

# Electronic Design 25

FOR ENGINEERS AND ENGINEERING MANAGERS

VOL. 21 NO.  
DEC. 6, 1973

**Picking a power supply is tough.** There are thousands of units from many hundreds of vendors. Spec sheets often leave out important information — like derating and

spikes on the output. And users and vendors don't seem to speak the same language. Still worse, the wrong supply can injure your equipment. Learn why on p.58.





# Start with Dale

...when you need openwound resistors.

There's a Dale wirewound resistor potted inside Chrysler Corporation's unique new electronic ignition control. Openwound models like this are one of our fastest growing product lines. We make them from high quality resistance wire wound on a specially impregnated fiberglass core... with end caps and leads locked on to prevent "opens". The result is nothing fancy. But just the same, you'll find Dale CA and CR resistors in a growing number of high prestige consumer applications. In some, our quality is most important; in others, it's our price. In either case, it's the same Dale resistor. Need openwounds fast... call Dale at 402-564-3131 for complete information.

## OPENWOUND SPECIFICATIONS

**Styles:** Axial (CA) and Radial (CR) leads

**Power:** To 5 watts per inch

**Resistance:** .1 ohm to 7K ohms, depending on core length

**Tolerance:**  $\pm 10\%$  standard,  $\pm 5\%$  available

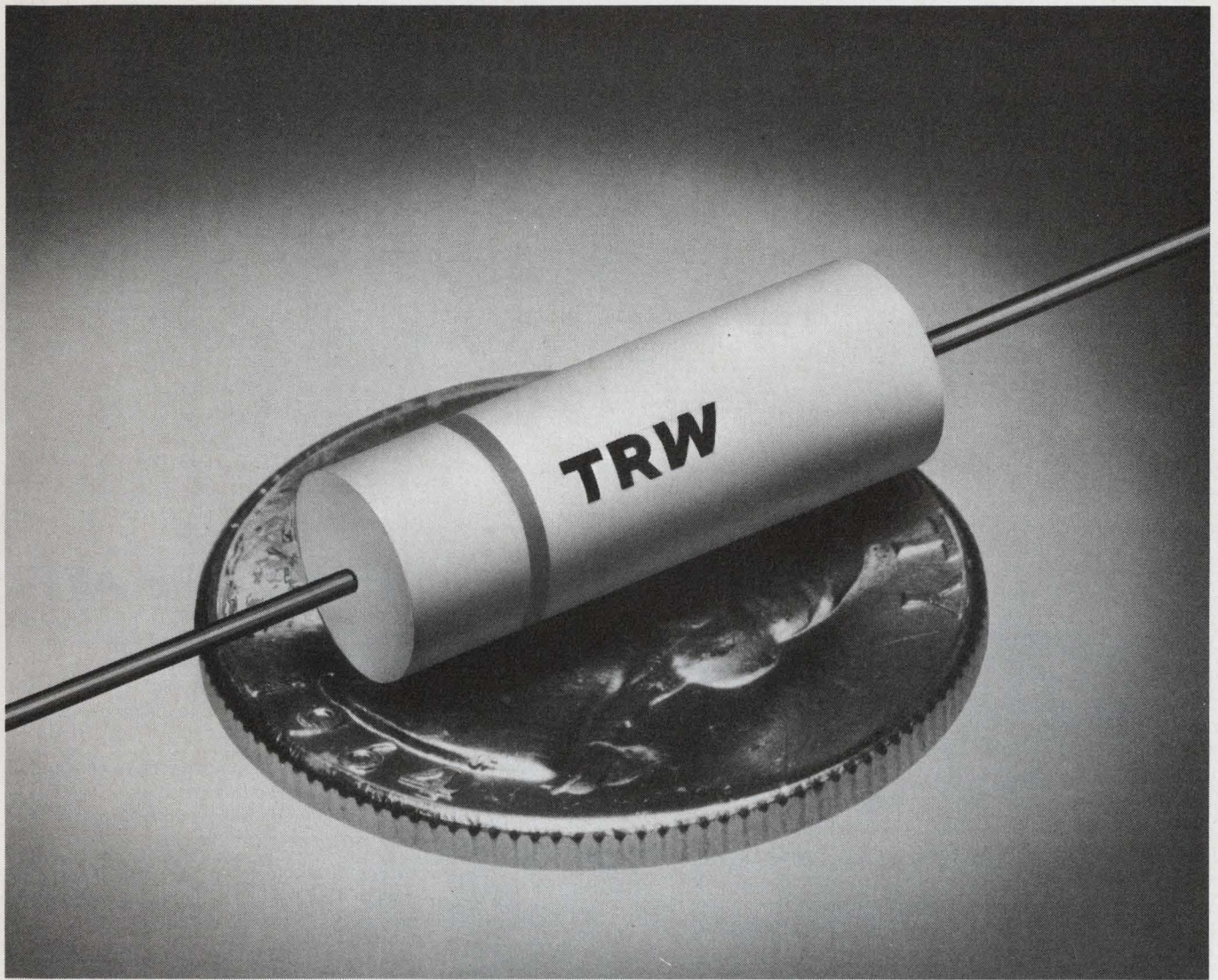
*(Available with special smokeproof coating for abrasion protection.)*



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INFORMATION RETRIEVAL NUMBER 246



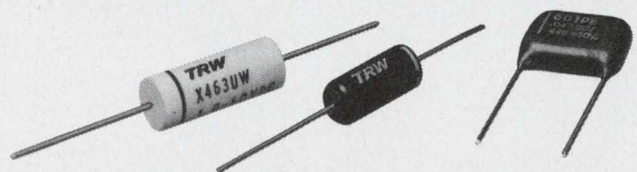
## Pay a little more for our products. Get more for yours.

In wound film and solid tantalum capacitors, TRW offers you a capability second to none. For one simple reason.

We figure you can't make quality capacitors and me-too capacitors under the same roof. Because sooner or later, one operation will foul the other one up. So we take the quality route. Count on it.

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INFORMATION RETRIEVAL NUMBER 2

# WHAT MADE CRYSTAL CAN RELAYS OBSOLETE?

## THE TO-5 RELAY!

Crystal can relays (full size and fractional sizes) have been obsoleted by the outstanding performance, high reliability, low power requirement and cost effectiveness of the TO-5 Relay.

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When you buy a Teledyne TO-5 Relay, you buy a 10-year record of remarkable reliability, superior performance, on-time delivery and service from people who really care. Teledyne provides experienced application engineers anxious to assist you with your relay problems.

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 **TELEDYNE  
RELAYS**



# Electronic Design 25

FOR ENGINEERS AND ENGINEERING MANAGERS

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**Cover:** Photo by Stu Peltz, courtesy of Lambda Electronics Corp.

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# The more you need the more you need

Silicon power has come a long way since its birth. And Motorola had more to do with it than anyone. Because state-of-the-art doesn't stop with today's designs, we're leading the way to tomorrow's.

## For designs that need TECHNOLOGY . . .

They said it couldn't be done — but Motorola introduced the first deep-junction, single-diffused, Uni-Base\* power Darlington in 1972. They proved the answer to innovative designers' prayers for power devices with super gain, super SOA for series pass regulators, unclamped inductive loads, medium-speed power switching.

Double-diffused, EpiBase\* Darlington offers versatile, high-gain/high-frequency response for audio, inverter and

fast power switching. Even simpler, lower-cost, split power supplies using just one 4-lead package are possible with EpiBase *dual* Darlington, common-collector-connected to give 2 separate output voltages.

More sophistication — and more voltage — can be had with double-diffused Annular and triple-diffused etch-cut devices. Whatever your applications preference, Motorola has the Darlington technology.

## For designs that need VOLTAGE . . .

Off-the-shelf units with 350-volt, 3 A capability satisfy many line-operated requirements. Soon-to-be introduced 10 and 20 A versions of this family will widen Darlington use in heavy industrial designs.

## For designs that need GAIN . . .

Gain command with power Darlington. Minimum  $h_{FE}$  of 500 is common — with 750 and 1,000 gain figures of merit offered in several families. Go from milliamperes to amperes directly, compatibly, easily using IC-driven supplies. For example, the 2N6294 series with typical gain of 3,000 boosts load currents

1973  
Power Circuits



from regulators sourcing only milliamperes.

## For designs that need SWITCHING . . .

The 20 kHz revolution in switching supplies is here! Use new, fast-switching EpiBase Darlington drivers with 5 MHz switching devices to raise inverter frequency from an audible 10 MHz to a quiet 20 MHz for better efficiency, smaller transformers. You can even handle kilowatt loads.

## For designs that need ECONOMY . . .

There's nothing like a power Darlington. Cut space/heat sinking needs, assembly time, components. Driver, output device, base-emitter resistors and output diode are all on one monolithic chip in one package. And less silicon is used than for comparable discrete devices. Add that to the economy realized from 100-up prices from 72¢ up.

## For designs that need COMPLEMENTS

Complementary Darlington afford the equivalent of 10 circuit components in two packages. You can positive- or negative-ground-connect them . . . or use them as pairs in audio



1956  
Silicon  
Alloy Device



1970  
Aluminum  
TO-3, TO-66  
Packages



1970  
EpiBase Darlington Device



1967  
Double-Diffused  
Planar Device

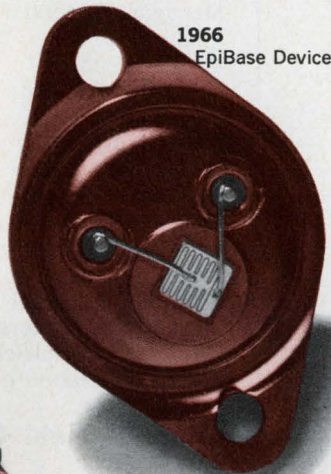
# from

\*Trademark Motorola Inc.

# state-of-the-art... power Darlingtons



1956  
TO-3 Package



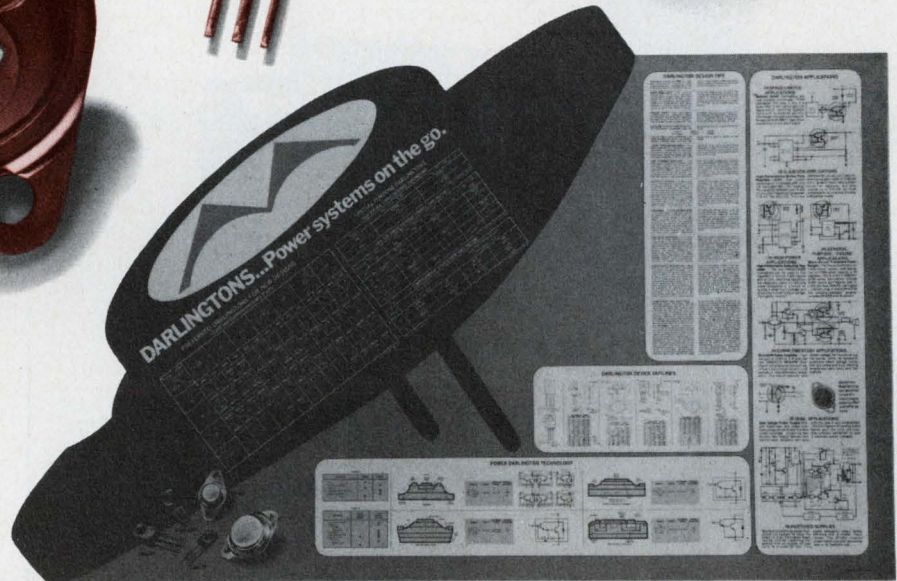
1966  
EpiBase Device



1967  
Plastic Package 77



1966  
Plastic  
Package  
90



amps.  
Only EpiBase  
technology possesses  
inherent capability to  
yield NPN/PNP Darlingtons  
with up to 3,000 typical  $h_{FE}$ .

24 JEDEC-REGISTERED, preferred pairs are available for applications to 20 A, 100 V . . . including a direct, plug-in replacement for the industry-standard, general-purpose 2N3055 and its driver . . . at the same price!

Send for DARLINGTONS . . . POWER SYSTEMS ON THE GO — a new, Selector/Design Guide that tells how to optimize your power system's cost, performance and package count. P. O. Box 20912, Phoenix, AZ 85036.  
The more you need, the more you need power Darlingtons . . .



1957  
Single-Diffused Device



1972  
Dual Darlington Device

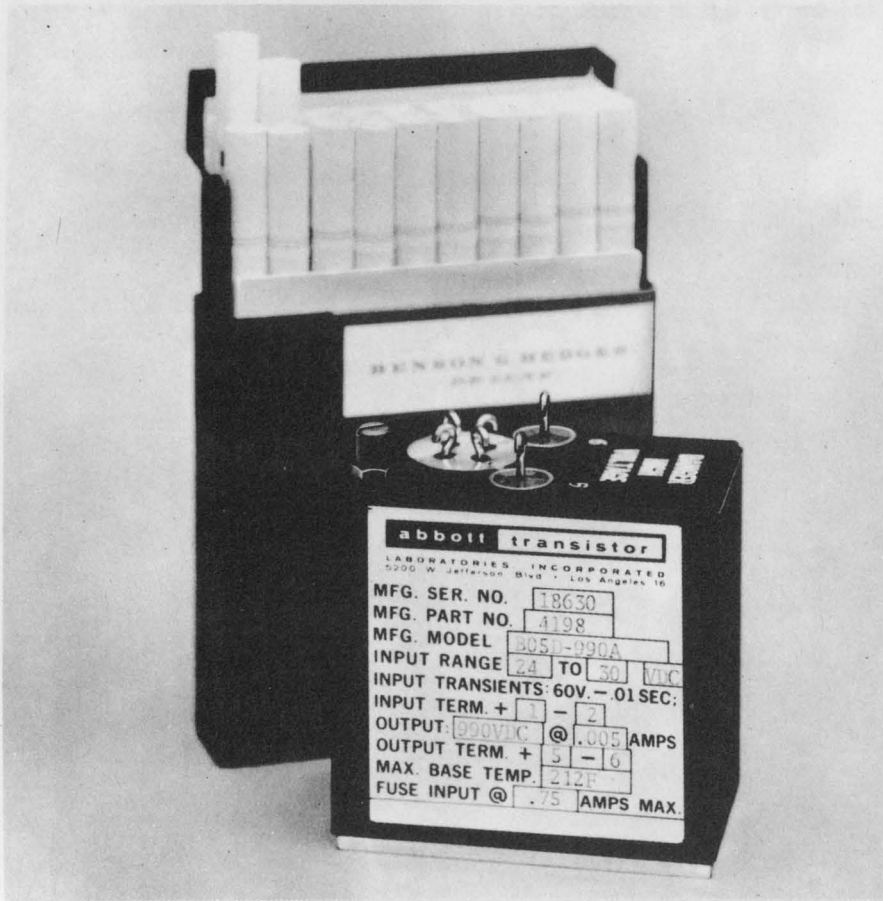
1959  
Triple-Diffused  
Interdigitated  
Device



*Darlington*

# Motorola, the power producer.

# A Smart Way to Beat Your Power Supply Size Problem



1½" thin, 2¾" narrow, 2¾" short

yet this converter produces 1000 volts DC, regulated, from a battery input of 28 VDC! It weighs less than 15 ounces. This is only one of our wide variety of many small light weight converters, inverters and power supplies — there are over 3000 models listed in our newest catalog, including size, weight and prices. If you have a size problem, why not send for an Abbott catalog?

**MIL SPEC ENVIRONMENT** — All of the power modules listed in our new catalog have been designed to meet the severe environmental conditions required by modern aerospace systems, including MIL-E-5272C and MIL-E-5400K. They are hermetically sealed and encapsulated in heavy steel containers. New all silicon units will operate at 100°C.

Please see pages 581-593 of your 1973-74 EEM (ELECTRONIC ENGINEERS MASTER Catalog) for complete information on Abbott Modules.

Send for our new 56 page FREE catalog.

**RELIABLE** — Highest quality components are used in Abbott power modules to yield the high MTBF (mean time between failure) as calculated in the MIL-HDBK-217 handbook. Typical power modules have over 100,000 hours MTBF — proving that the quality was built in from the beginning.

**WIDE RANGE OF OUTPUTS** — Any voltage from 5 volts DC to 3,650 VDC is available by selecting the correct model you need from our catalog with any of a variety of inputs including:

- 60 $\phi$  to DC, Regulated
- 400 $\phi$  to DC, Regulated
- 28 VDC to DC, Regulated
- 28 VDC to 400 $\phi$ , 1 $\phi$  or 3 $\phi$
- 24 VDC to 60 $\phi$ , 1 $\phi$

**abbott transistor**

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INFORMATION RETRIEVAL NUMBER 5

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## VR step motors come in small steps, too

"Focus on Small Motors" (ED No. 20, Sept. 27, 1973, p. 52) suggests that step motors with small step angles (15° or less) are usually available only in the PM design. I would like to point out that small-angle step motors are readily available in the variable reluctance design, as evidenced by our line of VR step motors—which include such step angles as 1.8°, 4.5°, 5°, 6°, 7.5°, 10° and 15°, with holding torque ratings for catalog motors spanning the range from 30 oz. in. to 1100 oz. in.

As for the lack of agreement among step-motor manufacturers on the expression of such parameters as torque, inertia and inductance, I feel that this will continue to exist until such time as a standards organization for step motors (possibly sponsored by NEMA) is created to define terminology, to describe methods of test measurement and to standardize mounting dimensions and tolerances. At Warner Electric, we have been promoting the creation of such an organization for some time.

Kenneth M. Senica  
Application Engineer  
MCSD

Warner Electric Brake & Clutch Co.  
Beloit, Wis. 5351

## That kp unit was no error

In the "Focus on Small Motors" (ED No. 20, Sept. 27, 1973, p. 52), you assume that the unit "kp" in a manufacturer's catalog is a printer's error and that the unit must

really be "kg." The unit "kp" for "kilopond" is used quite frequently in some European countries for the designation of force and weight in technical calculations, to avoid confusion with the use of kg, or kilograms, for mass. Keeping this in mind, we derive the following conversion:

$$f = m \cdot g \quad f = \text{force}$$

$$m = \text{mass} = 1 \text{ kg}$$

$$g = \text{gravity} = 9.80665 \text{ m/sec.}^2$$

$$f = 1 \text{ kg} \cdot 9.81 \text{ m/sec.}^2 = 9.81 \text{ mkg/sec.}^2$$

Since 1 Newton (N) is defined as 1 kgm/sec.<sup>2</sup>, we find

$$1 \text{ kp} = 9.81 \text{ N.}$$

Eugen Will  
Design Engineer

3M Co.  
3M Center  
Instrumentation and Control  
Systems Lab  
St. Paul, Minn. 55101

*Ed. Note: A check of over a dozen standard American engineering handbooks showed no mention of the kp unit.*

## Stop thief

The editorial, "My Friend's a Thief," in the September 1st issue, drew some rather heavy response. A sampling follows:

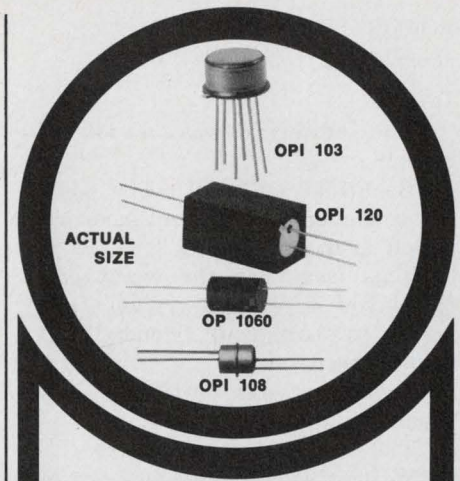
"My friend's a thief—excellent."

"Your editorial left me livid. Perhaps I'll write more when I simmer down."

"Excellent editorial!"

"I thoroughly agree with your editorial concerning dishonesty both high and low."

(continued on page 8)



## OPTRON OPTICALLY COUPLED ISOLATORS

HIGH RELIABILITY  
STABLE CHARACTERISTICS  
IMMEDIATE DELIVERY

OPTRON optically coupled isolators feature true hermetically sealed packages for the utmost in reliability for coupling, switching, relaying, or isolating an electrical signal.

They consist of high efficiency gallium arsenide light emitting diodes coupled with silicon sensors. Each OPTRON isolator is available in phototransistor or photodarlington versions to offer the design engineer a greater choice in matching device performance with circuit requirements.

OPTRON's broad selection of isolator packages (see photos) provides electrical isolation from 1 to 25 Kv for maximum electrical and mechanical design flexibility.

**OPI 103** 1 Kv isolation and 100% current transfer ratio. Phototransistor base lead available. Hermetic TO-5 package.

**OPI 120** 25 Kv isolation and 10% current transfer ratio. Hermetic sensor and LED in 0.30 x 0.60" plastic package.

**OP 1060** 5 Kv isolation and 10% current transfer ratio. Hermetic sensor and LED in .200" dia. plastic package.

**OPI 108** 1 Kv isolation and 20% current transfer ratio. 5 μsec switching time in a welded axial lead hermetic package.

Detailed technical information on these and other OPTRON optoelectronic products . . . chips, discrete components, assemblies, and PC board arrays . . . is available from your nearest OPTRON sales representative or the factory direct.



OPTRON, INC.

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Carrollton, Texas 75006  
214/242-6571

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.

"The editorial was a lot of bunk!"

"Beautiful editorial! The logic is consistent with engineering, which is sorely lacking."

"This issue has the worst editorial you have ever written. Quit trying to share your friend's guilt with others."

"Amen to your editorial. Keep them coming."

"The editorial stunk!"

"Without exception, every one of your editorials is superb, timely and must reading!"

"Yes. Your friend is a thief!"

"You can't justify anything by 'but they do it,' or 'it's society's fault,' etc. Each is still responsible for his own actions—even a friend."

"Great Watergate editorial."

"I must object to the political editorial."

"I agree very strongly with this issue's editorial."

"I would like to see Comrade George Rostky think, if that is possible for a person of his limited intellectual capacity, before he writes."

"Write on, George."

"Your editorial makes one wonder, doesn't it?"

"Are you trying to justify criminal activity?"

"I liked the editorial."

"Moral stature is not a communicable disease."

## For the record: Only one SLIMLINE

This is in reference to the New Product release "Slimline Counters Offered for Systems Use" (ED No. 16, Aug. 2, 1973, p. 121).

SLIMLINE is a trademark of Nationwide Electronic Systems, Inc., and is used for a line of panel-mounting digital clocks, counters and other instruments. I have written to Durgin & Browne, manufacturers of the unit described in the release, to inform them of the trademark status, and I felt that you should also be informed, since the release appeared in your publi-

cation without proper credit to NES.

As an aside, I should point out that Durgin & Browne's counter is fat in comparison with our SLIMLINE units, which are a mere 9/16-inch thick and require no space behind the panel.

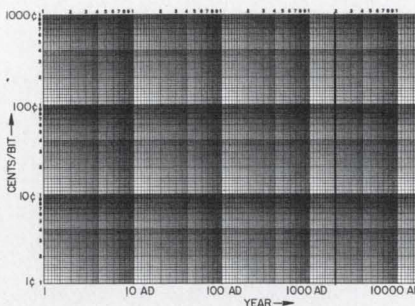
Robert H. Lounsbury Jr.  
National Sales Manager

Nationwide Electronic Systems, Inc.  
7N662 Route 53  
Itasca, Ill. 60143

## The memory price plot

Reader R. W. Wiegel of Collins Radio Co. in Cedar Rapids, Iowa, reports the following:

"We were recently commissioned the task of reviewing the cost of semiconductor-memory storage elements.



Per-bit memory cost (from 1000¢ to 1¢) as a function of time (1 A.D. to 10,000 A.D.).

"After a cursory, but thorough, examination of the evidence (three undated, clipped ads; two manufacturers' preliminary data sheets; and the opinions of a newly employed graduate), we were able accurately to plot the trend in semiconductor storage-element prices in cents/bit vs time. The attached chart clearly shows the decline in costs which has occurred in recent years, especially towards the end of the current millennium."

## Don't forget heat fatigue in solid-state relays

Jules H. Gilder's article "Solid-State Relays Are Finding Gradual Acceptance—at Last," (ED No. 19, Sept. 13, 1973, p. 26) states that "solid-state devices have no known

wear-out modes if operated within specified limits." This is true, if we overlook a very real breakdown mechanism called thermal fatigue. Thermal fatigue is caused by continuous, extreme temperature cycling of the device, which in turn is caused by surge currents that exceed normal service. What does this have to do with solid-state relays? Nothing, if the loads serviced by these devices are resistive. But if the loads are incandescent lamps, in-rush currents 10 times normal can be expected. The number of cycles of in-rush current at this magnitude is governed not by the heat sink used or by maximum-load current specified by the product manufacturer, but by the thermal-fatigue factor of the SCR, triac, etc.

Thyristors have one-cycle, non-repetitive current specifications. Solid-state relay manufacturers who print this spec as their relay maximum one-cycle surge are guaranteeing only 100 cycles or more of operation. Therefore the manufacturer should state the number of one-cycle surges that can be allowed before failure.

Carl W. Thomsen  
Electronic Products

Harvey Hubbell, Inc.  
Wiring Device Div.  
State St. and Bostwick Ave.  
Bridgeport, Conn. 08602

## Watch those specs on the 555 timer

Are you thinking of using the Signetics 555 timer for a TTL clock? The spec sheet lists that one of the main features of the device is that it can sink up to 200 mA. It also claims TTL-compatibility for the timer.

Before you decide that a TTL fanout of 20 to 30 is fair play, you had better look more closely at the specs. Unfortunately, the impressive rating of 200 mA leaves the output active with a logic ZERO voltage output (5-V supply) of 2.5 V, which is certainly not TTL-compatible.

To insure the maximum logic ZERO output voltage of standard

(continued on page 19)



# MEASUREMENT COMPUTATION

innovations from Hewlett-Packard

# NEWS

DECEMBER, 1973

## in this issue

New desktop  
business calculator

Take along our portable  
strip-chart recorder

A digital thermometer for  
hot projects



### New battery-powered dmm improves field service

Measure resistance, ac and dc voltage with a new autoranging digital multimeter that fits the palm of your hand.

HP's pocket-sized 970A digital multimeter is one of the most significant user-oriented instruments of the seventies. It operates on rechargeable batteries; automatically ranges ac, dc, volts and ohms through five ranges; displays measurements on a 3½ digit LED readout; yet weighs just 7 ounces (200 grams). This new probe is so small, so convenient that you can carry it on your belt or in your pocket—it's ideal for field service, as well as bench and lab use.

With thin film and MOS IC technologies, HP packed the electronic equivalent of 3000 transistors into this handheld probe. You can measure:

- dc voltage from 100 mV full scale

*(continued on page 3)*

## A few ways to use HP storage displays

In this simulated radar exercise, an HP storage display helps train pilots.



Storage and variable persistence displays offer many advantages where information must be gathered over a relatively long period of time, then processed and presented for display. The bright stored information provides easy viewing in high ambient light, and highly burn-resistant CRTs ensure long life with no special operating precautions.

A unique medical application for HP storage displays is in conjunction with an ultrasonic diagnostic system that provides a "picture" of internal organs or tissues in selected areas of the body. Storage allows build-up of the display by using as many scans as needed for the desired image detail.

Another application is in a simulated radar acquisition system which provides pilots with a realistic training environment. By adjusting the variable persistence in an HP 1331 storage display to match the scan rate, the pilot can see relative position trends that are not possible to view with long fixed-persistence phosphors.

*A new brochure describes other storage scope and display applications. For your copy, check E on the HP Reply Card.*

## Now, run FORTRAN faster with new HP software

Good news for 2100A and 2100S computer users: HP's new fast FORTRAN processor (FFP) dramatically speeds execution of FORTRAN programs and subroutines. Typical applications demonstrate that FFP generally causes programs to execute 10 times faster.

FFP contains microcoded library subroutines including double-precision floating-point operations, single-to-double-precision conversions, as well as address and control transfer routines. And you can call the FFP subroutines with ALGOL and assembly language,

as well as FORTRAN.

The processor is available in Read Only Memory (ROM) chips or in binary tape with two Writeable Control Store cards; and it can be either factory or field installed.

*To learn more about fast FORTRAN, check R on the HP Reply Card.*

FORTRAN Double Precision Programs	Software Execution Time (Sec)	FFP Execution Time (Sec)	Improvement Factor
Conversion Process of Mathematical Equation	319	16	19.9
Analysis of Variance	1800	210	8.57
Data Conversion	3780	425	8.89

## New mass memories expand calculator storage



With this new mass memory, you can store or read a complete 250-line calculator program in about 2 seconds.

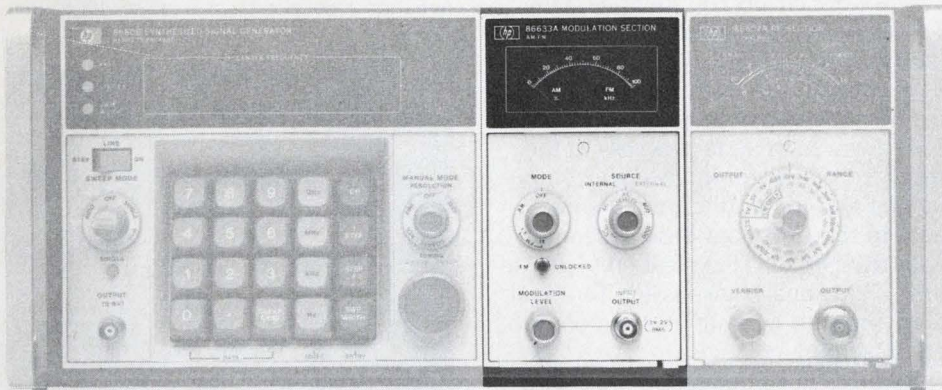
For calculator users who need lots of storage, there are two new mass memories for HP's powerful 9830A programmable calculator. Now, you can have large data storage for such varied applications as general ledgers, accounts payable, personnel records, patient data, laboratory tests, real estate listings, structural design, and statistical analysis.

The 9880A is a single disc memory subsystem that stores 2.4 megabytes; the dual-disc 9880B has capacity for 4.8 megabytes. Both have a photoelectric mechanism for fast, accurate read/write head positioning. It takes just 50 ms (average) to access and transfer a data item from the memory to the calculator.

The subsystem is versatile, too. You can connect up to 4 memory discs, in any combination (A or B), to one HP 9830A calculator through a controller—or connect up to 4 calculators to one mass memory subsystem. However, only one calculator can access the memory at a time.

*For more on calculator memories, check P on the HP Reply Card.*

## New options expand RF synthesizer capabilities



New modulation section for HP 8660 signal generators permits FM with phase-locked center frequency.

With the new 86633A modulation plug-in for HP 8660A/B synthesized signal generators, the center frequency is phase-locked while operating in the FM mode. This brings highest stability when you're making narrowband FM measurements—for example, in mobile radio receiver tests.

The 8660A/B signal generators provide fully-calibrated AM, FM and CW signals with synthesizer accuracy and spectral purity—from 10kHz to 1300 MHz. Some key performance characteristics are:  $3 \times 10^{-8}$ /day frequency

stability,  $-80$  dB spurious,  $<1.5$  Hz residual FM, and calibrated output levels from  $+10$  to  $-146$  dBm. Now, the 8660 signal generators can be supplied with an optional ASCII interface which means they can be controlled from a 9820A calculator.

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

## New bipolar power supply doubles as an amplifier

HP's new bipolar power supply/amplifier is really three instruments in one package:

- A fast 50W bipolar power supply with continuous through-zero output.
- A fixed-gain power amplifier with dc—40 kHz bandwidth.
- A dc—15 kHz power amplifier with programmable gain.

As a power amplifier, the supply teams up with many lab-type function generators to produce signals at voltage and current levels high enough to test deflection yokes, zener diodes, transistors, power relays, resolvers, motors, and many other devices. Individual units can supply outputs up to 40V p-p at 2A pk, 100V p-p at 1A pk, or 200V p-p at 0.5A pk. Auto-series or auto-parallel connections of multiple units further extend the range of possible outputs. Input/output impedance of  $10 \text{ k}\Omega/0.5 \text{ m}\Omega$  means minimum loading of the signal source and plenty of output drive.

When operated as a bipolar power supply, output ratings are:

6825A/6830A:  $\pm 20\text{V}$  at 0—2A

6826A/6831A:  $\pm 50\text{V}$  at 0—1A

6827A/6832A:  $\pm 100\text{V}$  at 0—0.5A

The voltage output of all models can be programmed remotely (0.1% accuracy).

For specifications, check K on the HP Reply Card.

(continued from page 1)

to 500 V with worst case accuracy of  $\pm 0.9\%$  at full scale.

- ac voltage from  $100 \mu\text{V}$  to 500 V rms, from 45 Hz to 1 kHz, with an accuracy of  $\pm(2\%$  of reading  $+ 0.5\%$  of range).

- resistance from  $1 \Omega$  to  $11 \text{ M}\Omega$ , at an accuracy of  $\pm(1.5\%$  of reading  $+ 0.2\%$  of range).

Yet the 970A is fast and easy to use—no confusing inputs or manual adjustments need be selected. You set only one function control, and there are just two input terminals, instead of the usual three to eight.

Select one of three probe tips, depending on your application: one for normal use; a longer tip for reaching otherwise inaccessible circuit test

points; and a concave tip to cup wire-wrapped terminals and test pins. For other applications, the tip socket will accept a standard banana plug.

Simply touch the probe tip to the test point, push a button, and the LED readout displays the correct polarity and reading. Should the display be upside down when you hold the probe, a front panel switch electronically inverts the display. Thus, you won't mistake 6's for 9's.

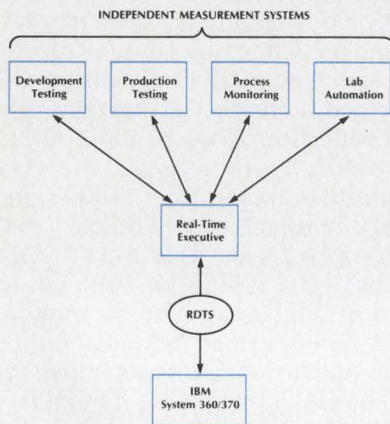
There's more. For all the details, check D on the HP Reply Card.



Choose between the laboratory versions with meters and front panel controls (models 6825A-6827A) or the system versions with blank panels (6830A-6832A).

## Now, interface HP automatic measurement systems with an IBM 360/370

A new software/hardware package enables communication between an HP Real-Time Executive (RTE) system and an IBM 360/370 system. This gives you three-level distributed systems capability, with HP 9600 series measurement systems (first level) operating as satellites to an HP 9600C/E RTE sys-



With RDTs, your measurement systems double as remote job entry terminals.

tem (second level), which in turn communicates with the IBM 360/370 batch computer (third level).

The new HP 91780 Remote Data Transmission Subsystem lets the satellite systems and RTE system operate independently, yet communicate with the IBM batch computer when desired. This gives each system access to the batch computer for large-scale computations and for storing measurement data in the IBM data base. Essentially, with RDTs the RTE system emulates an IBM 2780 Data Transmission Terminal, allowing it to operate as a remote job entry terminal.

Some major application areas are:

- **Manufacturing**
- **Military/aerospace**
- **Colleges, universities**
- **Health services**

Full information is available; just check Q on the HP Reply Card.

## New business calculator challenges a computer

Now, there's an HP desktop business calculator especially for accountants, bankers, financial and tax analysts, investors, real estate agents, stock-brokers, and bond dealers. Like the popular pocket-sized HP-80, the HP-81 business calculator can perform 40 financial functions...plus interest per period, depreciation schedules, discounted rate of return for uneven cash flow, coupon equivalent yield, amortized loan schedules, bond and note calculations.

For statistical analysis, use the HP-81 to calculate mean and standard deviation, correlation coefficient, percent and % difference. You can also compute a two-variable trend line, and/or multiply and divide by any constant. Enter both x and y values of a data point; the correlation coefficients are calculated automatically when the trend line is calculated.

Answers are printed on a tape so you have a permanent record. Negative numbers are printed in red. If you make an operational error, such as dividing

by zero, the calculator immediately prints an error message.

With the time and money you'll save, the HP-81 pays for itself within weeks.

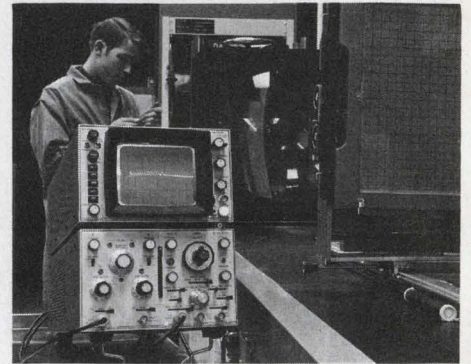
For more information, check C on the HP Reply Card.



The streamlined, compact HP-81 weighs just 13.5 lbs (6.12 kg).

## HP storage oscilloscopes for a variety of uses

At the U.S. Air Force Academy, an HP 181A storage scope is used in a research project on how cracks develop in such critical structures as aircraft wings.



HP storage oscilloscopes enable you to capture nanosecond transients or low rep-rate signals in bright, flicker-free displays. Very high speed signals, single-shot events, or low frequency applications are easily resolved with storage writing speeds of 0.5 cm/ $\mu$ s. to 400 cm/ $\mu$ s. These stored displays are bright up to 100 foot-lamberts and are highly burn-resistant so that they require relatively little care. Improved storage CRTs make it possible to capture and view high-speed phenomena that previously you could document only by difficult photographic techniques. Multi-mode capability means that our storage CRTs also satisfy general purpose applications.

For high-speed data, the 184A storage scope with fast writing speed (up to 400 cm/ $\mu$ s) captures infrequent events and retains them long enough for visual waveform analysis.

For low duty-cycle traces that can't be seen on a conventional CRT or are barely discernible under a viewing hood, the storage scope with variable persistence integrates low rep-rate signals to a bright display without annoying flicker. Also, with variable persistence you can retain a signal until a second signal is captured, allowing you to readily compare differences in time, amplitude and shape.

For the complete storage scope story, check F on the HP Reply Card.

## Two scientific calculators fit your computation needs, your pocket and your budget

HP-35



HP-45



Which HP scientific pocket calculator should you choose? That's a difficult decision. Both the HP-35 and HP-45 weigh just 9 ounces each, operate on batteries, perform trigonometric and logarithmic functions, are accurate up to 10 significant digits, and feature LED display and solid-state memories. Both are designed for a variety of applications in science, engineering, surveying, navigation, statistics, and mathematics.

The HP-35 has an operational stack of four registers, plus a data storage register for constants. The stack holds intermediate answers and, at the appropriate time, brings them back for further use. With the HP-35, you can perform addition, subtraction, multiplication, division, exponentiation, square roots, reciprocals, trigonometric and logarithmic functions in a fraction of a second... in the palm of your hand.

The HP-45 advanced scientific pocket calculator has nine addressable memory registers and, like the HP-35, a four-register stack that holds intermediate answers for future calculations. There are three trigonometric operating modes—degrees, radians or grads—and you can easily convert from any mode to degrees/minutes/seconds and vice versa. Other additional capabilities include polar/rectangular coordinate conversions, percent and % difference, metric/U.S. unit conversions,  $n$  factorial (for permutations and combinations), mean and standard deviation. A special storage register, "last x," lets you correct an error without having to start over in the midst of a long calculation.

To  
learn more, check A or B on the HP Reply Card.

## New battery-powered strip-chart recorder goes anywhere

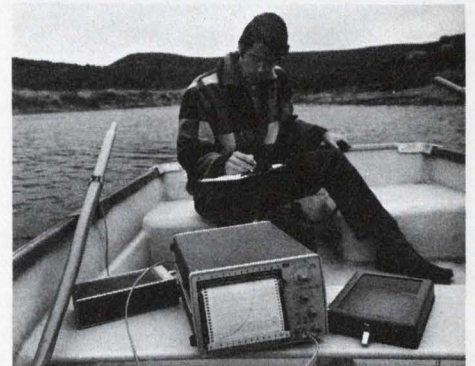
Now, there's a lab quality, portable strip-chart recorder that operates up to 9 hours on internal rechargeable batteries or on an external ac or dc power from 48 to 440 kHz. Compact size (5-inch or 12.7 cm writing width) and rugged durability means the new 7155 recorder works well in trucks, field stations, airplanes, or any remote location.

Seven chart speeds range from 20 sec/in. to 60 minutes/in. Accuracy is 0.5% of full scale with overshoot <0.05 in. (.13 cm). Disposable pens and coated paper give you a sharp, clean trace that dries instantly. The writing system is so trouble-free you can even run the recorder upside down. It's ideal for recording at locations where ac line power is not available—for example, monitoring air and water pollution in the wilderness. And a see-through front cover protects the recorder from dirt and moisture.

Metric scaling is available.

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

Take our new strip-chart recorder into the wilderness—it weighs less than 30 lbs (13.6 kg).



## HP's new digital thermometer: a hot buy at a cool price

HP's new 2802A universal digital thermometer is a medium-priced unit that contains several features usually found only in expensive thermometers—features like two measurement ranges, linear analog output, high resolution, 4½ digital readout, and battery operation.

One temperature range extends from -200° to +600°C with 0.1°C resolution. Push a button to switch to the -100° to +200°C range with 0.01°C resolution. On both ranges, accuracy is always ±0.25% of reading ±0.5°C.

Linear analog output means you can connect the 2802A to any recorder for temperature charts and graphs. Snap in a 6-hour battery module, and the thermometer becomes completely portable, ready for field use. An optional BCD module for buffered output lets you send your digital temperature readings across the country. Various probes and sensors with standard or armored cable adapt the thermometer to a vari-

ety of needs. There are other optional snap-on modules that convert your thermometer to make voltage, current, and resistance measurements.

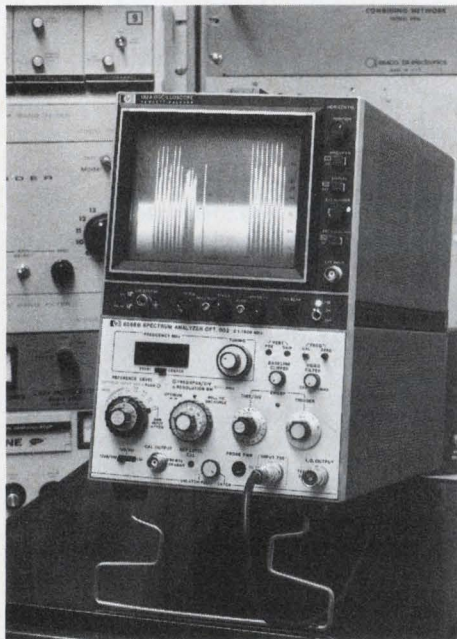
*This new digital thermometer leaves expensive units out in the cold. To learn more, check G on the HP Reply Card.*

Cryogenic measurements are easy with the new 2802A thermometer. Here, it measures the temperature of a device being cooled with liquid nitrogen.



## New 75-ohm spectrum analyzer for communications and CATV

Spectrum analysis of CATV system signals is accurate and convenient with the HP 8558B spectrum analyzer.



For measurements in 75-ohm systems, two versions of the low-cost 8558B spectrum analyzer are now offered: one is calibrated in dBm for 75-ohm communications systems, and the other is calibrated in dBmV especially for CATV and television broadcasting. Major features of the 8558B are precision performance and ease of operation. Most measurements are made using only three controls.

Both versions offer a 0.1 to 1500 MHz frequency range and a 70 dB spurious-free amplitude display range. Resolution bandwidths are from 1 kHz to 3 MHz, and frequency response is <math>\pm 1</math> dB. The analyzer has digital LED readout to show either center or "start-of-sweep" frequency.

*For details, check M on the HP Reply Card.*

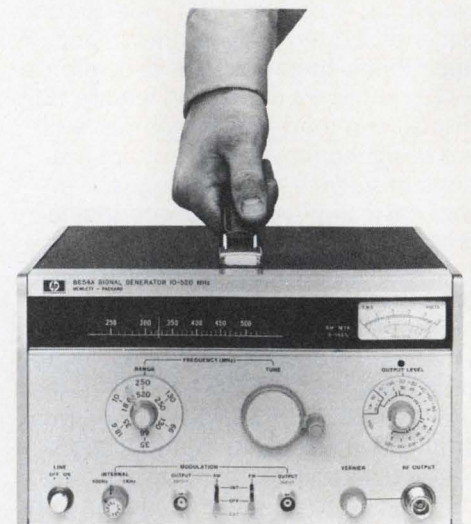
## New low-cost RF signal generator is portable

The HP 8654A VHF signal generator—solid-state, portable, and low cost—provides calibrated output and versatile AM and FM modulation from 10 to 520 MHz. Compact and small in size, this precision instrument fits easily into production, mobile, airborne, and shipboard test locations.

The 8654A produces stable RF signals for testing receivers, amplifiers, antennas, and filter networks. Calibrated output range is +10 to -130 dBm. An auxiliary RF output is also available at the rear panel to use with a counter or other external equipment. Stability is 0.002% per 5-minute operating period, after two-hour warmup.

Portability, stability, and versatility make this a high-value VHF signal source for economy-minded users.

*For specifications, check N on the HP Reply Card.*



Carry it with you—the versatile 8654A AM/FM signal generator weighs just 16.5 lbs (7.5 kg).



## HP offers "how to" newsletter for service technicians

*Bench Briefs*, a bimonthly publication, is your private line to HP Customer Service. It is offered to personnel servicing HP instruments and to service managers—and is particularly useful to anyone doing repair, calibration, incoming inspection, and system configuration of HP electronic instruments.

