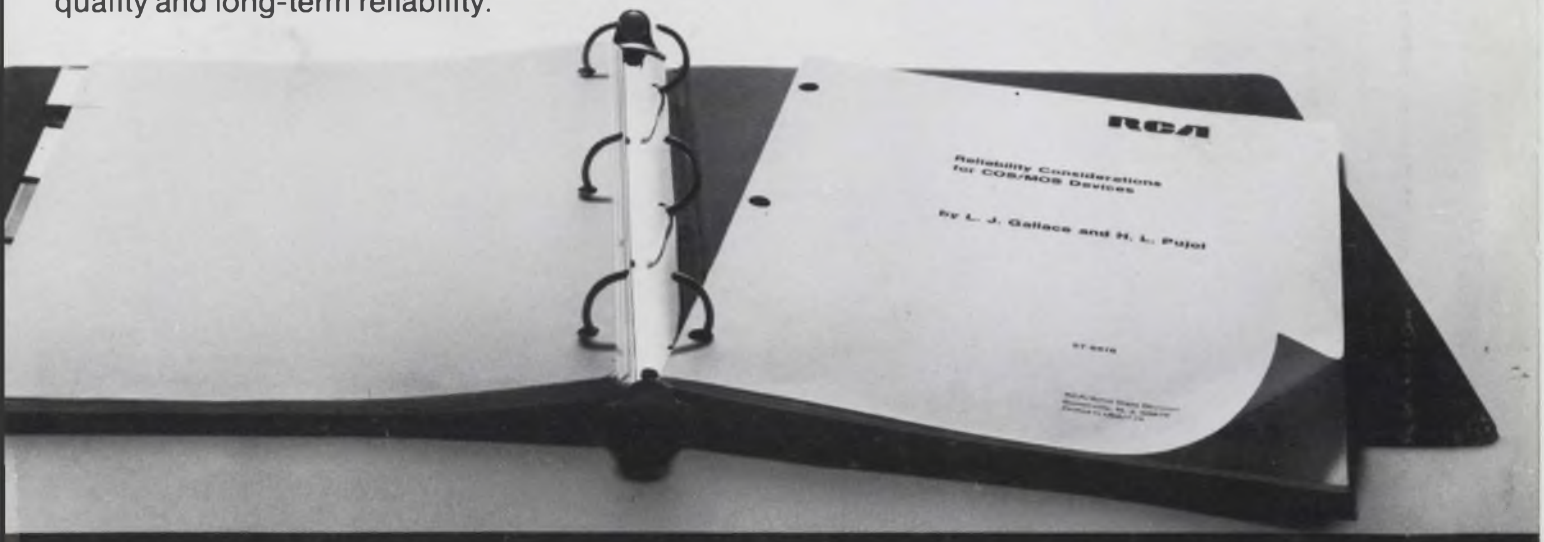
RCA



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