This attractive 8-page bulletin contains service tips, instrument modifications, new methods of testing, and new tools that simplify service and troubleshooting. *Bench Briefs* are full of practical information, such as the effects of

IC tarnish or how to remove solder flux. There are tutorial articles to upgrade your technical knowledge in areas such as digital techniques or Boolean equations. Also included periodically are listings and order forms for Service Notes, as well as factory recommendations for updating or modifying HP products.

For two sample issues and a subscription qualification form, check T on the HP Reply Card.



*Bench Briefs*: an HP service that improves your service.

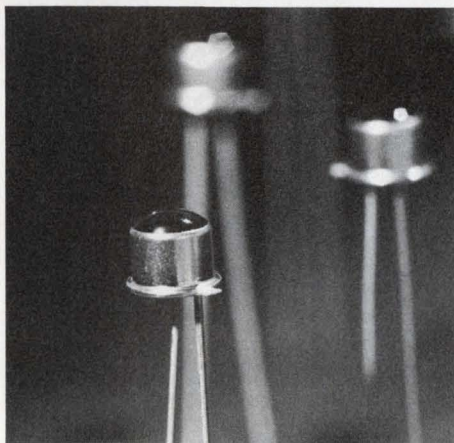
# HEWLETT-PACKARD COMPONENT NEWS

## New hermetic LED meets military specs

A new hermetically-sealed gallium arsenide phosphide LED lamp has been formally approved for use in military systems as a JAN/JANTX component. The JAN 1N5765 and JANTX 1N5765 alleviate the need for users to generate a special military specification and apply for non-standard parts approval.

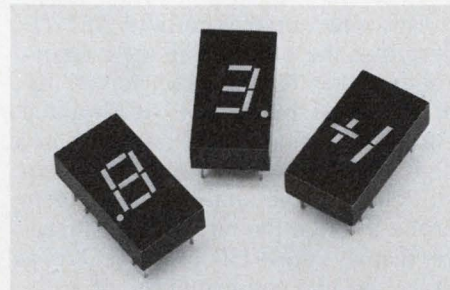
This hermetically-sealed solid-state lamp offers a minimum luminous intensity of 0.5 mcd at 20 mA and an operating temperature range of  $-65^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$ . The HP commercial part number is 5082-4420.

For specifications and reliability data, check I on the HP Reply Card.



LED lamp for high reliability applications

## New LED over-range digit expands display family



The new plus/minus one digit LED for HP 5082-7700 series LED displays.

A new plus/minus one digit is now available for applications requiring polarity designation or over-range capability. The 5082-7732 LED display is ideal for instrumentation such as digital voltmeters and digital multimeters. The unique feature of this display is the decimal feature to the left of the "1" which allows the designer to show an additional range on the meter without the cost of an extra digit.

Designed for use with HP's 5082-7700 series of 0.3 inch (0.8 cm) LED displays, the 5082-7732 offers uniformly lit segments with wide viewing angle. They are available from stock or from any HP franchised distributor.

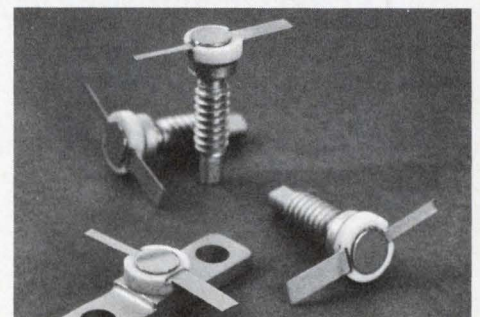
For details, check J on the HP Reply Card.

## Use new medium-power microwave transistors

Our new 35850 series microwave transistors deliver  $\frac{1}{2}$  watt power output to 3 GHz with documented high reliability. They're ideal for applications requiring linear, broadband power and for Class C saturated power.

Available as chips or in rugged, hermetic metal/ceramic packages, these NPN silicon bipolar transistors fill both common emitter and common base design needs. The common emitter versions provide linear power up to +26 dBm at 2 GHz for broadband amplifiers. The common base versions fit Class C saturated power amplifiers.

For specifications and reliability data, check H on the HP Reply Card.



HP's high-reliability linear microwave power transistors come in two packages plus chip form.

## New logic analyzer book tells how to troubleshoot digital circuits easily



The 5000A logic analyzer solves a broad spectrum of problems that range from determining the logic state of

a circuit node to locating a spike that occurs 850,000 clock periods after a trigger.

When is that short reset pulse really occurring? Or is it? What causes this flip-flop to end in the wrong state at the end of each machine cycle? Are these two lines ever HIGH at the same time? If these problems sound familiar, send for "The Logic Analyzer—A Step to Easier Digital Troubleshooting" and learn how HP's 5000A logic analyzer can help you solve such digital problems.

This new application note (167-1) describes the easy-to-use logic analyzer as a practical problem-solver. To display the sequence of HIGHS and LOWs occurring at several points in a digital circuit, simply connect the circuit clock to the analyzer, then freely probe through the circuit. The analyzer displays these HIGHS and LOWs as "bits" on two rows of LEDs. At a glance, you can determine if a flip-

flop is toggling, if the output of a shift register is following its input, or if a decade counter is really dividing the clock by ten. Even single-shot or very slow data is captured and stored for easy viewing.

The particular 32 bits displayed on each channel are selected by a combination of the versatile triggering controls and the digital delay. The trigger controls permit selection of any single input or any combination of up to three inputs for triggering. Digital delay lets you display information anywhere from 64 clock periods before the trigger event to 999,999 clock periods after the trigger event.

AN 167-1 also explains how to do more complex tasks such as investigating the output sequence generated by a ROM-controlled state machine, determining the content of Teletype data transmitted to a computer interface, or displaying jitter-free data from a moving-head disc as it is transmitted to the computer.

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

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**Canada**—275 Hymus Boulevard, Pointe Claire, Quebec, Canada, Ph. (518) 561-6520.

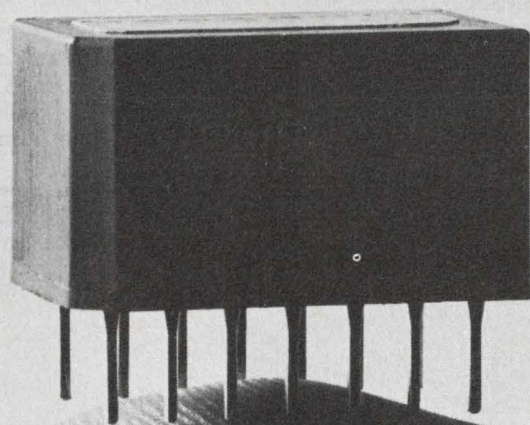
**Japan**—Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.

**If you've been looking for a miniature crystal-controlled clock oscillator in a 14 pin DIP package to fit standard PC board sockets, stop looking and start ordering. Get details on model K1091A from Motorola Component Products Dept. 2553 No. Edgington Franklin Park, Ill. 60131**



**MOTOROLA**

INFORMATION RETRIEVAL NUMBER 221



Specifications: 4 to 20 MHz range; 0.01% stability; prototype quantities available for immediate delivery in 4.9152 MHz, or 5.0, 10.0 or 20.0 MHz.

2001  
 -2000  
 \$320.

**The big difference between these high-frequency sweepers is \$320.**

The little differences are on the front panel (a start/stop mode of operation and a tape drive readout). Some people think they add up to \$320. For them, we built the 2001.

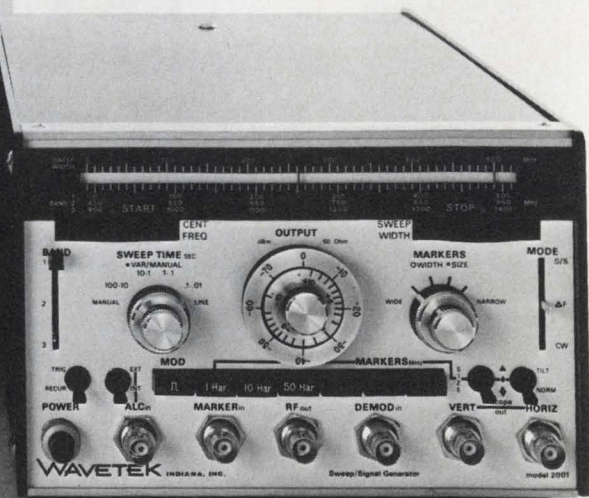
And for those people who don't require these features, we built the 2000. The 2000 is the only sweeper under \$1400 to offer frequency coverage of 1 MHz to 1.4 GHz, solid-state design, calibrated RF output from -80 to +10 dBm, P.I.N. diode leveling and a crystal-controlled marker system.

In addition, its frequency, bandwidth, and output level are programmable, making it ideal for production test and systems use as well as in the design laboratory. If you're still not sure which sweeper we built for you, send for more information. Just circle the reader service number or give us a call.

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Model 2000  
 \$1375



Model 2001  
 \$1695

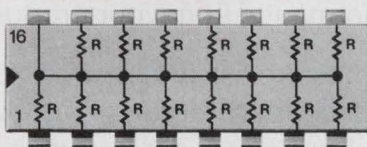
# 191 FLAVORS OF BECKMAN DIPS



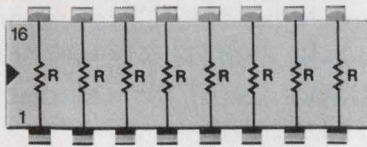
All 191 flavors of RESNET™ DIPs offer system compatibility because we use the same packages you use for I.C.s; plus you get ceramic dependability at plastic prices.

Whether you're inserting resistors automatically or by hand — call your local Beckman/Helipot representative and ask how you can save money using RESNET DIPs. He stocks locally for immediate delivery.

If you need immediate technical literature or the telephone number of your local Beckman/Helipot representative, call H.E.L.P. (Helipot Express Literature Phone) toll-free (800) 437-4677.



898-1 (15 resistors)  
Price (1,000-4,999) \$.85

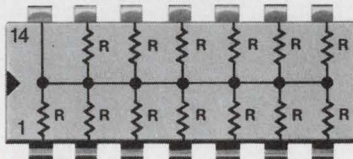


898-3 (8 resistors)  
Price (1,000-4,999) \$.76

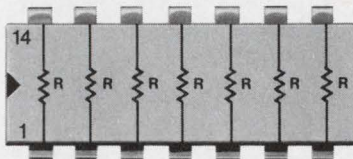
**STANDARD RESISTANCE VALUES**  
(±2% or ±2Ω)

62*	110	330	1.0K	2.2K	6.0K	15.0K
68	150	470	1.5K	3.3K	6.8K	22.0K
100	220	680	2.0K†	4.7K	10.0K	

\*Standard in 898-3 only.  
†Standard in 898-1 only.



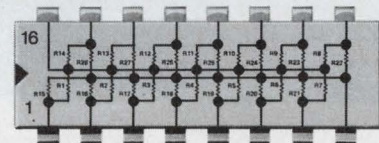
899-1 (13 resistors)  
Price (1,000-4,999) \$.81



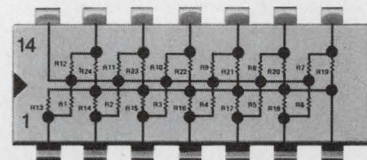
899-3 (7 resistors)  
Price (1,000-4,999) \$.72

**STANDARD RESISTANCE VALUES**  
(±2% or ±2Ω)

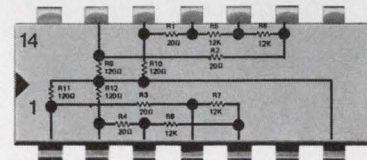
22	62	180	510	1.5K	4.3K	11K
24	68	200	560	1.6K	4.7K	12K
27	75	220	620	1.8K	5.1K	13K
30	82	240	680	2.0K	5.6K	15K
33	91	270	750	2.2K	6.0K	16K
36	100	300	820	2.4K	6.2K	18K
39	110	330	910	2.7K	6.8K	20K
43	120	360	1.0K	3.0K	7.5K	22K
47	130	390	1.1K	3.3K	8.2K	
51	150	430	1.2K	3.6K	9.1K	
56	160	470	1.3K	3.9K	10K	



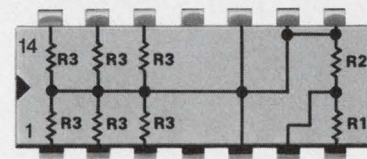
898-5-R220/330  
Pulse squaring TTL terminator.  
Price (1,000-4,999) \$1.45



899-5-R220/330  
Pulse squaring TTL terminator.  
Price (1,000-4,999) \$1.35



899-19  
DIP interface network providing resistors  
for μA711 core sense amplifier configuration.  
Price (1,000-4,999) \$1.18



899-40  
DIP network provides six line terminators  
and the threshold setting divider for the Intel  
3208A sense amplifier.  
Price (1,000-4,999) \$1.35

**Beckman**

HELIPOT DIVISION

INFORMATION RETRIEVAL NUMBER 223

# Don't let the low price of our peripherals frighten you.

One of your toughest problems is cutting costs without cutting corners. So when someone comes in with an all-too-tempting price on peripherals, you start to get a little scared.

Microdata understands. So when we came up with a disc drive and tape transport at a frighteningly low price, we made sure

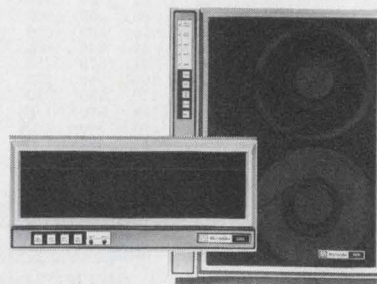
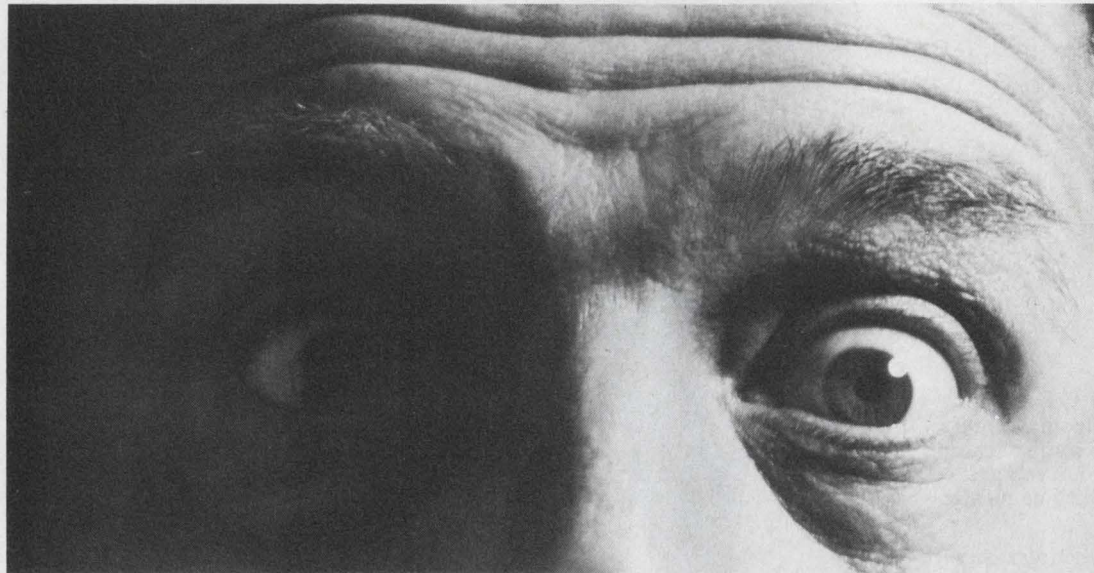
the performance, quality, and delivery were downright reassuring.

Our high speed, 25 and 50 million bit disc drives are designed for the 5440 cartridge. Track-to-track access time is a mere 10 milliseconds. And a mean-time-between-failures of

more than 5,000 hours assures on-line reliability.

Our equally impressive mag tape drives offer the security of file protection. Precisely controlled dynamic braking. And 200 inches per second fast forward and rewind to get full performance from your product.

If you're still afraid, write for descriptive literature and ask about our guarantee. But if you're ready to talk terms, call us. Microdata Corporation, 17481 Red Hill Avenue, Irvine, California 92705. Telephone 714/540-6730.



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**IMMEDIATELY AVAILABLE IN PRODUCTION QUANTITIES...  
GENERAL INSTRUMENT'S**

# 8K

**FEATURING:**

- 2048 x 4 ORGANIZATION
- 1.2  $\mu$ s TYPICAL ACCESS TIME
- TTL/DTL COMPATIBILITY—  
Inputs and clocks TTL/DTL compatible without external interfacing components
- PROGRAMMABLE CHIP SELECT—  
Simplifies design of large memory systems
- TOTALLY AUTOMATED MASK GENERATION—  
"RO-5-8192/Custom Coding information," describing punched card and truth table data specification, is available.
- STANDARD PATTERN—  
The 8K ROM is available pre-programmed as a 4-bit random number generator, part #RO-5-8192-001.

# ROM

**PROTOTYPE TURNAROUND 3-4 WEEKS**

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General Instrument Corporation, Microelectronics Division, 600 West John Street, Hicksville, N.Y. 11802.

**MICROELECTRONICS DIVISION**



INFORMATION RETRIEVAL NUMBER 225

**DEC,  
EAT YOUR  
HEART  
OUT.**



For the past few months, DEC has been the biggest name in real-time and disk-based standard operating systems.

But the picnic's over.

Now we've got two new standard hardware/software systems. And both of them have price/performance stories that can beat the socks off DEC's corresponding models.

## **SAVE \$20,000 ON OUR NEW DBOS.**

DEC's disk-based systems will run you about \$60,000.

Our DBOS-II is only \$39,500 and it's superior to any disk-based system on the market.

If we haven't got your attention yet, maybe we should mention that our DBOS-II lets you do more computation with less memory in far less time.

You get faster program generation because we give you both scientific and commercial languages.

While other systems are confined to either interactive or batch operation, DBOS-II offers a combination of both. Plus a comprehensive file management system, text editors, interactive debug routines, mathematical functions and commercial libraries. That explains our faster program implementation.

As for program execution, we do it faster because the heart of our system is the SPC-16/65 minicomputer which has the most powerful instruction set available and therefore requires less memory.

## **AND UP TO \$40,000 ON OUR NEW RTOS.**

If you want to combine your program generation and computation with control of real-time tasks, DEC's RSX-11D will set you back more than \$80,000.

Our new RTOS-II will do the job for \$46,950. And if you don't need a line printer and card reader, we can start you out at \$29,950.

RTOS-II has all the advantages of DBOS-II in background, with a very responsive foreground for handling events that occur in real time.

And compared to DEC's RSX-11D, we pack more power and features in far less memory.

You can tailor our system to fit your application starting with as little as 16K memory, expandable to 128K.

## **NOW IT CAN BE TOLD.**

Some manufacturers go to incredible lengths to protect their juicy trade secrets.

We publish ours.

The reasons we can give you price/performance advantages are all spelled out in "The Value of Power." For a free copy, or for more information on RTOS-II or DBOS-II, write General Automation, 1055 South East Street, Anaheim, Calif. 92805. If you're in a hurry, call (714) 778-4800.

# **GENERAL AUTOMATION**

# Most of your design problems can be solved by an unknown.



Put down your pencil. Give the pocket calculator to your kids. Stop waiting in line at the EDP department.

If you've got problems, we've got a solution. The very first and only programmable hand-held micro computer in the world. The CompuCorp Micro Scientist. The professional's machine.

It thinks the way you think. It does stress analyses. Works design problems. Breezes through drafting calculations. Solves systems headaches. Plucks the best engineering solution out of a dozen possibilities.

The Scientist allows you to have two different 80-step programs in memory at the same time. Which means repetitive calculations are a snap. And you can take it wherever you go because it's battery operable.

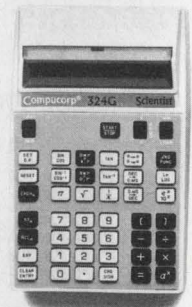
The CompuCorp Scientist is the first hand-held machine with 13-digit accuracy and a big, bright 10-digit display. And it's the first one with an algebraic keyboard and nested parentheses.

It's also the first one with built-in polar to rectangular; rectangular to polar; trig functions;  $\log_{10}$ ;  $\log_e$ ;  $10^x$  and  $e^x$ . It also handles different forms of angle entry.

You can do register arithmetic in and out of ten storage registers. And you can set the decimal point anywhere you want it and change it whenever you want to.

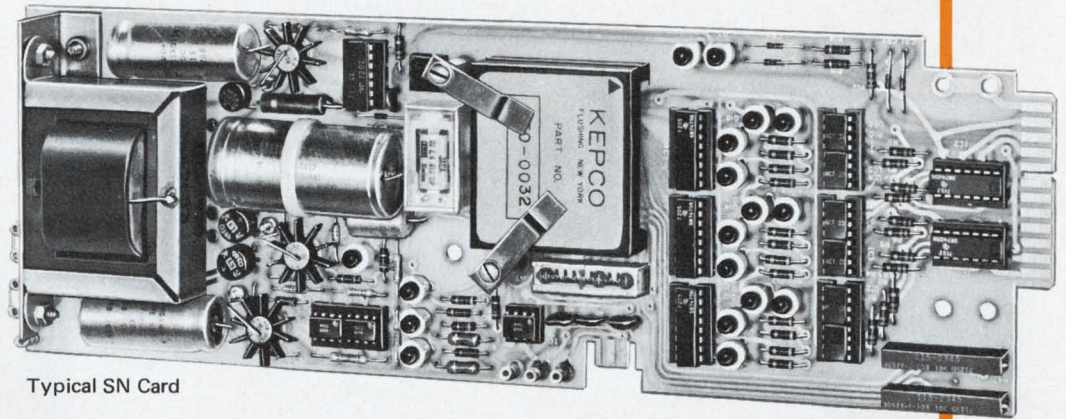
Get all the facts on CompuCorp Micro Computers. We may be an unknown to you, but we're already solving tough problems for thousands of design engineers around the world.

See your local CompuCorp dealer. Or write Computer Design Corporation, 12401 Olympic Boulevard, Los Angeles, California 90064.



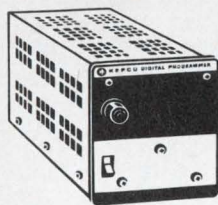
**CompuCorp®**  
**The Unknown Factor in 63 countries.**

INFORMATION RETRIEVAL NUMBER 226



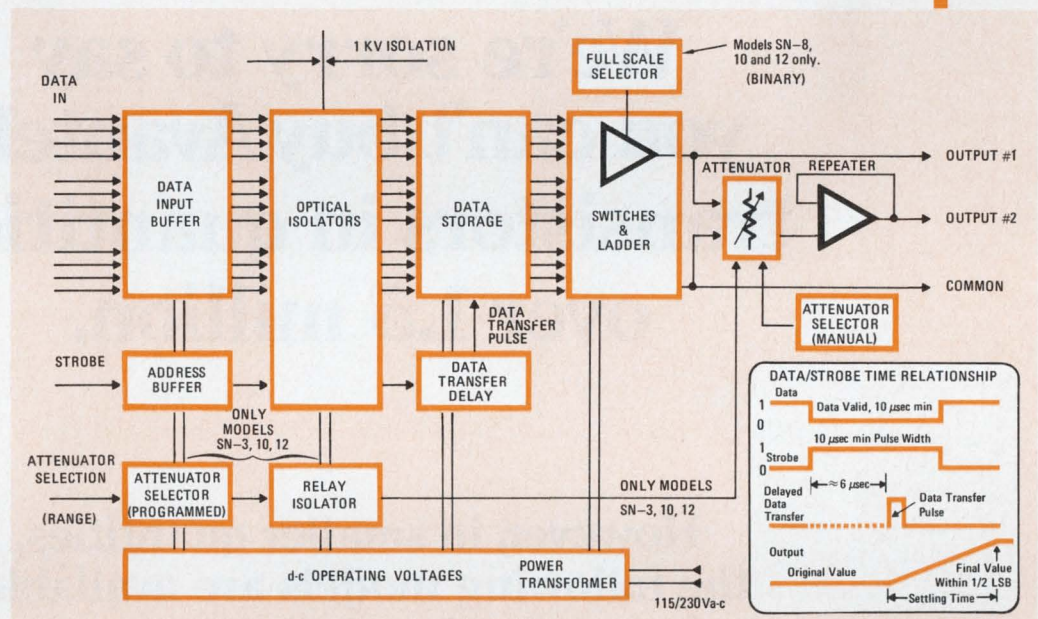
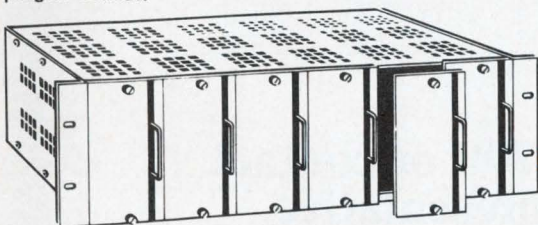
Typical SN Card

The five Kepco SN models offer a selection of DAC's for the digital control of anything that can be programmed by a 10V analog signal. You need no digital experience to use the SN. We've built-in the power—all you need is the 115/230V a-c line. We've built-in the data storage and delayed strobe for glitchless programming. All you need is a 10 microsecond pulse or a switch closure. We've built-in the isolation—so you don't need to worry about grounding. We've built the PC board and a variety of housings—all you need to mount them is a bench top or rack space or a small slot in your equipment.



The CA-6 enclosure accommodates 2 SN Cards.

The SN Cards mount up to 6 abreast in a convenient plug-in format.



SPECIFICATIONS	MODEL SN-2	MODEL SN-3	MODEL SN-8	MODEL SN-10	MODEL SN-12
RESOLUTION	2-Digit	3-Digit	8-Bit	10-Bit	12-Bit
INPUT DATA CODING	COMPLEMENTARY BINARY CODED DECIMAL 4 LINES PER DIGIT 8-4-2-1		BIPOLAR OUTPUT: COMPLEMENTARY OFFSET BINARY UNIPOLAR OUTPUT: COMPLEMENTARY BINARY		
ACCURACY @ 25°C (% OF FULL SCALE READING) SCALE FACTOR ERROR <sup>(1)</sup>	±0.2%	±0.1%	±0.1%	±0.1%	±0.05%
ZERO OFFSET	ZEROING TRIMMER IS BUILT-IN.				
LINEARITY	±0.2%	±0.05%	±0.2%	±0.05%	±0.01%
PRICE	\$336.00	\$484.00	\$336.00	\$426.00	\$519.00

(1) May be calibrated with optional trimmer, Option "R" - Price: \$10.00. Add the option letter as a suffix to the model number.

For complete specifications and applications notes, write Dept. EH- 5

# KEPCO

# We're sorry to say you can't buy Avantek transistors in quantities over 1.5 million.

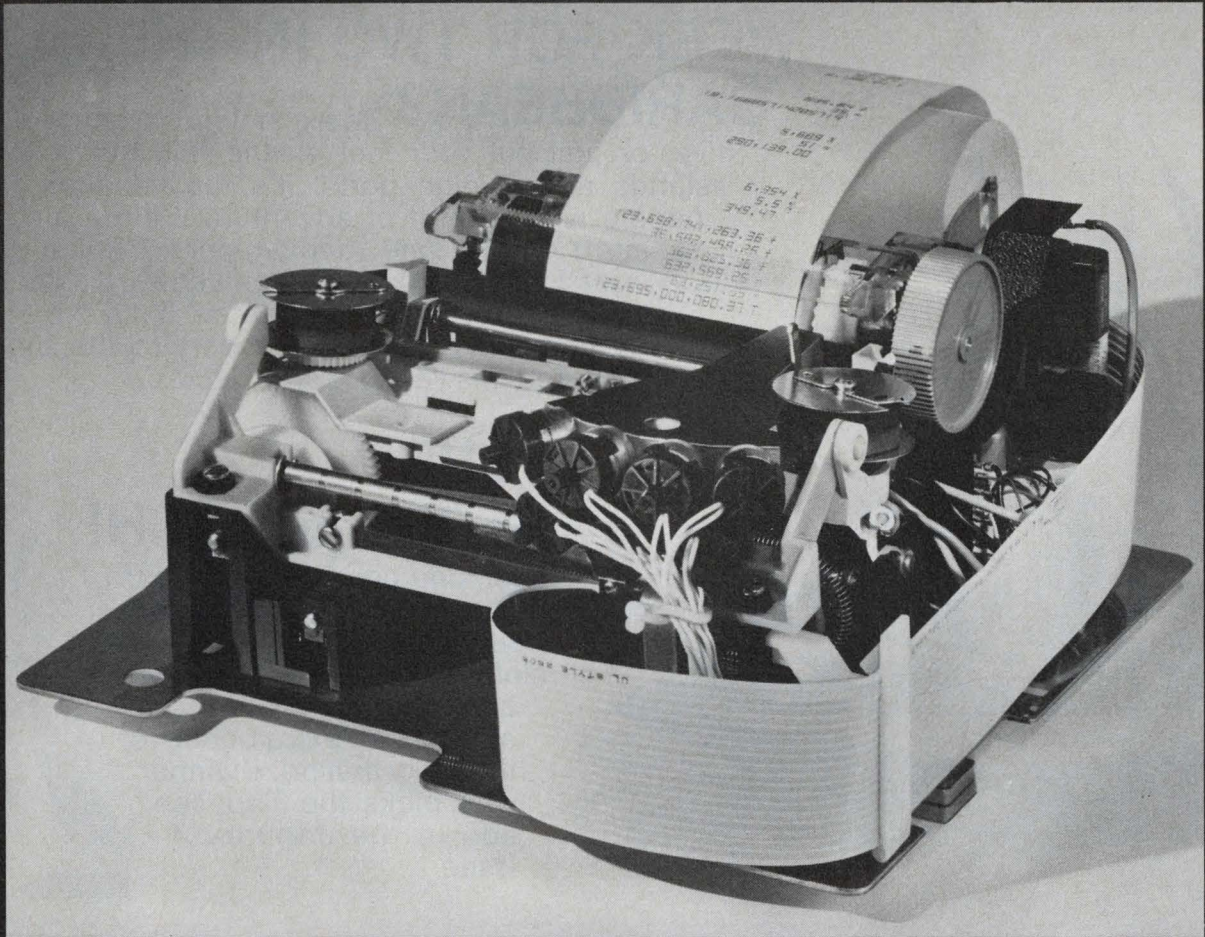
However, in smaller quantities,  
the following models are available  
for fast delivery:

		V <sub>CB</sub> = 10 Volts						
Test Frequency		Noise Figure <sup>1</sup>	G <sub>po</sub> <sup>2</sup>	I <sub>c</sub>	G <sub>max</sub> <sup>1</sup>	I <sub>c</sub>	f <sub>T</sub>	Package
		Maximum (dB)	Typical (dB)	(mA)	Minimum (dB)	(mA)	Typical (GHz)	
<b>VHF Types</b>								
	MHz							
AT-0017	60	1.5	25	5	—	—	3.5	TO-72
AT-0025	500	2.5	11	3	12	10	3.5	TO-72
AT-0025A	500	2.0	12	3	13	10	3.5	TO-72
AT-0045	500	1.5	13	3	14	10	3.5	TO-72
<b>UHF Types</b>								
	GHz							Stripline
AT-1425	1.0	3.0	13	5	14	15	5.0	.140 dia.
AT-1445	1.0	2.5	13	5	14	15	5.0	.140 dia.
AT-1445A	1.0	2.2	15	5	14	15	5.0	.140 dia.
<b>L-Band Types</b>								
	GHz							Stripline
AT-2625	2.0	4.5	8.5	5	9	15	5.0	.070 sq.
AT-2645	2.0	3.5	11	5	12	15	5.5	.070 sq.

<sup>1</sup>Guaranteed at test frequency and bias shown, others typical. All gains unneutralized.

<sup>2</sup>Approximate gain at bias and tuning conditions for noise figure.

**Call Avantek at (408) 249-0700 or contact  
your nearest Avantek representative.**



# Our Supersonic Printer can speed up your next design.

If your next design requires a narrow print-out,  
consider Victor's high-speed matrix printer.

## Why?

Because it's outstandingly reliable. Reliable enough to  
print 35 million characters without periodic maintenance.

Because its 5 x 7 dot matrix head can form alphabetical,  
numeric, and symbolic characters. 34 per line.  
110 per second. In two colors.

Because it's a compact unit—8½" wide, 5" high, 12" long  
—that accepts adding machine tapes up to 3¾" wide.

And because it utilizes all technology and expertise  
that Victor's design engineers and factory personnel  
can build into a machine.

That's why we use it in our own top-line  
electronic calculators. Victor's Supersonic Matrix  
printer. It can speed up your next design.

Victor Comptometer Corporation  
Component Products  
3900 North Rockwell Street  
Chicago, Illinois 60618

Please send me complete specifications  
on the Victor Matrix Printer.  
 Also have a representative call.

Name \_\_\_\_\_

Title \_\_\_\_\_

Firm \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_

Zip \_\_\_\_\_

Phone \_\_\_\_\_

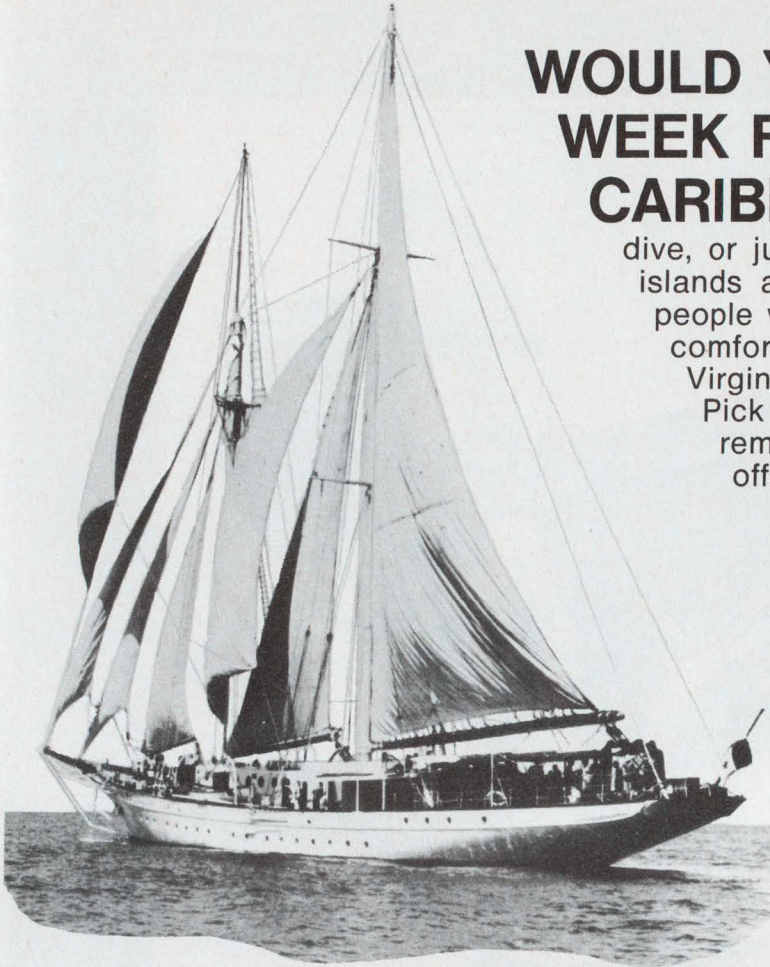
State \_\_\_\_\_

 **VICTOR**

ED

# WOULD YOU LIKE A CAREFREE WEEK FOR TWO IN THE BLUE CARIBBEAN?

Relax or lend a hand, swim, scuba dive, or just put your feet on the rail. Visit exotic tropical islands and foreign ports. It's the vacation for thinking people with a spirit of adventure. Sail in air conditioned comfort on big, safe windjammers. Choice of Bahamas, Virgin Islands, Windward or Leeward islands cruises. Pick your own departure dates. It's a trip you'll always remember. AND it's only part of the big first prize offered this year.



## PLUS: \$1,000 IN CASH!

Everyone can use some extra money—especially on a cruise. Use it for babysitters, tropical clothes, shop the free ports, bank it or spend it. It goes along as an extra bonus to the lucky first prize winner who picks the Top Ten ads in the January 4 issue.



**REPEATING  
BY POPULAR  
DEMAND**

**Electronic**  
**1974 SUPER TOP**

LOOK FOR COMPLETE INFORMATION—LIST OF PRIZES—

## AND: FREE AIR TRANSPORTATION

This really makes the 1st prize complete. Think about it! The cruise . . . the \$1,000 in cash, AND free round-trip tickets for two on



regularly scheduled airlines to the cruise's point of departure. It all adds up to the vacation of a lifetime. AND, **you** can be the lucky winner!

## AND: YOU CAN WIN VALUES UP TO \$4,500—OR MORE— FOR YOUR COMPANY

Another big feature of the Top Ten Contest is the free advertising you can win for your company. Here's what your company can win if it has an ad in the January 4 issue:

**A FREE RERUN . . .** for each of the ads that are voted in the Top Ten by *Electronic Design's* readers.

**A FREE RERUN . . .** if one of your company's engineers wins any one of the first 3 prizes — whether or not your ad placed in the top ten.

**A FREE RERUN . . .** if one of your company's advertising or marketing people, or your advertising agency, wins any of the first 3 prizes.

Suppose you are one of the first three prize winners. If your company has a full page, 2-color ad in the January 4 issue, your company will receive a free rerun worth \$2,375. But suppose it is a 4-color spread. You've just racked up space worth \$4,700 for your top brass.

Be sure to alert your advertising or marketing manager to these possibilities. Urge him to schedule your company's ad in the January 4 issue . . . It's an opportunity no company can afford to miss.

## PLUS 99 OTHER VALUABLE PRIZES

There are two separate Top Ten Contests, one for **Electronic Design's** engineer-readers, and one for advertisers and their advertising agencies.

### PRIZES (Reader Contest)

- 1st Prize: Windjammer cruise for two.  
Air transportation for two.  
\$1,000 cash.  
Free ad rerun.
- 2nd Prize: Portable color TV.  
Free ad rerun.
- 3rd, 4th & 5th Prizes: Bulova timepieces.  
Free ad rerun (3rd Prize only).
- 6th thru 100th Prizes: Technical books.  
(Title to be announced.)

### PRIZES (Advertiser Contest)

- 1st Prize: Windjammer cruise for two.  
Air transportation for two.  
\$1,000 cash.  
Free ad rerun.
- 2nd Prize: Portable color TV.  
Free ad rerun.
- 3rd Prize: Bulova timepiece.  
Free ad rerun.

## NO STRINGS, NO GIMMICKS ... HERE'S ALL YOU HAVE TO DO TO ENTER

- (1) Read the January 4th issue of *Electronic Design* with extra care.
- (2) Select the ten advertisements that you think will be best remembered by your 79,666 fellow engineer readers.
- (3) Identify the advertisements by company name and *Information Retrieval Number* (Reader Service Number) on the entry blanks bound in the issue. Mail before midnight February 15.



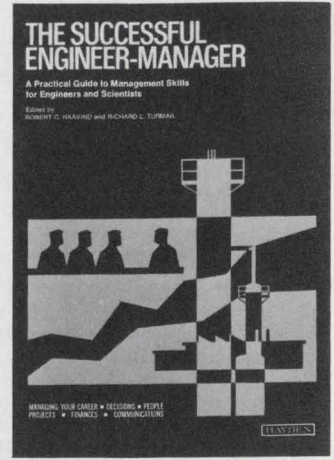
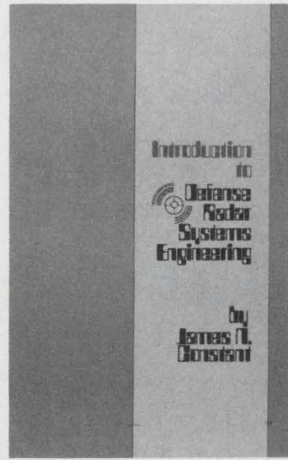
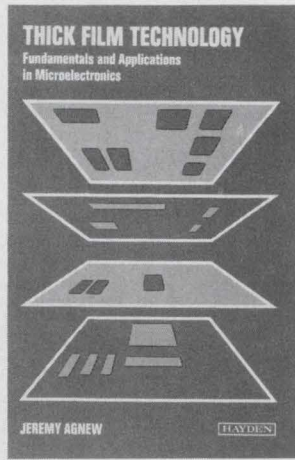
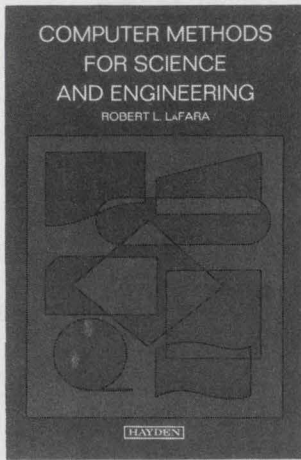
## MARK JANUARY 4 ON YOUR CALENDAR NOW

Try for the Top Ten. Contest judges will compare your selections with "Percent Recall Seen" scores on Reader Recall—*Electronic Design's* method of rating readership. Complete information, rules, and entry blanks will appear in the January 4 issue.

# Design

# TEN CONTEST

RULES — ENTRY BLANKS IN THE JANUARY 4 ISSUE



## 4 GUIDES AND REFERENCES FOR YOUR ON-THE-JOB ENGINEERING NEEDS... AVAILABLE ON 15-DAY EXAMINATION.

### COMPUTER METHODS FOR SCIENCE AND ENGINEERING

By Robert L. LaFara

Offers basic computing methods scientists and engineers need to solve many numerical problems. Features clear-cut methods for problem organization and flowcharting with practical applica-

tions; unique chapters on smoothing of experimental data; and FORTRAN techniques for iterative solutions of equations. 336 pp., #5766-0, cloth, \$12.95.

### THICK FILM TECHNOLOGY: Fundamentals and Applications in Microelectronics

By Jeremy Agnew

A complete, working guide on thick film principles, techniques and applications. Details processing phases, describes what to do and what pitfalls to avoid. Includes techniques for using various "add-on" components and outlines methods of attaching

active and passive devices and wires. Covers packaging methods and processing hazards and precautions. 176 pp., #5803-9, cloth, \$20.00.

### INTRODUCTION TO DEFENSE RADAR SYSTEMS ENGINEERING

By James N. Constant

Comprehensive, logical coverage of the techniques, tools and analytical procedures radar systems engineers need to develop optimized systems for particular environments and users. Covers

everything from fundamental equations to a step-by-step development of a system for a given application. 176 pp., #9194, cloth, \$8.50.

### THE SUCCESSFUL ENGINEER-MANAGER

Edited by Robert C. Haavind

A "variety pack" of valuable advice carefully selected from articles which various experts prepared for *Electronic Design*. A logically ordered success course covering six crucial phases in

managing: career, decisions, people, projects, finances, and communications. 176 pp., #5879-9, cloth, \$8.95.



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Please send the book(s) checked on 15-day free examination. At the end of that time, I will remit payment plus postage, or return the book(s) with no further obligation.

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**\$10.00 minimum for free exam orders.**

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**Save Money!** On all prepaid orders Hayden pays postage — same return privilege.

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ISBN Prefix 0-8104

73-65a



# new, pocket-size Tri-Phasic<sup>TM</sup> multimeter



**MODEL 245, ACTUAL SIZE**

# Try It

**\$295.00**  
COMPLETE

You can't match Data Precision's Model 245 for price/performance, size, reliability and usability.

**PERFORMANCE:** .005% RESOLUTION, .05% BASIC ACCURACY FOR 6 MONTHS, MEASURES ACV, DCV, DC AND AC CURRENT, AND RESISTANCE WITH 100% OVERRANGING.

*DC Volts*, 1 volt to 1000 volts full scale, 100  $\mu$ V resolution.

*AC Volts*, 1 volt to 500 volts RMS full scale, 100  $\mu$ V resolution, 30HZ-50KHZ.

*DC Current*, 1 ma to 1A f.s., 1  $\mu$ A resolution.

*AC Current*, 1 ma to 1A f.s., 1  $\mu$ A resolution, 30HZ-50KHZ.

*Resistance*, 1 K $\Omega$ -10M $\Omega$  full scale, 100 milliohms resolution.

Calibration guaranteed 6 months minimum.

**PRICE:** \$295 COMPLETE

Includes rechargeable battery module, line cord/recharger, fused input probes, carrying case and strap, complete software and test documentation, full Data Precision calibration Instruction Manual and separate Operator's Manual, and one year warranty.

**RELIABILITY:**


Proven LSI P-MOS and C-MOS Components plus our improved autozeroing Tri-Phasic<sup>TM</sup> conversion, Isopolar<sup>TM</sup> reference, Ratiohm<sup>TM</sup> resistance provide reliability normally found in instruments costing 3 to 4 times as much.

**USABILITY:** IDEAL FOR LAB, PRODUCTION OR FIELD USE. Truly portable, pocket size 1 $\frac{3}{4}$ " x 3 $\frac{1}{2}$ " x 5 $\frac{1}{2}$ " packaged in a rugged impact resistant case, rechargeable 6 hour battery for in-spec operation and line recharge.

To get your hands on this remarkable instrument, phone your local sales representative.

AL	(205)536-1941	GA	(404)252-5360	NJ	(215)925-8711
AZ	(602)946-7252	IL	(312)593-0282	NM	(505)265-6471
CA/S	(714)540-7160	IN	(317)293-9827	NY/W	(315)446-0220
CA/W	(415)321-7323	MA	(617)273-0198	NY/S	(516)482-3500
CO	(303)449-5294	MD	(301)552-2200	OH/W	(216)243-7430
CT	(203)527-1245	MI	(313)482-1229	OH/S	(513)298-3033
FL/S	(305)581-6611	MN	(612)781-1611	OR	(503)238-0001
FL/E	(305)622-6850	MO/W	(913)236-6600	TX/W	(214)234-4137
FL/W	(813)726-2373	MO/E	(314)731-2331	TX/S	(713)461-4487
FL/N	(305)727-3205	NC	(919)275-3725	WA	(206)763-2210

Data Precision Corporation  
Audubon Road Wakefield, MA 01880  
(617) 246-1600

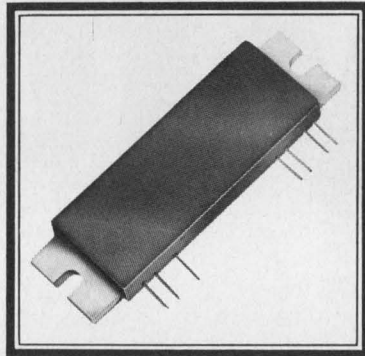
 **DATA PRECISION**  
...years ahead

# Available! RCA UHF Power Amplifier Modules... in production quantities.

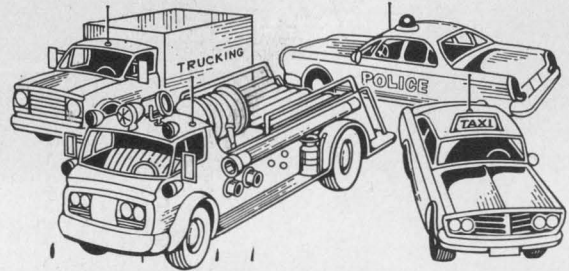
RCA Solid State invites you to meet its broad family of UHF Power Amplifier Modules. This complete line covers the 395 MHz to 512 MHz band with three different power levels of 10, 13, and 15 watts.

Consider the economical and technical advantages of IC power modules. They're ready for instant use ... designed, developed, pre-tuned and tested ... ready to plug them into your system.

RCA UHF Power Amplifier Modules incorporate a reliable thin-film technology. And they are designed to meet stringent reliability specs. All modules feature 50-ohm input and output impedance, infinite load-VSWR



and compact size for high density packaging. Take a look



at the variety of modules available to you.

And best of all they are available now ... in volume production quantities — at very attractive prices.

So if you have a need for high performance, broad bandwidth UHF Power Modules, come to RCA Solid State — the home of the RF Performance Expanders.

Want more information? Write: RCA Solid State, Section 57L-6 Box 3200, Somerville, N.J. 08876. Or phone: (201) 722-3200.

CHARACTERISTICS	R44M10	R44M13	R44M15	R47M10	R47M13	R47M15	R51M10	R51M12
Frequency Range (MHz)	395-440	395-440	395-440	440-470	440-470	440-470	470-512	470-512
Power Output, Min. (W)	10	13	15	10	13	15	10	12
Supply Voltage, Nom.	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Power Gain, Min. (dB)	20	20	20	20	20	20	20	20
Overall Efficiency, Min. (%)	35	35	35	35	35	35	35	35

RCA Solid State family of UHF Power Modules

**RCA** Solid State  
products that make products pay off

**ACROSS THE DESK**  
(continued from page 3)

TTL (maximum  $V_L = 0.8$  V), the fanout must be limited to driving nine gates.

Marc Brown  
Co-op Engineer

The Warner & Swasey Research Center  
Servo Dept.  
28999 Aurora Rd.  
Solon, Ohio 44139

**Signetics replies**

Casual perusal of a data sheet has led more than one engineer down the garden path. The statement that the Signetics 555 timer is TTL-compatible and can sink 200 mA is correct. It is in no way implied that both of these above criteria are met simultaneously. To the contrary, the data sheet contains three sets of curves—"Low Output Voltage vs. Output Sink Current" for three supply voltages ( $V_{cc} = 5$  V, 10 V and 15 V)—which show that both criteria are not met simultaneously. From these curves, it becomes apparent that with  $V_{cc}$  at 15 V, the sink current capability of the device is far greater than that of the same device with 5-V supply. Mr. Brown's contention that for TTL-compatibility the fanout must be limited to driving nine gates is absolutely correct. Only at a supply voltage of 15 V is the device rated to sink or source 200 mA.

George W. Opalinsky  
Linear Applications

Signetics  
811 E. Arques Ave.  
Sunnyvale, Calif. 94086

**... What pornography?**

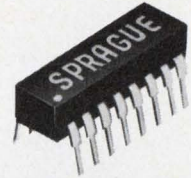
What's with all this pornographic ad stuff? I've looked over several of your back issues and haven't found a thing the kids shouldn't see. Apparently I've been missing some good stuff. Please mail all your recent pornography as soon as possible. Plain brown envelope, please.

Donald Loundy

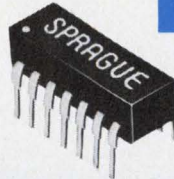
Mica Corp.  
Box 2578  
Culver City, Calif. 90230

**Higher component density...**

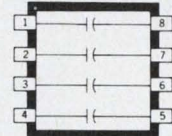
**Lower insertion costs... with**



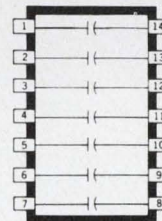
**MULTI-COMP<sup>®</sup> DIP MONOLYTHIC<sup>®</sup> CERAMIC CAPACITORS**



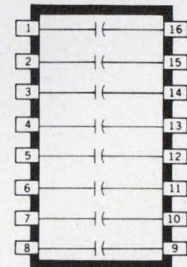
**STANDARDIZED DESIGN\* FOR BETTER AVAILABILITY, BETTER PRICES**



**TYPE 939C**  
(4 capacitor sections)



**TYPE 934C**  
(7 capacitor sections)



**TYPE 936C**  
(8 capacitor sections)

Compatible with ICs and other standard DIP devices. Especially useful for noise bypassing and signal coupling in high-frequency signal or data processing systems. Molded package provides mechanical protection and reliability under severe environmental conditions. Monolithic<sup>®</sup> construction . . . alternate layers of ceramic dielectric material and metallic electrodes are fired into an almost indestructible homogeneous block. Standard ratings, 18 pF to 0.1  $\mu$ F @ 100 WVDC. Temperature range, -55 C to +70C.

\*Other circuit configurations (including internally-paralleled capacitor sections, commoned capacitor leads, and various ratings within single package) are available on special order.

**Sprague puts more passive component families into dual in-line packages than any other manufacturer:**

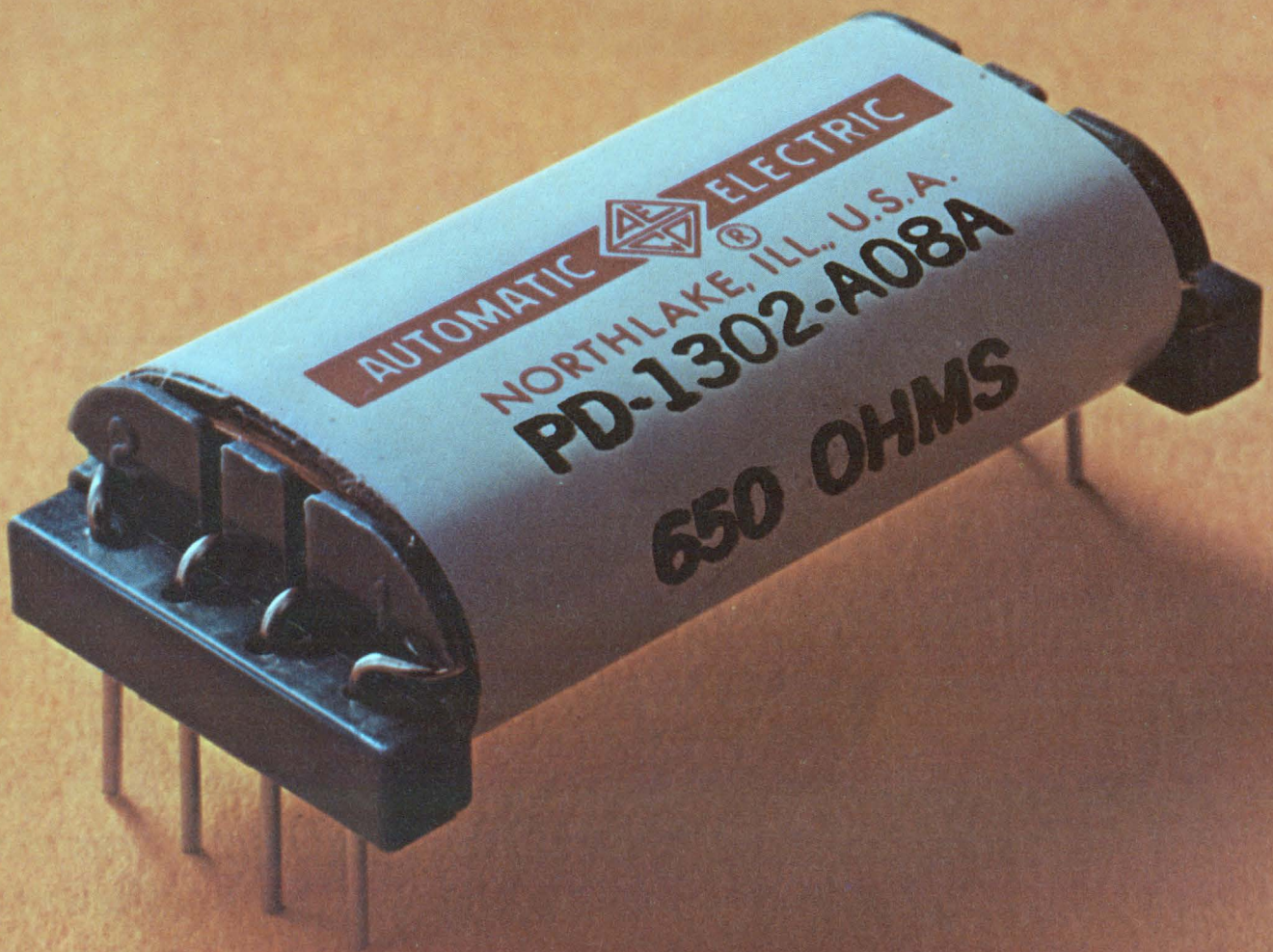
- TANTALUM CAPACITORS
- CERAMIC CAPACITORS
- TANTALUM-CERAMIC NETWORKS
- RESISTOR-CAPACITOR NETWORKS
- PULSE TRANSFORMERS
- TOROIDAL INDUCTORS
- HYBRID CIRCUITS
- TAPPED DELAY LINES
- SPECIAL COMPONENT COMBINATIONS
- THICK-FILM RESISTOR NETWORKS
- THIN-FILM RESISTOR NETWORKS
- ION-IMPLANTED RESISTOR NETWORKS

For more information on Sprague DIP components, write or call Ed Geissler, Manager, Specialty Components Marketing, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247. Tel. 413/664-4411.

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS



**Everyone talks  
correed reliability,**



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INFORMATION RETRIEVAL NUMBER 8



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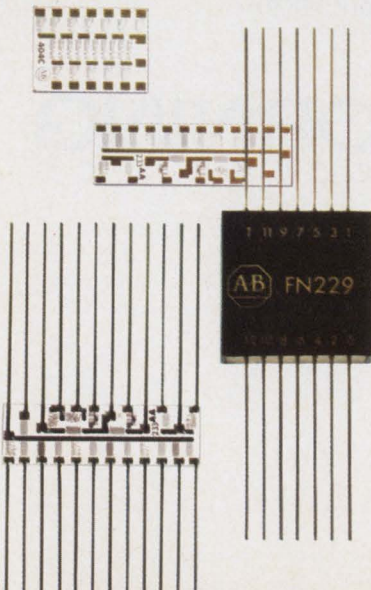
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## An insulin 'pacemaker' for diabetics sought

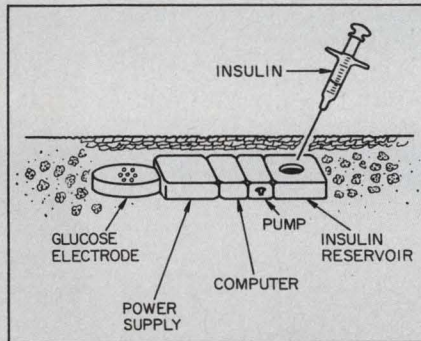
An implantable device to help diabetics the way pacemakers aid heart patients is under development by a team of three doctors in the Boston area.

What the device would do is to provide a substitute for a diabetic's malfunctioning beta cells in the pancreas. In a normal person these cells constantly monitor the amount of glucose the body is manufacturing and injecting into the blood stream and—when the level rises too high or falls too low—the cells inject insulin into the blood to get the level back to normal.

The implantable device eventually is to consist of a miniature glucose sensor, a power supply, computer, insulin reservoir and pump. Thus far the research team has developed an implantable glucose monitor that provides a warning of low or high glucose levels by means of a tiny, implanted radio transmitter. The monitor has been tested successfully in animals. If implanted in a human, the monitor would warn the patient to alter this pattern of hypodermic injection of insulin.

The research team, working at the Space Sciences Div. of Whitaker Corp. in Waltham, Mass., hopes ultimately to develop a device that will go all the way: a totally implantable setup that would not only monitor the glucose level but would automatically dispense insulin when needed.

Finding a device to measure glucose in the laboratory was no problem. But developing one small enough to implant in human tissue called for ingenuity. The researchers found that under certain conditions—and in the presence of certain catalysts—glucose could be converted into gluconic acid and that an electric current was generated in this process. It was decided to capitalize on this oxida-



**Implanted glucose electrode** measures the body's blood glucose moment by moment and—on command of a computer—pumps the correct amount of insulin from a silicon rubber receptacle, implanted just beneath the skin. The receptacle is refilled once a week by injection.

tive reaction, which could be measured by a sensor small enough to be implanted.

The experimental device consists essentially of two platinum electrodes—a fuel anode and an oxygen cathode—both of which are in compartments surrounded by semipermeable membranes and separated by an ion-exchange membrane. The platinum catalyzes the conversion of glucose to gluconic acid and thereby generates a small electric current. The special semipermeable membranes assure that the reaction rate is a function of glucose concentration in the surrounding fluid or tissue.

This glucose sensor has been implanted in monkeys, dogs and rabbits with successful recording of body-tissue glucose levels for as long as 117 days, the researchers say. Current efforts are focused on the design and testing of a totally implantable sensor served by a telemetry system for long-term studies in animals.

Dr. K. W. Chang, project manager of the effort, notes that the power supply of the device is now

a mercury battery but will eventually be either nuclear or a battery that can be recharged by rf energy through the tissue. The computer will be "an operational amplifier or some other such logic," Dr. Chang says, and the insulin reservoir will probably be made from silicon rubber. Once a week the patient would be able, by hypodermic injection, to refill the reservoir, which would be just beneath the skin in the abdomen.

## Next: A programmable HP pocket calculator

A pocket-sized programmable calculator that contains a magnetic card reader is under development at Hewlett-Packard and may be placed on the market in about six months.

The new calculator, expected to be called the HP-65, is said to contain a random-access memory and to be programmed by magnetic cards about the size of chewing-gum sticks. Peter Nelson, sales promotion manager for HP's Advanced Products Div. in Cupertino, Calif., while declining to give details, confirms that HP is working on a portable programmable calculator and that it will be available in about six months.

The HP-65 is expected to be the same size as the company's other scientific calculators—the HP-35 and the HP-45. Prototypes of the HP-65 have been seen at the company's Cupertino plant, and reports are that the calculator may sell for about \$500.

While the new calculator will be programmable, it is not expected to be capable of originating programs. Instead, preprogrammed cards of basic applications would be made available by HP either free or at nominal cost. Later HP may offer separate programmers.

## Superconducting magnet yields 165,000 oersteds

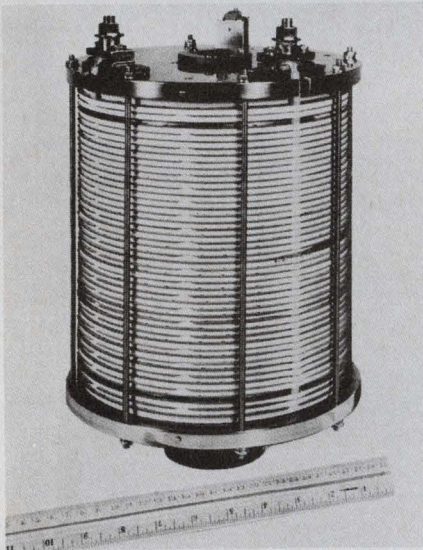
A new superconducting magnet, described as the most powerful ever produced, could help make nuclear-fusion power generation a reality one day, according to its developer.

Paul Swartz, vice president of

the company that built the magnet, Intermagnetics General Corp. of Guilderland, N.Y., says the new device is made from a niobium-tin alloy. Its volume is about 1 cu. ft. and it operates at  $-452$  F. It produces a magnetic field of 165,000 oersteds.

In explaining the role of a superconducting magnet in a nuclear reactor, Swartz notes that fusion would take place at a temperature of several million degrees. Since no material can withstand such high temperature, he says, about the only way to confine and shape the hot gases within the reactor is to use ultra-intense magnetic fields of about 100,000 to 200,000 oersteds.

Such fields could be produced by copper electromagnets Swartz agrees, but reactors that use these magnets would consume 5 mW—



**'Strongest' superconducting magnet** built so far produces a magnetic field of 165,000 oersteds.

more power than they would generate.

With superconducting magnets—like the one from Intermagnetics General—the same magnetic field can be produced with an input power of only 20 to 30 W. Unlike conventional electromagnets, the superconducting magnets do not dissipate energy, and when a superconducting magnet de-energizes, the same 20 to 30 W that was put into it initially is returned to the power source.

This phenomenon, Swartz says, provides another possible solution to the energy crisis. If the energy

of the sun could be converted efficiently into electricity, part of the power produced during the daytime could be used to energize large superconducting magnets, which would store the energy until evening. At that point the superconducting magnets would be de-energized, and the power stored in them could be used. Both the National Science Foundation and the Atomic Energy Commission have groups studying the possibility of use of such magnets to store power, Swartz says.

## Unmanned observatory would detect A-blasts

A concept for an advanced unmanned seismic observatory that would record and relay data on underground nuclear blasts has been studied and found feasible. The observatory could be used in the event an international test-ban treaty were signed. Installed in countries that were party to the treaty, it would be capable of five years of unattended, tamper-protected operation.

Tests on the concept were made at Sandia Laboratories in Albuquerque, N.M., for the U.S. Arms Control and Disarmament Agency.

The advanced seismic observatory, which would transmit via satellite, would be a successor to an earlier version developed for the Defense Dept.'s Advanced Research Projects Agency in 1966. That unit was capable of unattended operation for 120 days, at which time the magnetic tapes for data storing were collected and new tapes installed.

The advanced unit would consist basically of a package placed underground at a depth of 1500 to 2000 feet via a six-inch-diameter borehole. The package would be connected by cable to a surface system that would include power supplies, data storage and playback equipment, a data transmitter, command receiver and antenna.

The borehole package would contain three newly developed broadband seismic instruments in an orthogonal configuration (N-S, E-W, vertical). These instruments—either force-balance or quartz-fiber torsional accelerometers—would be capable of detecting earth-motion waves with periods

varying from 0.1 to more than 40 seconds.

Data from the seismometers would be digitized and fed into an authentication encoder within the borehole package. The data would then be stored on magnetic tape for later transmission. Data could be transmitted through regular commercial-satellite channels.

## IBM trying new way to build X-ray laser

The latest entry into the race to produce an X-ray laser is IBM's Thomas J. Watson Research Laboratories, Yorktown Heights, N.Y.

Using what he calls an "inner shell vacancy production mechanism," Richard McCorkle, a research physicist for IBM, hopes to produce an X-ray laser more easily than with laser-produced plasma systems.

McCorkle bombards a target with ions. If the atoms of the targets and ions have the same energy levels, electrons in these levels are rearranged during the collision process and some are released. Holes are thereby created in the atoms, ions or both.

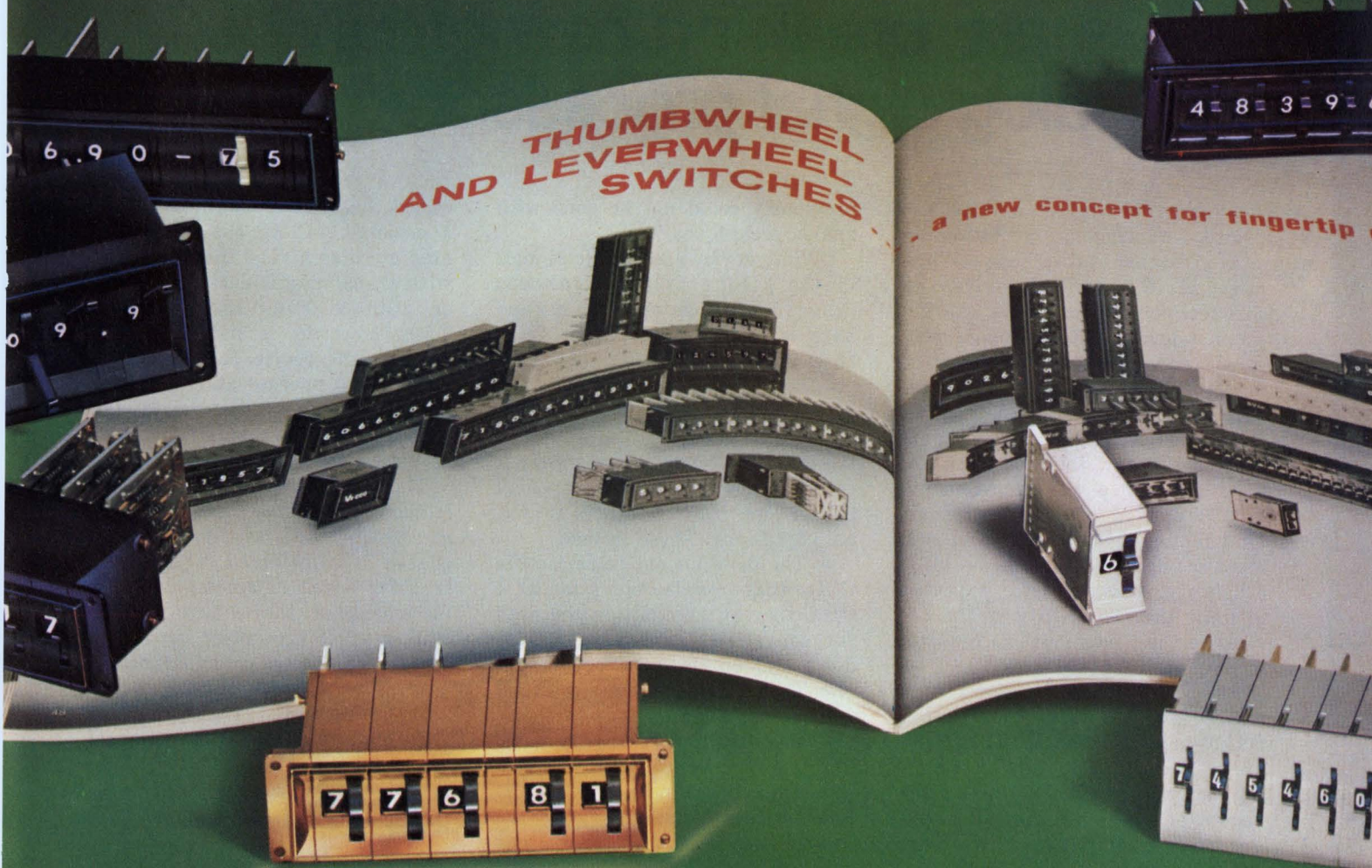
If a hole is in the inner shell of the atomic structure, McCorkle continues, an electron inversion (electrons jumping from outer shells to inner ones) is produced and X-rays are emitted.

The major problem, the researcher reports, is that it is not yet clear whether the inversion produced by this technique is sufficient to cause laser action.

The technique differs from plasma techniques in that selective holes are produced in the atoms and these holes are de-energized when the electrons jump down from the outer to the inner shells; in the plasma method the electrons are forced to a higher, excited state and then dropped down to a lower level, with X-rays emitted in the process.

A major advantage of the inner-shell vacancy mechanism, McCorkle says, is that very fast rise-time pulses are not needed. Other X-ray laser approaches require pulses with a rise time on the order of  $10^{-14}$  sec. The new approach can use pulses with a rise time of only  $10^{-8}$  sec.

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# CCDs are breaking new ground as analog signal processors

Charge-transfer devices are quietly starting a revolution in analog signal processing. While most of the publicity given to this technology centers on charge-coupled-device (CCD) image sensors, companies like Texas Instruments, Westinghouse, General Electric and TRW are developing charge-coupled-device analog signal processors that, they say, can reduce cost and power requirements of current processing equipment by a factor of between 10 and 100. Most companies that have CCD capability, however, are expected to limit the availability of the devices to their own systems requirements.

The reason that charge-transfer devices—which include CCDs and bucket-brigade devices (BBDs)—are so popular for signal processing, says Marvin H. White, an advisory engineer in the Advanced Technology Laboratory at Westinghouse Electric Corp., Baltimore, Md., is that they can do jobs that

previously could not be done with analog techniques.

“What device can handle signals in the kilohertz-to-megahertz range, delay them up to 50 ms and have low loss? White asks, CCD, he concludes.

## Many advances made

Although it was introduced but three years ago, CCD technology has yielded many advances in signal processing. These include:

- The development of peristaltic CCDs that promise operation at 1 GHz, thereby eliminating the need for converting microwave signals down and up.

- The fabrication of practical transversal filters.

- The design of reprogrammable filters and cross-correlators.

- The development of CCD Fourier transformers.

Until recently the upper limit of operation for CCDs was generally considered to be 10 MHz. But with the announcement of a new device by L. J. M. Esser of Philips Research Laboratories in the Netherlands, this record, like so many

others, has fallen. The new device, a peristaltic CCD, has been operated at rates higher than 100 MHz with transfer efficiencies of greater than 99.99%, Esser reports. That, however, is not the upper limit of the device, he says; it is expected to operate at frequencies up to 1 GHz. This would put CCDs in direct competition with acoustic-wave devices.

The higher speed, Esser says, is achieved by increasing the speed at which the last fraction of charge is transferred. The rise in transfer speed is accomplished by placement of the charge a substantial distance away from the surface of the semiconductor (see box). The transfer of charge can also be increased if the charge fractions are subjected to external drive fields.

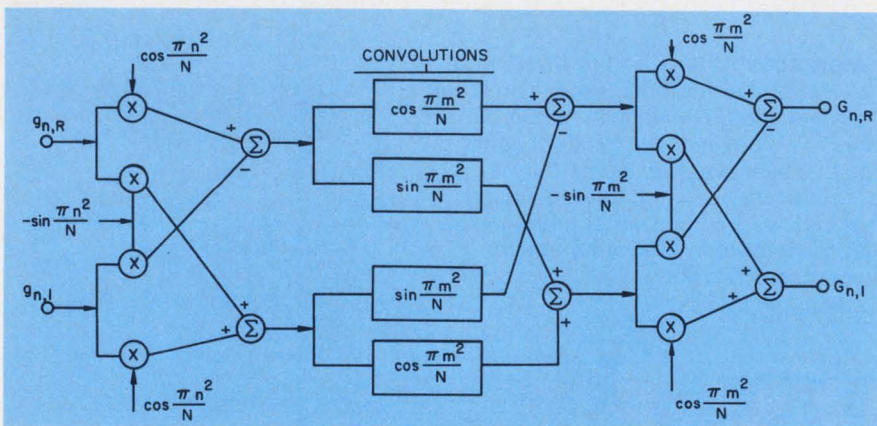
## Data converters not needed

In addition to improvements in the basic technology, progress is being made in the applications of CCDs.

Before the advent of CCDs, the processing of an analog signal often required passage of the signal through an analog-to-digital converter, digital processing and then reconstruction of the signal by passage through a digital-to-analog converter. This is not really a good way to process signals because the converters are usually very expensive compared with the rest of the circuitry.

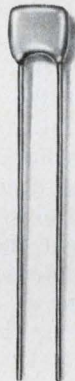
The CCD, however, eliminates the need for converters. It is an analog-sampled data delay line and, as such, is well suited for analog signal processing. The delay of a CCD can be varied by a simple change in the clock frequency. Increasing the clock frequency decreases the delay, and

**Jules H. Gilder**  
Associate Editor



The discrete Fourier transform is performed by two bucket-brigade chips that contain four convolution filters. This system was designed by TI.

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vice versa. CCDs can also be tapped easily, are distortionless and are very compact.

### CCDs make good filters

Dennis D. Buss, a member of the technical staff at the Texas Instruments Research and Development Center, Dallas, notes that the basic building block used in most CCD signal-processing applications is the transversal filter. Analog data are entered into a CCD delay line, the length of which corresponds to half the period of the frequency to be rejected. The delayed signal is then

added to the original signal, and a destructive interference results. This is a notch, or single-frequency elimination filter. By putting taps on the delay line at various points and feeding forward and back, Buss continues, the designer can form filters with low-pass, high-pass or bandpass characteristics.

Westinghouse's White notes that the taps can be weighted with either fixed or variable weights. They can also be digital—positive or negative—or analog, so that any fraction of the signal can be tapped off.

The digital taps, called pn (for

positive-negative) sequences, are used in matched filtering or code generation, White explains. The analog weighting is used, among other things, to perform correlation, which makes it easier to pick a signal out of noise.

White is going one step beyond the standard weighting of taps and is fabricating a transversal filter that has reprogrammable tap weights. The reprogrammable capability, he explains, is achieved by use of MNOS memory cells, and the tap weight is changed by simple variation of the threshold voltage of the MNOS transistor in these cells.

## Peristaltic CCD operation: It's different

The peristaltic CCD differs from the two other types of CCDs in general use—surface-channel and buried-channel devices.

In the surface channel device (a), charge is placed near the silicon/silicon-dioxide interface. This charge is called

a minority charge. If the substrate is made from a p-type material, the charges are electrons, or n-type. The charges are clocked from one well to the next by application of alternating voltages to the electrodes on the surface. One problem with these devices is that some of the charge gets trapped near the silicon/silicon-dioxide interface and efficiency is reduced.

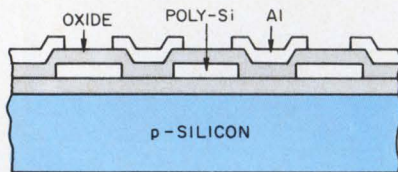
The buried-channel device (b) attempts to overcome loss of charge near the interface. It has an implanted layer, of the same type as the minority carriers, in the silicon—if the silicon is p-type, the implant is n-type. The implant is lightly doped, and the minority carriers are positioned halfway through that region. Thus the charge well has been transferred away from the silicon/silicon-dioxide interface and the losses

have been reduced.

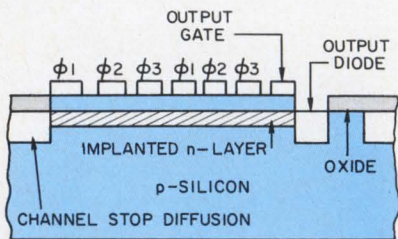
The peristaltic CCD (c) differs in that it has a 4- $\mu$ , n-type epitaxial layer on top of the p-type substrate. A p<sup>+</sup> diffusion is used to isolate a certain region of the epitaxial layer so that an n pocket is formed. N<sup>+</sup> source and drain regions are formed at opposite ends of the n pocket, and an electrode is put between the source and the drain, just as in a regular CCD.

When an electrode is pulsed negatively, electrons that are already in the region are pushed out, so that there is nothing but space charge in the device. Electrons are introduced from the source when information is entered. Instead of going up to the surface, the electrons go only about half way up into the epitaxial layer—2  $\mu$ —and thus they are positioned in a potential well that is away from the surface.

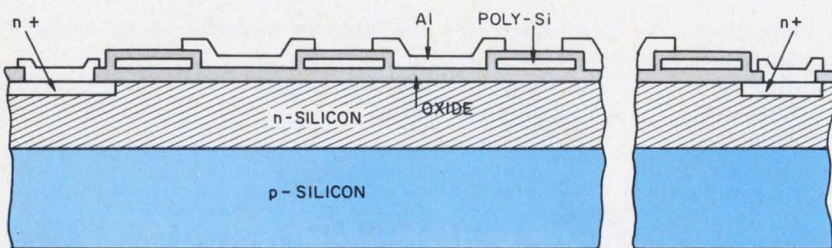
Although this device sounds like a buried-channel device, it isn't. The basic concept is different. There are no minority carriers moving in a buried channel. These carriers are injected from the source and are trapped by space-charge regions on all sides.



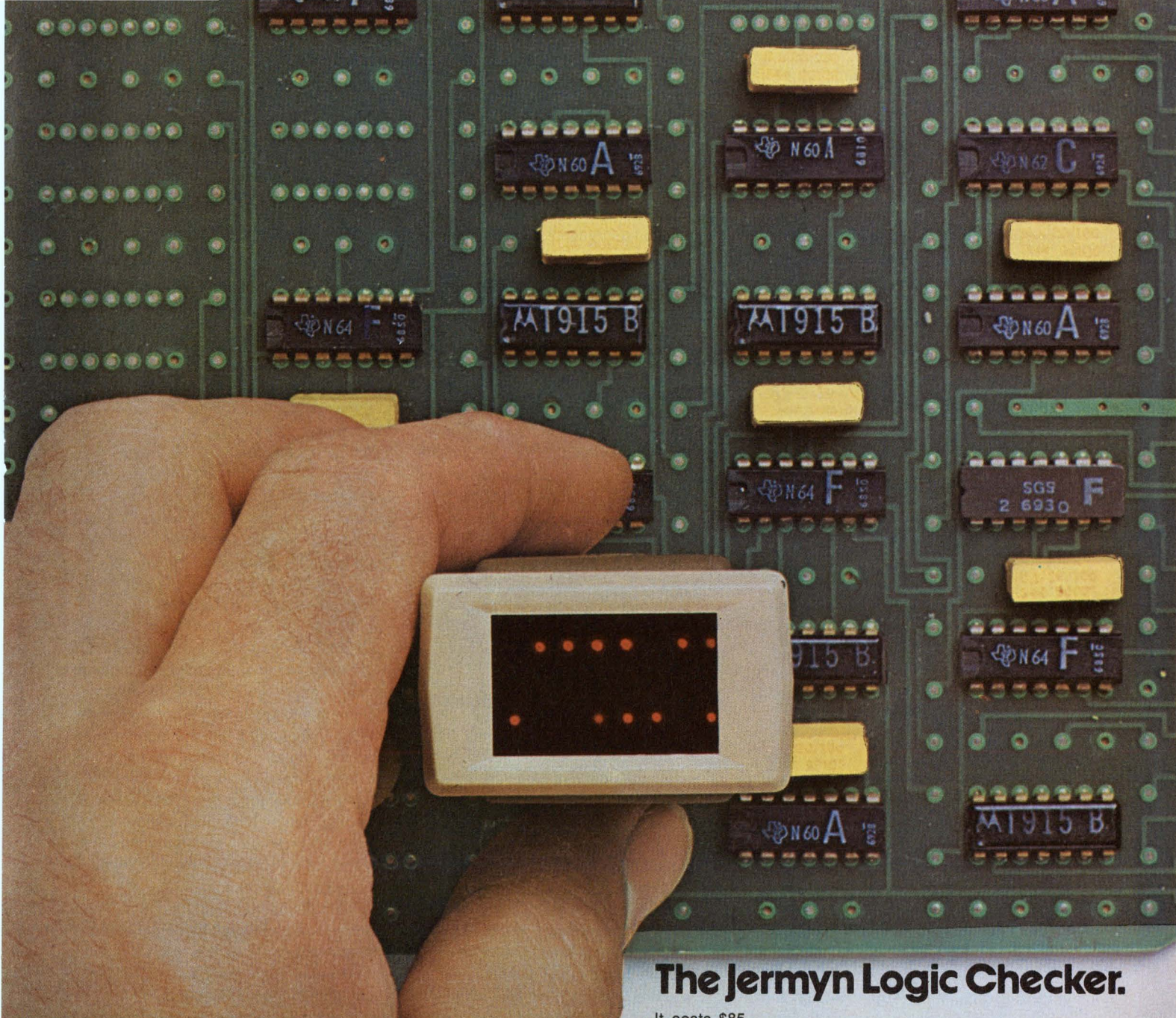
(a)



(b)



(c)



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By reprogramming the tap weights, White goes on, the designer can make an adaptive system that continually updates itself. In such a system the parameters of a particular signal-processing function are chosen on the basis of outputs from previous processes.

An adaptive system could find widespread use in modems to adjust for the changing characteristics of a telephone channel. It could also be used in voice recognition and remote intrusion detection.

### All-purpose processor developed

Another advance in CCDs is a general-purpose signal-processing element from General Electric, known as a cross-correlator. According to Jerry Tiemann, developer of the new device at the GE Research and Development Center in Schenectady, N.Y., it is similar to the Westinghouse unit in that it is programmable. It differs from that device, however, in that it does not use MNOS memory cells to store the tap-weight data. Rather it uses a second input signal to provide this information. The use of this input signal, Tiemann says, means that the correlator can be programmed in real time.

The big advantage of the cross-correlator, he explains, is that it can implement all possible transversal filters. And since the transversal filter can accomplish any linear process, the new GE device is capable of implementing all linear functions. "Thus, we can use

one set of hardware to construct any filter," Tiemann says.

Major areas of application for the cross-correlator, the researcher reports, are in multiplexed systems, secure systems and adaptive systems.

In the multiplexed, programmability cuts system cost. With a programmable element, only one piece of hardware is needed to perform an entire repertoire of processing functions on many different input signals. In some cases the tap-weight functions can be computed from data, and in others individual functions may be stored in a read-only memory. Either way, the cost of computation or storage of the tap weights will be less than the cost of separate transversal filters.

In secure systems, the cross-correlator can change codes quickly and automatically.

### CCDs perform Fourier transforms

Real-time Fourier transforms, previously done with digital techniques, are now being done with charge-transfer devices. Work by Buss at Texas Instruments has resulted in two bucket-brigade chips that perform the discrete Fourier transform with use of what is called the chirp-Z transform. Current Fourier transformers are bulky and require much power and space.

Although originally conceived of as an algorithm for the discrete Fourier transform on a digital computer, the chirp-Z transform never gained wide acceptance because of the popularity of the fast-

Fourier transform. The chirp-Z is ideal for charge-transfer devices, however, because it allows all of the processing to be done in analog format.

In operation, the transformer requires premultiplication of the time signal, convolution and post-multiplication—all by a complex FM chirp. These operations are performed in real arithmetic by four convolution filters operating in parallel (see diagram).

While the present two-chip device operates with only 100 points, Buss notes that it's possible to make Fourier transformers that can handle up to 1000 points. The limiting factor beyond that, he continues, is charge-transfer efficiency. If that increases, so will the number of points a Fourier transformer can handle.

While CCDs are making big strides in signal processing, the average engineer probably won't see them for another few years. The reason, says Westinghouse's White, is that manufacturers want to use them in their own systems to get the competitive edge. CCD IC business may be worth \$10-million a year to manufacturers, but systems using the devices are worth \$300-million to \$500-million annually.

TI's Buss agrees. CCDs will appear in equipment before the average engineer can get hold of them.

Where can you get a CCD if you really must have it? The only answer CCD researchers suggest is to go to a small MOS manufacturer and try to get him to make the parts for you. ■■

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## RCA achieves mass holography in iron-doped lithium niobate

A dramatic advance that makes possible volume holography—the storage of hundreds of permanent holograms in a small electro-optic crystal—has been achieved through use of a new technique that fixes holograms within a crystal of iron-

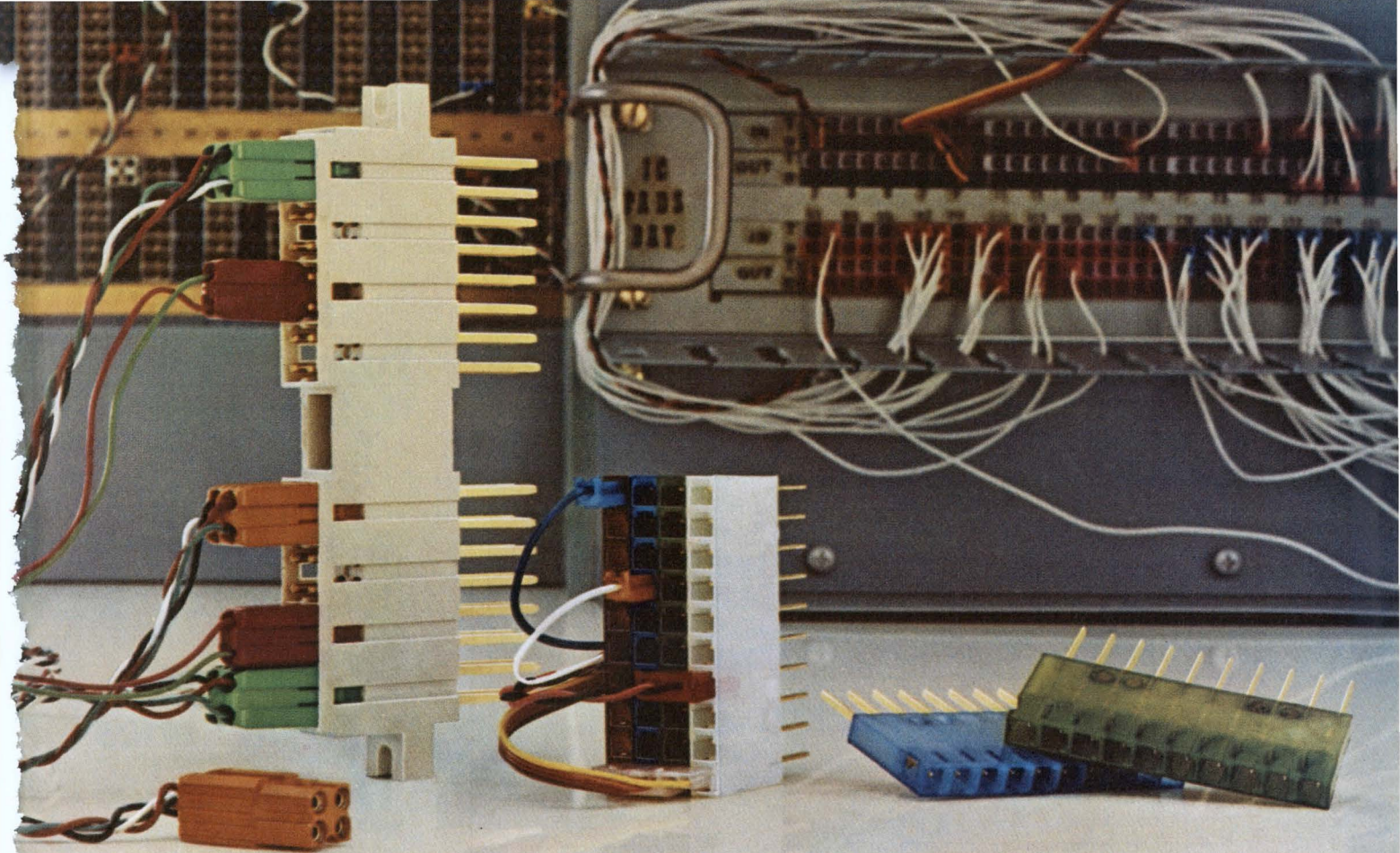
doped, lithium-niobate.

"We've already stored 100 holograms, in a niobate crystal and can certainly store up to 500 of them," says Dr. David L. Staebler, technical staff member at RCA Laboratories, Princeton, N.J. "And 1000

is definitely within reach."

The RCA technique eliminates a stumbling block to previous efforts—the optical damage and erasure of holograms already stored in the crystal by subsequent recording of newer holograms. And the





# Update your telecommunications cross-connects—and save.

AMP pluggable modules make cross-connect programming easier, and save space and materials. Being modular also means that AMP can provide completed panels or provide the means for building your own.

Two kinds of modules are available; quad layout and in-line. Both have pins on .200-inch centers. Both are posted for wrap-type, rear-bay wiring. Quad types have eight 4-socket, or sixteen 2-socket, snap-in patch plugs. In-line modules are presently available in 1 through 5 positions. Cabling by twisted pair, shielded twisted pair and coaxial can be accommodated.

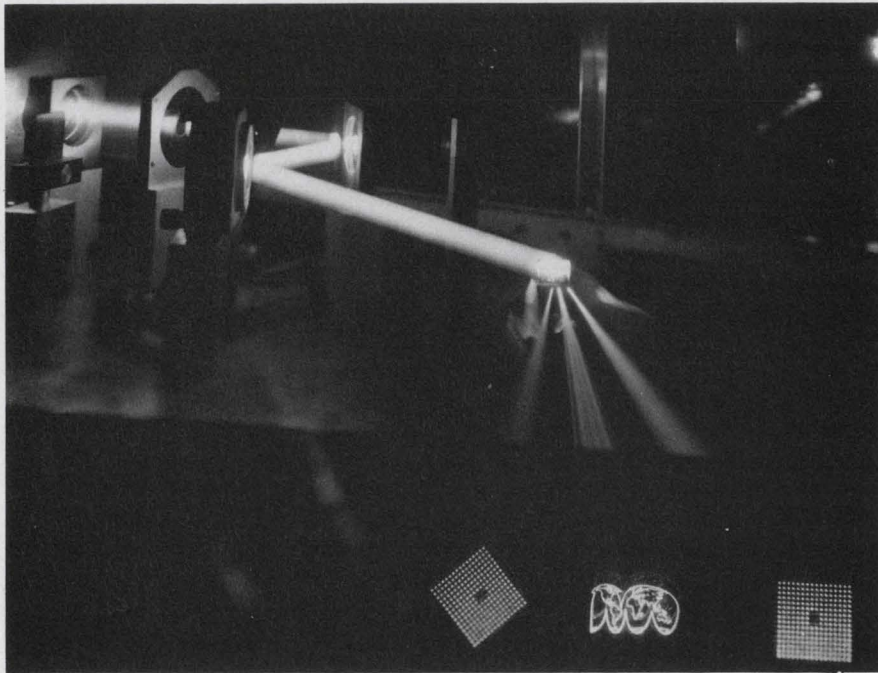
Both plug types have locking features, with the in-line type having the additional benefit of not requiring dedicated removal tools. Color-coded plug and receptacle housings provide quick lead length and circuit identification, and are polarized for accurate installation.

Snap-in plug contacts are designed for volume production and maximum serviceability. They're available in strip form or loose piece, and can be applied with high-speed machines or hand tools.

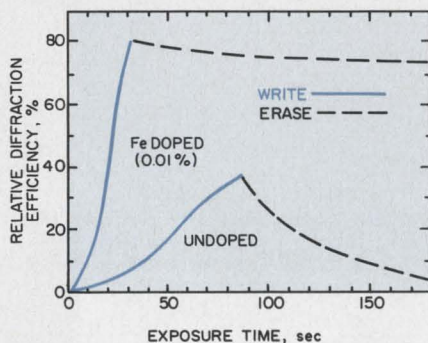
For more information on either type module or on AMP Circuit Concentration Panels, write AMP Incorporated, Harrisburg, Pa. 17105.

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INFORMATION RETRIEVAL NUMBER 14



Multiple holograms stored by RCA in the volume of a heat-fixed, iron-doped (0.02%) lithium-niobate crystal are separated by the angles at which they were originally recorded. Here, an argon laser reference beam reads them out.



Iron-doped lithium-niobate crystals are more sensitive and retain holograms longer than undoped crystal.

method also permits the use of materials of higher sensitivity and higher storage capability, according to Staebler.

#### Crystal heating essential

As he describes it, a sequence of holograms can be stored in a lithium-niobate crystal having 0.01% or more of iron doping.

To record a hologram, the crystal is heated to between 150 and 160 C. Next, the crystal is exposed to the laser reference beam and to the object beam, which contains the information to be stored. Exposure varies from 10 or 20 seconds to two minutes.

To make the second hologram,

the elevated temperature is maintained and the crystal rotated slightly, so that the beams can enter at a new angle. The recording beams are reapplied, with new information in the object beam, and the second exposure is made.

This process is repeated, with the stored holograms being separated within the volume of the crystal by the small angular differences between the various sequential hologram exposures.

After the multiple exposures the crystal is cooled to room temperature, and the holograms are "frozen in" in ionic charge patterns.

The RCA heat-fix technique produces holograms that are insensitive to readout beams. For example, Staebler points to a 2-mm-thick crystal of 0.05% iron doped lithium-niobate in which RCA recorded 10 high-quality holograms with a diffraction efficiency of 20%. After more than a year of continual use, no observable degradation of the holographic images occurred, Staebler reports.

RCA has been working with crystals from 2 to 5 mm thick and about 10 by 15 mm on the front area. The stored holograms can be individually accessed by simple variations in the angle of the crystal with respect to the readout beam. ■■

If your copy of these Lambda brochures is missing in this issue:

LX series  
LY-LV-LW series  
LM series  
LT series  
LC series

or if you would like more information about these power supplies, circle the proper number on the reader service card.

**LAMBDA**  
ELECTRONICS CORP.

A **Veeco** Company

515 BROAD HOLLOW RD. MELVILLE, N.Y. 11746

Do you face  
a make or buy  
decision on  
power supplies?

# **BUY LAMBDA'S LX SERIES, UP TO 28 VOLTS, UP TO 85 AMPS.**

**1. Built with Lambda's 100,000-hr  
MTBF Power Hybrid Voltage Regulators.**

**2. Built with Lambda's magnetics  
designed to MIL-T-27C grade transformers  
(180° class H).**

**3. Contains Sprague 105°C 602D  
premium grade electrolytic capacitors.**

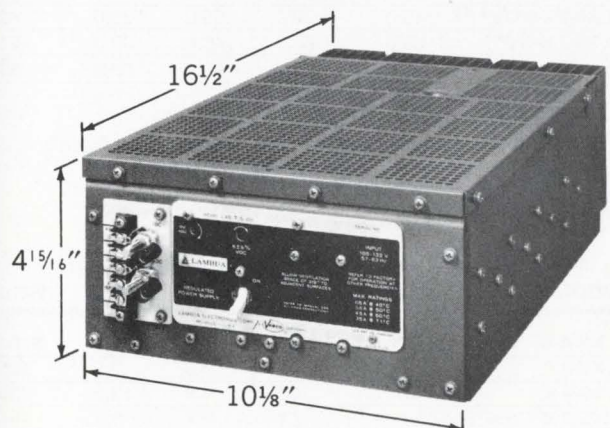
**4. Broadest power supply line  
with 11 package sizes and 68 models.**

**5. Available in  
single, dual and  
triple output voltage  
models.**

**6. All guaranteed  
5 years.**

**7. All with 1-day  
delivery.**

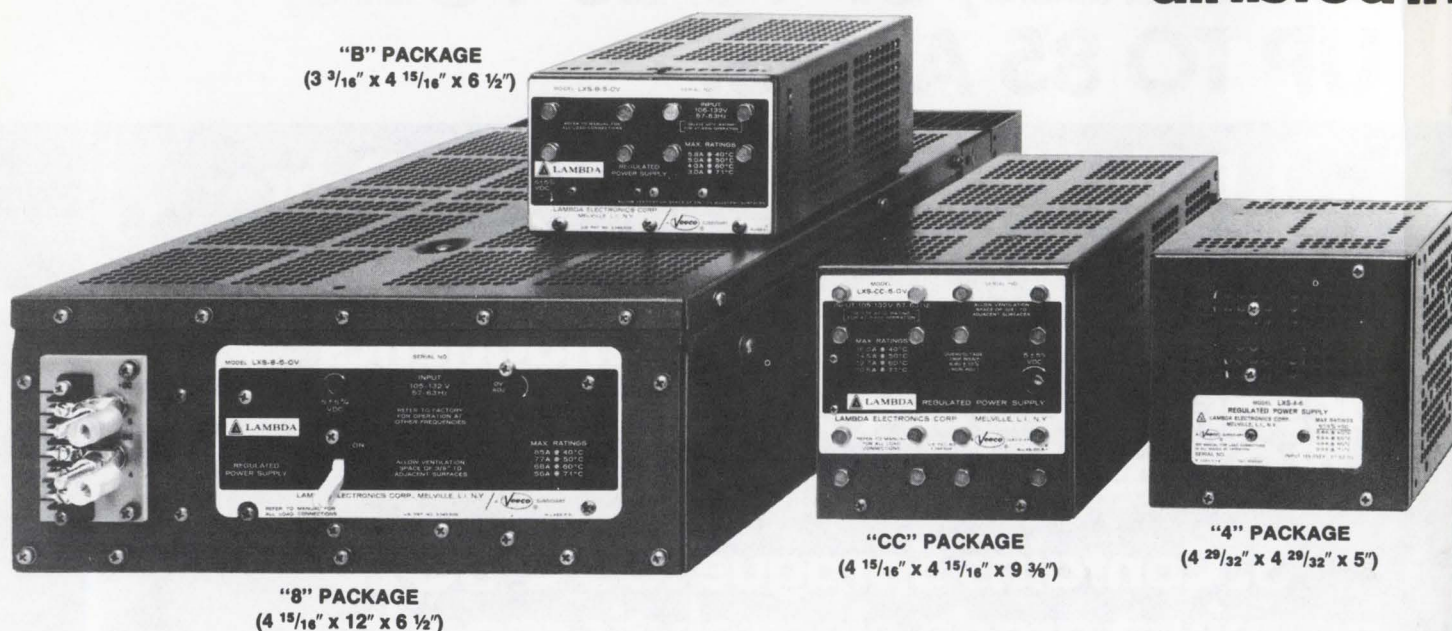
## **ANNOUNCING THE NEW LX-7**



**LXS-7-5-OV 5V, 65A  
Up to 28 Volts • Up to 65 Amps**

**\$515**

# LAMBDA'S LX ...ALL DESIGNED all listed in



**"B" PACKAGE**  
(3 3/16" x 4 15/16" x 6 1/2")

**"CC" PACKAGE**  
(4 15/16" x 4 15/16" x 9 3/8")

**"4" PACKAGE**  
(4 29/32" x 4 29/32" x 5")

**"8" PACKAGE**  
(4 15/16" x 12" x 6 1/2")

## 5 VOLTS ± 5% SINGLE OUTPUT

MODEL	MAX. AMPS AT AMBIENT OF:				PRICE <sup>(4)</sup>
	40°C	50°C	60°C	71°C	
LXS-A-5-OV* (2)	4.0	3.4	2.7	2.0	\$ 85.
LXS-B-5-OV* (2)	5.8	5.0	4.0	3.0	125.
LXS-4-5-OV* (2)	7.4	6.5	5.4	3.9	135.
LXS-C-5-OV* (2)	9.0	8.0	6.8	5.3	150.
LXS-CC-5-OV* (2)	16.0	14.5	12.7	10.5	200.
LXS-D-5-OV* (2)	27.5	24.2	20.5	16.5	235.
LXS-E-5-OV* (2)	35.0	30.0	24.0	17.5	300.
LXS-EE-5-OV* (2)	45.0	39.0	32.0	25.0	425.
LXS-7-5-OV**	65.0	56.0	46.0	35.0	515.
LXS-8-5-OV**	85.0	77.0	68.0	56.0	560.

\*Includes fixed overvoltage protection at 6.8V±10%

\*\*Built-in continuously adjustable overvoltage protection crowbars output when trip level is exceeded. Included on all LXS-7, LXS-8 models

## 6 VOLTS ± 5%

MODEL	MAX. AMPS AT AMBIENT OF:				PRICE <sup>(4)</sup>
	40°C	50°C	60°C	71°C	
LXS-A-6	3.7	3.1	2.5	1.9	\$ 85.
LXS-B-6	5.5	4.7	3.8	2.9	125.
LXS-4-6	6.6	5.8	4.8	3.5	135.
LXS-C-6	8.8	7.8	6.7	5.2	150.
LXS-CC-6	15.2	13.8	12.1	10.0	200.
LXS-D-6	26.5	23.4	19.8	16.0	235.
LXS-E-6	34.0	29.0	23.0	16.5	300.
LXS-EE-6-OV** (2)	42.0	36.0	30.0	22.0	425.
LXS-7-6-OV	59.0	50.0	41.0	32.0	515.
LXS-8-6-OV	70.0	70.0	68.0	56.0	560.

\*\*Includes fixed overvoltage protection at 7.4V±10%.

## 12 VOLTS ± 5%

MODEL	MAX. AMPS AT AMBIENT OF:				PRICE <sup>(4)</sup>
	40°C	50°C	60°C	71°C	
LXS-A-12	2.7	2.2	1.8	1.5	\$ 85.
LXS-B-12	3.8	3.6	3.0	2.2	125.
LXS-4-12	4.4	3.8	3.1	2.5	135.
LXS-C-12	6.5	6.1	5.5	4.6	150.
LXS-CC-12	10.5	9.4	8.2	5.0	190.
LXS-D-12	16.0	14.0	11.9	8.0	235.
LXS-E-12	21.0	18.0	15.0	12.5	300.
LXS-EE-12	32.0	27.0	22.0	16.0	400.
LXS-7-12-OV	40.0	36.0	30.0	23.0	515.
LXS-8-12-OV	50.0	45.0	40.0	34.0	560.

## 15 VOLTS ± 5%

MODEL	MAX. AMPS AT AMBIENT OF:				PRICE <sup>(4)</sup>
	40°C	50°C	60°C	71°C	
LXS-A-15	2.4	2.0	1.6	1.3	\$ 85.
LXS-B-15	3.2	2.8	2.5	1.5	125.
LXS-4-15	4.0	3.5	2.8	2.3	135.
LXS-C-15	6.0	5.6	5.1	4.5	150.
LXS-CC-15	9.5	8.6	7.4	4.8	190.
LXS-D-15	14.0	12.3	10.4	7.5	235.
LXS-E-15	19.0	17.0	14.0	12.0	300.
LXS-EE-15	28.0	24.0	19.5	14.0	400.
LXS-7-15-OV	36.0	32.0	26.0	20.0	515.
LXS-8-15-OV	45.0	41.0	36.0	30.0	560.

# 12 REASONS WHY ONLY LAMBDA CAN GIVE YOU A MEANINGFUL 5-YEAR GUARANTEE...LX SERIES

**1** Lambda's MIL-T-27C grade 6 magnetics.

**2** Lambda offers a rugged convection cooled chassis.

**3** Lambda uses computer grade hermetically sealed 10-year life electrolytic capacitors.

**4** Lambda LX power supplies have a minimum component count. PHVR replaces discrete components for higher reliability.

**5** Lambda engineering assures performance reproducibility and the LX power supplies are designed for large volume production.

**6** Lambda uses MIL-R-22684 type film resistors.

**7** Lambda's LX power supplies are listed in Underwriters' Laboratories recognized component index.

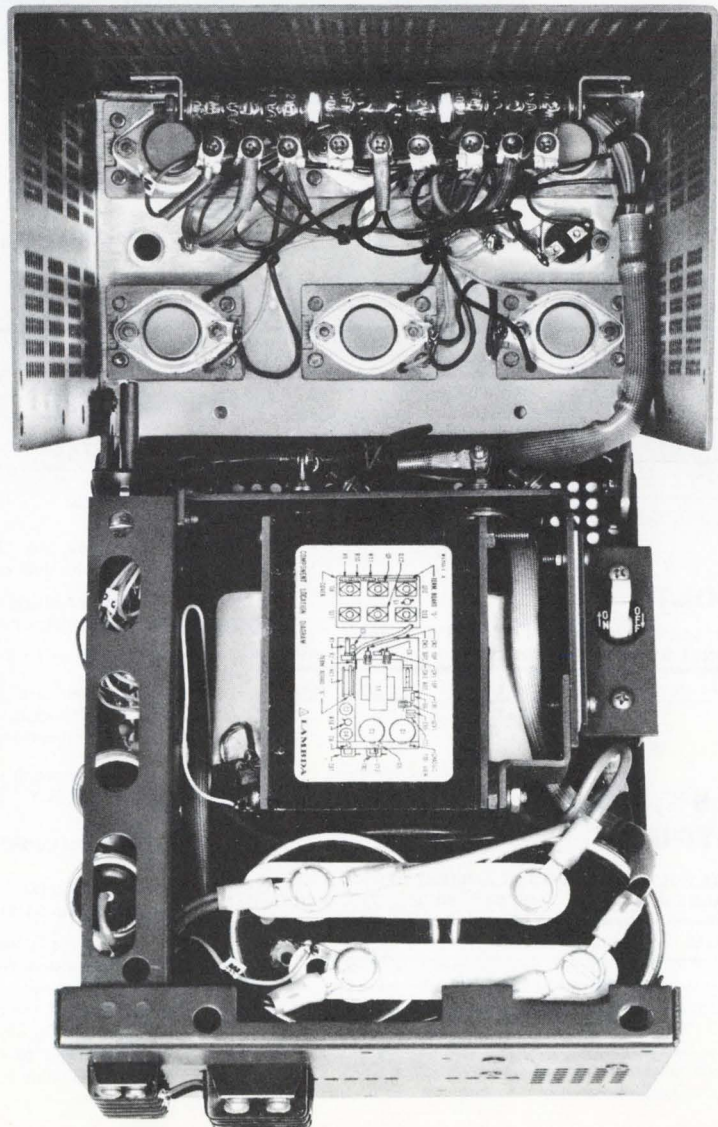
**8** Lambda features a heavy duty barrier strip on their LX power supplies.

**9** Lambda builds the LX power supplies with MIL-R-11 composition resistors.

**10** Lambda designed the LX power supply to meet military environmental specifications.

**11** Lambda builds LX power supplies with MIL-R-26 type wire wound resistors.

**12** Lambda's power hybrid voltage regulator has 100,000 hours MTBF.



# PACKAGE SIZES SPECIFICATIONS.

## Index. †

"3" PACKAGE  
(3 3/16" x 3 3/4" x 5")



"C" PACKAGE  
(3 3/16" x 4 15/16" x 9 3/8")

"A" PACKAGE  
(3 3/16" x 3 3/4" x 6 1/2")



"D" PACKAGE  
(4 15/16" x 7 1/2" x 9 3/8")

"EE" PACKAGE  
(4 15/16" x 7 1/2" x 16 1/2")

### 6 TO ± 3 VOLTS

MODEL	ADJ. VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:				PRICE <sup>(4)</sup>
		40°C	50°C	60°C	71°C	
KD-B-062 <sup>(1) (3)</sup>	±6	2.7	2.4	1.9	1.4	\$160.
	to					
	±3	2.1	2.0	1.6	1.2	
KD-C-062 <sup>(1) (3)</sup>	±6	3.5	3.3	2.7	1.7	\$170.
	to					
	±3	2.6	2.4	1.9	1.3	

### 4 TO 30 VOLTS

MODEL	ADJ. VOLT. RANGE VDC	MAX. mA. AT AMBIENT OF:				PRICE <sup>(4)</sup>
		40°C	50°C	60°C	71°C	
KD-3-152 <sup>(1)</sup>	24-30	400	370	340	300	\$85.

### 5 VOLTS ± 5%, ± 15 TO ± 12 VOLTS TRIPLE OUTPUT

MODEL	ADJ. VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:				PRICE <sup>(4)</sup>
		40°C	50°C	60°C	71°C	
KT-D-5152	5±5%	12.0	11.5	11.0	9.5	\$375.
	±15	3.1	2.7	2.2	1.7	
	to					
	±12	2.3	2.0	1.7	1.3	

\*5 volt output has fixed overvoltage protection at 6.8V ±10%.  
±15 to ±12 output is dual tracking output.

### OVERVOLTAGE PROTECTOR ACCESSORIES

MODEL	ADJ. VOLT RANGE VDC	PKG SIZE	PRICE <sup>(4)</sup>
LM-OV-1	3-8	A-E	\$30
LM-OV-2	6-20	A-E	30
LM-OV-3	18-70	A-E	30
LM-OV-8	6-20	EE	75
LM-OV-9	18-70	EE	75

#### NOTES:

1. Only one (1) overvoltage protector accessory is required on LX Series dual output power supplies.
2. Overvoltage shutdown may occur anywhere within the voltage trip-point range for units with built-in overvoltage.
3. ±15 to ±12 Volts and ±6 to ±3 Volts are each dual tracking outputs.
4. Prices are USA list prices only. FOB Melville, N.Y.; North Hollywood, Calif.; Chicago, Ill.; Montreal, Canada. All prices and specifications are subject to change without notice.

The following charges are applicable for shipment from other than Melville, N.Y.

Value of Order**	Handling Charges*	Value of Order**	Handling Charges*
up to \$50.00	\$1.00	\$181.00 to \$300.00	\$5.00
\$51.00 to \$180.00	3.00	\$301.00 to \$500.00	\$8.00

\*Not applicable when shipped from Montreal to Canadian customers.  
\*\*For orders with values in excess of \$500.00 add handling charges for the value(s) in the "Value of Order" list needed to cover the total value of the order being placed; for example with an order value of \$1274.00, double the \$8.00 handling charge for \$500.00 order value and add to it the \$5.00 handling charge for the \$181.00-\$300.00 order value for a total handling charge of \$21.00.

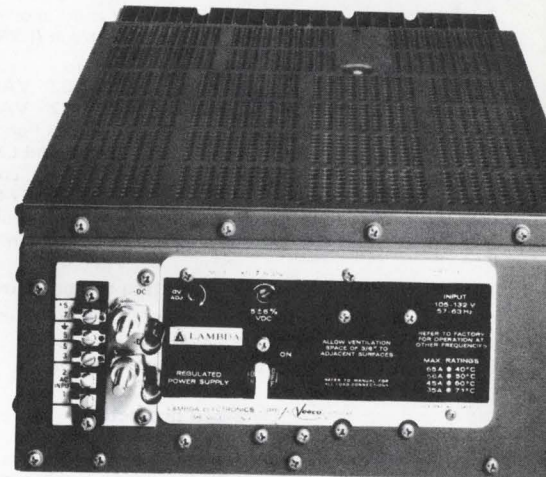
# ERIES... NOW 68 MODELS AND 11 P D TO MEET MIL ENVIRONMENTAL SP Underwriters' Laboratories Recognized Component

## LAMBDA'S NEW LXS-E PACKAGE



(4 15/16" x 7 1/2" x 11 3/4")

## LAMBDA'S NEW LXS-7 PACKAGE



(4 15/16" x 10 1/8" x 16 1/2")

### 20 VOLTS ± 5%

#### MAX. AMPS AT AMBIENT OF:

MODEL	40°C	50°C	60°C	71°C	PRICE <sup>(4)</sup>
LXS-CC-20	7.7	7.2	6.5	4.4	\$190.
LXS-D-20	11.5	10.0	8.6	6.8	235.
LXS-E-20	15.0	13.0	10.5	7.0	300.
LXS-EE-20	22.0	18.5	14.5	10.0	400.
LXS-7-20-OV	28.0	25.0	20.5	15.5	515.
LXS-8-20-OV	32.0	29.0	25.0	17.0	560.

### 24 VOLTS ± 5%

#### MAX. AMPS AT AMBIENT OF:

MODEL	40°C	50°C	60°C	71°C	PRICE <sup>(4)</sup>
LXS-CC-24	6.8	6.4	5.7	4.4	\$190.
LXS-D-24	10.0	8.8	7.5	6.0	235.
LXS-E-24	13.0	11.0	9.5	6.0	300.
LXS-EE-24	19.0	16.5	13.0	9.5	400.
LXS-7-24-OV	25.0	22.0	18.0	14.0	515.
LXS-8-24-OV	30.0	27.0	23.5	17.0	560.

### 28 VOLTS ± 5%

#### MAX. AMPS AT AMBIENT OF:

MODEL	40°C	50°C	60°C	71°C	PRICE <sup>(4)</sup>
LXS-CC-28	6.0	5.6	5.0	4.3	\$190.
LXS-D-28	9.0	8.0	6.8	5.5	235.
LXS-E-28	11.0	10.0	8.5	5.5	300.
LXS-EE-28	17.0	15.0	12.0	9.0	400.
LXS-7-28-OV	22.0	19.5	16.0	12.5	515.
LXS-8-28-OV	28.0	25.5	22.5	17.0	560.

### ± 15 TO ± 12 VOLTS DUAL OUTPUT

MODEL	ADJ. VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:				PRICE <sup>(4)</sup>
		40°C	50°C	60°C	71°C	
LXD-A-152 <sup>(1)(3)</sup>	±15	1.0	1.0	0.9	0.7	\$125.
	to —					
LXD-B-152 <sup>(1)(3)</sup>	±15	1.6	1.4	1.2	0.7	150.
	to —					
LXD-C-152 <sup>(1)(3)</sup>	±15	2.5	2.3	1.9	1.5	160.
	to —					
LXD-CC-152 <sup>(1)(3)</sup>	±15	4.0	3.7	3.2	2.4	235.
	to —					
LXD-D-152 <sup>(1)(3)</sup>	±15	6.2	5.6	4.9	4.0	280.
	to —					
LXD-EE-152 <sup>(1)(3)</sup>	±15	12.5	11.0	9.0	7.0	435.
	to —					
	±12	10.0	9.0	7.8	6.0	

### + 12 TO 15 VOLTS/ - 12 TO - 15 VOLTS

MODEL	ADJ. VOLT. RANGE VDC	MAX. mA. AT AMBIENT OF:				PRICE <sup>(4)</sup>
		40°C	50°C	60°C	71°C	
LXD-3-152 <sup>(1)(3)</sup>	+ (12 to 15)	400	370	340	300	\$85.
	- (12 to 15)	400	370	340	300	

## Specifications for LX Series

### DC Output

voltage ranges shown in tables

#### Regulated Voltage

regulation, line .....	0.1%
regulation, load .....	0.1%
ripple and noise .....	1.5 mV RMS, 5 mV pk-pk with either positive or negative terminal grounded
temperature coefficient .....	0.03%/°C
remote programming resistance ..	1000 ohms/volt, nominal for package A, 4, 7, 8, CC, D and E models 200 ohms/volt nominal for package B and C models
remote programming voltage .....	volt/volt (LXS units only)

### AC input

line .....	105-132 VAC; 47-440 Hz. For 187-242 VAC, see A.C. input options. For operation of LXS-E, LXS-7, and LXS-8 units at 50 Hz or at 400 Hz, consult factory. Ratings apply to 57-63 Hz. For all other models delete 40°C rating for 50 Hz operation.
------------	---

### Ambient operating temperature range

continuous duty from 0° to +71°C with corresponding load current ratings for all modes of operation.

### Storage temperature range

-55°C to +85°C

### Overload protection

#### Thermal

thermostat, automatic reset when over-temp. condition is removed. (Not applicable to LXD-3); circuit breaker must be reset on LX-8 models.

#### Electrical

external overload protection, automatic electronic current limiting circuit limits the output current to the preset value, thereby providing protection for load as well as power supply.

### Overshoot

no overshoot on turn-on, turn-off or power failure.

### Input and output connections

through terminal block on chassis; output terminals on LX-7, LX-8 models are two heavy duty studs.

### Power hybrid voltage regulator or integrated circuit regulation

some models have Power Hybrid Voltage Regulator providing complete regulation system while others have an integrated circuit providing regulation system except for input and output capacitors, rectifiers and series regulation transistors.

### Controls

#### DC Output Control

simple screwdriver voltage adjustment over entire voltage range.

#### Remote sensing

provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

### Transformer

MIL-T-27C, Grade 6

### Mounting

three mounting surfaces, designed to mount in Lambda standard rack adapters. LX-E, LX-EE and LX-8 models have only one mounting surface.

### Accessories

rack adapters, blank panels, chassis slides; overvoltage protectors are available for all models except 5V models which have built-in fixed overvoltage protection at 6.8 volts ±10%, and 6V LXEE models at 7.4 volts ±10%. All LXS-7, LXS-8 units have built-in continuously adjustable overvoltage protection.

### Options

#### AC input

add suffix "V" to model number for operation at 187-242 VAC, 47-440 Hz, and add 12% or \$30.00 to the price, whichever is greater.

#### Fungus proofing

add suffix "R" to model number and add \$20.00 to price.

### Meets military environmental specifications

Altitude: MIL STD 810B Method 500 Procedure I; high temperature: MIL STD 810B, Method 501, Procedures I & II, MIL-E-5272C, Para. 4.1.2, Procedure II; low temperature: MIL STD 810B, Method 502, Procedure I; temp. shock: MIL STD 810B, Method 503, Procedure I, MIL-E-5272C, Para. 4.3.1, Procedure I; humidity: MIL STD 810B, Method 507, Procedure I, MIL-E-5272C, Para. 4.4.1, Procedure I; shock: MIL STD 810B, Method 516, Procedures I, III, MIL-E-5272C, Para. 4.15.5.1, 4.15.4.2; vibration: MIL STD 810B, Notice 1, Method 514, Procedures X, XI; emi: MIL I-6181D.

### Physical data

#### Weight

LXD-3 3.0 lbs. net, 4.0 lbs. ship; LXS-A, LXD-A 6.0 lbs. net, 7.0 lbs. ship; LXS-B, LXD-B 7.0 lbs. net, 8.0 lbs. ship; LXS-4 8.5 lbs. net, 9.5 lbs. ship; LXS-C, LXD-C 10.0 lbs. net, 11.0 lbs. ship; LXS-CC, LXD-CC 15.0 lbs. net, 17.0 lbs. ship; LXS-D, LXD-D, LXT-D 23.0 lbs. net 26.0 lbs. ship; 23.0 lbs. net, 26.0 lbs. ship; LXS-E 28.0 lbs. net, 31.0 lbs. ship; LXS-EE, LXD-EE 37.0 lbs. net, 47.0 lbs. ship; LXS-7 48.0 lbs. net, 60 lbs. ship; LXS-8 58.0 lbs. net, 70.0 lbs. ship.

#### Size

LXD-3, 3<sup>3</sup>/<sub>16</sub>" x 3<sup>3</sup>/<sub>4</sub>" x 5" dual output models; LXS-A, LXD-A, 3<sup>3</sup>/<sub>16</sub>" x 3<sup>3</sup>/<sub>4</sub>" x 6<sup>1</sup>/<sub>2</sub>" single and dual output models; LXS-B, LXD-B, 3<sup>3</sup>/<sub>16</sub>" x 4<sup>1</sup>/<sub>16</sub>" x 6<sup>1</sup>/<sub>2</sub>" single and dual output models; LXS-4, 4<sup>29</sup>/<sub>32</sub>" x 4<sup>29</sup>/<sub>32</sub>" x 5" single output models; LXS-C, LXD-C, 3<sup>3</sup>/<sub>16</sub>" x 4<sup>15</sup>/<sub>16</sub>" x 9<sup>3</sup>/<sub>8</sub>" single and dual output models; LXS-CC, LXD-CC, 4<sup>15</sup>/<sub>16</sub>" x 4<sup>15</sup>/<sub>16</sub>" x 9<sup>3</sup>/<sub>8</sub>" single and dual output models; LXS-D, LXD-D, LXT-D, 4<sup>15</sup>/<sub>16</sub>" x 7<sup>1</sup>/<sub>2</sub>" x 9<sup>3</sup>/<sub>8</sub>" single, dual and triple output models; LXS-E, 4<sup>15</sup>/<sub>16</sub>" x 7<sup>1</sup>/<sub>2</sub>" x 11<sup>3</sup>/<sub>4</sub>" single output models; LXS-EE, LXD-EE, 4<sup>15</sup>/<sub>16</sub>" x 7<sup>1</sup>/<sub>2</sub>" x 16<sup>1</sup>/<sub>2</sub>" single and dual output models; LXS-7, 4<sup>15</sup>/<sub>16</sub>" x 10<sup>1</sup>/<sub>8</sub>" x 16<sup>1</sup>/<sub>2</sub>" single output models, LXS-8, 4<sup>15</sup>/<sub>16</sub>" x 12" x 16<sup>1</sup>/<sub>2</sub>" single output models.

#### Finish

gray, FED. STD. 595 No. 26081.

### Tracking accuracy (dual models)

2% absolute voltage difference; 0.2% change for all conditions of line, load and temperature.



# Announcing Better Frequency Synthesis Options than the MC12012 or the 95H90

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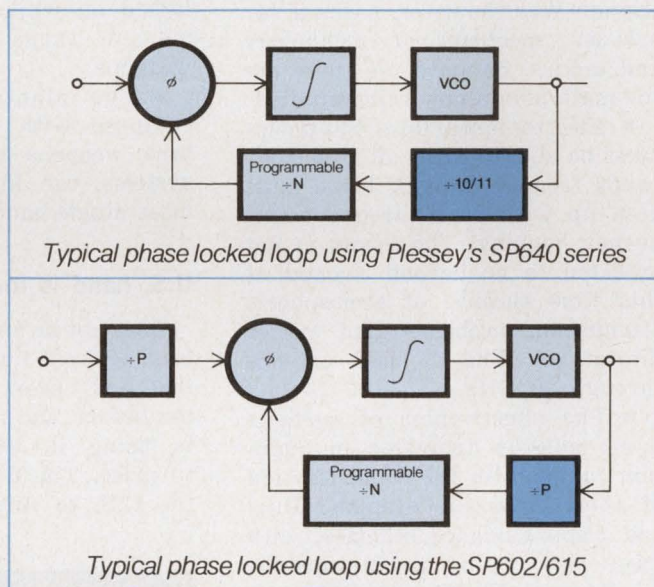
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# Mideast War is forcing changes in American military electronics

The Yom Kippur War, the latest outbreak in Arab-Israeli hostilities and scene of the most recent confrontation between U.S. and Soviet arms technology, has vast ramifications for the future of military electronics.

During the 1967 Six Day War, the Egyptians fired a Soviet-built Styx cruise missile and sank the Israeli ship Eilat. That incident caused the U.S. Navy to go into a crash program to develop electronic warning systems, countermeasures and missiles for defense against cruise missiles. It also set the U.S. on its own development of a family of cruise missiles.

The lessons learned in the Yom Kippur War, however, cover a far broader spectrum of technology and tactics. Summed up, these are the main points now being studied:

- Electronic-warfare equipment must be able to cover all frequency bands from A through J and must keep up with rapid, frequent frequency hopping. The Soviet is not expected to go beyond J band at this time because of atmospheric attenuation problems and power limitations. The J band extends through 20 GHz.

- The effectiveness of surface-to-air missiles increases in quantum jumps with the sophistication of their electronic systems. Dual and triple-guidance schemes, with frequency-hopping radar capability, dramatically increase the effectiveness of the missiles.

- "Smart" bombs, with electro-optical or laser guidance for precise delivery, are vastly superior to "dumb" bombs, especially when the target can be acquired electronically and the missile guidance



New Soviet-built SA-6 missiles in Egypt caught Israel without adequate ECM and knocked down many Israeli planes.

locked on while the aircraft gets out of range of surface-to-air weapons.

- The infantry soldier, if he is equipped with sophisticated anti-tank weapons with dual-guidance systems, can knock out tanks almost single-handedly.

## U.S. hand is forced

The appearance in the Middle East of front-line Soviet equipment that had never been used in combat before, and the Egyptians' skill in using it, were a tremendous surprise. The developments forced the U.S. to ship in planeloads of



Israel has asked for seven extended-coverage EA-6B electronic warfare aircraft, built by Grumman Aerospace.

electronic countermeasures (ECM) equipment capable of operating in the higher frequencies used by the new SA-6 surface-to-air missile system.

The fact that the Soviet was willing to commit advanced systems to its allies has also spurred a new look at the American policy of holding back front-line equipment from its allies, especially in the electronic-warfare area.

In addition electronic-warfare proponents are hoping that the experience will spur the military services to act on technology breakthroughs more quickly. It was not until the 1967 Mideast war, when top Soviet radars were exposed, that there was a decision to cover the higher frequencies E through I. It took two years after that decision to modify the American ALQ-99 countermeasures system to cover them. There were hints at that time that J band might be used by the Soviet, but the U.S. did not take action to develop that capability until around 1970.

Until now, Congress has tended to support the more tangible items in the military budget, like fighter

Heather M David  
Washington Correspondent



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aircraft, attack aircraft or ships. The effectiveness of ECM is hard to illustrate.

"ECM is one of the hardest things to put in quantitative terms," says Roger Bush, Grumman marketing official for the EA-6B electronic-warfare aircraft in Bethpage, N.Y. "You can't have bomb-damage assessment of electrons. A lot of people don't realize in black-and-white terms how effective ECM is."

### Extra billions sought

Defense Secretary James Schlesinger has indicated that the Defense Dept. will ask for some \$3-billion for new ECM, missiles and

model EA-6Bs.

Theoretically the extended-coverage EA-6B could handle the Soviet SA-6 anti-aircraft missile radar, which operates in the G, H and even I bands, and the Soviet Quad 23-mm anti-aircraft machine-gun system, which operates in J band.

The ALQ-99 on the extended-capability EA-6B has an "exciter," a new device that is essentially a voltage-control oscillator that works with the plane's computer to control the transmitters. By using different voltages, the exciter can make the transmitters hop frequencies and time-share signals, so that there is more than one jamming signal for each transmitter. It also uses frequency-sec-

sought to test the concept.

The Air Force would like eventually to outfit 42 F-111s to the EF configuration. Although at one time there was concern that the high powers generated by the ALQ-99 might cause electromagnetic interference with other aircraft avionics or even pose a threat to the crew, these problems have been worked out, the Air Force says.

The Air Force and Navy have been installing some passive ECM equipment and warning systems on strike and attack aircraft, and the Israelis reportedly were given some Air Force equipment to cover the E to I frequencies.

The programs to update U.S. aircraft include new digital-processing ECM warning receivers to replace older, hard-wired receivers that were geared to the lower-frequency radars used in Vietnam.

The Air Force is outfitting its strike force with Itek-Dalmo Victor ALQ-46 warning receivers, and the Navy is putting in Itek ALQ-45s. Both systems have small, general-purpose receivers that give pilots surveillance information. The receivers can select the "priority threat," or the missile most likely to hit an aircraft. The systems can be tailored for various types of enemy radars by substitution of special software. Both cover the entire spectrum of SAM radars the Soviet is believed to have.

The Navy is pushing for an advanced version of the Itek ALR-45—a more sophisticated system that can tell the receiver what kind of pulse traffic to look for. The service also is buying quantities of the ALR-50, built by Magnavox, a warning receiver that concentrates on missile launchings while the ALR-45 and 46 concentrate on terminal threats.

Navy aircraft also are being fitted with the ALQ-126 Sanders deceptive ECM jamming system, which receives an enemy radar signal, reorganizes it and sends it back, giving the enemy a false reading for the aircraft's position or speed.

Air Force aircraft are being fitted with the ALQ-119, which covers three broad areas of the spectrum, and the new Westinghouse ALQ-131, a programmable system.



Antitank, wire-guided TOW missile, built by Hughes Aircraft, was launched by the Israelis from mobile tracked vehicles with great success.

equipment to act on the lessons learned in the Mideast fighting and to replenish stores given to the Israelis. The Israelis have asked for an additional \$2.2-billion in foreign military aid for new equipment and aircraft to replenish their losses.

One thing Israel wants badly is the Navy's EA-6B electronic-jamming aircraft; seven new extended-coverage EA-6Bs have been requested. The newer version is equipped with ALQ-99 jammers that cover the complete spectrum of radar threats, from A to J. The original EA-6B, used effectively in the last few months of American participation in the Vietnam War, covered the bands from A through E. The Navy has 11 of the new-

tor jamming if the computer calculates that there is more than one signal coming from the same target area or the same frequency band.

No decision has been made yet on whether the EA-6B will be given to the Israelis.

### Improved F-111 planned

The Mideast experience could also give a boost to the Air Force's plan to develop an electronic jamming version of the F-111, to be called the EF-111. The service plans to put the ALQ-99 jamming system on the F-111 aircraft, updating it with directional jamming antennas and onboard switching. A total of \$15-million is being

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But the trouble with deceptive jamming, as Lt. Gen. Otto Glasser, Air Force deputy chief of staff for research and development, told the Senate Armed Services Committee recently, is that "it is explicitly aligned against a known threat.

"You have to understand exactly what the format of the threat is," he explained. "And if you err in your understanding of what that threat is, or should he [the enemy] change it, you no longer deceive at all. Whereas the noise jamming is a much cruder approach, it accommodates an awful lot of variations in its threat. But the penalty for that is that you have to squirt out an awful lot of power."

### Expendable jammers being built

The Mideast war may also spur the development of expendable jammers. The Air Force has been developing a family of small, 1-by-1-by-5-inch jammers that can be released by parachute from aircraft or drones. These low-power jammers would be dropped at close range, creating a confusion of signals for the SAM radar.

The Soviet Quad 23-mm machine-gun anti-aircraft system poses a different problem for U.S. equipment, because it operates in J band and tremendous power is needed to jam it. Its dish-type radar, using the 15.36-GHz frequency, has a narrow beam and is difficult to detect or evade. Proponents of the American A-10 close-support, heavily armored aircraft say it may be the only weapon that can go in against it and survive.

Another weapon system that may get impetus from the success of the Soviet SA-6 missiles is the Air Force's Wild Weasel program, an F-4 that is equipped to detect and attack SAM radars. The service is modifying several F-4D Phantom fighter aircraft with an IBM receiver, a Texas Instruments airborne computer and Loral control indicator to detect the SA-6 radar. The procedure is to get precise homing and warning information and to attack with standard anti-radiation missiles. A decision whether to produce the system and outfit a quantity of F-4Ds is expected to be made early next year. But the problem is far more com-

plicated than just the additional radar frequency coverage of the SAM missiles, as was demonstrated in the recent war.

There was some indication, for instance, that the SA-6 had an electronic counter-countermeasures capability and could actually track the jamming signals. This can be done by installing receivers on the missile that operate in the known jamming frequencies, which are a fairly limited number but range from 100 MHz to 18 GHz.

Several SA-6s captured by the Israelis are being studied now.

Radar is not the only problem. The SA-6 also has an optical command guidance link that can be operated by a ground controller



**TV-guided Maverick** air-to-surface missile, built by Hughes, has been very effective in the Mideast War.

with a telescope and a joystick. This mode apparently was highly successful in the Yom Kippur War, permitting the operator to shut down his radar and leave anti-radiation missiles like the Standard ARM and Shrike helpless, with no signal to home on.

The success of this mode, which also was used by the Egyptians to fire the SA-7 IR shoulder-fired anti-aircraft weapon, is spurring considerable thought about a new field of "optical countermeasures." These could be laser systems to blind the missile operator, or homing systems with in-flight processing to home on telescope reflections, or reflective devices to keep the missile operator from sighting the attacking aircraft.

Both the SA-6 and SA-7 have infrared terminal guidance somewhat more sophisticated than expected. The missiles had some filtering to discriminate between

targets, a fact made obvious because they were fired in salvos. Military analysts say it is not yet clear how sophisticated the filters are and how well the Soviet missiles can discriminate between IR countermeasures, such as flares and decoys, in the U.S. inventory. What is needed, they agree, is an extremely sensitive IR receiver that can tell that a missile has been ignited on the launching pad.

### RPV development urged

The Mideast conflict may well be the push the Air Force and Navy have been looking for to get funding for remotely-piloted-vehicle and drone programs. Some Congressional sources see a clear-cut need for RPVs as a result of the heavy aircraft losses in the Mideast, particularly during the early days of fighting.

The Air Force has a fleet of Teledyne Ryan BQ-34 drones, which are launched from DC-130 control aircraft and guided by microwave data link from the plane or the ground. A number of ways of updating the force are being examined. The improvements include a new data link, involving new noninterfering channels so more RPVs can be handled.

The service wants the RPV systems for several missions: to carry Maverick and Shrike missiles for strike purposes; to carry expendable jammers for ECM; to carry out reconnaissance, and to act as decoys when strike aircraft are used.

The war also could spur the effort to build a new generation of high-altitude drones, called the Compass Cope program.

The case for smart bombs with electro-optical or laser guidance was proven for all time, most analysts feel. The TV-guided Maverick missile, which the pilot can launch and leave while the missile continues locked on the target, proved exceedingly effective, as did the electro-optically guided Bullpup. The U.S. also sent a new device to Israel called the Target Identification System Electro-Optical, essentially an electronically steered telescope that enables the pilot in an attacking plane to see the target when he is still out of the range of the missile or anti-aircraft gun. ■■

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# TERADYNE



# washington report



Heather M. David  
Washington Bureau

## **Navy improving its classified communications**

Five years after the Pueblo affair and the tragic consequences of the crew's inability to communicate with other American ships, the Navy continues to wrestle with the problem of how to provide secure, speedy command communications for the fleet. The service presently is upgrading equipment in its 11 "Tacamo" very-low-frequency aircraft with a new, highly classified vlf modulation and signal-processing system named Verdin. The Tacamo aircraft, with trailing wire antennas several miles long, are able to get messages to surface ships and submarines down to a depth of about 100 feet. The Navy also has worked out a method of coupling some of its messages into Loran-C navigation transmitters operating at 100 kHz. In yet another effort, the Navy is developing a new hf spread-spectrum system with capability for frequency-hopping for covert one-way, ship-to-shore communications. This system will use a satellite relay. But the Navy's proposed ultimate survivable communications system, the extremely low-frequency Project Sanguine, continues to encounter citizen resistance wherever the Navy proposes to place its massive barbed antenna grid.

## **New ocean-surveillance systems planned**

The Navy has begun developing sophisticated sensors for surveillance of large areas of the oceans' surface. It is trying to get some of the Air Force's high-flying U-2 aircraft, which it would like to fit with the special sensors. The plan is to fly the planes at 60,000 to 80,000 feet, tracking ocean traffic by radar and other sensors. In addition, a radar package will be developed for an ocean-surveillance satellite. Data from the two sources would be fed into a control collection point, analyzed and relayed to fleet commanders. The Navy expects to spend \$50.2-million developing the aircraft sensor system and \$147.5-million on the satellite radar system.

## **An air-launched Minuteman considered**

The Air Force is considering using a Boeing 747 aircraft as a missile launch platform for the strategic Minuteman III ICBM. According to Lt. Gen. William Evans, deputy chief of staff for research and development, three or four Minuteman missiles could be launched from either a bomb bay or the back cargo door. The difficulty, however, is in determining exactly where the aircraft is at the time the missile is fired. This would require an extremely accurate system for updating the Minuteman III's inertial

platform and special survivable command data links to the ground or to airborne command posts. The advantage of an airborne launch pad is that the fast-moving missiles would be undetectable to Soviet satellites and far less vulnerable to enemy ICBMs than fired, silo-based missiles. Funding for the electronics portion of the program is around \$1-million this year, and a decision will be made next year whether to go ahead with the program.

## **Multiple-RPV control system developed**

RCA, under contract to the Air Force, has developed a system for controlling multiple numbers of remotely controlled vehicles (RPVs). The company's concept is to fit the RPVs with computers and navigation systems that the drone operator could monitor and override, if necessary. RCA is looking at various navigation schemes, including radar-tracking, hyperbolic, inertial, airborne trilateration, doppler and satellite systems, with the operator taking over control as the drone reaches its mission target. The data link would be able to accommodate a variety of sensors, including television and infrared. The Air Force is enthusiastic about the concept but worried about keeping RPV costs down.

## **Aerosat plans still not firm**

The European Space Research Organization (ESRO) has finally agreed to U.S. demands that the proposed joint aeronautical communications satellite include vhf as well as L-band communications. But in making this concession, ESRO is insisting that there be no reduction in the number of L-band channels originally planned. This poses the problem of whether adding vhf—a capability U.S. commercial airlines insist upon because of their tremendous investment in vhf equipment—will drive the weight of the satellite up to the point that a larger, more expensive launch vehicle will be needed. A team of technical experts from ESRO will meet with officials of the Federal Aviation Administration soon to try to work out the problems.

**Capital Capsules:** Hughes Aircraft is building a new phased-array system for the Army that can spot enemy mortar shells in flight and determine their firing point. Sophisticated signal processing filters out ground clutter, birds, insects and other false targets. . . . NASA is negotiating with Honeywell for a preliminary system design study for a digital fly-by-wire flight control system. This would go one step further than the military efforts toward all-electronic flight control, all of which thus far have involved analog systems. . . . Seven companies are receiving requests for proposals for a 10-month R&D contract to develop a terminal homing guidance system—believed to be infrared—for the Army's shoulder-launched missile system. . . . Sen. Lowell Weicher (R-Conn.) has introduced a bill to abolish the Office of Telecommunications Policy, transferring its functions to the Federal Communications Commission. . . . The Air Force has started construction on a giant \$19.5-million electromagnetic pulse simulator at Kirtland AFB, N.M. When it is completed, it will subject aircraft such as the Boeing 747 Advanced Airborne Command Post and the B-1 bomber to the kinds of radiation present in a nuclear explosion.

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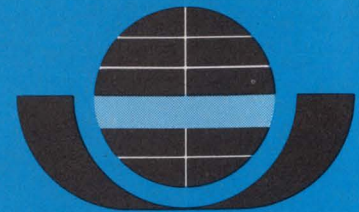
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INFORMATION RETRIEVAL NUMBER 909

# Centralab perspectives

FOR USERS OF ELECTRONIC COMPONENTS



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Electronics Division  
GLOBE-UNION INC.

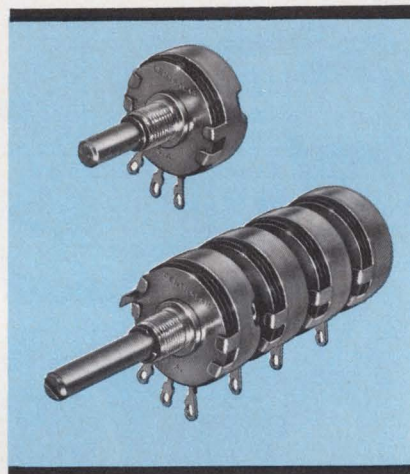
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## One million cycles make this potentiometer the right choice for any application requiring high rotational life.

Meeting the demands of continuous motion or other extreme service, the **Ultralife™** potentiometer finds use where extra life, reliability, smooth action and low noise are required.

Design and application engineers specifying potentiometers for high rotational life requirements, now have another choice with substantial savings in cost. From the extensive line of Centralab potentiometers comes the **ULTRALIFE**—a 2¼ watt hot molded carbon control.

The **ULTRALIFE** incorporates a specially developed Lifelon bearing that prevents the shaft from contacting the bushing. The bearing is self lubricating to guarantee rotational life exceeding one million cycles with smooth feel, uniform operating torque and an extremely low mechanical noise. Low contact resistance variation (CRV) throughout the long life



Available in up to four sections, Ultralife offers resistance values from 10 ohms to 5 megohms. Standard tolerances are  $\pm 20\%$  to 499K ohms,  $\pm 30\%$  to 5 megohms.

of the potentiometer is assured by the use of a hot molded resistor track and contact brush. In addition, wear-resistant plating applied to the collector ring further maintains minimal CRV.

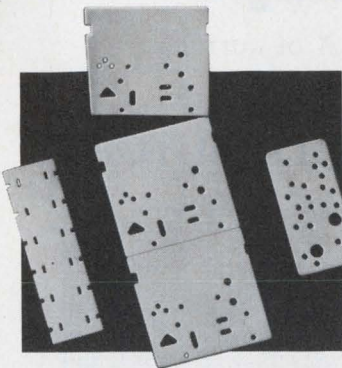
Today, **ULTRALIFE** potentiometers are being used in many industrial and commercial applications. Musical instruments like electronic organs and guitars. For servo-systems and motor drives. And in high temperature applications. With stainless steel cover and shaft, they meet salt-spray environmental requirements as well.

For full information on **ULTRALIFE**, write Centralab for Bulletin 1374P.

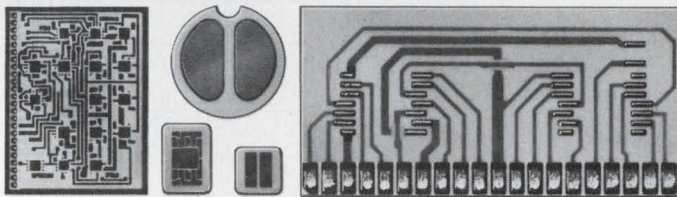
Unit No.	Initial Resistance	After 100,000 Cycles		After 250,000 Cycles		After 500,000 Cycles		After 1,000,000 Cycles	
		Resistance	% Ch.	Resistance	% Ch.	Resistance	% Ch.	Resistance	% Ch.
1	99.319 K ohm	97.998 K ohm	-1.33	98.079 K ohm	-1.25	96.839 K ohm	-2.50	94.979 K ohm	-4.37
2	105.350 K ohm	104.600 K ohm	-.712	105.190 K ohm	-.152	104.080 K ohm	-1.21	101.810 K ohm	-3.36
3	95.289 K ohm	94.629 K ohm	-.693	94.619 K ohm	-.703	94.089 K ohm	-1.26	91.849 K ohm	-3.61
4	108.360 K ohm	107.010 K ohm	-1.25	107.240 K ohm	-1.03	106.900 K ohm	-1.35	104.300 K ohm	-3.75
5	101.090 K ohm	101.060 K ohm	-.030	101.630 K ohm	+.534	101.660 K ohm	+.564	101.040 K ohm	-.049
6	99.059 K ohm	99.049 K ohm	-.010	100.020 K ohm	+.970	99.709 K ohm	+.656	97.839 K ohm	-1.23
			Av. -.670		Av. -.272		Av. -.850		Av. -2.73

Testing proves the reliability of Centralab's Ultralife potentiometer. After 1,000,000 cycles at 3,000 cycles per hour, resistance change averaged 2.73% for six tested units.

# Centralab perspective:



The next best thing to our plain ceramic substrates . . .



## our metallized substrates

We can furnish high alumina substrates in any shape or size. With holes, notches, slots or scorelines — and with your choice of two metallizing systems:

- Refractory metallization with high temperature molybdenum or tungsten — for applications requiring bond strengths up to 14,000 psi. You get the pattern adhesion necessary for die or wire bonding, metallic seals, metal hardware or lead attachment. Plus excellent stability for high temperature processing in most types of atmospheres.
- Noble metallization using silver, palladium silver or palladium gold is ideal for conductive patterns in hybrid circuits. You can have complex patterns with 10 mil lines over large areas — 5 mils over small areas. Bond strengths meet requirements for subsequent soldering and/or die and wire bonding.

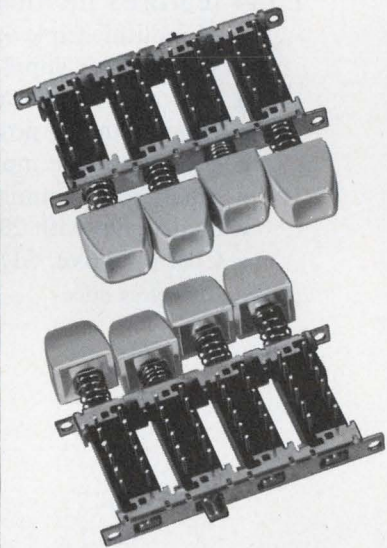
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1057TC

# Centralab perspective:

Pushbutton  
switches.\*  
With 4 lockout  
options.



Centralab offers four lockout options for its momentary, push-push and interlocking action pushbutton switch modules. Lockout prevents actuating more than one switch at the same time — even if they're *not* adjacent. Another example of design flexibility. Other features include:

- 10, 12.5, 15, 17.5 and 20 mm spacing options.
- Epoxy sealed terminals.
- Modular LINE SWITCH — mounts in any station.
- 25 button styles and 18 colors.

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\*Isostat licensed



# 150 Microwatt Triple Op Amp

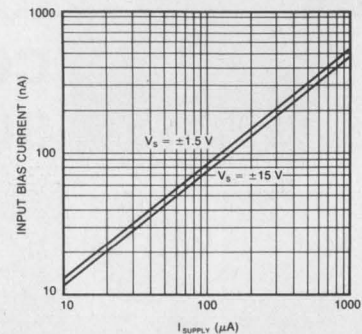
The L144 monolithic triple op amp draws only  $50\mu\text{A}$  of current per amplifier, from a  $\pm 1.5\text{ V}$  supply. What's more, it is

**AVAILABLE NOW FROM YOUR LOCAL DISTRIBUTOR!**

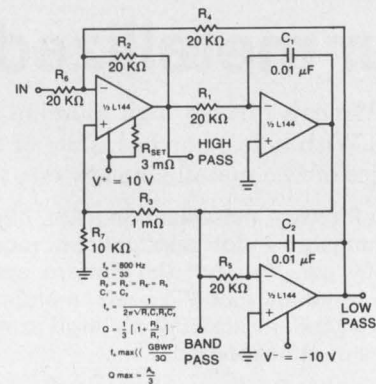
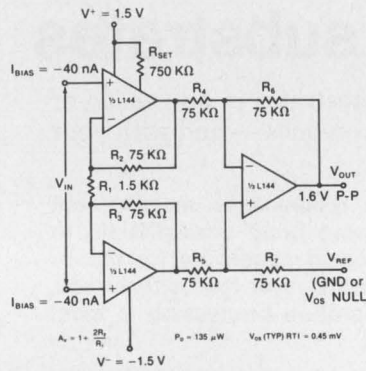
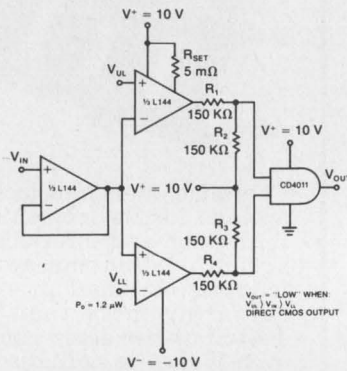
L144 features include:

- Monolithic triple op amp in DIP or Flatpac packages
- Wide power supply range— $\pm 1.5\text{ V}$  to  $\pm 15\text{ V}$
- Internal compensation
- Programmable power dissipation
- Programmable input bias current
- Single programming resistor
- 80 dB gain with  $20\text{ K}\Omega$  load
- Cost effective: \$1.63 per single op amp<sup>(1)</sup>

<sup>(1)</sup>L144CJ 100-piece price



Applications examples:



The L144 is a practical industry-standard operational amplifier for use when low current drain, low voltage, low power, or very small physical size are controlling criteria. If your circuit requirements are unique—and whose aren't—our applications people are eager to help.

For complete information

**write for data**

IC Applications: (408) 246 8000, Ext. 120



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INFORMATION RETRIEVAL NUMBER 24



## You were awful

It was after I had delivered a speech to several dozen executives of the Japan Electric Measuring Instruments Manufacturers Association that my translator whispered to me, "You were awful"—and then, after a long pause while he groped for the right word, added: "good." The temporary despondency caused by his slow translation made me wonder how many design, business, and social problems are caused by difficulties in translation—not merely from Japanese to English, but from English to English as well.



How many of us have been stung because a vendor didn't really understand our requirements, though we thought we made them clear? And how many of us are absolutely certain that we completely understand all the implications of a vendor's data sheet. It's no surprise that many military specifications go on for dozens of pages in an effort to remove ambiguity. Unfortunately clarity isn't always proportional to length. Those long MIL specs often include self-defeating internal contradictions. So the answer to translation difficulties does not lie in mere words alone. It may lie in more questions.

Few of us have such perfect command of our verbal output that it is subject to only a single interpretation—the intended one. In most cases the reader or listener sees or hears what he wants to—modified perhaps by what we have presented. One might think that the semanticists have mastered this problem. But having read some of their writings, I would argue that some of them might be well served by some good English-to-English translation.

All languages have come about in an evolutionary fashion. They were developed by multi-generation committees, so they suffer the problems of countless committee designs. No language was designed by a clear-headed engineer using worst-case analysis to check for faults. And since a newly designed language, however perfect, is not likely to find widespread acceptance, we must learn to live with the languages we have. But if we are to live better—as engineers and as humans—we must learn to compensate for the weaknesses in our languages.

The key may lie in the heavy use of the question mark. "Do you mean this?" "May I infer that?" "Is such-and-such a consequence?" Questions like these don't guarantee perfect information transmission. But they can drastically reduce the error rate.

GEORGE ROSTKY  
Editor-in-Chief

# FOCUS

on  
Power  
supplies

You can get burned—literally and metaphorically—if you end up with the wrong power supply. And getting what you don't want is easy.

First, the scramble by over 1000 vendors for the \$350-million off-the-shelf and custom power-supply market has resulted in some pretty imaginative spec writing.

Second, the still-widespread engineering attitude of stick-it-in-any-hole-at-the-last-minute practically guarantees trouble.

Third, despite a new power-supply standard from the National Electrical Manufacturers Association (NEMA), vendors and users still don't talk the same language.

It all adds up to problems galore for the power-supply user and specifier. Not only can the wrong supply cause a loss of time and money, but if you're very unfortunate, the supply can burn itself up, blow up the rest of your system, or both.

How can you avoid this? First, don't overspecify or underspecify. Study your application thoroughly. Next, sidestep the language problem by learning what the various power-supply terms really mean. Then study the data sheets for misleading, confusing and fragmented specs—and, perhaps more important, for what the sheet doesn't say. Finally, avoid delivery problems and unreliable or poorly designed supplies by checking your vendor.

Let's tackle each of these problem areas, starting with the specs.

## Shaky regulation specs

Regulation, more than any other spec, has been used to characterize a supply. And with good reason. The ideal supply regulates its out-

put—that is, it holds either the voltage or current output constant—despite changes in load, line, temperature and other factors.

So good regulation is a desirable attribute for a supply. And herein lies a pitfall.

To make his supply look as good as possible, a vendor may forget to tell you that the simple 0.01% figure listed under regulation doesn't tell the whole story.

Actually, changes in a power-supply's output can result from steady-state (static) or dynamic (transient) changes in the factors that influence the output. But, unless told otherwise, you can be pretty sure that the figure for regulation encompasses only the static, or slowly varying, effects.

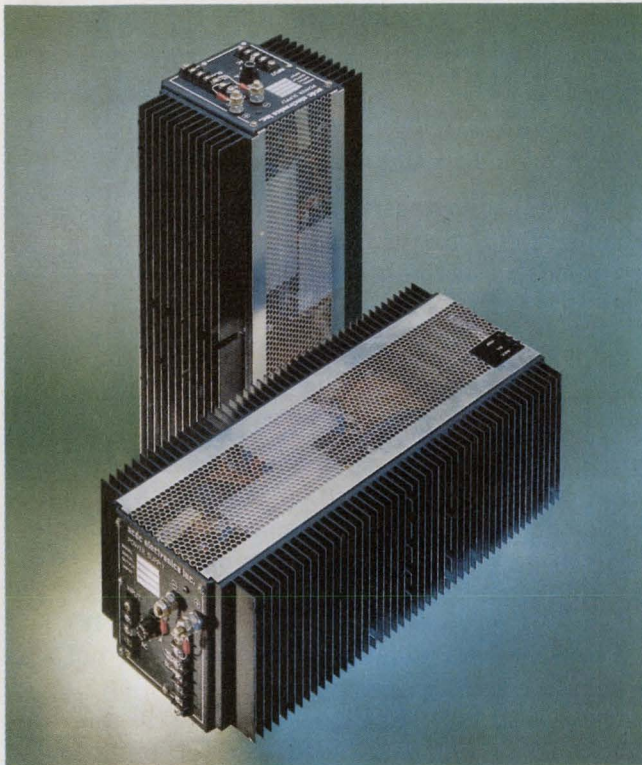
However, when your load demands abrupt current changes from your supply, dynamic regulation becomes important. But where do you find it on the spec sheet? In most cases, you don't.

What you may find instead are equations or numbers for output impedance, or frequency response, or transient response, or recovery time, or response time—or perhaps a statement of output resistance, inductance and capacitance. Or you may find nothing at all.

If output impedance is listed, make sure it's not just the incremental dc ( $\Delta E_{dc}/\Delta I_{dc}$ ) resistance. This gives the static—not dynamic—regulation. Then look for curves of impedance vs frequency. You'll need them to complete the picture.

Frequency response—a term that's rarely used these days—indicates the rate at which the load current can vary without affecting the load voltage.

Some vendors, however, define frequency response as the rated input-frequency range, while others claim that it's a measure of a program-



JP Series, from ACDC Electronics, uses a 20-kHz switching regulator to provide outputs up to 500 W at efficiencies to 80%. The 500-W unit weighs only 19 lb.

mable supply's ability to respond to fast program changes.

Rated input frequency and programming speed, of course, describe entirely different characteristics of a supply and have nothing at all to do with dynamic load regulation. But recovery time does.

### Recovering from recovery time

According to PY1-1972, the NEMA standard covering stabilized dc supplies, recovery time is the time interval between a step change in one of the quantities that influence the output and the instant the output returns to, and stays within, the transient recovery band (regulation band, or in NEMA's terminology, effect band).

The recovery band is centered on either the final value of the output or the nominal value (when it's called tolerance band).

But not all vendors agree on this definition of recovery time. And those who do, don't use the same values for step size, rise time and width of the band.

It's generally agreed that a load step should be from no load to full load, or vice versa, and that a line step should transit from 90 to 110%



Power Designs markets a wide range of units, from OEM to lab to high-voltage. Shown are various configurations of the company's universal dc power source—

a unit that responds to load demands and control settings by automatically selecting combinations of unregulated sources and power-transistor regulators.

of the nominal line voltage.

Some vendors talk about response time (a term NEMA doesn't use at all), and they define it as the time for the output to return to 37% of its peak deviation following the step disturbance.

Others feel that descriptions of recovery must include the amplitude and time characteristics of the overshoots and undershoots experienced by the output.

What it all boils down to is that it's difficult to characterize or standardize a transient—by its very nature, a transient is elusive, being caused and influenced by many factors. Your best bet: Measure a supply's response yourself with your own equipment. When you do, check turn-on and turn-off transients as well. Though rarely specified, these can damage a sensitive load if they are large enough—or if, as occasionally happens, the power supply's output polarity reverses during the transient.

Other influences or effects, too, can cause a supply's output to vary. And in most cases you can safely assume that these unwanted departures from pure dc aren't included in the regulation spec.

These other effects include periodic and random deviations (PARD), drift, temperature-caused variations, settling effects and, possibly, changes due to line-frequency variations. All of

these tend to push the regulation figure way up. So vendors tend to list them separately or merely ignore them.

### Watch for hidden specs

Like the unobtrusive kick at the bottom of a wine bottle, a microscopic-print qualifier—tacked on or buried at the bottom of a spec sheet—often cuts into the highlighted figure for regulation.

Especially in ranger supplies, you might find a statement that says, "regulation is 0.01% or 1 mV, whichever is greater." The part after the 0.01% figure may be justified to overcome the difficulty of specifying a supply with an output range rather than a fixed output. But the qualifier should be right out in the open and not buried.

Even more insidious, the "whichever is greater" phrase may be completely dropped, or the spec sheet may say: "0.01% plus 1 mV." It's left up to the reader to determine whether or not this means the same thing.

Of course, the vendor hopes that in the confusion you'll come up with a lower number for maximum regulation than is actually the case. Perhaps a better way to characterize a ranger would be to plot regulation against output voltage. Such a curve seldom appears on spec sheets, however.

A less subtle way to slash the regulation figure is to stick an unobtrusive  $\pm$  sign in front of the number. This immediately chops the figure in half.

And, if this isn't enough, the vendor can always cut the figure further by specifying regulation over a limited range—say, half load to full load, or less—instead of the usual no load to full load.

Another ploy: When line regulation is given, what's the load current? Zero, or what? Don't assume that the regulation is given for full rated current. It may not be. For that matter, it's probably best to find out what the line regulation is at the load current you expect to draw.

We've seen that the regulation spec usually doesn't account for transient effects or for the unwanted extras riding on a supply's output: ripple, noise, spikes, rfi, ringing and drift. Now let's take a closer look at these extras.

### Spikes belong on railroads

All supplies have some ripple, of course. The better ones have less, but usually cost more. Since ripple is sinusoidal, with a frequency that's harmonically related to that of the line, it can be spec'd with an rms value.

Noise and spikes are a different story. Since these come in all shapes and sizes—from white noise to popcorn noise to long, narrow impulses—



Hewlett-Packard's low-cost bench supplies come in a compact, 3-1/4 x 5-1/4 x 8 in. package, and with a choice of constant-voltage/constant-current or constant-voltage/current limiting.



The BOP Series from Kepco is a bipolar operational power supply that responds to programming commands

in either direction from zero. The unit shown outputs +36 to -36 V, and +1.5 to -1.5 A.

they aren't easily quantized.

But some vendors are undaunted. They casually lump all noise, ripple and spikes together in a single rms value. Or they multiply the rms value by some number—usually 2.8—and present this as a peak-to-peak rating.

This would be fine if noise or spikes were sinusoidal. But neither is, and conversion to peak-to-peak isn't so simple.

Don't be placated by a low rms ripple value either. After a few ICs have burned out, you'll probably discover that large-amplitude, narrow spikes—whose presence was not even intimated by the vendor—are the culprit. These spikes contribute little to an rms measurement but pack enough wallop to clobber an IC or trigger sensitive circuits.

Thus both rms and peak-to-peak specs can hide unwanted outputs. And if that weren't bad enough, the numbers can be made to look even smaller; all the vendor need do is limit the bandwidth of his measuring equipment. By so doing, high-frequency components—such as those found in spikes—don't contribute to the measurement.

### PARDon the terminology

The NEMA standard apparently tries to solve the ripple and noise problem by renaming the quantities. Consequently the terms "ripple" and "noise" have disappeared from NEMA's repertoire of power-supply terms, having been replaced by "periodic and random deviations," or PARD.

As a matter of fact, the word "regulation" has also been dropped, in favor of "stabilization."

Thus line and load regulation are replaced by source and load-effect stabilization bands.

PARD, says NEMA, may be stated in rms and/or peak-to-peak values. Though this doesn't solve the spec-manipulation problem, at least a measurement bandwidth—20 Hz to 10 MHz—is included.

Also helping is the fact that the standard separates drift and settling effects from the PARD spec.

Drift is defined as the maximum change in the output during the eight-hour period following the warm-up time and within the frequency range of dc to 20 Hz—the lower PARD limit. Thus drift includes periodic and random deviations that occur below 20 Hz. However, it doesn't include the drift caused by changes in temperature.

Settling effect is the relatively slow change in output that follows the initial, more abrupt output change that occurs when an influence quantity (load, line, temperature, etc.) changes. Settling is generally attributed to the gradual re-establishment of thermal equilibrium within a power supply after a change.

Settling is rarely—if ever—spelled out on a spec sheet. Of course, it may be included in one of the other effects, but you have no way of knowing if this is so. Which brings us to another problem: combined specs.

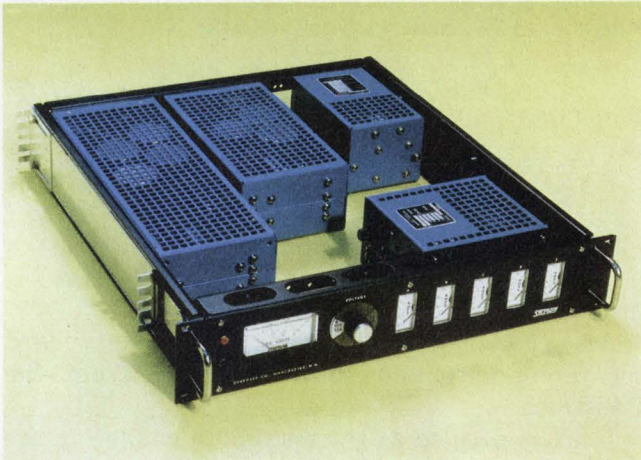
To be able to compare any supply with any other, it would be nice if a single spec could show the over-all effect of all quantities that influence a supply's output. Indeed, some vendors do publish composite specs, and NEMA's definitions include such terms as "combined effect" and "total effect."

But there's a potential pitfall here: Does one man's combined spec include the same influence quantities as another's? How are the individual specs aggregated—by root-sum-square, algebraically, or what? Since source (line) and load effects mutually interact, the combined source and load effect may or may not be equal to the sum of the individual effects.

Here's another stickler: Does a total spec include all possible contributions, including the ones difficult to measure, like shock, vibration, temperature, humidity?

And language problems still prevail. NEMA's "combined effect" includes changes in load, source voltage and frequency and temperature, but it excludes PARD, drift and settling. But a "total effect" is also defined; it includes all three, and this can cause confusion.

From an economic viewpoint, composite specs



Multi-output systems can be built with Sorensen's 3-1/2 or 5-1/2-inch rack adapters, up to four QSA Series modular supplies and a choice of accessories, such as meters, switches, fuses and indicators.

will probably never catch on—at least on spec sheets. A vendor would cut his own throat if he listed a composite spec of, say, 0.5% when his competition was still listing individual specs on the order of 0.01%.

And the question arises: How realistic is a total spec anyway? Will the load, line, temperature and other factors ever change simultaneously or in a sequence that results in a maximum change in output? Perhaps not. But if you know the maximum possible change, at least you can design your equipment for a worst-case situation.

Finding out just what the departures from the nominal output and from pure dc are can certainly cause headaches. When power rating is thrown in as well, expect a migraine.

You'd expect a supply's power rating to be right up front in bold print, shouting to the world: "I can deliver 100 W." And often it is.

But just as often, what the supply delivers in print, it fails to deliver in your equipment.

Two sins of omission surface here. First, you may have taken the bait and assumed that because the supply was "rated" for 10 A and 0 to 10 V, it could deliver 100 W. This appears to be a reasonable assumption.

Unfortunately the vendor forgot to mention that you can't get the 10 A and 10 V simultaneously. You might get the 10 A at 5 V, and the 10 V at 5 A, but never the twain shall meet.

This practice is certainly intended to mislead. But, another omission may be worse: power ratings that turn out to be obtainable only in Antarctica or in the middle of a wind tunnel. The problem here is heat—or, rather, the removal of heat.

### Heat kills

Heat is probably the No. 1 killer of power supplies. If none is removed, it will cause a continuous internal temperature rise until the semiconductor junctions start to melt.

If you don't remove the heat fast enough, the supply may run continuously hot. Components may not burn up, but degradation can occur—altering performance or shortening life.

So heat must be removed. And the rate of removal must not only prevent damage or degradation but must also allow you to draw the rated current from the unit.

Now some manufacturers forget to tell you that an infinite heat sink or forced-air cooling is necessary to obtain the published maximum current spec. Or you aren't told that when the temperatures exceed room temperature, you must derate the supply—that is, draw less current as the unit heats up.

Some vendors don't sidestep the derating question. They claim that because their units run cooler than the competition's under high-line, full-load conditions, the supplies don't have to be derated—up to a limit, of course. Or, the claim continues, derating starts at a much higher temperature.

Vendors who do derate, imply that those that don't are in the wrong.

Probably the only way out of this conflict is to be suspicious of published specs and to ask lots of questions. Find out what kind of heat sink or cooling is necessary. The construction of the supply—whether it's an encapsulated unit, in an open-frame or perforated enclosure, or has a finned heat sink—will give a clue to the type of cooling needed. But don't depend on this alone.

Ask for derating factors or curves, as well as for mounting and cooling details. And while you're at it, ask about operating temperature.

First, ask if the maximum rated temperature and maximum rated current are obtainable simultaneously. They may not be. Next, ask what is meant by operating temperature.

Most vendors state that the operating temperature range of a power supply is the range over which the specified performance can be obtained.

But exactly which temperature is meant? Is it the ambient? Or is it the case or heat-sink temperature? And where is ambient measured—below the unit, above the unit, at the air intake or three feet away?

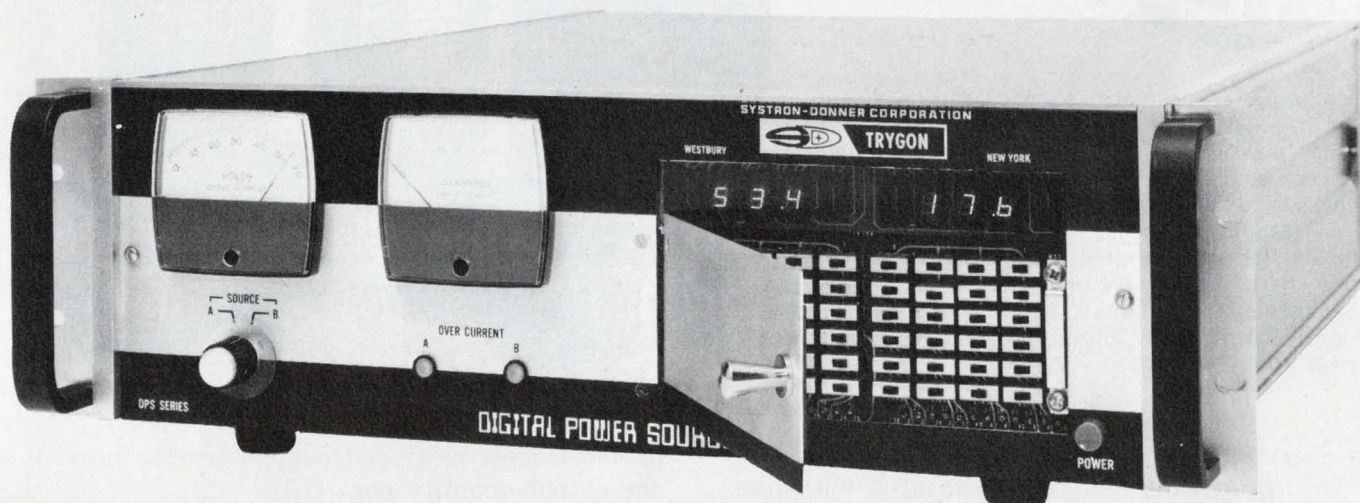
Here's another question: Does the vendor turn his supply on when measuring the ambient temperature?

At first this question may seem ridiculous. Everyone knows a supply generates heat that can affect the ambient. But a vendor may not include self-heating in the spec. He justifies this by

to your output level to get the maximum possible output. Being cautious, you check your calculation with a measurement and what happens? You're chagrined to discover that the change is much more than the calculation indicated. What went wrong?

Several things may have happened. The chances are, however, that the blame rests squarely with that innocent-looking figure for tempco. A tempco spec can mislead for a number of reasons. First, in a ranger supply, does the percentage for tempco refer to the set value or to the maximum output? Second, the problem of which temperature and where is it measured, arises here, too. Finally the question arises: How is the tempco measured?

In many cases the listed tempco is an average figure, obtained by dividing the difference in output at two temperature extremes by the ex-



**DPS Series is Trygon/Systron-Donner's** digitally-programmable power source. The unit consists of a dual,

digital programmer and two independent supplies that provide 0 to 50 V at 1 A or 0 to 100 V at 0.5 A.

arguing that this heating depends, to a large extent, upon a user's application. And since he doesn't know how the user will mount the supply, or what other heat-producing equipment is present, the vendor claims it's the user's responsibility to determine the effects of self-heating.

The solution? If the vendor doesn't ask how you intend to use the supply, tell him. Or find out the maximum-allowable temperature of the heat sink, case or most vulnerable component in the supply, and then calculate the cooling yourself.

When a power supply does heat up—whatever the cause—the output level changes. This is usually called out in a temperature coefficient, which quantifies the change in so many volts or milliamps per degree.

So you confidently multiply your expected temperature rise by the tempco and add the result

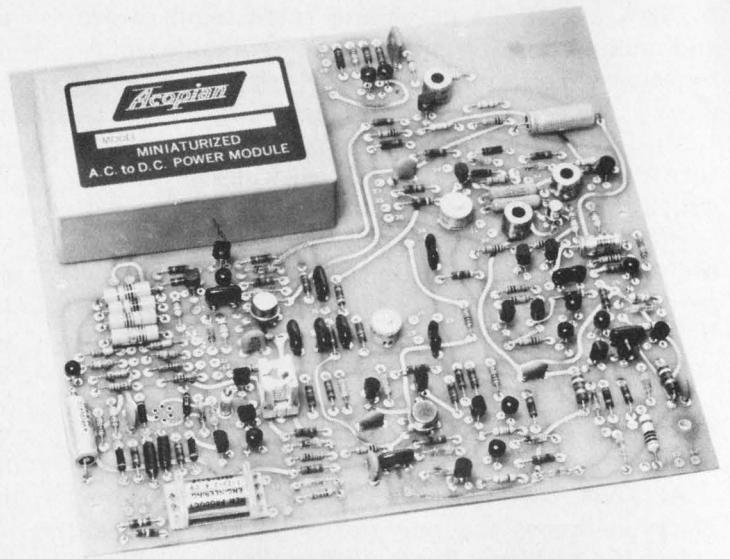
cursion in temperature.

To get the values, a vendor lets a supply sit at one temperature for several hours, making sure that other factors—such as line voltage and load—remain constant. He then changes the ambient temperature, lets the supply stabilize for a few hours and measures the new output.

If the temperature extremes used are 0 and 100 C, and the output—say, 100-V nominal—changes by 1 V, the tempco is listed by the vendor as 0.01%/°C. On the surface this seems valid. Upon close inspection, a flaw appears.

This end-point measurement assumes that the output variations between the two chosen extremes (end points) are linear. In fact, tempco may be nonlinear, and much greater changes may occur somewhere between the chosen end points.

If that "somewhere" happens to be in the temperature region at which you expect your supply



Miniature, encapsulated supplies can be mounted on a printed-circuit board, right at the load. This point-of-load technique avoids voltage drops and ground loops that frequently occur in a large system when a single, central power supply is used. PC supplies are intended mostly for op amps requiring  $\pm 15$  V, and for 5-V digital logic. Pictured are supplies from Semiconductor Circuits (top left), Acopian (top right), Burr-Brown (bottom left) and Analog Devices (bottom right).



to operate, you've got problems.

On top of this, tempco is measured with line, load and other factors held constant. Is this a realistic expectation in actual usage conditions? Chances are it isn't. And when operating conditions—such as load, line, set voltage—change or are intentionally changed, the tempco can shift in both magnitude and direction.

This occurs because power supplies have internal temperature gradients between components, from component to frame or chassis, and from chassis to the outside world. Any change tends to redistribute these thermal gradients, resulting in output changes.

Where are these effects specified? Nowhere. You've got to discover them yourself—the hard way.

The new NEMA standard attempts to rectify the situation by calling out a method for tempco in which changes are measured at 10-degree intervals. Measurements are taken from the lowest to the highest specified operating temperature, and then repeated for descending temperatures.

The tempco is then reported, the spec states, in terms of the largest percentage change per  $^{\circ}\text{C}$

or the largest measured change in the units of the output quantity per  $^{\circ}\text{C}$ .

Some vendors don't agree with this incremental, worst-case method. They feel that tempco should be the shape of the average, or best fit, line from the low to high end. In this way, they say, test-equipment errors are carried from point to point throughout the measurement and are, consequently, canceled over the complete measurement.

There are also objections to the test method. It's claimed that because of the time required to stabilize, the ascending/descending method is impossible to implement in practice.

As yet, however, few manufacturers use the NEMA method; so finding out what the temperature changes actually are is still a problem.

Other specs besides tempco can also be problems, and they're worth mentioning, because they may be important for specific applications.

Included are specs that spell out a supply's programming capabilities, isolation, tracking (in dual or multiple-output supplies), common-mode coupling and interactions (both also in multiple output supplies) and remote sensing.



All of these can trap the unwary. And while you're being cautious about what a vendor can do to you, watch out for what you can inadvertently do to yourself.

### Mistakes and tradeoffs

Mistakes in specifying and—even worse, in application—are all too common when it comes to power supplies. Generally the mistakes stem from two causes.

First, the engineer doesn't consider the supply as a vital part of his system; he looks at it as a black box that can be shoved into leftover space at the last minute. This results in all kinds of last-minute headaches, some of which have no solution.

It should be recognized that a power supply generally is no longer the simple transformer-rectifier-filter combination of the past but a complex piece of gear that must be used with some sophistication.

The second major cause of mistakes stems from the all-too-human tendency to hedge or attempt to build-in a safety factor. This results in the most common error of all—overspecifying.

There's no doubt that overspecifying regulation ranks as the top error. That 0.01% or 0.001% figure for regulation may make you feel secure, but chances are it's totally unnecessary. And overspecifying can result in higher cost, increased size and dissipation, as well as reduced reliability. Here's why tight regulation isn't needed in many cases:

1. The circuitry doesn't require it. For instance, it's rare for logic and digital circuitry to require 0.01% regulation. High-resolution analog circuits on the other hand, may be a different story. But many devices, such as op amps and a/d converters, have a high power-supply rejection ratio—that is, such specs as offset and gain exhibit little change with shifts in power-supply voltage. Tight regulation probably isn't needed here. And don't forget that some CMOS and other circuits perform satisfactorily on unregulated power.

2. Tight regulation is swamped by changes in other parameters. It's useless to spec 0.001% for regulation when drift and changes in temperature, input frequency and other factors cause larger output changes.

3. External wiring, components and distribution busses destroy the regulation. Remember that regulation is given at the supply output terminals. Any impedance between terminals and load will cut into the regulation figure. When high current is drawn, even a few milliohms will wipe out tight regulation.

4. The load doesn't vary. If your load is constant, why spec a tight load regulation? You should be more interested in stability and the

other influence factors.

You can use remote sensing to overcome the resistance of wiring between the load and supply. But only static regulation can be maintained, since this method doesn't compensate for capacitance and inductance. Thus noise, ripple, spikes and fast changes still get through. And another problem can surface: Remote-sensing leads have series inductance and shunt capacitance; since the leads are usually part of a feedback loop, the supply can become unstable and break out into neat oscillations.

The vendor can take steps to prevent this—such as limiting the response of his control amplifier or bypassing ac at the supply terminals. But what happens then? Regulation, recovery time or output impedance are degraded.

Overspecification doesn't stop with regulation. Frequently overspecified are current ratings, transient performance and protective features. All will add significantly to cost and perhaps to size, so check your real needs carefully.

Don't make the mistake of underspecifying either. This is easy if you buy a supply on price alone or don't analyze your requirements thoroughly. Oversights, of course, lead to additional trouble. Here are some common specifying mistakes:

- Not paying attention to volumes, form factors, airflow and cooling. You may be able to squeeze a lot of power into a small volume, but the added heat stress may cause reliability problems later on.

- Overlooking transient and peak-level load demands or, conversely, specifying too high a current rating to meet a brief, heavy demand.

- Forgetting about EMI and susceptibility to magnetic fields.

- Failing to specify the load.

- Confusing isolation with ripple.

- Not maintaining harmony between specs—for example, specifying a 12-V supply with a ripple of 10 mV concurrently with a regulation of 5%. To meet the ripple spec, the required circuitry would yield a regulation of much better than 5%—at higher cost.

- Buying from the catalog alone, without evaluating a unit or its vendor.

- Failing to read the fine-print specs or to watch for derating factors—not just for temperature but for such influence quantities as input frequency.

- Ignoring protection characteristics.

Many vendors offer this advice to avoid mistakes: Tell the vendor your required total operating tolerance band for all factors, and make him responsible for holding the output within the maximum-allowable deviation.

To do this, you've got to identify all outside influences the power supply is likely to see—no

easy task. In any case, some form of protection is essential—not just for the supply itself, but for your load as well.

### Is a fuse enough?

In the task of wading through power-supply ratings, a specifier often forgets an important item—protection.

Questions that should be asked here are: What failure modes are possible that can cause the supply to clobber the load—and vice versa? What can happen if there's an accidental short to ground or someone removes a remote-sensing lead? What damage can turn-on and turn-off transients cause? What about fast-changing, pulsed and capacitive/inductive loads—can these cause problems?

Ask one further question: What's the cost of extra protection when weighed against the cost of possible catastrophic damage?

You'll have to decide what forms of protection your application requires. The most common are overvoltage and overcurrent protection, short-circuit protection and back-voltage or current protection. For loads that require it, undervoltage protection is also available.

Other types of protection may be required. When many interconnected supplies are used in a system, for example, what happens when a circuit fails or when one supply "comes up" faster than the others at turn-on?

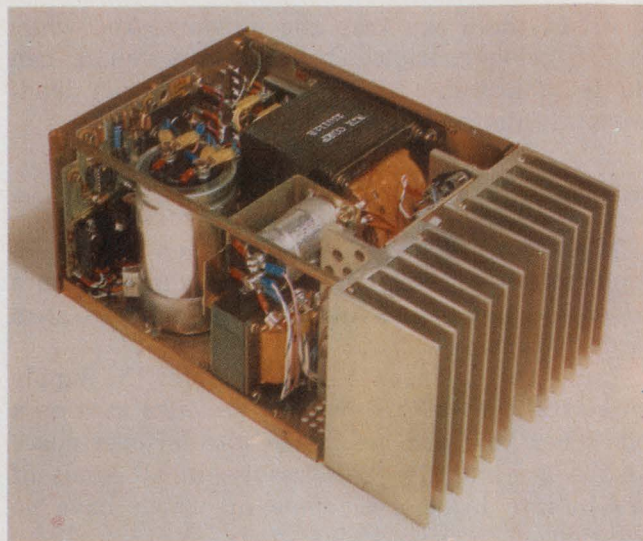
When this happens, the supply with the greatest power rating can dump damaging current into the other supplies. Or a back voltage of the same or opposite polarity wreaks havoc at the output stage of a supply.

To prevent this, you might opt for some type of turn-on/turn-off sequencing or delays. But some vendors feel that this form of protection should be part of the external system, not the supply. Others feel that a vendor should offer spigots on his supply that can be fed by inhibit circuits set up by the user. If an undesirable situation is sensed, the supply is told to shut down before damage occurs.

Mostly because of the increased use of temperature-sensitive monolithic and hybrid regulators, another form of protection—thermal shutdown—is becoming more prevalent.

In thermal shutdown, a temperature sensor and trigger circuit—usually integrated on the IC chip—shut off the regulator pass transistors when some elevated chip temperature is reached.

Vendors who use IC regulators, to lower the cost of building a supply, promote thermal shutdown as a desirable feature. But some vendors, who use discrete designs, claim that thermal shutdown is absolutely necessary with the more sensitive IC regulators to prevent self-destruction



**NJE Corporation's RX1-EE-5/OVP** is a modular supply that offers an output of 5 V at 45 A, plus overvoltage protection. Price of the unit is \$379.

from thermal runaway.

However, many discrete or hybrid designs have used thermal shutdown for at least nine years to protect against high ambients; so the concept isn't new or confined to supplies with IC regulators.

Whatever protection you opt for, there's apt to be a problem: While the advantages of a circuit are touted loud and clear, shortcomings are often not mentioned.

Crowbar circuits, for example, are the most prevalent form of overvoltage protection. Generally this type of circuit operates by sensing an overvoltage condition and then shorting the supply via an SCR across the output terminals. Output voltage is thereby reduced to zero and potentially damaging currents are shunted through the SCR instead of the load. This means, of course, that some form of overcurrent protection must be included as well to prevent damage to the supply.

This is all well and good. But how fast does the crowbar throw the short across the supply? If it isn't fast enough, a sensitive IC in the load may go poof.

Obviously no circuit operates in zero time. But when the response time is omitted from the specs, isn't the vendor implying just that? Or perhaps he's hoping you won't ask.

When the response time of a crowbar (not to be confused with transient recovery or programming speed) is listed, find out how it's defined. It should be the interval from the moment the overvoltage is sensed to the instant the short is complete—not the SCR trigger time.

Current protection can be as simple as a fuse or breaker (which must be manually reset after an overload), or it can take the form of current limiting or current foldback.

With limiting, current is restrained to a preset



For general bench use, Heath/Schlumberger offers a low-cost unit, the IP-17A. Available as a kit or assembled, the unit outputs 0 to 400 V at up to 100 mA.

maximum value. Usually the output restores automatically when the overload is removed. With foldback, both current and voltage are simultaneously reduced when the maximum allowable current is exceeded by some preset amount.

One supply that can't be overloaded is the automatic crossover type. In this supply the method of regulation automatically changes from constant voltage to constant current—or vice versa—depending on the load. The crossover point is usually adjustable. Consequently, this supply can operate into any load resistance from zero ohms to infinity.

With any of these forms of protection, ask about the following: (1) Trip-point sensitivity and setting location; (2) The amount of overcurrent allowed before foldback occurs; (3) Time delays, if any, before the supply can be turned on after an overload; (4) Panel indicators to inform of problem conditions, and (5) Internal fuse links that self-protect the supply.

The question as to which protection to buy rests greatly on the application. Tougher questions are: Which supply shall I buy? Should I build my own supply? And—perhaps the toughest of all—which vendor can I trust?

### Would you rather switch than pass?

Supplies can be classified according to their construction, intended application or by the circuit technique for stabilization (regulation). The most common are laboratory supplies (which tend to be the most accurate); modular open-frame and caged OEM supplies; and encapsulated, miniature supplies intended for PC mounting.

By stabilization type, you can get linear series or shunt-stabilized supplies, switching-stabilized supplies, SCR phase-control types and various

forms of constant-current transformer/ferro-resonant supplies.

By far, the bulk of power supplies sold today are of the linear series-pass type, in which the voltage drop across one series-pass transistor—or more—is varied by an amount necessary to hold the output voltage constant. Since the full load current flows through the series transistor, the supply must dissipate a good deal of heat. And since heat is the power supply's mortal enemy, therein lies the greatest weakness of the linear unit.

The large heat dissipation makes the linear unit inefficient—typical efficiency is about 35%—and this is why a lot of attention must be paid to mechanical design and mounting.

You can get around the heat problem by going to a switching-regulator supply. Although there are many variations, this type of supply generally regulates by controlling the duty cycle of alternately conducting transistors. In this way the switching regulator delivers current only on demand and therefore dissipates little heat at no load.

The result is a supply that runs much cooler than the linear, dissipative type—efficiencies run around 75% and even higher.

And because today's switching regulator operates at about 20 kHz, another benefit accrues: The switching supply is much smaller and weighs less than a linear unit of the same rated power. Thus if space and weight are of prime importance, the switcher is a must.

How do these two types stack up in terms of performance? In general, although it runs hotter, the linear supply beats the switching type with respect to reliability, noise and ripple, transient response, price and probably static regulation as well.

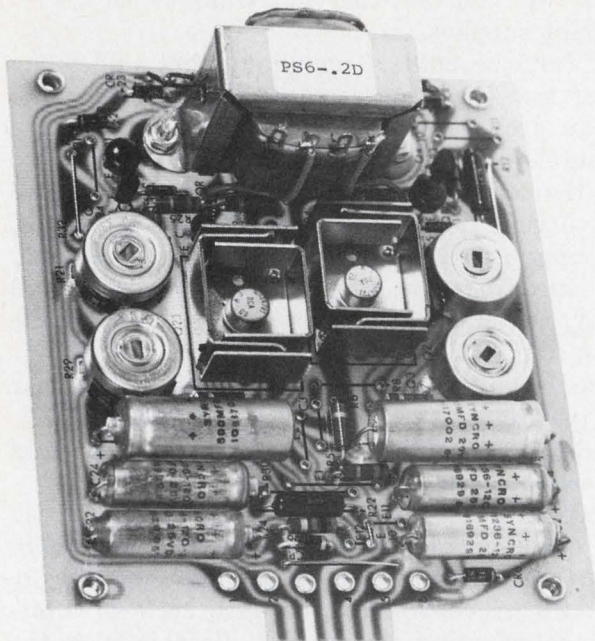
In terms of price and efficiency, however, there appears to be a breakpoint—somewhere between 200 and 500 W—above which the switcher stands out as the best choice.

Switchers may also be the best choice for low-voltage power: Series-pass units, which need some voltage drop to operate, are notoriously inefficient at the 5-V level that's so common in today's logic.

Though the switcher is a long-time veteran of military service, it isn't well understood in the commercial world. There's no doubt that the switcher is much more complex, more difficult to design and more prone to problems than its linear counterpart.

High-frequency, high-power magnetics and semiconductors are hard to get. Also, they're less predictable in performance and have greater thermal problems at high ambient temperatures.

Control and protection circuits are also more difficult to design and—since the switcher has



**Deltron's PS Series** is a dual-output, tracking supply built on a card module. Designed for op amps, the units can be connected for master/slave operation.

many failure modes—increased protection is a must. It's also harder to design multiple-output supplies with the switching technique.

And because the switching technique inherently generates noise, power-line and output filters are essential with the switcher. EMR can be a problem, too.

All of this means that switchers tend to be less reliable than linears. In fact, one vendor who makes both types says that switchers are an order of magnitude less reliable.

Despite all its problems, the switcher is being used more and more. And the increasing energy shortage will probably mandate it as the supply of the future—the one that conserves the most energy.

Another decision besides the type of regulation must be made, and preferably early in the game. For large systems, or for ones that need many different voltages, you have a choice between one large, central supply or many individual supplies. Other choices involve supplies hooked up in a master-slave arrangement or in series or parallel.

With the plunging prices of small, PC-board supplies, it's becoming more common to locate the supply right at the load. This solves the problem of long busses, with the inherent voltage drop and grounding problems.

Or you can opt for a central supply, with loose regulation, and use local regulators on each PC board. These point-of-load regulators can offer improved isolation and regulation in a large system.

Of course, a large central supply is easier to

install and often costs less than several independent supplies. The choice isn't easy.

Another choice may be easier: Should you build your own supply? Most vendors are unequivocal on this. They say don't.

### Build or buy?

A few vendors do offer these grounds that may justify the building of an in-house supply: (1) If the supply must be integral with the equipment; (2) If the quantities involved are very large—say, greater than 10,000 units per year; (3) If the supply is a unique, one-of-a-kind unit, or (4) In situations where the design is likely to change as the project proceeds.

Otherwise, most manufacturers say, it's a mistake to build your own supply—it takes expertise, resources and experience, which most companies don't have. Also, say supply manufacturers, users often forget such factors as capital investment, rate of return, component stock, field servicing and other costs besides materials and labor.

In general, with the thousands of catalog units available, and with many custom houses specializing solely in supplies, it's rare not to find what you need. But which vendor is reliable?

### Whom can you trust?

Because it looks so easy to build a power supply, many would-be entrepreneurs jump into the business, convinced that they can turn out a better product for less money. But making a supply is a tough business. Half of all power-supply manufacturers weren't here last year, and half won't be next year. Out of the hundreds of companies that manage to stick it out, less than 50 carry 50% of the catalog market.

It's clear, then, that you must evaluate a vendor—check his reputation, his resources and his experience—before you buy.

Reputation for delivery may be as important as that for turning out a good product. When two competitive supplies are ostensibly equal in rating and performance, availability may give one supply the edge. This is especially true today, when components are in such short supply.

Don't buy on the basis of catalog specs alone. Two competitive supplies may have the same power rating, but one has plenty of reserve power in case of a fault, while the other works at its design limit when operated under rated conditions. At the first fault or overload, the huffer-and-puffer supply drops dead. Does the catalog tell you this? You can bet it doesn't.

Don't be misled by equivalent or fantastically high MTBFs, either. Plenty of games can be played with these figures. And, whatever you

do, don't buy on price alone.

Anyone who buys on price alone stands a good chance of getting burned. While it's true that prices can be lowered by high-production manufacturing techniques, some vendors try to cut prices by cutting corners: They use cheap components and underdesign, among other things.

Visit the vendor's plant, check his design, his manufacturing techniques and his components. It can be an eye-opener. Here are some things to look for:

- *Component power and tempco ratings.* Are low-tempco components (zeners, trimmers, resistors) used? Are components potential Molotov cocktails, on the verge of glowing, melting or catching fire? Check for paper-based PC boards, unprotected transformer bias windings (low current, but what happens on a short?).

- *Types of components and materials.* Are rectifiers controlled-avalanche type? Is hookup wire Teflon or plastic? Are resistors metal-film or composition? Are semiconductors plastic or metal-cased? Are ICs ceramic or plastic cased?

- *Design and construction.* Does the vendor guard against second breakdown in power transistors? How does he rate power transistors? Are paralleled transistors matched? Does the fuse blow before the rectifier or transformer? What class of insulation, what kind of magnetic material and construction are used in the transformer? Finally, what's the rms ripple-current rating of the filter capacitors? And does the ripple exceed the rating?

Many other guideposts exist, so do some research before you visit a vendor's facility.

## Who's who in power supplies

Not all power-supply vendors compete in the mainstream of the market. Some are custom

houses, with no catalog items. Others specialize in high-power or high-voltage units. Still others concentrate on miniature, encapsulated units. Only the largest offer a full-line of supplies, encompassing many different types.

Lambda Electronics is probably the leading vendor of power supplies. Its line ranges from custom units to power components and kits, to laboratory, OEM and encapsulated PC-board units.

Both Acme Electric and North Electric are leading custom houses, following Lambda closely in sales volume. North also offers catalog units.

Hewlett-Packard is mainly known for laboratory supplies, but it has in the last few years started emphasizing OEM modular units, including switching-regulator types.

Active and significant in modular OEM and other supplies are ACDC Electronics, Acopian, Kepco, Powertec, Power Designs, Power/Mate and Sorensen.

Others include Abbott Transistor Labs, Deltron, Elasco, Electrostatics, Modular Power, NJE, Standard Power, Technipower, Tele-Dynamics/Wanlass, Transistor Devices, Triad-Utrad and the Trygon Div. of Systron-Donner.

Specialists abound. For example, RO Associates concentrates on switchers; Elcor specializes in high-isolation supplies; Spellman offers high-voltage units; the Transrex Div. of Gultron builds high-power supplies.

If you need standby power, check with Terado Corp. Another company, Rosemount Nashville, stresses plug-in units. Powercube's Cirkitblock modules let you assemble your own supply from a series of basic circuits. Arnold Magnetics offers a similar building-block concept. Most of Voltex's supplies are custom, as are Reacor's.

Heath/Schlumberger concentrates on inexpensive lab supplies, both in kit and wired form.



Various models in Lambda's LX Series of modular units output from 35 to 850 W in 10 package sizes.

These single-output, fixed-voltage supplies feature 0.1% regulation and 1.5-mV ripple.

And Instant Instruments markets small lab units.

An unusual new design is the Controfluxer from Advanced Power—a self-regulating transformer that is insensitive to broad changes in input frequency, load current and line voltage.

Sola Electric offers, among other units, its SCRDC—a high-power, phase-controlled switching regulator. And Vectrol specializes in SCR phase-controlled units.

One class of supply that's being used more and more is the encapsulated PC-board unit. It's being offered by a host of companies. Some of the vendors make their own, while others buy private-label supplies from large-volume manufacturers like Semiconductor Circuits and Computer Products—companies that also market under their own brand names.

Leading the field in encapsulated units is Analog Devices, with a broad line of units specifically designed to power op amps, logic and other circuitry.

Others significant in the field are Burr-Brown; Datel, with its miniature switchers; National Semiconductor, a new entry; National Power Products; Technetics; Teledyne Philbrick; and Zeltex.

### What's coming?

The upcoming trends in power supplies? Besides the low-dissipation switcher to conserve energy, monolithic and hybrid regulators and control amplifiers will be used more and more. And less-accurate units—ferroresonant, parametric and SCR-controlled devices—will gain new

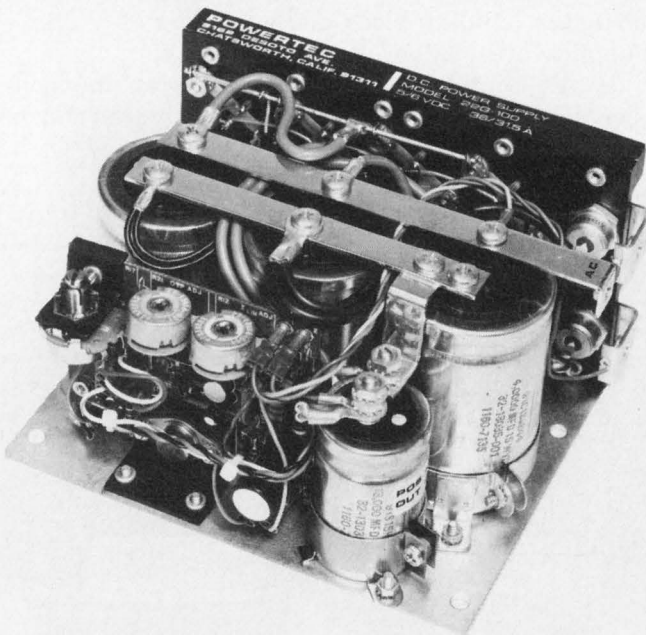
ground because of their low costs.

With the dropping of circuit voltages—and the price and size of miniature units—point-of-load supplies, with  $\pm 5\text{-V}$  and  $\pm 15\text{-V}$  outputs,

## Need more information?

The products cited in this report don't represent the manufacturers' full lines. And many companies not mentioned may offer similar products. For additional details, circle the appropriate information retrieval number:

- ACDC Electronics, Oceanside Industrial Center, Oceanside, Calif. 92054. (714) 757-1880. (D.W. Purkey). **Circle No. 380**
- Aaron-Davis Co., 1720 22nd St., Santa Monica, Calif. 90404. (213) 829-1834. (Richard Walden). **Circle No. 381**
- Abbott Transistor Labs, 5200 W. Jefferson Blvd., Los Angeles, Calif. 90016. (213) 936-8185. (Roy Baldarrama). **Circle No. 382**
- Acme Electric Corp., 28 Water St., Cuba, N.Y. 14727. (716) 968-2400. (Gary O. Rathbun). **Circle No. 383**
- Acopian Corp., P.O. Box 585, Easton, Pa. 18042. (215) 258-5441. (Thomas E. Skopal). **Circle No. 384**
- Advanced Power, 1621 S. Sinclair St., Anaheim Calif. 92806. (714) 997-0034. (John Franek). **Circle No. 385**
- AMP Inc., Captron Div., 1595 S. Mount Joy St., Elizabethtown, Pa. 17022. (717) 367-1105. (W. L. Pharmed). **Circle No. 386**
- Analog Devices, Inc., Route 1 Industrial Park, Norwood, Mass. 02062. (617) 329-4700. (Fred Pouliot). **Circle No. 387**
- Arnold Magnetics, 11520 W. Jefferson Blvd., Culver City, Calif. 90230. (213) 870-7014. (Ron Pizer). **Circle No. 388**
- Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706. (602) 294-1431. (C. R. Teeple). **Circle No. 389**
- Burwen Labs, 209 Middlesex Turnpike, Burlington, Mass. 01803. (617) 273-1488. (Richard S. Burwen). **Circle No. 390**
- Computer Products, Box 23849, Fort Lauderdale, Fla. 33308. (305) 974-5500. (William G. Ford). **Circle No. 391**
- Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. (617) 828-6395. (John H. Gallagher). **Circle No. 392**
- Del Electronics Corp., 250 E. Sandford Blvd., Mount Vernon, N.Y. 10550. (914) 699-2000. (Walter Young). **Circle No. 393**
- Deltron, Inc., Wissahickon Ave., North Wales, Pa. 19454. (215) 699-9261. (Aaron Anton). **Circle No. 394**
- Dynage, Inc., 1331 Blue Hills Ave., Bloomfield, Conn. 06002. (203) 243-0315. (Peter J. Klein). **Circle No. 395**
- Dynamic Measurements Corp., 6 Lowell Ave., Winchester, Mass. 01890. (617) 729-7870. (Kevin M. Corbett). **Circle No. 396**
- ERA Transpac Corp., 67 Sand Park Rd., Cedar Grove, N.J. 07009. (201) 239-3000. (S. Moskowitz). **Circle No. 397**
- Elasco, Div. of Buchbinder Corp., Northwest Industrial Park, Box 276, Bloomfield, Conn. 06002. (203) 242-0708. (Ronald H. Wolff). **Circle No. 398**
- Elcor Products, Welx Electronics, Halliburton Co., 2431 Linden Lane, Silver Spring, Md. 20910. (301) 589-6614. (Bud Evans). **Circle No. 399**
- ELDEC Corp., P.O. Box 100, Lynnwood, Wash. 98036. (206) 743-1313. (Kevin Hall). **Circle No. 449**
- Electronic Measurements Inc., 405 Essex Rd., Neptune, N.J. 07753. (201) 922-9300. (Bob Hill). **Circle No. 400**
- Electrostatics, Inc., 7718 Clairemont Mesa Rd., San Diego, Calif. 92111. (714) 279-1414. (Robert D. McCartney). **Circle No. 401**
- Elgar Corp., 8159 Engineer Rd., San Diego, Calif. 92111. (714) 279-0800. **Circle No. 402**
- Essex Data Information Systems, 17 Arthur Rd., Lincoln Park, N.J. 07035. (201) 696-8788. **Circle No. 403**
- Faratron Corp., 280 Green St., Hackensack, N.J. 07606. (201) 488-1440. (Ed Stulpin). **Circle No. 404**
- Function Modules, Inc., 2441 Campus Dr., Irvine, Calif. 92664. (714) 833-8314. (G. S. Osgood). **Circle No. 405**
- General Electric Co., Electronic Component Sales Dept., 1 River Rd., Schenectady, N.Y. 12305. (518) FR-4-2211. **Circle No. 406**
- Heath Co., Benton Harbor, Mich. 49022. (616) 983-3961. (Charles Gilmore). **Circle No. 407**
- Hewlett-Packard, Green Pond Rd., Rockaway, N.J. 07866. (201) 627-6400. (Bob Muggleston). **Circle No. 408**
- Hipotronics, Inc., Route 22, Brewster, N.Y. 10509. (914) 279-8091. **Circle No. 409**
- Instant Instruments Inc., 306 River St., Haverhill, Mass. 01830. (617) 373-9260. (J. Bonfiglio). **Circle No. 410**
- Intech, 1220 Coleman Ave., Santa Clara, Calif. 95050. (408) 244-0500. (Bill Jumper). **Circle No. 411**
- Intronics, Inc., 57 Chapel St., Newton, Mass. 02158. (617) 332-7350. (Arthur Pfaelzer). **Circle No. 412**



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- Lambda Electronics, 515 Broad Hollow Rd., Melville, N.Y. 11746. (516) 694-4200. (Irving Gutman). **Circle No. 414**
- Metronix, 14-3 1-Chome, Chidori, Ota-ku, Tokyo, Japan. **Circle No. 415**
- James Millen Manufacturing, 150 Exchange St., Malden, Mass. 02148. (617) 324-4108. (R. Wade Caywood). **Circle No. 416**
- Modular Power, 7364 Convoy Ct., San Diego, Calif. 92111. (714) 279-1641. (R. H. Baumann). **Circle No. 417**
- NJE Corp., Sub. Technical Development, P.O. Box 50, Culver Rd., Dayton, N.J. 08810. (201) 329-4616. (J. Robert Hoeffler). **Circle No. 418**
- National Power Products Inc., P.O. Box 292, Haverhill, Mass. 01830. (617) 374-0777. (John T. Parent). **Circle No. 419**
- National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. (408) 732-5000. (Dean Coleman). **Circle No. 420**
- INQUIRE DIRECT**
- North Electric Co., Electronics Div., 553 S. Market St., Galion, Ohio 44833. (419) 468-8100. (Jerry Neff). **Circle No. 420**
- Power Designs, 1700 Shames Dr., Westbury, N.Y. 11590. (516) 333-6200. (Herb Roth). **Circle No. 421**
- Power/Mate, 514 S. River St., Hackensack, N.J. 07601. (201) 343-6294. (Marvin Charter). **Circle No. 422**
- Power One, 6324 Variel Ave., Bldg. E, Woodland Hills, Calif. 91364. (213) 887-5730. **Circle No. 423**
- Power Supplies Inc., 1388 Dixwell Ave., Hamden, Conn. 06514. (203) 281-0298. (F. W. Clark). **Circle No. 424**
- Powercube Corp., Sub. Unitrode Corp., 214 Calvary St., Waltham, Mass. 02154. (617) 891-1830. (John C. Prestidge). **Circle No. 425**
- Powertec Inc., 9168 De Soto Ave., Chatsworth, Calif. 91311. (213) 882-0004. (John E. Poturny). **Circle No. 426**
- RO Associates, Inc., 3705 Haven Ave., Menlo Park, Calif. 94025. (415) 322-5321. (Robert H. Okada). **Circle No. 427**
- Reacor, Inc., 740 S. Sherman, Richardson, Tex. 75080. (214) 235-1952. (Roy Bartlett). **Circle No. 428**
- Rosemount Nashville, Inc., 100 Heil-Quaker Blvd., Laverne, Tenn. 37086. (615) 793-7561. (Paul Kelso). **Circle No. 429**
- Semiconductor Circuits, Inc., 306 River St., Haverhill, Mass. 01830. (617) 373-9104. (Paul LaBrie). **Circle No. 430**
- Sola Electric Div., Sola Basic Industries, 1717 Busse Rd., Elk Grove Village, Ill. 60007. (312) HE-9-2800. (Ruxton G. Tucker). **Circle No. 431**
- Sorensen Power Supplies, Div. of Raytheon, 676 Island Pond Rd., Manchester, N.H. 03103. (603) 668-1600. (Ken Lent). **Circle No. 432**
- Spellman High Voltage Electronics Corp., 1930 Adee Ave., Bronx, N.Y. 10469. (212) 671-0300. (Michael A. Civin). **Circle No. 433**
- SRC Div., Moxon, Inc., 2222 Michelson Dr., Newport Beach, Calif., 92664. (714) 833-2000 (Jerry Heyer). **Circle No. 434**
- Standard Power, Inc., 1400 S. Village Way, Santa Ana, Calif. 92705. (714) 558-8512. (Carroll Goldsworth). **Circle No. 435**
- Technipower Inc., Benrus Center, Ridgefield, Conn. 06877. (203) 438-0333. (Albert R. Saenz). **Circle No. 436**
- Tele-Dynamics/Wanlass, Div. AMBAC Industries, 525 Virginia Dr., Fort Washington, Pa. 19034. (215) 643-6161. (Murray Kraus). **Circle No. 437**
- Teledyne Philbrick, Allied Dr. at Route 128, Dedham, Mass. 02026. (617) 329-1600. (James Q. Dolan). **Circle No. 438**
- Terado Corp., 1068 Raymond Ave., St. Paul, Minn. 55108. (612) 646-2868. (Wayne Sorenson). **Circle No. 439**
- Transistor Devices, 85 Horsehill Rd., Cedar Knolls, N.J. 07927. (201) 267-1900. (Richard F. Blake). **Circle No. 440**
- Transrex Div., Gulton Industries, 2001 W. Artesia Blvd., Torrance, Calif. 90504. (213) 327-9224. (Mel Anderson). **Circle No. 441**
- Triad-Utrad, Div. of Litton Systems, Inc., 305 N. Briant St., Huntington, Ind. 46750. (219) 356-6500. (Newton Cook). **Circle No. 442**
- Trio Labs, Inc., 80 Dupont St., Plainview, N.Y. 11803. (516) 681-0400. (Jay Salz). **Circle No. 443**
- Trygon Electronics, Sub. Systron-Donner, 1200 Shames Dr., Westbury, N.Y. 11590. (516) 997-6200. (Harvey Rait). **Circle No. 444**
- Vectrol, Inc., 1010 Westmore Ave., Rockville, Md. 20850. (301) 424-6900. (Roy A. Mitchell). **Circle No. 445**
- Venus Scientific, 399 Smith St., Farmingdale, N.Y. 11735. (516) 293-4100. **Circle No. 446**
- Voltex Co., Inc., 115 Marine St., Farmingdale, N.Y. 11735. (516) CH-9-2336. (Nathaniel Rothenberg). **Circle No. 447**
- Zeltex, Inc., Sub. Redcor Corp., 1000 Chalומר Rr., Concord, Calif. 94520. (415) 686-6660. (Russ Ferreira). **Circle No. 448**

# DO-IT-YOURSELF grabber



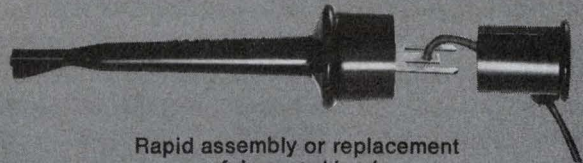
**NEW**

- Simplified Assembly
- Versatile
- Comfortable Finger Grip Action
- Completely Field Serviceable
- Molded of Tough Lexan\*

**Model 3925  
Mini Test Clip  
Shown Actual Size**

This test clip with gold plated hook is excellent for rapid testing of components and Wire Wrap† pins. Clip is completely insulated to point of connection. Build any combination of test leads with wire up to .090 dia. Easy and comfortable to operate. Molded of rugged Lexan to resist melting when soldering. Write for literature and prices.

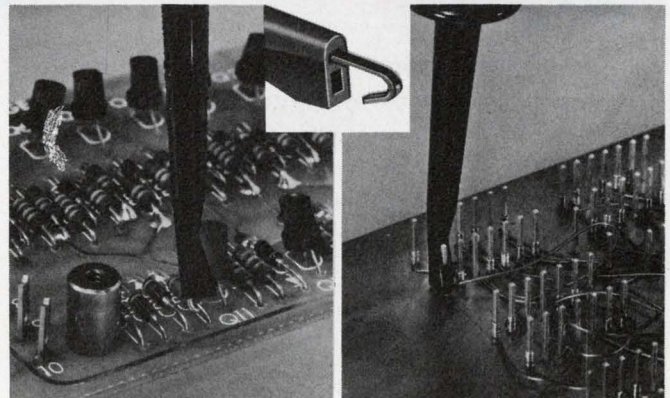
## SIMPLIFIED ASSEMBLY



Rapid assembly or replacement of damaged lead.

## MODEL 3925

hooks onto components or slips over square Wire-Wrap pins



\*Lexan is a General Electric trade-mark. †Registered trade-mark of Gardner-Denver Co.



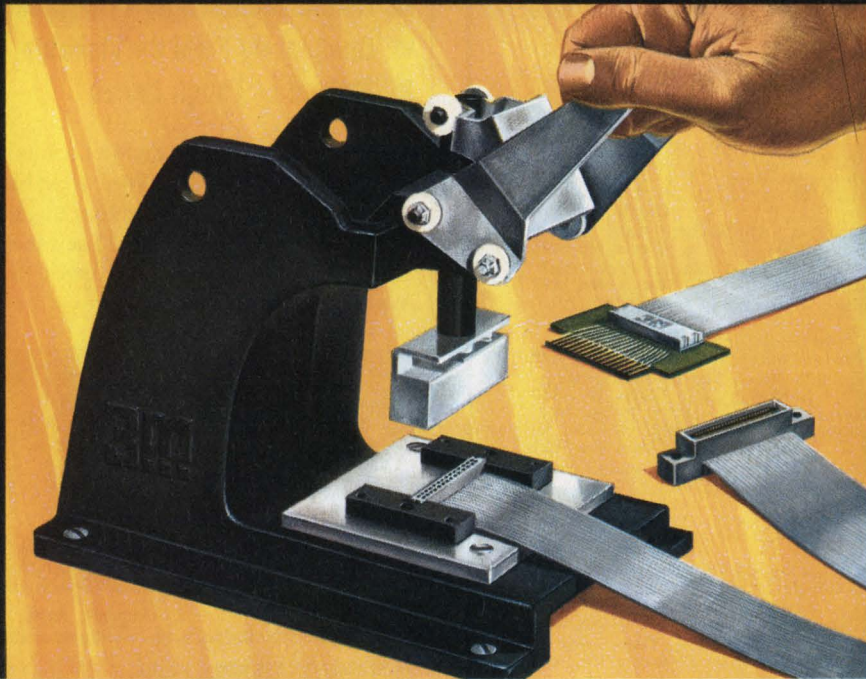
**POMONA ELECTRONICS**

A Subsidiary of ITT

1500 East Ninth St., Pomona, Calif. 91766  
Telephone (714) 623-3463

INFORMATION RETRIEVAL NUMBER 25

# “Scotchflex” Flat Cable Connector System makes 50 connections at a time.



“SCOTCHFLEX” IS A REGISTERED TRADEMARK OF 3M CO.

Build assembly cost savings into your electronics package with “Scotchflex” flat cable and connectors. These fast, simple systems make simultaneous multiple connections in seconds without stripping or soldering. Equipment investment is minimal; there’s no need for special training. The inexpensive assembly press, shown above, crimps connections tightly, operates easily and assures error free wiring.

Reliability is built in, too, with “Scotchflex” interconnects. Inside of connector bodies, unique U-contacts strip through flat cable insulation, grip each conductor for dependable gas-tight connections.

“Scotchflex” offers you design freedom, with a wide choice of cable and connectors. From off-the-shelf stock you can choose: 14 to 50-conductor cables. Connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards. Headers for de-pluggable connection between cable jumpers and PCB. Custom assemblies are also available on request.

For more information, write Dept. EAH-1, 3M Center, St. Paul, Minn. 55101.

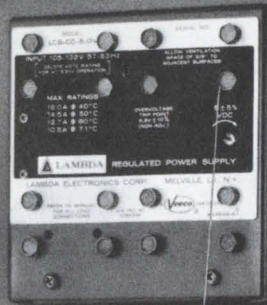


**“Scotchflex”.**  
**Your systems approach  
to circuitry.**



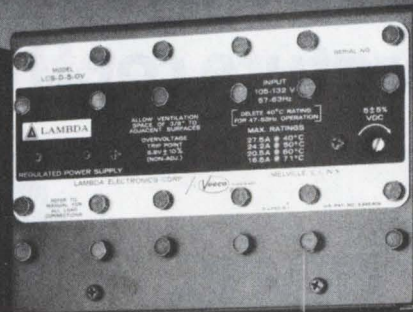
Do you face a make or buy decision on power supplies?

# BUY LAMBDA'S O.01% REGULATION; 250 $\mu$ V RIPPLE LC SERIES.



LCS-CC-5-0V  
5V, 16A  
**\$220**

**NEW**



LCS-D-5-0V  
5V, 27.5A  
**\$300**

**NEW**



LCS-E-5-0V  
5V, 35A  
**\$350**

**NEW**



LCS-EE-20  
20V, 22A  
**\$440**

**NEW**



LCS-7-5-0V  
5V, 65A  
**\$560**

**NEW**

**12 PACKAGE SIZES...  
THE BROADEST LINE  
OF MODULAR SUPPLIES  
FOR LABORATORY,  
BREADBOARD AND  
PROTOTYPE USE.**

- 0.01% regulation... line or load
- 0.01%/°C temperature coefficient
- 250  $\mu$  V RMS ripple
- 1-day delivery
- 5-year guarantee

# LAMBDA'S LC SERIES POWER SUPPLIES, SINGLE & DUAL OUTPUTS, FIXED AND WIDE VOLTAGE MODELS

O.01% regulation, 250 $\mu$ V ripple, O.01%/ $^{\circ}$ C temperature coefficient



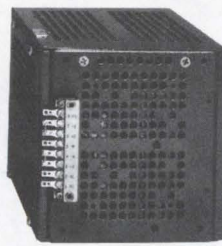
**"1" Package**  
(1 21/32" x 3 5/32" x 3 9/32")



**"2" Package**  
(3 5/32" x 3 9/32" x 3 9/32")



**"3" Package**  
(3 3/16" x 3 5/16" x 5")



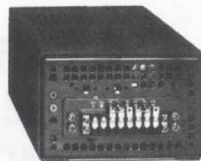
**"4" Package**  
(4 29/32" x 4 29/32" x 5")



**"7" Package**  
(4 15/16" x 10 1/8" x 16 1/2")



**"A" Package**  
(3 3/16" x 3 3/4" x 6 1/2")



**"B" Package**  
(3 3/16" x 4 15/16" x 6 1/2")



**"C" Package**  
(3 3/16" x 4 15/16" x 9 3/8")



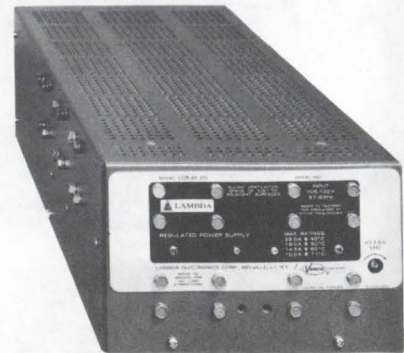
**"CC" Package**  
(4 15/16" x 4 15/16" x 9 3/8")



**"D" Package**  
(4 15/16" x 7 1/2" x 9 3/8")



**"E" Package**  
(4 15/16" x 7 1/2" x 11 3/4")



**"EE" Package**  
(4 15/16" x 7 1/2" x 16 1/2")

# 12 REASONS WHY ONLY LAMBDA CAN GIVE YOU A MEANINGFUL 5-YEAR GUARANTEE...LC SERIES

**1** Lambda's MIL-T-27C grade 6 magnetics.

**2** Lambda offers a rugged convection cooled chassis.

**3** Lambda uses computer grade hermetically sealed 10-year life electrolytic capacitors.

**4** Lambda uses an integrated circuit that replaces up to 32 discrete components for higher reliability.

**5** Lambda engineering assures performance reproducibility and the LC power supplies are designed for large volume production.

**6** Lambda uses MIL-R-22684 type film resistors.

**7** Lambda's LC power supplies are listed in Underwriters' Laboratories recognized component index.

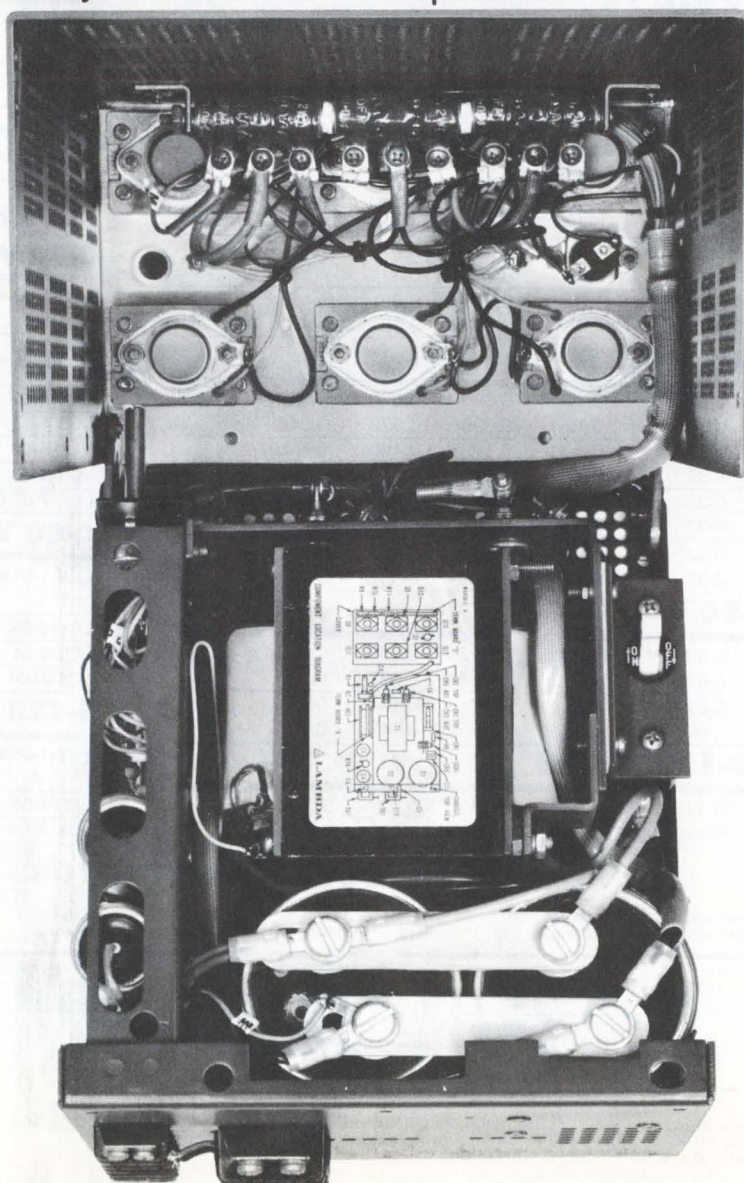
**8** Lambda features a heavy duty barrier strip on their LC power supplies.

**9** Lambda builds the LC power supplies with MIL-R-11 composition resistors.

**10** Lambda uses wire that meets MIL-W-16878 where necessary.

**11** Lambda builds LC power supplies with MIL-R-26 type wire wound resistors.

**12** Lambda's power supplies are thoroughly tested throughout production for high performance operation.



## WIDE RANGE VOLTAGE MODELS

### 0-7/0-7 VOLTS

### DUAL OUTPUT

MODEL	ADJ. VOLT. RANGE VDC (Each Side)	MAX. AMPS AT AMBIENT OF:				PRICE
		40°C	50°C	60°C	71°C	
LCD-2-11	0-7	0.300	0.240	0.175	0.115	\$125.
	0-7	0.300	0.240	0.175	0.115	
LCD-3-11	0-7	0.700	0.590	0.480	0.340	145.
	0-7	0.700	0.590	0.480	0.340	
LCD-A-11	0-7	1.0	0.9	0.7	0.5	155.
	0-7	1.0	0.9	0.7	0.5	
LCD-4-11	0-7	1.8	1.5	1.2	0.7	190.
	0-7	1.8	1.5	1.2	0.7	

### 0-7/0-18 VOLTS

LCD-2-12	0-7	0.300	0.240	0.175	0.115	125.
	0-18	0.160	0.130	0.100	0.065	
LCD-3-12	0-7	0.700	0.590	0.480	0.340	145.
	0-18	0.400	0.350	0.300	0.210	
LCD-A-12	0-7	1.0	0.9	0.7	0.5	155.
	0-18	0.5	0.45	0.4	0.3	
LCD-4-12	0-7	1.8	1.5	1.2	0.7	190.
	0-18	1.0	0.8	0.65	0.4	

### 0-7/0-32 VOLTS

LCD-4-13	0-7	1.8	1.5	1.2	0.24	190.
	0-32	0.6	0.53	0.4	0.7	

### 0-18/0-18 VOLTS

LCD-2-22	0-18	0.160	0.130	0.100	0.065	125.
	0-18	0.160	0.130	0.100	0.065	
LCD-3-22	0-18	0.400	0.350	0.300	0.210	145.
	0-18	0.400	0.350	0.300	0.210	
LCD-A-22	0-18	0.5	0.45	0.4	0.3	155.
	0-18	0.5	0.45	0.4	0.3	
LCD-4-22	0-18	1.0	0.8	0.65	0.4	190.
	0-18	1.0	0.8	0.65	0.4	

### 0-32/0-32 VOLTS

LCD-2-33	0-32	0.120	0.095	0.070	0.045	125.
	0-32	0.120	0.095	0.070	0.045	
LCD-3-33	0-32	0.225	0.190	0.160	0.120	145.
	0-32	0.225	0.190	0.160	0.120	
LCD-A-33	0-32	0.35	0.3	0.25	0.2	155.
	0-32	0.35	0.3	0.25	0.2	
LCD-4-33	0-32	0.6	0.53	0.4	0.24	190.
	0-32	0.6	0.53	0.4	0.24	

### 0-60/0-60 VOLTS

LCD-2-44	0-60	0.065	0.052	0.037	0.023	170.
	0-60	0.065	0.052	0.037	0.023	
LCD-A-44	0-60	0.2	0.18	0.14	0.12	180
	0-60	0.2	0.18	0.14	0.12	

### 0-120/0-120 VOLTS

LCD-2-55	0-120	0.030	0.030	0.022	0.014	170.
	0-120	0.030	0.030	0.022	0.014	

## FIXED VOLTAGE MODEL DUAL OUTPUT

### 15v ±5%

MODEL	ADJ. VOLT. RANGE VDC (Each Side)	MAX. AMPS AT AMBIENT OF:				PRICE
		40°C	50°C	60°C	71°C	
LCD-4-152	15±5%	1.5	1.3	1.0	0.6	220
	15±5%	1.5	1.3	1.0	0.6	

## WIDE RANGE MODELS

### 0-7 VOLTS

### SINGLE OUTPUT

MODEL	MAX. AMPS AT AMBIENT OF:				PRICE
	40°C	50°C	60°C	71°C	
LCS-1-01A †	0.275 (.250)	0.220 (.180)	0.165 (.120)	0.110 (.075)	\$ 70.
LCS-2-01	0.550	0.455	0.350	0.240	80.
LCS-3-01	1.200	1.000	0.750	0.500	90.
LCS-A-01	2.0	1.9	1.6	1.1	99.
LCS-4-01	3.3	3.0	2.3	1.5	130.
LCS-B-01	3.7	3.3	2.7	1.7	130.
LCS-C-01	4.5	4.1	3.8	3.3	150.
LCS-7-01-OV (2)	28.0	25.5	22.0	18.5	560.

### 0-18 VOLTS

LCS-1-02A †	0.130 (.115)	0.130 (.115)	0.100 (.080)	0.085 (.040)	70.
LCS-2-02	0.330	0.275	0.210	0.140	80.
LCS-3-02	0.750	0.620	0.480	0.320	90.
LCS-A-02	1.1	1.0	0.9	0.7	99.
LCS-4-02	1.8	1.6	1.2	0.8	130.
LCS-B-02	2.0	1.8	1.6	1.2	130.
LCS-C-02	2.3	2.1	1.9	1.6	150.
LCS-7-02-OV (2)	12.5	11.5	10.0	8.5	560.

### 0-32 VOLTS

LCS-1-03A †	0.090 (.080)	0.090 (.080)	0.090 (.050)	0.050 (.025)	70.
LCS-2-03	0.240	0.205	0.155	0.095	80.
LCS-3-03	0.400	0.350	0.265	0.170	90.
LCS-A-03	0.69	0.64	0.60	0.45	99.
LCS-4-03	1.0	0.9	0.7	0.5	130.
LCS-B-03	1.1	1.0	0.8	0.5	130.
LCS-C-03	1.6	1.5	1.4	1.2	150.
LCS-7-03-OV (2)	7.5	6.8	5.9	4.9	560.

### 0-60 VOLTS

LCS-1-04A †	0.050 (.045)	0.050 (.045)	0.050 (.035)	0.030 (.015)	90.
LCS-2-04	0.145	0.115	0.087	0.057	90.
LCS-3-04	0.240	0.190	0.140	0.085	99.
LCS-A-04	0.37	0.34	0.31	0.25	99.

### 0-120 VOLTS

LCS-1-05A †	0.018 (.015)	0.018 (.015)	0.018 (.015)	0.018 (.010)	90.
LCS-2-05	0.050	0.050	0.045	0.030	90.
LCS-A-05	0.10	0.10	0.10	0.10	109.

## OVERVOLTAGE PROTECTORS ACCESSORIES

MODEL	ADJ. VOLT. RANGE VDC	FOR USE WITH PACKAGES	PRICE	MODEL	ADJ. VOLT. RANGE VDC	FOR USE WITH PACKAGES	PRICE	MODEL	CROWBAR VOLTAGE VDC	FOR USE WITH MODELS	PRICE
LC-OV-10	3-24		\$20	LH-OV-4	3-24	Wide Range Models in	\$35	LZ-OV-13	6.8±10%	LCS-1-01A, LCS-2-01 LCS-3-01, LCS-A-01 LCD-2-11, LCD-3-11 LCD-4-11, LCD-A-11	\$10
LC-OV-11	3-47	1, 2 and 3	20	LH-OV-5	3-47	Packages A, B, C, 4,	35				
LC-OV-12	3-70		25	LH-OV-6	3-70	5, CC, D, and E	35				
LM-OV-1	3-8	Fixed Voltage Models	30	LM-OV-7	3-8		75	LZ-OV-14	16.8±1.3V	LCS-1-02A, LCS-2-02 LCS-3-02, LCS-4-02 LCS-A-02, LCS-A-15 LCS-B-02, LCD-2-22 LCD-3-22, LCD-4-22	\$10
LM-OV-3	6-20	in Packages	30	LM-OV-8	6-20	EE	75				
LM-OV-3	18-70	A, B, C, 4, CC, D, E	30	LM-OV-g	18-70		75				

Overvoltage shutdown may occur anywhere within the voltage trip point range for LZ-OV-13, -14  
All dual LC series supplies require one overvoltage protector for each output.  
†Bracket ratings are for 47-53 Hz operation

## FIXED VOLTAGE MODELS

### 2 VOLTS ±5%

### SINGLE OUTPUT

MODEL	MAX. AMPS AT AMBIENT OF:				PRICE
	40°C	50°C	60°C	71°C	
LCS-A-2	3.0	2.5	2.0	1.4	\$ 99
LCS-B-2	6.5	5.3	4.5	3.3	130
LCS-C-2	9.0	8.0	6.8	5.3	160
LCS-7-2-OV (2)	65.0	63.0	55.0	40.0	560

### 5 VOLTS ±5%

LCS-A-5	2.7	2.3	1.8	1.2	99
LCS-4-5	4.4	3.7	2.9	1.8	130
LCS-B-5-OV (1)(4)	5.8	5.0	4.0	3.0	130
LCS-C-5-OV (1)(4)	9.0	8.0	6.8	5.3	160
LCS-CC-5-OV (1)(4)	16.0	14.5	12.7	10.5	220
LCS-D-5-OV (1)(4)	27.5	24.2	20.5	16.5	300
LCS-E-5-OV (1)(4)	35.0	30.0	24.0	17.5	350
LCS-EE-5-OV (1)(4)	45.0	39.0	32.0	25.0	465
LCS-7-5-OV (2)	65.0	56.0	46.0	35.0	560

### 6 VOLTS ±5%

LCS-A-6	2.6	2.2	1.8	1.2	99
LCS-4-6	4.0	3.4	2.6	1.5	130
LCS-B-6	5.5	4.7	3.8	2.9	130
LCS-C-6	8.8	7.8	6.7	5.2	160
LCS-CC-6 (4)	15.2	13.8	12.1	10.0	210
LCS-D-6 (4)	26.5	23.4	19.8	16.0	290
LCS-E-6 (4)	34.0	29.0	23.0	16.5	330
LCS-EE-6-OV (3)(4)	42.0	36.0	30.0	22.0	465
LCS-7-6-OV (2)	59.0	50.0	41.0	32.0	560

### 8 VOLTS ±5%

LCS-A-8	2.4	2.0	1.7	1.1	99
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### 10 VOLTS ±5%

LCS-A-10	2.1	1.8	1.5	1.0	99
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### 12 VOLTS ±5%

LCS-A-12	1.9	1.7	1.3	0.9	99
LCS-4-12	3.1	2.8	2.2	1.3	130
LCS-B-12	3.8	3.6	3.0	2.2	130
LCS-C-12	6.5	6.1	5.5	4.6	160
LCS-CC-12 (4)	10.5	9.4	8.2	5.0	210
LCS-D-12 (4)	16.0	14.0	11.9	8.0	290
LCS-E-12 (4)	21.0	18.0	15.0	12.5	330
LCS-EE-12 (4)	32.0	27.0	22.0	16.0	440
LCS-7-12-OV (2)	40.0	36.0	30.0	23.0	560

### 15 VOLTS ±5%

LCS-A-15	1.8	1.5	1.2	0.9	99
LCS-4-15	2.8	2.6	2.1	1.3	130
LCS-B-15	3.2	2.8	2.5	1.5	130
LCS-C-15	6.0	5.6	5.1	4.5	160
LCS-CC-15	9.5	8.6	7.4	4.8	210
LCS-D-15	14.0	12.3	10.4	7.5	290
LCS-E-15	19.0	17.0	14.0	12.0	330
LCS-EE-15	28.0	24.0	19.5	14.0	440
LCS-7-15-OV (2)	36.0	32.0	26.0	20.0	560

### 18 VOLTS ±5%

LCS-A-18	1.6	1.3	1.1	0.8	99
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#### NOTES:

- (1) Includes fixed overvoltage protection at 6.8V±10%
- (2) Built-in continuously adjustable overvoltage protection crowbars output when trip level is exceeded. Included on all LCS-7 models.
- (3) Includes fixed overvoltage protection at 7.4V±10%
- (4) Consult factory for delivery.

## FIXED VOLTAGE MODELS

### 20 VOLTS ±5%

### SINGLE OUTPUT

MODEL	MAX. AMPS AT AMBIENT OF:				PRICE
	40°C	50°C	60°C	71°C	
LCS-A-20	1.4	1.2	1.0	0.8	\$ 99
LCS-4-20	2.4	2.2	1.9	1.1	130
LCS-B-20	2.7	2.3	2.0	1.4	125
LCS-C-20	4.2	4.0	3.5	3.0	150
LCS-CC-20 (4)	7.7	7.2	6.5	4.4	210
LCS-D-20 (4)	11.5	10.0	8.6	6.8	290
LCS-E-20 (4)	15.0	13.0	10.5	7.0	330
LCS-EE-20 (4)	22.0	18.5	14.5	10.0	440
LCS-7-20-OV (2)	28.0	25.0	20.5	15.5	560

### 24 VOLTS ±5%

LCS-A-24	1.1	1.0	0.85	0.70	99
LCS-B-24	2.1	2.0	1.8	1.2	125
LCS-4-24	2.2	1.8	1.5	0.95	130
LCS-C-24	3.6	3.4	3.0	2.5	150
LCS-CC-24 (4)	6.8	6.4	5.7	4.4	210
LCS-D-24 (4)	10.0	8.8	7.5	6.0	290
LCS-E-24 (4)	13.0	11.0	9.5	6.0	330
LCS-EE-24 (4)	19.0	16.5	13.0	9.5	440
LCS-7-24-OV (2)	25.0	22.0	18.0	14.0	560

### 28 VOLTS ±5%

LCS-A-28	1.0	0.9	0.75	0.60	99
LCS-B-28	1.8	1.7	1.6	1.0	125
LCS-4-28	2.0	1.6	1.4	0.85	130
LCS-C-28	3.0	2.7	2.6	2.2	150
LCS-CC-28 (4)	6.0	5.6	5.0	4.3	210
LCS-D-28 (4)	9.0	8.0	6.8	5.5	290
LCS-E-28 (4)	11.0	10.0	8.5	5.5	330
LCS-EE-28 (4)	17.0	15.0	12.0	9.0	440
LCS-7-28-OV (2)	22.0	19.5	16.0	12.5	560

### 36 VOLTS ±5%

LCS-A-36	0.90	0.80	0.70	0.50	99
LCS-B-36	1.4	1.3	1.1	0.7	125
LCS-C-36	2.3	2.2	2.1	1.6	150

### 48 VOLTS ±5%

LCS-A-48	0.60	0.55	0.50	0.45	99
LCS-B-48	1.1	1.0	0.9	0.6	140
LCS-4-48	1.2	1.1	0.9	0.75	140
LCS-C-48	1.8	1.7	1.6	1.3	170
LCS-7-48-OV (2)	12.0	10.5	8.5	6.0	560

### 100 VOLTS ±5%

LCS-A-100	0.18	0.18	0.18	0.18	109
LCS-B-100	0.46	0.46	0.46	0.34	140
LCS-C-100	0.65	0.65	0.65	0.65	170

### 120 VOLTS ±5%

LCS-A-120	0.15	0.15	0.15	0.15	109
LCS-B-120	0.40	0.40	0.40	0.30	140
LCS-C-120	0.55	0.55	0.55	0.55	170

### 150 VOLTS ±5%

LCS-A-150	0.10	0.10	0.10	0.10	109
LCS-B-150	0.32	0.32	0.32	0.25	150
LCS-C-150	0.42	0.42	0.42	0.42	170

## Specifications of LC Series

### DC output

Voltage range shown in tables

#### Regulated voltage

regulation, line . . . . .	0.01% + 1 mV
regulation, load . . . . .	0.01% + 1 mV
ripple and noise . . . . .	250 $\mu$ V RMS, 1 mV pk-pk
remote programming resistance	1000 ohms/volt, nominal
remote programming voltage	volt per volt
temperature coefficient . . . . .	(0.01% + 300 $\mu$ V)/ $^{\circ}$ C with external programming resistor; (0.015% + 300 $\mu$ V/ $^{\circ}$ C with internal programming resistor.

### AC input

line . . . . .	105-132 Vac; 47-440 Hz. Derate 10% for 50 Hz operation. For operation at other than 57-63 Hz and 187-242 Vac, see AC input option.
power . . . . .	LCS-1 13 watts; LCS-2, LCD-2 20 watts; LCS-3, 40 watts; LCS-A 80 watts; LCD-A 55 watts; LCS-4, LCD-4 125 watts; LCS-B 125 watts. LCS-C 215 watts; LCS-CC 300 watts; LCS-D 460 watts; LCS-E 600 watts; LCS-EE 850 watts; LCS-7 1300 watts.

### Overshoot

no overshoot on turn-on, turn-off, or power failure

### Ambient operating temperature range

continuous duty from  $-20^{\circ}$ C to  $+71^{\circ}$ C with corresponding load current ratings for all modes of operation.

### Storage temperature range

$-55^{\circ}$ C to  $+85^{\circ}$ C

### Overload Protection

#### Thermal

thermostat; automatic reset when over-temperature condition is eliminated. (Not applicable to LCS-1, LCS-3, LCD-3, LCS-A, and LCD-A models.)

#### Electrical

external overload protection: automatic electronic current limiting circuit limits the output current to a preset value, thereby providing protection for the load as well as the power supply.

### Input and output connections

thru terminal block on chassis.

### Integrated circuit regulation

integrated circuit provides regulation system, except for input and output capacitors, rectifiers and series regulation transistors.

### Convection cooled

no external heat sinking or forced air required.

### Controls

#### DC output control

simple screwdriver voltage adjustment over entire voltage range.

#### Remote sensing

provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

#### Current limit

140% of  $40^{\circ}$ C rating for LCS-1, LCS-2, LCD-2, LCS-3, LCD-3, LCS-A, LCD-A, 110% of  $40^{\circ}$ C rating for LCS-4, LCD-4, LCS-B, LCS-C, LCS-CC, LCS-D, LCS-E, LCS-EE, LCS-7.

#### Mounting

LCS-1 five mounting surfaces; LCS-2, LCD-2 four mounting surfaces; LCS-3, LCD-3, LCS-A, LCD-A, LCS-4, LCD-4, LCS-B, LCS-C, LCS-CC and LCS-D three mounting surfaces, designed to mount in Lambda standard rack adapters. LCS-E, LCS-EE and LCS-7 one mounting surface in horizontal plane.

### Physical Data

#### Weight:

LCS-1 1 lb. net, 1 7/8 lbs. ship; LCS-2, LCD-2 2 1/4 lbs. net, 3 1/8 lbs. ship; LCS-3, LCD-3 3 1/2 lbs. net, 4 1/2 lbs. ship; LCS-A 6 lbs. net, 7 lbs. ship; LCD-A 5 lbs. net, 6 lbs. ship; LCS-4, LCD-4 8 lbs. net, 9 lbs. ship; LCS-B 7 lbs. net, 8 lbs. ship; LCS-C 10 lbs. net, 11 lbs. ship; LCS-CC 15.0 lbs. net, 17.0 lbs. ship; LCS-D 23.0 lbs. net, 26.0 lbs. ship; LCS-E 28 lbs. net, 31 lbs. ship; LCS-EE 37.0 lbs. net, 47.0 lbs. ship; LCS-7 48 lbs. net, 60 lbs. ship.

#### Size

LCS-1 3 5/32" x 3 9/32" x 1 21/32" single output models; LCS-2, LCD-2, 3 5/32" x 3 9/32" x 3 9/32" single and dual output models; LCS-3, LCD-3 3 3/16" x 3 3/4" x 5" single and dual output model; LCS-A, LCD-A 3 3/16" x 3 3/4" x 6 1/2" single and dual output models; LCS-4, LCD-4 4 29/32" x 4 29/32" x 5" single and dual output models; LCS-B 3 3/16" x 4 15/16" x 6 1/2" single output models; LCS-C 3 3/16" x 4 15/16" x 9 3/8" single output models; LCS-CC 4 15/16" x 4 15/16" x 9 3/8" single output models; LCS-D 4 15/16" x 7 1/2" x 9 3/8" single output models; LCS-E 4 15/16" x 7 1/2" x 11 3/4" single output models; LCS-EE 4 15/16" x 7 1/2" x 16 1/2" single output models; LCS-7 4 15/16" x 10 1/8" x 16 1/2" single output models.

#### Finish

gray, FED. STD. 595 No. 26081

### Accessories

rack adapters, overvoltage protectors, chassis slides and blank panels.

### Option

#### A.C. input

add suffix -V to model number for operation at 187-242 Vac, 47-440 Hz, except LCS-1 series and derate current 10% for 47-53 Hz operation except LCS-1 series. Add 12% or \$15.00 to price, whichever is greater. For 360-440 Hz operation consult factory.

# 10 Reasons to Switch to Switchers\*

Nominal Output Voltage (±5% Adj)	Maximum Rating (amps) 40°C	Case Size (inches)	Weight	Model Number	Price
5	60	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 10 $\frac{1}{4}$	15 lbs.	JP5N60	\$425
5	100	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 15	19 lbs.	JP5N100	\$550
12	26	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 10 $\frac{1}{4}$	15 lbs.	JP12N26	\$425
12	43	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 15	19 lbs.	JP12N43	\$550
15	21	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 10 $\frac{1}{4}$	15 lbs.	JP15N21	\$425
15	35	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 15	19 lbs.	JP15N35	\$550
20	16	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 10 $\frac{1}{4}$	15 lbs.	JP20N16	\$425
20	27	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 15	19 lbs.	JP20N27	\$550
24	14	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 10 $\frac{1}{4}$	15 lbs.	JP24N14	\$425
24	23	4 $\frac{7}{8}$ x 7 $\frac{1}{8}$ x 15	19 lbs.	JP24N23	\$550

70% to 80% efficiency

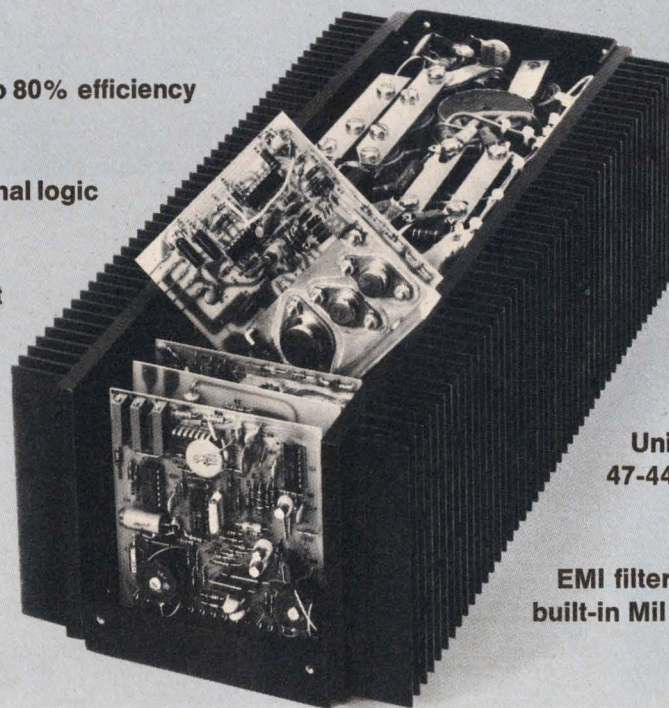
Controllable from external logic

Low inrush current  
on turn-on for soft start

20KHz (inaudible)

Remote sensing

0.1% regulation



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and overload protection,  
externally adjustable

Up to three switchers  
can be paralleled  
in master-slave configuration

Universal input: 115/230VAC,  
47-440Hz or 150VDC

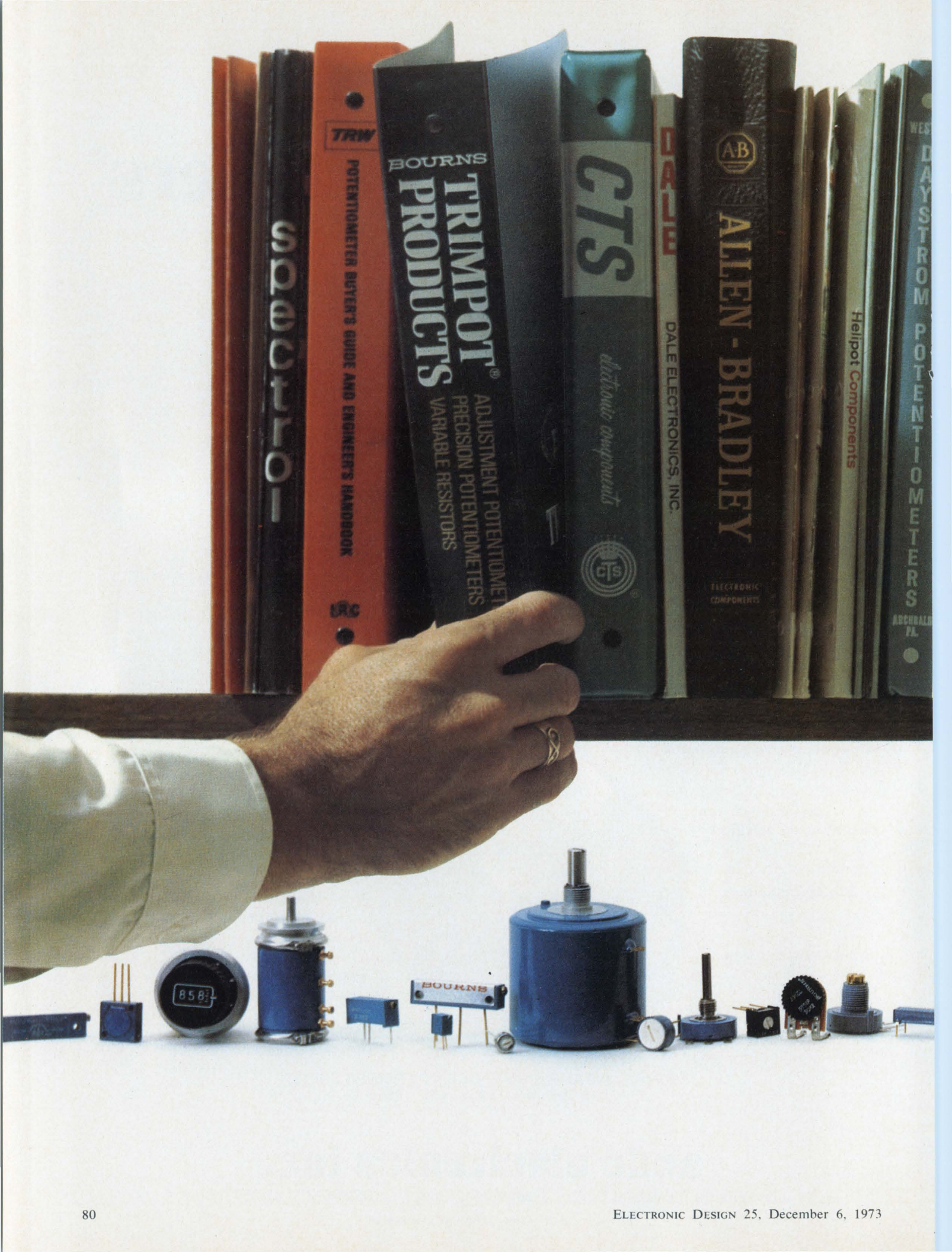
EMI filtering and shielding (or optional  
built-in Mil Std 461, CE03 Input Filter)

\* 5 VOLT, 100 AMP HIGH EFFICIENCY POWER SUPPLY  
19 LBS., 4 $\frac{7}{8}$ " x 7 $\frac{1}{8}$ " x 15": \$550

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# Protect series-pass transistors from thermal overloads by adding current-limiting circuitry to the power-supply regulator. Pick one of the many ways to do it.

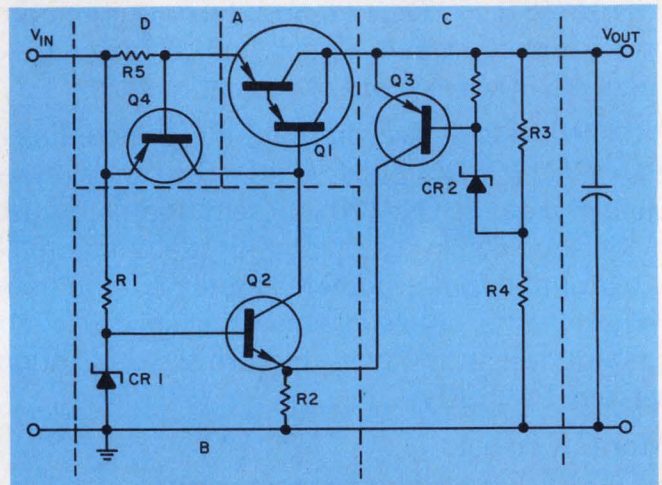
When the output of a series regulator is shorted, there is a good chance that the series-pass element will burn out—unless it is protected. You can prevent the loss of these high-power transistors by adding an overload-sensing circuit to the regulator.

Such a circuit can monitor input voltage, output voltage, current and temperature and limit the maximum available load current to a safe value. Under extreme conditions current can be cut off completely. During transient conditions, peak load currents well in excess of the steady state current are available. The peak current amplitudes and durations can be fixed by design to match the thermal properties of the series-pass transistor and package.

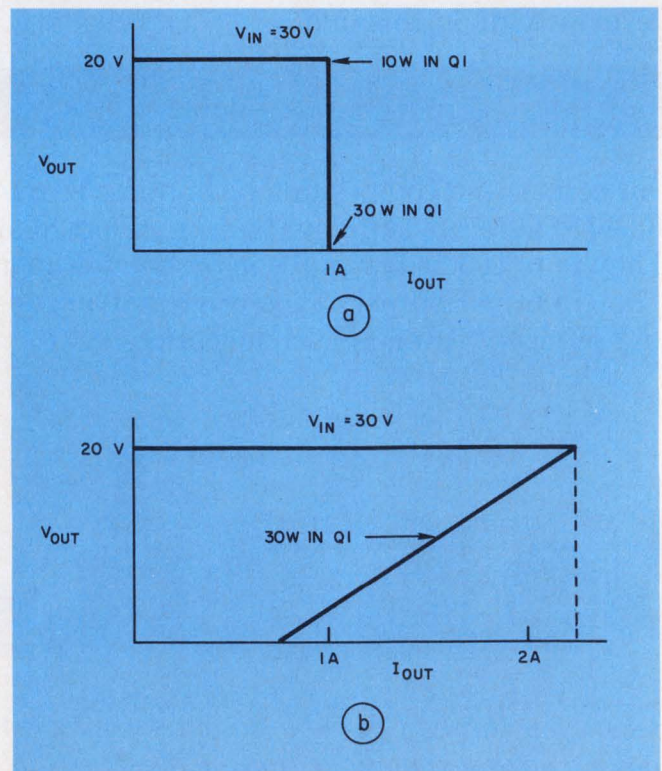
These protective circuits are useful when the same regulator design must accommodate a variety of input and output voltage combinations. The circuits are applicable equally to pnp or npn series-pass elements for either positive or negative voltage regulators.

The circuit in Fig. 1 shows a fairly simple series regulator with a simple overcurrent protection circuit. The major sections of the circuit can be split into the following:

- Section A—the series-pass element, in this case, a Darlington transistor ( $Q_1$ ).
- Section B—the current bias for  $Q_1$ . Transistor  $Q_2$  and associated components provide a low drop-out voltage and good rejection of input-voltage variations. These properties can be improved further by placement of a high-value resistor between the  $V_{in}$  terminal and the emitter of  $Q_2$ . The resistor cancels the minor effects of input-voltage variations caused by the slope resistance of the zener  $CR_1$  and the output resistance of  $Q_1$ .
- Section C—the voltage-control circuit. Zener  $CR_2$  and error amplifier  $Q_3$  feed back a control signal to the emitter of  $Q_2$ . This signal regulates the output voltage, since  $Q_3$  draws collector current from the emitter of  $Q_2$ , so less current is available at the base of  $Q_1$ .



1. The basic series regulator usually incorporates some form of current-overload protection.

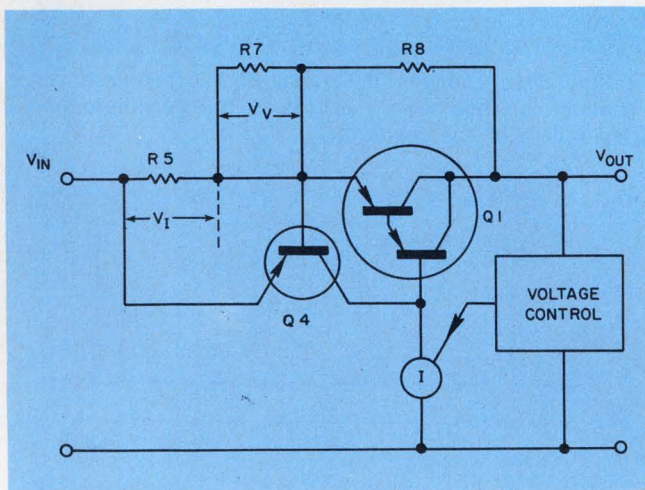


2. Two basic current-overload conditions cause constant-current limiting (a) and current foldback (b). The fold-back circuit gives a higher output current for a given transistor power dissipation.

Maurice Wright, Group Research Center, Joseph Lucas, Ltd., Solihull, Warwick, England.

■ Section D—the current-overload protection circuit. Resistor  $R_5$  limits the maximum value of the output current since it turns on  $Q_4$  when the IR drop is more than the predetermined value. Transistor  $Q_4$ , in turn, removes the base current from  $Q_1$ ; thus the collector current is limited.

If we assume that the maximum allowable power dissipation is 30 W for  $Q_1$ , the circuit described in Fig. 1 is constant-current-limited according to the curve of Fig. 2a. Highest transistor dissipation occurs under short-circuit condi-



3. A simple change in the basic regulator gives the current-foldback characteristic.

tions when the full input voltage is dropped across the series-pass element and  $R_5$ . For a 30 V input and 30 W dissipation, the maximum permitted current is 1 A. Under a normal 20 V output condition, maximum load current is still 1 A although the 30 W transistor is capable of supplying 3 A with only 10 V across the series element.

### Current foldback can be incorporated

Foldback, an improved protection characteristic, is depicted graphically in Fig. 2b and schematically in Fig. 3. For the same 30-W maximum, transistor  $Q_1$  can now provide 2.25 A with  $V_{in} = 30$  V and  $V_{out} = 20$  V. Under short-circuit output conditions, the current folds back to 0.75 A.

If the circuit of Fig. 1 is rearranged so transistor  $Q_1$  senses the sum of the current through  $Q_4$  and the voltage across  $Q_1$ , a foldback characteristic appears. Resistors  $R_7$  and  $R_8$ , as shown in Fig. 3, provide the additional sensing signal  $V_V$ . The limiting values of current and voltage obey the straight-line relationship

$$V_I + V_V = V_{EB} \text{ (for } Q_4 \text{ conducting).}$$

Fig. 4 is a plot of maximum output current vs the voltage difference ( $V_{in} - V_{out}$ ) for values of

$R_5$ ,  $R_7$  and  $R_8$  equal to 0.16  $\Omega$ , 200  $\Omega$  and 15 k $\Omega$ , respectively, and for  $V_{EB}$  at 100 C = 0.5 V.

By use of  $V_{in} - V_{out}$  and  $I_{out}$  as the two axes, the single-line plot of Fig. 4 gives the maximum output current for any combination of input and output voltages. For example, if the input is 30 V and the output is 20 V, there is a 10-V difference and the maximum output current is 2.25 A. If the output is short-circuited, the difference voltage increases to 30 V and the output current decreases to 0.75 A. Now the regulator can operate in the cross-hatched area of the graph of Fig. 4. If the voltage across the series-pass transistor exceeds 40 V—because of abnormal conditions—the current from the base of  $Q_1$  is removed, and the load is cut off completely. The risk of component burnout is reduced considerably.

### Temperature effects

Let's look at temperature variations. The allowed power dissipation of a transistor is derated linearly against case temperature and reaches zero at the maximum allowable junction temperature. A transistor rated for 30 W at 100-C case temperature would vary typically with temperature as follows:

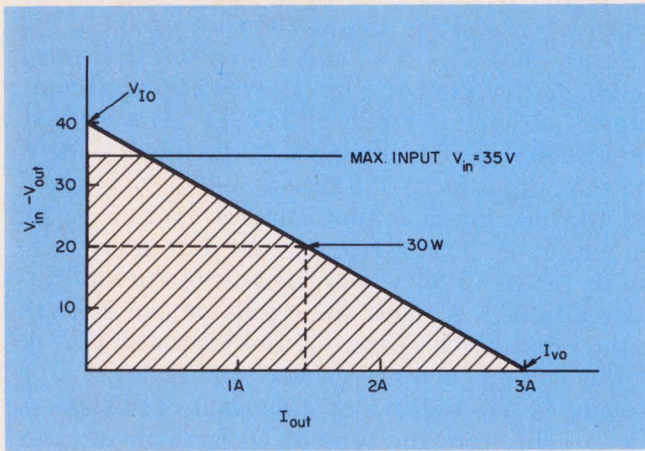
Case temperature C	-25	0	25	50	75	100	125
Continuous dissipation W	80	70	60	50	40	30	20

For the circuit in Fig. 3, the maximum power point is given by

$$P_{max} \times V_{EB} = \frac{I_{VO}}{2} \times \frac{V_{IO}}{2} = \frac{1}{2} \times \frac{V_{EB}}{R_5} \times \frac{1}{2} \times \frac{R_7 + R_8}{R_7} = \frac{R_8 + R_7}{R_5 \times R_7} \times \frac{V_{EB}^2}{4}$$

The voltage  $V_{EB}$  required for conduction, has a temperature coefficient of  $-2.2$  mV/ $^{\circ}$ C. Thus  $I_{VO}$ ,  $V_{IO}$  and  $P_{max}$  vary with temperature as shown in Fig. 5.  $P_{max}$  is proportional to  $V_{EB}^2$ ; thus the relationship is given as:

$Q_4$ temperature C	-25	0	25	50	75	100	125
$V_{EB}$ for conduction V	0.775	0.72	0.665	0.61	0.555	0.5	0.445
Max power limit W	72	62	53	45	37	30	24



4. The current-foldback circuit can operate in the shaded area of the graph and allows the output power to stay at a constant 30 W when needed.

Thus if  $Q_4$  is mounted in good thermal contact with  $Q_1$ , the system allows an increase in power at temperatures below 100 C, which is close to—but just less than—the allowable increase in power of  $Q_1$ .

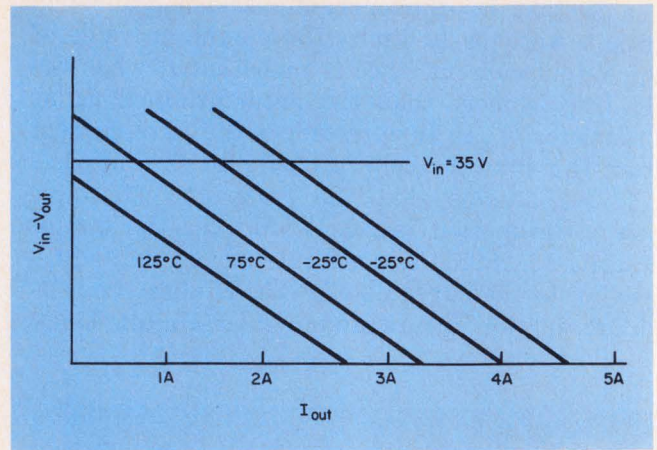
Extremes of high-temperature, high-input voltage and maximum loading force the circuit to switch the output current off regeneratively. In applications where high-temperature protective cutoff is important, it can be specified accurately by addition of a high-value negative-temperature-coefficient thermistor. The thermistor is in parallel with either  $R_s$  or a positive-temperature-coefficient resistor in series with  $R_7$ . This combination gives  $V_{10}$  a high rate of fall above a given temperature.

### Exploring the transient response

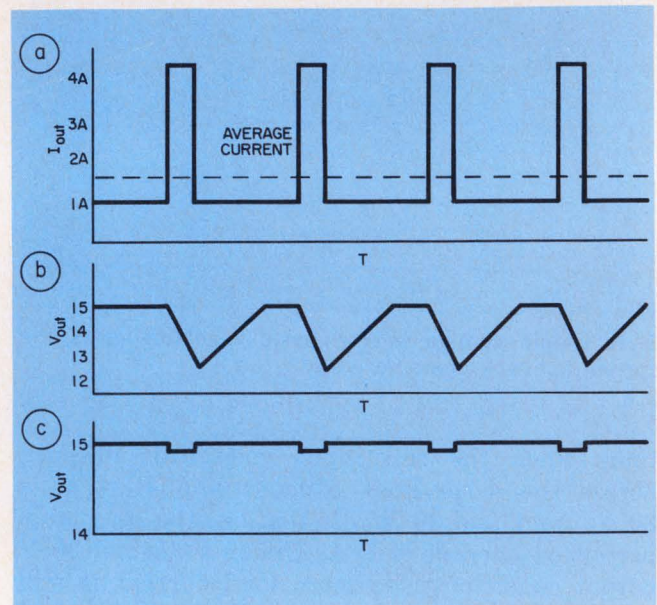
Power-supply loads often require peak currents that are higher than the steady average current. Fig. 6a shows the graph of a load that draws an average current of 1.8 A with a 2-ms duration peak of 4.5 A. To specify a supply, the user has two options:

1. To use a supply capable of delivering 4.5 A of continuous output.
2. To use a supply that delivers 2 A continuously and to provide the peak current from a capacitor at the supply-output terminals.

Option 1 increases bulk, weight and expense. Option 2 can result in serious voltage droop during the peaks of load current, and the capacitor is bulky. For a 2-A supply with a 2000- $\mu$ F smoothing capacitor, a 2.5-V droop occurs during the 2-ms pulse loading. During this time the power supply provides 2 A of the output current and the capacitor the remaining 2.5 A. When the required load current falls to 1 A, the supply provides 1 A for the load and 1 A for the capacitor to recharge. The split in current increases the



5. Temperature changes the value of  $V_{EB}$  required for  $Q_4$  conduction; thus a shift occurs in the permitted operating region of the regulator.



6. The pulsed current needed by the load (a) affects the output voltage of a regulator that limits at 2 A (b). By use of a regulator with a higher-current capacity, the output voltage doesn't vary as much (c).

time needed for recovery by another 5 ms, as shown in Fig. 6b. However, a series-pass transistor that is rated for 2 A continuous can usually supply the additional current, since the continuous-maximum-power rating of a power transistor is usually an average value over a 10-to-100 ms time period.

Unfortunately the usual current-limit protection circuits prevent 2 A from being exceeded for even short time periods. Without the protection circuit the response of a 2-A supply would be that shown in Fig. 6c. Typically the voltage droop during the 4.5-A output pulse would be 0.05 V and a large output capacitor would not be required.

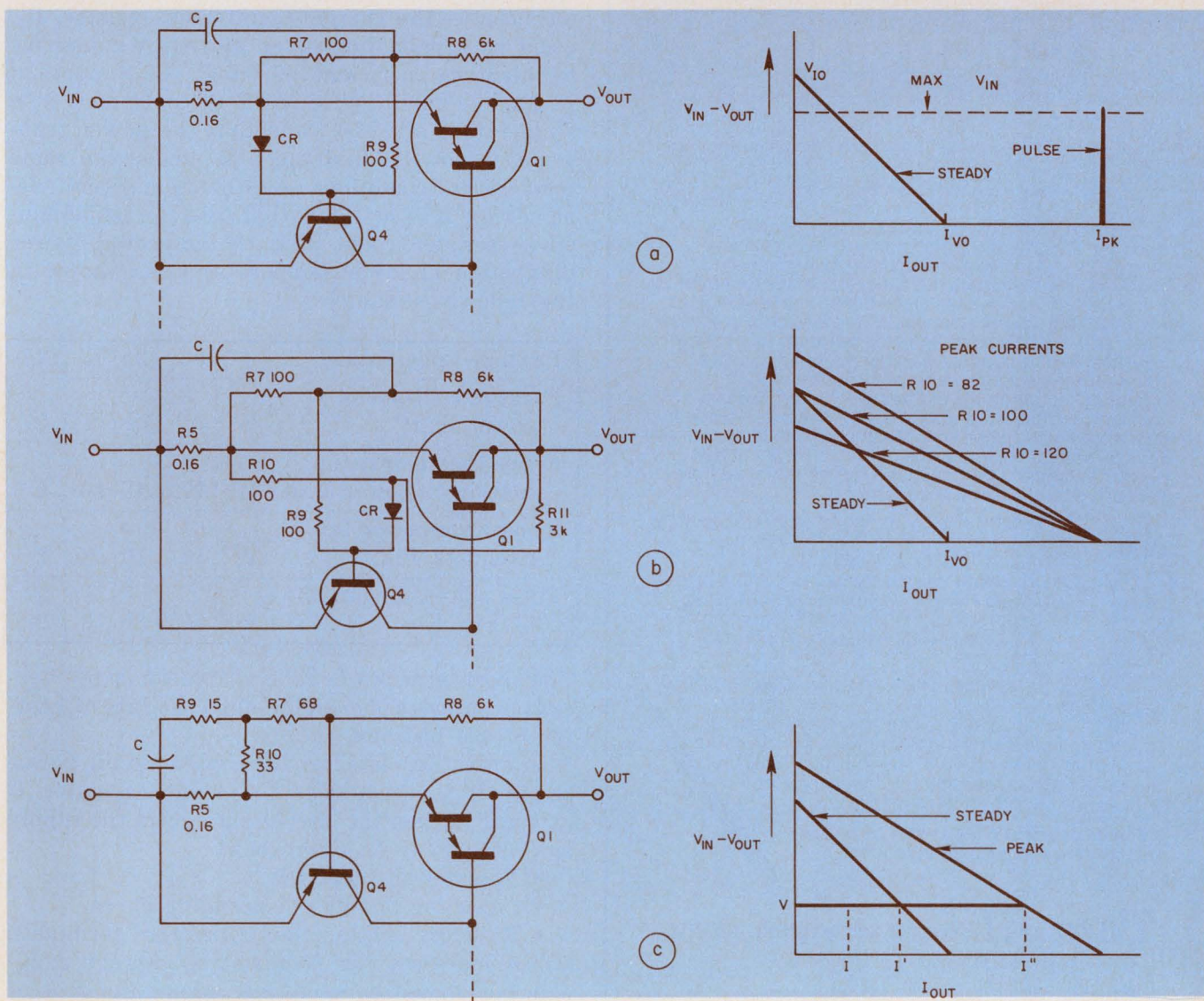
Fig. 7 shows several protection networks. Each includes a delay capacitor to allow high-pulse

currents to be drawn from the regulator with negligible voltage droop. These components also limit the continuous-output current to a lower value as in the circuit in Fig. 3. In Fig. 7a capacitor C delays the response of the current-voltage monitoring network to pulse currents, while the added diode limits the instantaneous peak current  $I_{pk}$  to twice  $I_{vo}$ . Then  $I_{pk}$  becomes independent of voltage conditions and continues to flow until capacitor C has charged to the voltage  $V_{EB}$ . When  $V_{EB}$  is reached, the current collapses back to the limits given by the steady line shown in the graph of Fig. 7a. The circuit also automatically allows  $I_{pk}$  to be drawn for longer periods of time if  $V_{in} - V_{out}$  is small and if the load current was low previously. Of course, the ratings of the series-pass elements must be high enough to withstand the instantaneous peak currents that are generated.

The circuit in Fig. 7b includes voltage monitoring in the peak-current section, which reduces peak current and transistor stress under high-voltage conditions. The axis-intersection point,

$V_{10}$ , may or may not have the same value for the peak and steady-state lines, depending upon the resistor values chosen. If the two lines intersect, both the peak and steady-state values of current follow the peak-current line for voltages above the intersection. Higher values of peak current in 7a and 7b can be obtained if only a fraction of the voltage across  $R_5$  is applied to the peak monitoring-voltage network. The junction of two resistors, in series across  $R_5$ , would provide a suitable return point.

An alternative approach is shown in Fig. 7c. Under steady-state load conditions, the voltage applied across the base-emitter of  $Q_4$  is the sum of the current component across  $R_5$  and the voltage components across  $R_7$  and  $R_{10}$ . For sudden increases in load current, resistors  $R_{10}$  and  $R_9$  and capacitor C attenuate the voltage change across  $R_5$ . Thus if the power supply operates under steady-state conditions (by the point V, I on the graph), the mean current could increase to the value of  $I'$ ; but the peak current before overload could increase to  $I''$ , where



7. Modification of the overload networks permits higher peak currents to be drawn from the regulators.

# Three Simple, Safe



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INFORMATION RETRIEVAL NUMBER 29

$$\frac{I'' - I}{I' - I} = \frac{R_9 + R_{10}}{R_9}$$

The peak current available depends upon the flow of the average current for the preceding time period. Also, the peak-current line collapses towards the steady-state line as soon as the increased current is taken. Thus the circuit must be designed to provide a higher-peak current and time constant than the load demands. The circuit of Fig. 7c can provide short and medium-duration pulses at low duty cycles, while the circuit of Fig. 7b is preferable for pulses exceeding 2 ms or for higher-duty cycle pulses.

### Problems with miniature packages

In miniature voltage regulators that have a high thermal resistance from package to ambient, the power-dissipating ability of the package is a greater restriction than the power transistor. To avoid gradual thermal runaway, the protection circuit must be designed to the package dissipation.

In this case—and particularly for thick-film technology—the current-monitoring resistor,  $R_5$ , could be a palladium-silver film with a positive temperature coefficient of 0.6%/°C. Suppose a package is able to dissipate 2 W continuous at a temperature of 125 C, and that the power transistor is able to dissipate 5 W under the same temperature conditions. A protection circuit designed for 2 W at 125 C that uses the palladium-silver resistor could give the improved power dissipation at lower temperatures, as shown in the following example:

Package temperature	C	0	25	75	125
Package continuous power limit	W	—	—	—	2
Series-pass transistor continuous power limit	W	17.5	15	10	5
Short-term power for circuit of Fig. 3	W	14	10	4.5	2
Pulse power for circuits of Fig. 7	W	40	30	13	2

The short-term power is available for a few seconds or minutes, depending upon the rate of heating of the package.

In an encapsulated or integrated-circuit power supply it is convenient to mount capacitor C externally. Then the user can program the supply according to these conditions:

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- Capacitor to suit pulse-loading curve.
- Resistor across the capacitor terminals, which increases the steady-state current available but should be used only where the risk of burnout under sustained overload is accepted. ■■

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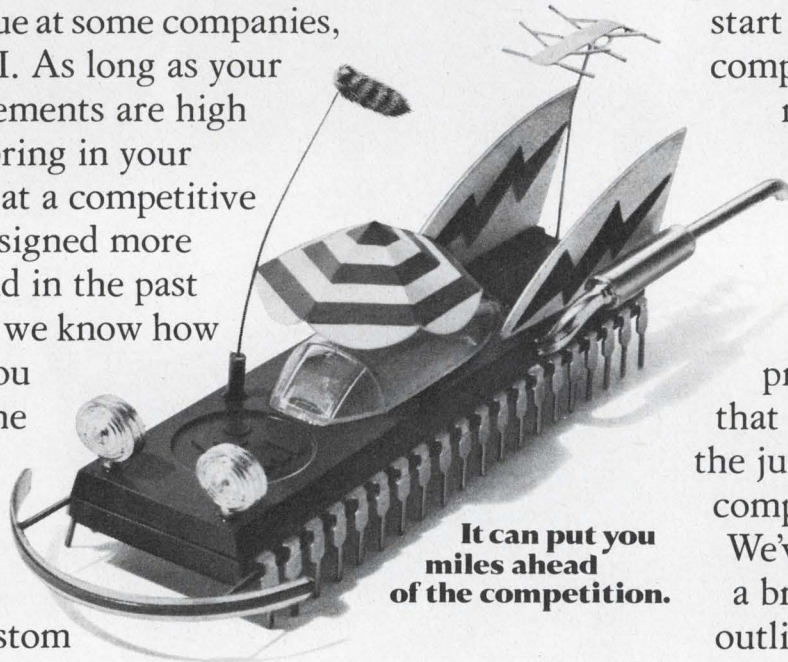
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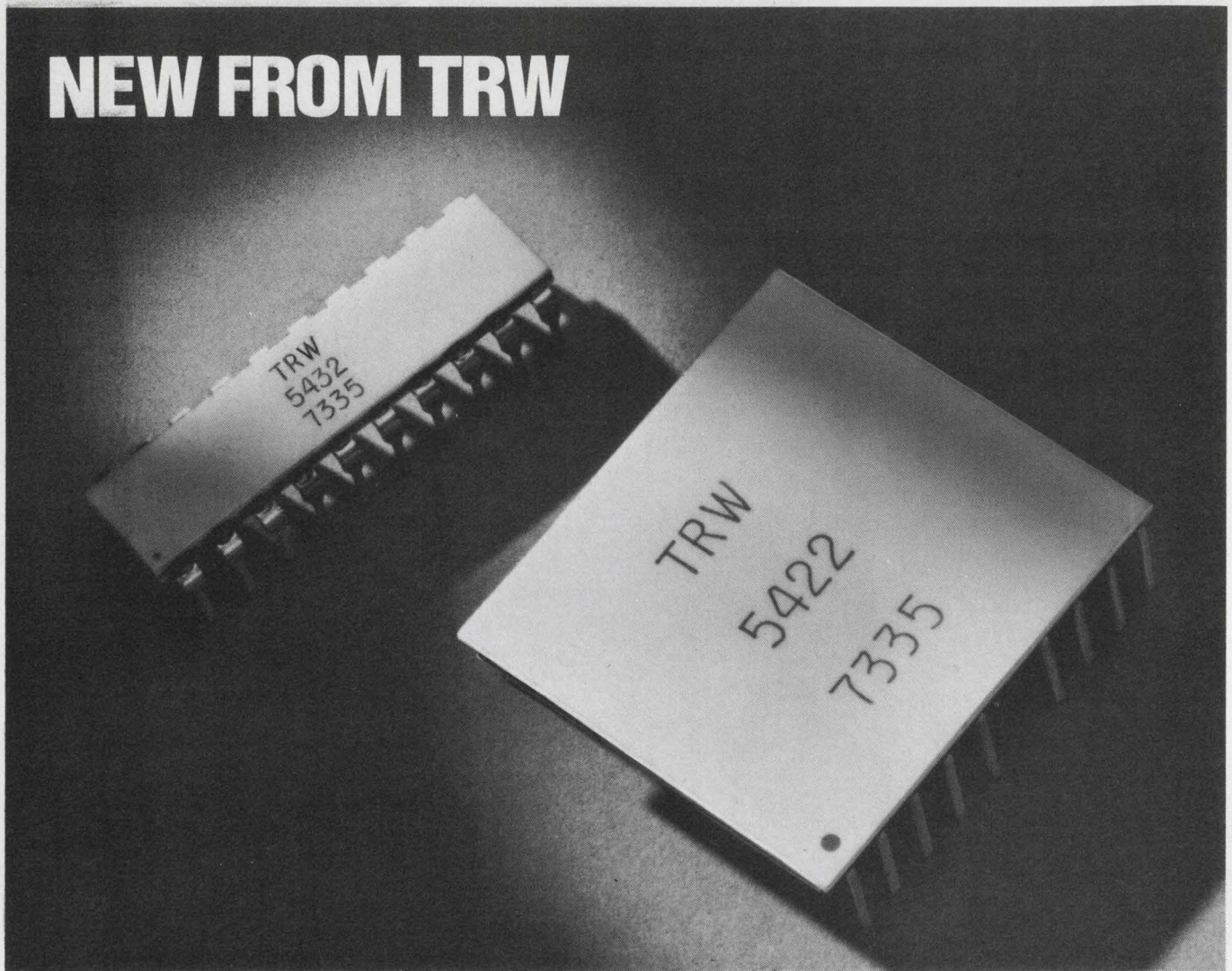


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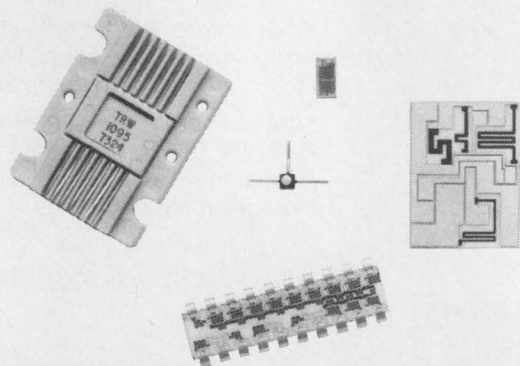
### Performance Characteristics

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Ladder resistance tolerance	..... ±1%
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Maximum input voltage	..... 20 volts
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Storage temperature	..... -65 to +150°C
Conversion accuracy*	..... ½ least significant bit (122 ppm)
Switch compensation	..... to 5 ohms
Settling time	..... to 20nSec.

\*Ladder voltage ratio accuracy is the maximum voltage ratio error expressed in ppm of full scale with any combination of bits activated.

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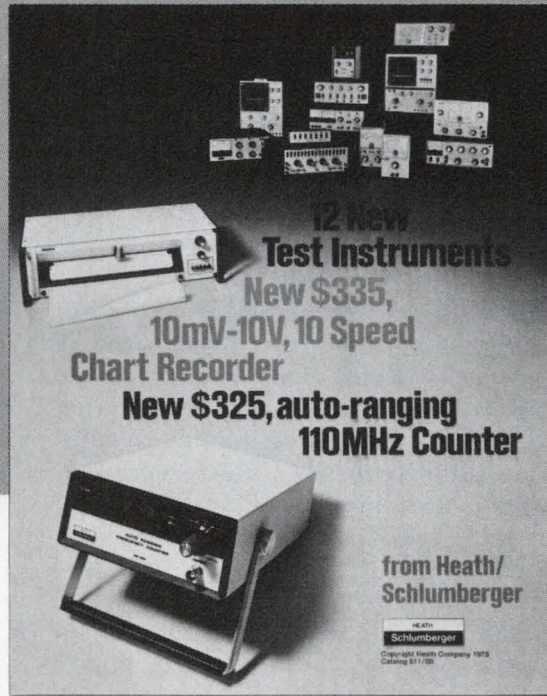


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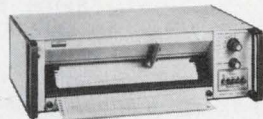
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# Which voltage regulator is best?

For loads over a few hundred milliamps, discrete-component switching types usually have more advantages than disadvantages.

So you want a packaged voltage regulator—one that's inexpensive, small and good. Confused by the wide choice? Here's a tip. If you expect the load to draw more than a few hundred milliamps, use a switching regulator rather than a conventional series-pass circuit. And if size isn't critical, favor discrete-component circuits over IC versions.

Granted, the switching regulator usually costs a little more than other regulator types. And it even has drawbacks (and name one regulator that *doesn't* have some drawback). The major potential problem is that the switching circuits may generate radio-frequency interference. In the end, however, switching regulators will pay for themselves by handling higher power loads with greater efficiency.

If size is the overriding consideration in your design, you may have no alternative but to go with a series-pass IC regulator. But you'll pay a penalty in lowered efficiency.

Table 1 gives the advantages and disadvantages of the three major types of series-pass regulators. Suppose we begin by comparing IC-regulator circuits to plain discrete-component modules.

## ICs or discrete?

Most IC regulator designs are a compromise—they trade off circuit performance to achieve low-cost monolithic construction. But the compromise has obvious failings. Zener diodes, FETs and other devices call for different resistivities of materials; this difference is not readily achieved on a single chip. Similarly the combination of npn and pnp transistors has not proved very promising in IC regulators, since both types require different base materials or extra, critical, processing steps for optimized performance. Also, the range of component values needed to optimize the performance is usually too wide to be achieved.

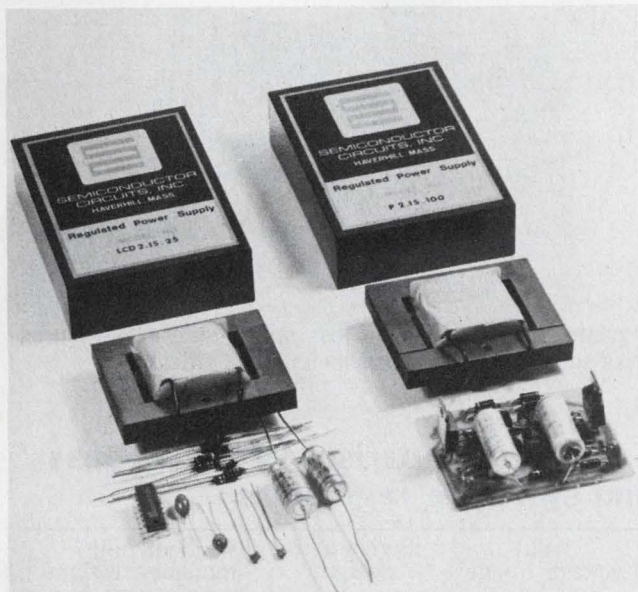
**Table 1. Overview of different regulator types**

Regulator type	Advantages	Disadvantages
Series-pass regulators (IC)	Least assembly time Small size Lowest weight	Lack of uniformity Low efficiency Narrow operating input range No immunity to line transients Heat sinks needed Low reliability due to heat High popcorn noise High quality magnetics required
Series-pass regulators (discrete)	Better performance than ICs Lower cost (except for low current use) Better heat distribution than ICs Better operating voltage range than ICs Some line transient immunity Higher efficiency than IC units Higher reliability than IC units Better tracking characteristics than ICs	More components needed Larger than IC regulators Good magnetics required
Series switching regulators (discrete)	Highest efficiency Smaller size than linear series pass Low heat dissipation Best operating input voltage range High line transient immunity (>60 dB) High reliability Smaller magnetics Simplest assembly	Generally higher cost, higher ripple Some RFI

Paul LaBrie, Executive Vice President, Semiconductor Circuits, 306 River St., Haverhill, Mass. 01830.

The largest single source of trouble in a power supply is heat. In any regulator, power dissipation is limited by the amount of heat that can be transferred from the source to the sink. Thus IC regulators are limited by the size of the chip and its heat sink. The chip acts as a point source of heat—rather than a distributed one, as in a discrete-component design. Therefore, warm-up drift is much worse.

Thermal shutdown must be incorporated in most ICs to protect them from self-destruction—



1. Different types of dual-output, series-pass, regulated supplies have roughly equal size, though the discrete component regulator on the right delivers four times the current of the IC version on the left.

usually called thermal runaway. Thermal shutdown is usually not needed in discrete voltage regulator designs; short-circuit protection is used instead.

Due to the IC regulator design inefficiencies, encapsulated modular supplies that use IC regulators tend to run 10 to 15 degrees hotter than equivalent discrete-component versions. This results in a decrease in mean time between failure of approximately 30,000 hours for the IC regulators.

### Performance and cost considerations

Efficiency becomes critical when the system housing the power supply begins to run hot. Because of the large differential voltage that an IC regulator needs for operation, a 10 to 15% increase in inefficiency converts, in a 5-V, 10-A unit, to an additional 75 to 100 W that must be dissipated. Obviously this is a considerable loss in systems where only 50 W or so of load power is required.

Ripple, a function of line isolation, is not consistent from IC to IC and is usually much higher

than with the average discrete-component regulator. However, because the cost of IC regulators is relatively low, many engineers are wooed into believing that a power supply built using them will be less expensive than an equivalent discrete-component version.

Actually—because of external components, assembly time and the testing time required to trim most IC regulators—their parts cost usually equals that of a discrete-component regulator. The testing time is about equal—the only saving, if any, comes in basic assembly time. The IC regulator chip and its supportive components can be inserted onto a printed-circuit board faster than a discrete component circuit, which might have double the number of components.

Since the IC design needs supportive components, there is almost no space saving. In fact, the biggest sham occurs when a 5-V, 1-A IC regulator is used to build a 5-V, 10-A supply. Here the cost is greater, performance is poorer, efficiency is lower and reliability is worse than that in even poor discrete-component designs.

### Enter the switching regulator

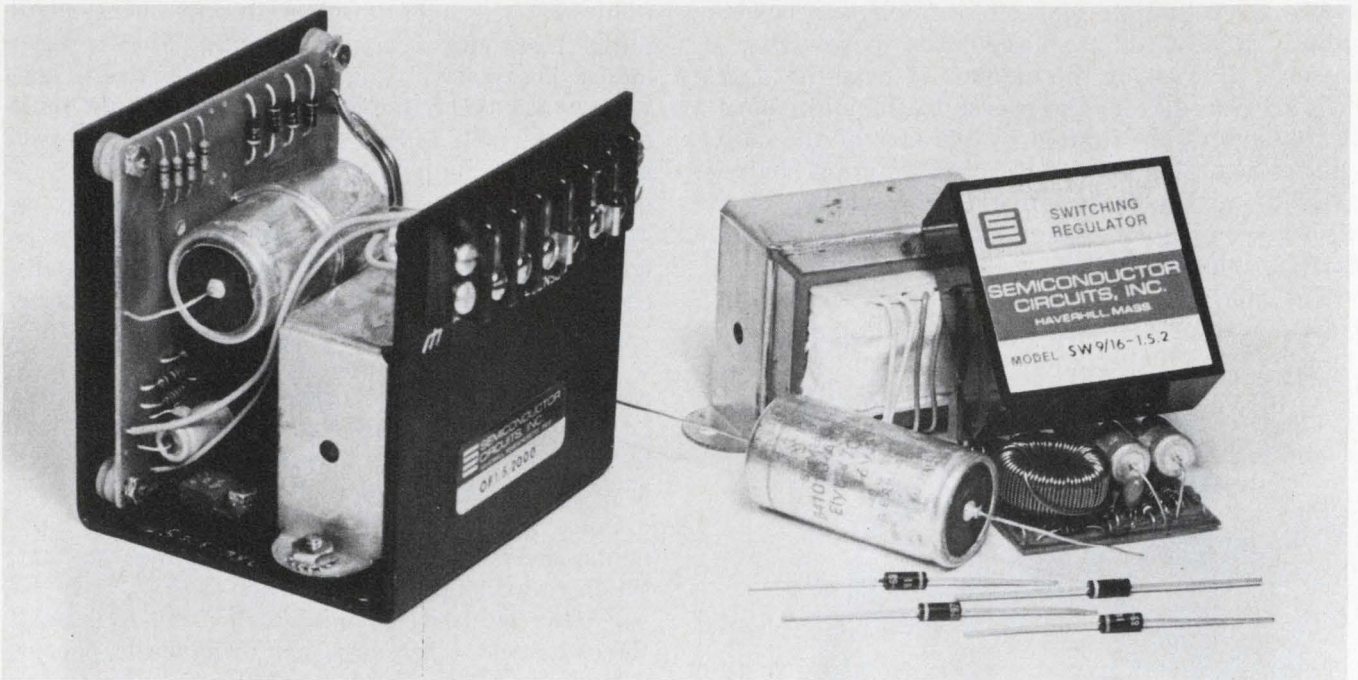
As an alternative to both IC and conventional discrete-component regulators, there is the switching regulator. As indicated in Table 1, it is more efficient, smaller, requires less quality in the magnetics design and has a high immunity to line transients. In low-power applications, the switching regulator will always be more expensive than any series-pass circuit because of component costs. Also, as we've seen, there is more ripple in the output.

Can your circuit tolerate a ripple of 15 to 20 mV pk-pk? Good series-pass techniques will result in a ripple of less than 3 mV pk-pk. It is impossible to design a switching regulator with that type of performance. However, the ripple associated with most switching-regulator designs is usually offset by the power-supply rejection of most op amps. And, for digital applications, 20-mV pk-pk ripple at a frequency of, say, 20 kHz or less, will not interfere with circuit operation.

In a plain series regulator there is almost no rejection to line transients, except for the isolation provided by the transformer. Even a transformer design with a Faraday shield offers only a 3-dB improvement over the standard transformer design.

The switching regulator, on the other hand, looks to the ac line like a two-pole, low-pass filter (L-section LC). It appears this way only during the charge cycle, and then only until the sense amplifier and switch disconnect the input. In the discharge cycle the leakage through the switch is about 1  $\mu$ A.

During the charge cycle the sensing circuit



2. **Switching regulators** offer tremendous size-and-weight advantages. The 2-A supply using a switching-

regulator (right) takes up less space than a 2-A series-pass supply (left) and provides higher efficiency.

and switch operate in less than  $10 \mu\text{s}$ . This, in turn, means that a line transient would be turned off by the switching action within less than  $10 \mu\text{s}$  from the time the voltage reached the detection level of the switching circuit. With a cut-off frequency of about 2 kHz, the rejection against a  $10\text{-}\mu\text{s}$  pulse is very high—about 60 dB.

At all other times of the charge-discharge cycle, the regulator would have even higher rejection. Furthermore, any low-frequency transient below 20 kHz would not degrade the performance of the supply, since the unrejected portion of the transient would change only the rate of charge—and then only if the transient occurred during the charge cycle; otherwise there would be no effect.

### Switching allows wider input voltages

For switching regulators, the input range is a function of the transformer only; it has little or no effect on efficiency. In contrast, the series-pass regulator efficiency depends heavily upon the transformer.

In a series-pass circuit, the amount of power dissipated by the pass element depends directly upon the input voltage range. A 55% efficient conventional series-pass regulator design used for a  $\pm 15\text{-V}$  power supply loses 35% in the regulator and 10% in the raw dc supply. For an increase in ac input voltage range from 20 V (105-125) to 45 V (90-125), the output of the raw dc supply would change by approximately 9 V instead of 4 V.

Thus the efficiency of the series-pass design

**Table 2. Comparison of series-pass and switching regulators**

Input voltage range	Series-pass designs	Switching regulator designs
105 to 125 V ac	5 V—40% efficient $\pm 15\text{ V}$ —55% efficient	5 V—65% efficient $\pm 15\text{ V}$ —75% efficient
90 to 135 V ac	5 V—25% efficient $\pm 15\text{ V}$ —45% efficient	5 V—60% efficient $\pm 15\text{ V}$ —70% efficient

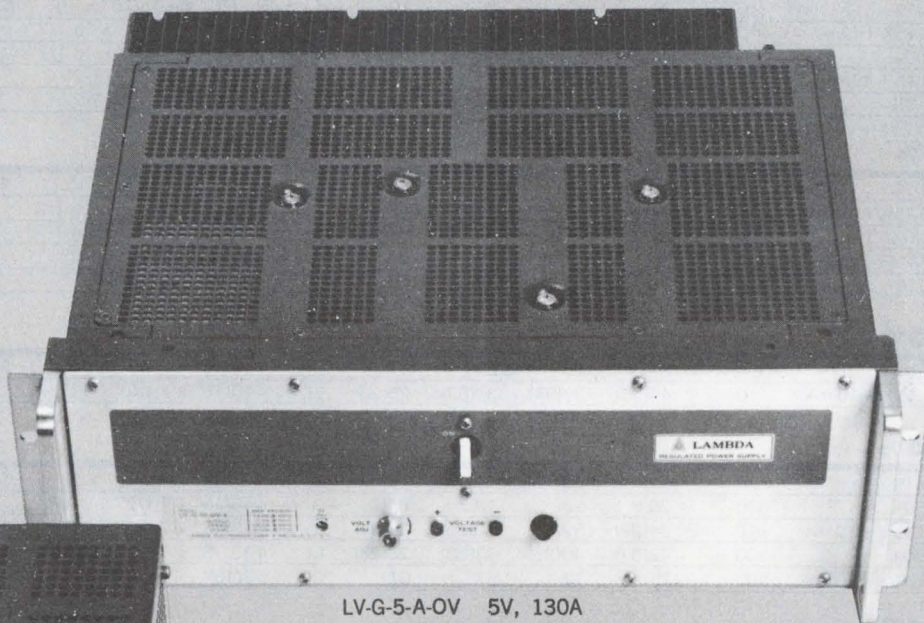
decreases by about 10%. The 90-to-135-V ac design would, at best, be a 45% efficient supply, as shown in Table 2. Still not too bad, but it would obviously run hotter and heat everything around it.

For the 5-V supply in Table 2, where the inefficiencies are greater, the additional losses generated by the wide input range become significant. A good series-pass design is usually 35 to 40% efficient (with 40% of the loss in the regulator and 20% in the raw dc). The increase in the input voltage range forces the regulator to drop an additional 3.5 V. In general, for every amp at a 5 V drawn from the supply, you also get 200 calories of heat (15 W) that must be removed.

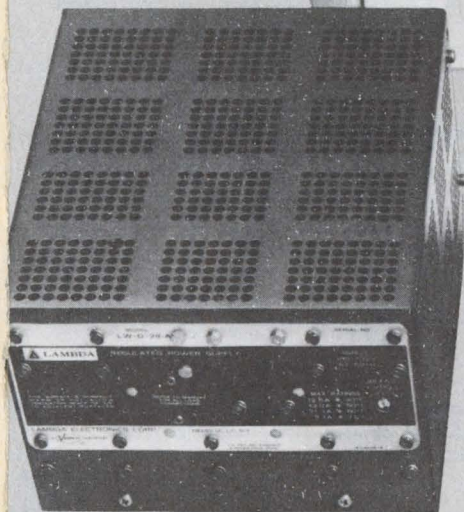
This type of design, therefore, is not the way to go if wide-input-range operation is needed. The switching-regulator efficiency stays within its rated value by a 5% margin for line changes, as previously mentioned. On top of that, it will deliver efficiencies of 70% in most cases. ■■

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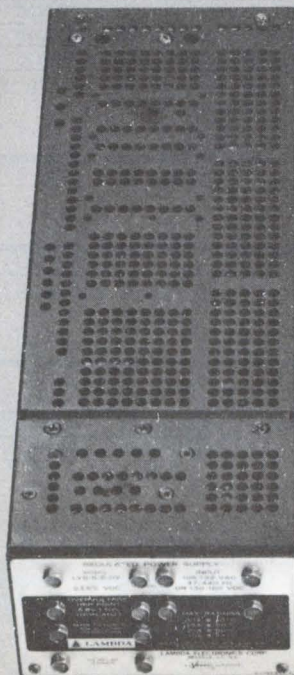
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LW-EE-5-A (1)	2.0%	300	91(80)	87(77)	82(72)	62(62)	EE 4 15/16" x 7 1/2" x 16 1/2"	400.	
LV-G-5-A-OV	0.15 + 10mV	10	130	126	115	100	G 5 3/16" x 19" x 16 1/2"	750.	
LW-G-5-A	2.0%	300	150	146	135	123	G 5 3/16" x 19" x 16 1/2"	675.	

### 6 VOLTS $\pm 5\%$

LYS-5-6	0.1%	10	25	21	17	8.5	5 3 3/16" x 4 15/16" x 15"	\$310.
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LW-EE-6-A (1)	2.0%	300	78(68)	75(65)	70(62)	54(54)	EE 4 15/16" x 7 1/2" x 16 1/2"	400.
LV-G-6-A-OV	0.15% + 10 mV	10	110	107	98	90	G 5 3/16" x 19" x 16 1/2"	750.
LW-G-6-A	2.0%	300	128	123	115	105	G 5 3/16" x 19" x 16 1/2"	675.

### 10 VOLTS $\pm 5\%$

LW-D-10-A	2.0%	300	27	25	23	17	D 4 15/16" x 7 1/2" x 9 3/8"	\$250.
LV-EE-10-A-OV (1)	0.15% + 10 mV	10	41(36)	39(34)	36(32)	25(25)	EE 4 15/16" x 7 1/2" x 9 3/8"	415.

### 12 VOLTS $\pm 5\%$

LYS-5-12	0.1%	15	21	18	14	8	5 3 3/16" x 4 15/16" x 15"	\$310.
LW-D-12-A	2.0%	300	26.5	20	13.7	8.8	D 4 15/16" x 7 1/2" x 9 3/8"	250.
LV-EE-12-A-OV (1)	0.15% + 10 mV	10	34(29)	32(27)	30(25)	21(21)	EE 4 15/16" x 7 1/2" x 16 1/2"	415.
LW-EE-12-A (1)	2.0%	300	42(37)	40(35)	37(33)	28(28)	EE 4 15/16" x 7 1/2" x 16 1/2"	350.
LW-G-12-A	2.0%	300	75	72	67	61	G 5 3/16" x 19" x 16 1/2"	675.

### 15 VOLTS $\pm 5\%$

LYS-5-15	0.1%	15	17	14.5	11.5	6.8	5 3 3/16" x 4 15/16" x 15"	\$310.
LW-D-15-A	2.0%	300	22.5	20	13.7	8.8	D 4 15/16" x 7 1/2" x 9 3/8"	250.
LV-EE-15-A-OV (1)	0.15% + 10mV	10	28(23)	26(22)	24(20)	18(17)	EE 4 15/16" x 7 1/2" x 16 1/2"	415.
LW-EE-15-A (1)	2.0%	300	35(31)	33(30)	31(28)	24(24)	EE 4 15/16" x 7 1/2" x 16 1/2"	350.
LW-G-15-A	2.0%	300	60	57	53	49	G 5 3/16" x 19" x 16 1/2"	675.

### 18 VOLTS $\pm 5\%$

LW-D-18-A	2.0%	300	19	18.3	13.7	8.8	D 4 15/16" x 7 1/2" x 9 3/8"	\$250.
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### 20 VOLTS $\pm 5\%$

LYS-5-20	0.1%	15	13.2	11.2	9	5.4	5 3 3/16" x 4 15/16" x 15"	\$310.
LW-D-20-A	2.0%	300	17.5	16.7	13.7	8.8	D 4 15/16" x 7 1/2" x 9 3/8"	250.

### 24 VOLTS $\pm 5\%$

LYS-5-24	0.1%	15	11	9.6	7.5	4.5	5 3 3/16" x 4 15/16" x 15"	\$310.
LW-D-24-A	2.0%	300	14.7	14	13.2	8.8	D 4 15/16" x 7 1/2" x 9 3/8"	250.
LW-EE-24-A (1)	2.0%	300	26(23)	25(22)	23(20)	17(17)	EE 4 15/16" x 7 1/2" x 16 1/2"	350.
LW-G-24-A	2.0%	300	48	46	42	39	G 5 3/16" x 19" x 16 1/2"	675.

#### NOTES:

- (1) Bracketed ratings are for 187 - 242 Vac, 47 - 63 Hz ("V" option) — See option section of LV-A & LW-A Series specifications.
- (2) All LV-A Series models are only available with built-in overvoltage protection.
- (3) LV-G-A & LW-G-A are only available without meters.
- (4) Overvoltage protection is not available on the LW-A series.
- (5) Includes fixed overvoltage protection at 6.8V  $\pm 10\%$ .



LV  
TC



# 11 REASONS WHY ONLY LAMBDA CAN GIVE YOU A MEANINGFUL 5-YEAR GUARANTEE... LY-LW-LV

**1** Lambda's MIL-T-27C grade 6 magnetics.

**2** Lambda offers a rugged convection cooled chassis.

**3** Lambda uses computer grade hermetically sealed 10-year life electrolytic capacitors.

**4** Lambda uses wire that meets MIL-W-16878 where required.

**5** Lambda engineering assures performance reproducibility and the LY, LW-A, LV-A power supplies are designed for large volume production.

**6** Lambda uses MIL-R-22684 type film resistors.

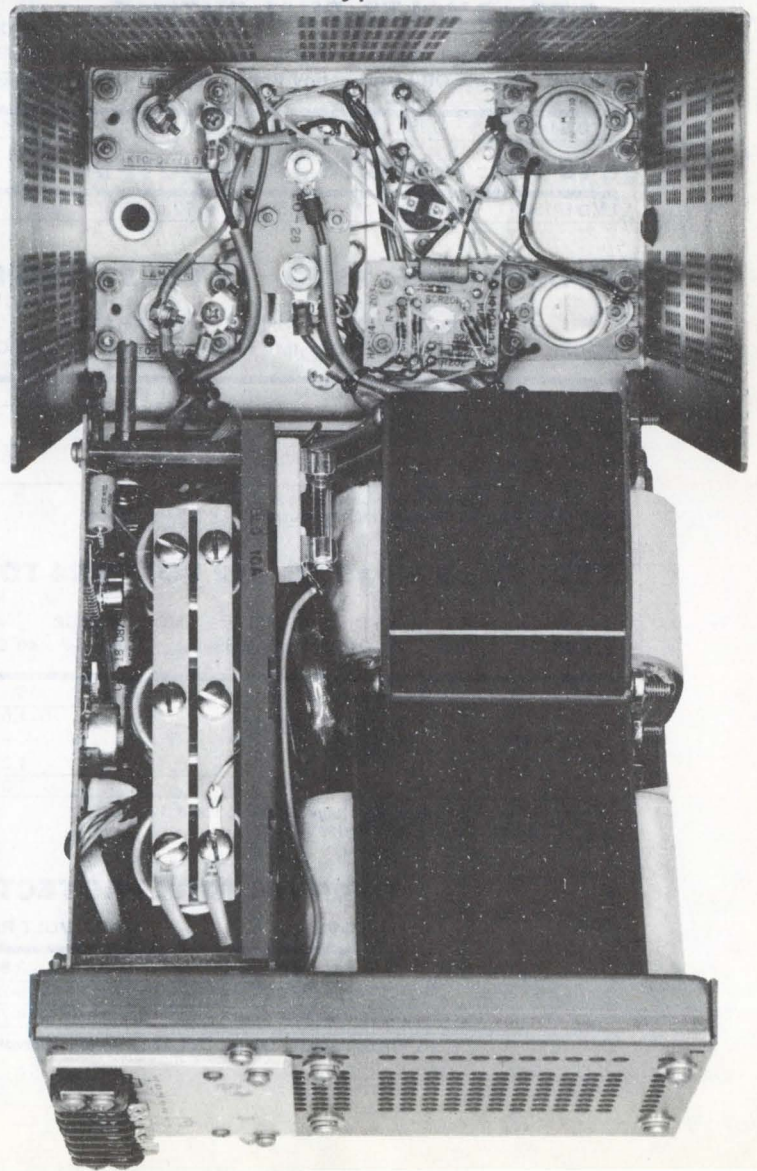
**7** Lambda's LY, LW-A, LV-A power supplies are listed in Underwriters' Laboratories recognized component

**8** Lambda features a heavy duty barrier strip on their power supplies.

**9** Lambda builds the LY, LW-A, LV-A power supplies with MIL-R-11 composition resistors.

**10** Lambda's power supplies are thoroughly tested throughout production for high performance.

**11** Lambda builds LY, LW-A, LV-A power supplies with MIL-R-26 type wire wound resistors.



# POWER SUPPLIES

## OVERVOLTAGE PROTECTION

### FIXED VOLTAGE MODELS, SINGLE OUTPUT (Cont'd.)

#### 28 VOLTS $\pm 5\%$

MODEL	REGULATION LINE OR LOAD	RIPPLE (MV RMS)	MAX. AMPS AT AMBIENT OF:				PKG. SIZE	DIMENSIONS	PRICE
			40°C	50°C	60°C	71°C			
LYS-5-28	0.1%	15	9.5	8.4	6.5	3.8	5	3 3/16" x 4 15/16" x 15"	\$310
LW-D-28-A	2.0%	300	12.5	12	11.1	7.7	D	4 15/16" x 7 1/2" x 9 3/8"	250.
LW-EE-28-A (1)	2.0%	300	22(19)	21(18)	20(17)	15(15)	EE	4 15/16" x 7 1/2" x 16 1/2"	350.
LW-G-28-A	2.0%	300	39	37	34	32	G	5 3/16" x 19" x 16 1/2"	675.

#### 48 VOLTS $\pm 5\%$

LW-D-48-A	2.0%	300	7.6	7.3	6.8	6.2	D	4 15/16" x 7 1/2" x 9 3/8"	\$250.
LW-EE-48-A (1)	2.0%	300	15(13)	13(11)	12(10)	9(9)	EE	4 15/16" x 7 1/2" x 16 1/2"	350.
LW-G-48-A	2.0%	300	24	23	21	19	G	5 3/16" x 19" x 16 1/2"	675.

### ADJUSTABLE VOLTAGE MODELS

#### $\pm 3$ TO $\pm 6$ VOLTS, DUAL OUTPUT

MODEL	REGULATION LINE OR LOAD	RIPPLE (MV RMS)	ADJ. VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:				PKG. SIZE	DIMENSIONS	PRICE
				40°C	50°C	60°C	71°C			
LYD-5-062	0.1%	15	$\pm 3$ to $\pm 6$	12.5	10.5	8.5	4.3	5	3 3/16" x 4 15/16" x 15"	\$420.

#### $\pm 12$ TO $\pm 15$ VOLTS, DUAL OUTPUT

LYD-5-152	0.1%	15	$\pm 12$ to $\pm 15$	8.5	7.2	5.6	3.3	5	3 3/16" x 4 15/16" x 15"	\$420.
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#### 5 VOLTS $\pm 5\%$ / $\pm 15$ TO $\pm 12$ VOLTS, TRIPLE OUTPUT

MODEL	REGULATION LINE OR LOAD	RIPPLE (MV RMS)	VOLT RANGE VDC	MAX. AMPS AT AMBIENT OF:				PKG. SIZE	DIMENSIONS	PRICE
				40°C	50°C	60°C	71°C			
LYT-5-5152	0.1%	10	5 $\pm$ 5%	18	15	11	6	5	3 3/16" x 4 15/16" x 15"	\$440.
		3	$\pm 15$	2	1.8	1.6	1.3			
			to $\pm 12$	1.6	1.5	1.4	1.2			

\*5 volt output has fixed overvoltage at 6.8V  $\pm 10\%$ .  
 $\pm 15$  to  $\pm 12$  output is dual tracking output.

#### 5 VOLTS $\pm 5\%$ / $\pm 15$ TO $\pm 12$ VOLTS/24 TO 28 VOLTS, QUADRUPLE OUTPUT

MODEL	REGULATION LINE OR LOAD	RIPPLE (MV RMS)	VOLT RANGE VDC	MAX. AMPS AT AMBIENT OF:				PKG. SIZE	DIMENSIONS	PRICE
				40°C	50°C	60°C	71°C			
LYQ-5-5153	0.1%	10	5 $\pm$ 5%	16	13.5	10	5	5	3 3/16" x 4 15/16" x 15"	\$495
		3	$\pm 15$	1.5	1.35	1.2	1.0			
			to	1.2	1.1	1.0	0.8			
			$\pm 12$	1.0	0.9	0.8	0.6			

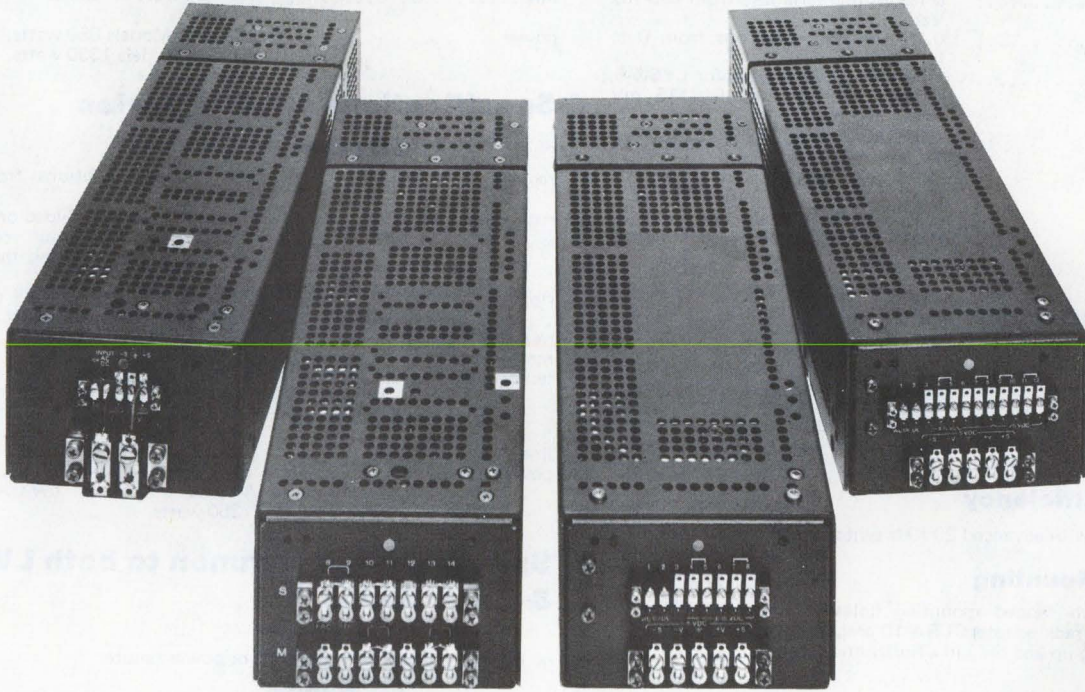
\*5 volt output has fixed overvoltage protection at 6.8V  $\pm 10\%$ .  
 $\pm 15$  to  $\pm 12$  output is dual tracking output.

### OVERVOLTAGE PROTECTORS FOR LY SERIES

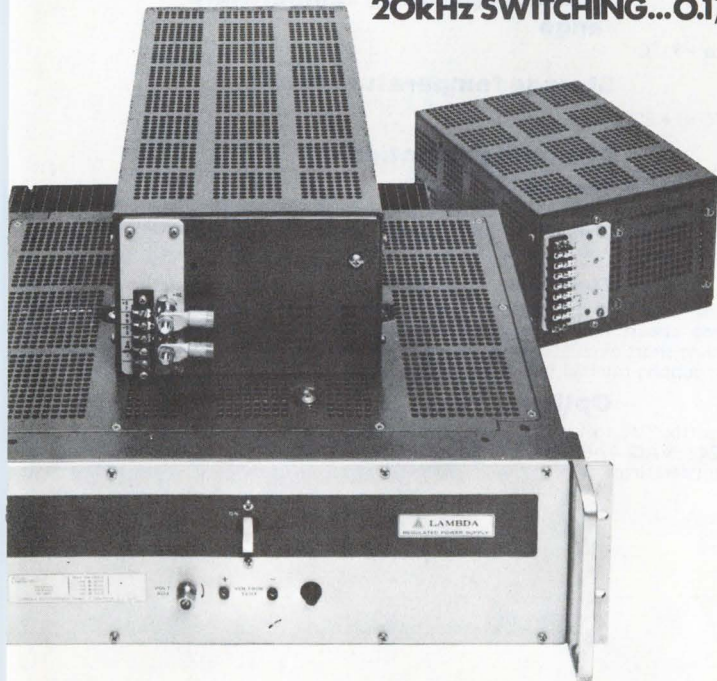
MODEL	ADJ. VOLT RANGE VDC	PRICE
LM-OV-1	3-8	\$30.
LM-OV-2	6-20	30.
LM-OV-3	18-70	30.

LY DUAL OUTPUT MODEL requires one overvoltage protector accessory for each output.

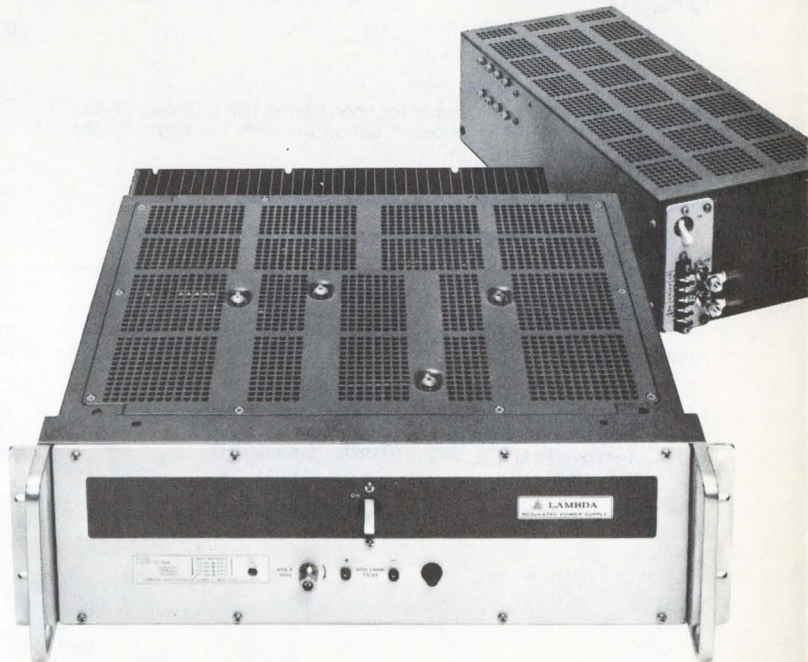
# CURRENT, HIGH EFFICIENCY MODULAR D...NO BLOWERS...WITH BUILT-IN OVER



**LY SERIES WITH GREATER THAN 50% EFFICIENCY...  
20kHz SWITCHING...0.1% LINE OR LOAD REGULATION**



**LV-A SERIES MODULAR SUPPLIES DESIGNED  
WITH POWER TRANSISTOR CIRCUITS & RELAYS...  
...2% regulation line or load**



**LV-A SERIES NOW WITH 2-SECOND MAX. TURN-ON TIME  
AT FULL RATING...designed to power TTL, RTL, DTL, and HTL logic  
0.15% +10mV regulation line or load**

## Specifications of LY Series

### DC output

regulation, line	0.1% for line variations from 105-132 Vac	
regulation, load	0.1% for load variations from 0 to full load	
ripple and noise	10 mV RMS, 35 mV p-p for LYS-5-5, 6 and LYD-5-062 models; 15 mV RMS, 100 mV p-p for LYS-5-12, -15, -20, -24, -28 and LYD-5-152 models.	
	10 mV RMS, 50 mV p-p on 5 Vdc output; 3 mV RMS, 70 mV p-p on $\pm 15$ to $\pm 12$ Vdc output; 3 mV RMS, 70 mV p-p on 24-28 Vdc output.	} LYT & LYQ models

### AC input

line	105-132 Vac 47-440 Hz
power	LYS-5-5-OV 280 watts; LYS-5-6 280 watts; LYS-5-12 thru LYS-5-28 405 watts; LYD-5-062 280 watts; LYD-5-152 405 watts; LYT-5-5152 320 watts; LYQ-5-5153 320 watts.

### Efficiency

greater than 50% with advanced 20 KHz switching circuitry

### Mounting

two surfaces with tapped mounting holes, designed to mount in Lambda standard rack adapters LRA-10 and LRA-11. Mount with top or right side facing up and only in a horizontal plane.

### Physical data

#### Weight:

11 1/2 lbs. net  
13 lbs. ship

### Option

#### A.C. input

add suffix "V" to model number for operation at 187-242 Vac, 47-440 Hz and add 12% to the price. V option available for single output models only.

## Specifications of LV-A Series

### DC output

regulation, line	0.15% + 10mV for line variations from 105-132 Vac.
regulation, load	0.15% + 10 mV, no load to full load or full load to no load.
ripple and noise	ripple reducer; 100 mV max. p-p as measured with 25 MHz bandwidth oscilloscope.
remote programming resistance.	200 ohms/volt nominal
remote programming voltage	volt per volt
temperature coefficient	(0.03% + 0.5 mV)/°C

## LV-A Specifications (Cont'd)

### AC input

line	105-132 Vac, 57-63 Hz
power	LV-EE-A Models 850 watts, LV-G-A Models 1350 watts.

## Specifications of LW-A Series

### DC output

regulation, line	2% for line variations from 105-132 Vac.
regulation, load	2%, 20% load to full load or full load to 20% load, or 2% full load to no load with a 20% preload throughout voltage adjust range.
ripple and noise	300 mV RMS, max., or 2% of output voltage, whichever is greater.
remote programming resistance.	200 ohms/volt nominal
remote programming voltage	volt per volt
temperature coefficient	0.03% + 0.5 mV/°C

### AC input

line	105-132 Vac, 57-63 Hz
power	LW-DA Models, 450 watts; LW-EEA Models, 850 watts; LW-GA Models, 1350 watts.

## Specifications common to both LV-A & LW-A Series

### Overshoot

no overshoot on turn-on, turn-off, or power failure.

### Efficiency

greater than 50%, with advanced SCR circuitry.

### Ambient operating temperature range

0°C to +71°C

### Storage temperature range

-55°C to +85°C

### Overload protection

#### Thermal

thermostat on all LV-EE-A, LW-D-A and LW-EE-A models automatic reset when over-temperature condition is eliminated; circuit breaker must be reset on LV-G-A and LW-G-A models.

#### Electrical

external overload protection: fixed, automatic electronic current limiting circuit limits the output current upon external overloads, including short circuit, thereby providing protection for load as well as power supply. Internal failure protection: provided input fuse.

### Option

add, suffix "V" to LV-EE-A or LW-EE-A models only for operation at 187-242 VAC 47-63 Hz and add 12% to the price; see tables for current deratings.

# TRAK

## You'd better believe TRAK's in the thin-film business!

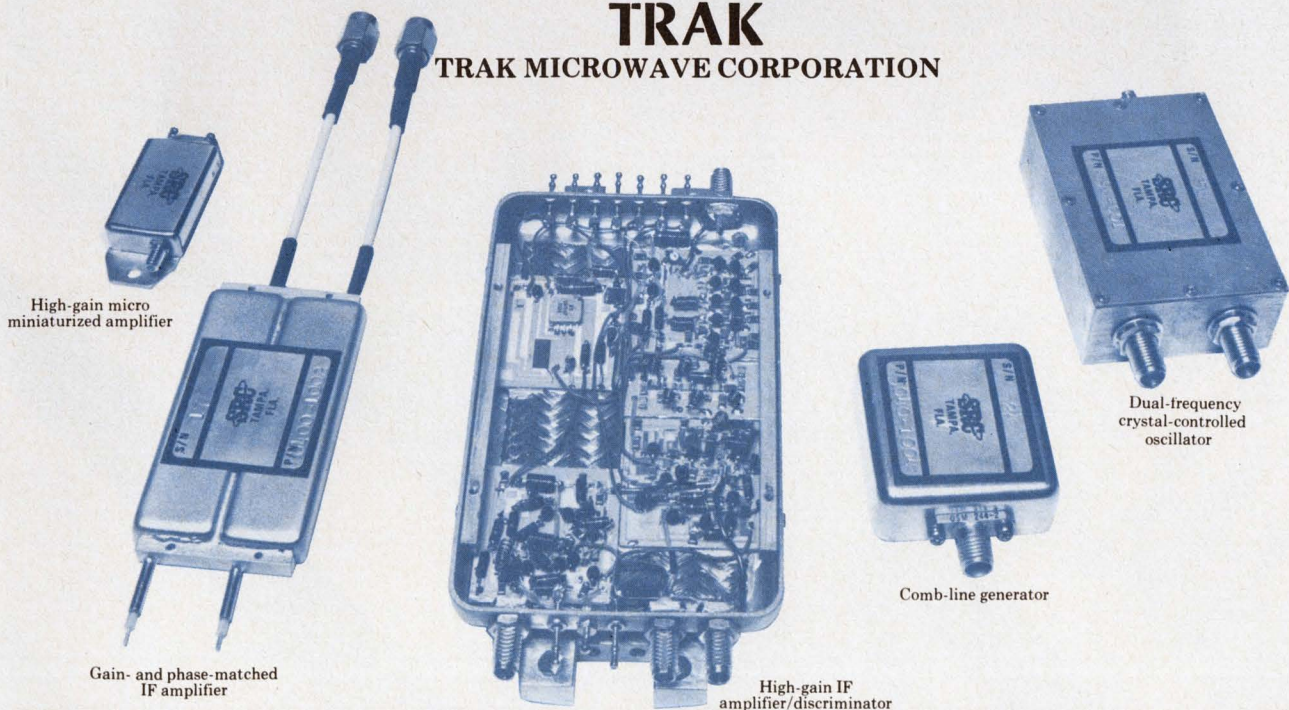
Just a few examples of some of our recent designs. A comb-line generator at 2 to 3.5 GHz generating 15 combs every 100 MHz. A matched-pair IF amplifier with a center frequency of 60 MHz and small signal gain of 60 db minimum. A high-gain IF amplifier with wide band limiter/discriminator in the same package.

We're definitely in the thin-film business! If it can be put on a substrate, we'll do it at a reasonable price. Contact us today for details on these devices or have us quote on your requirements. Trak Microwave Corporation, 4726 Eisenhower Boulevard, Tampa, Florida 33614. (813) 884-1411.

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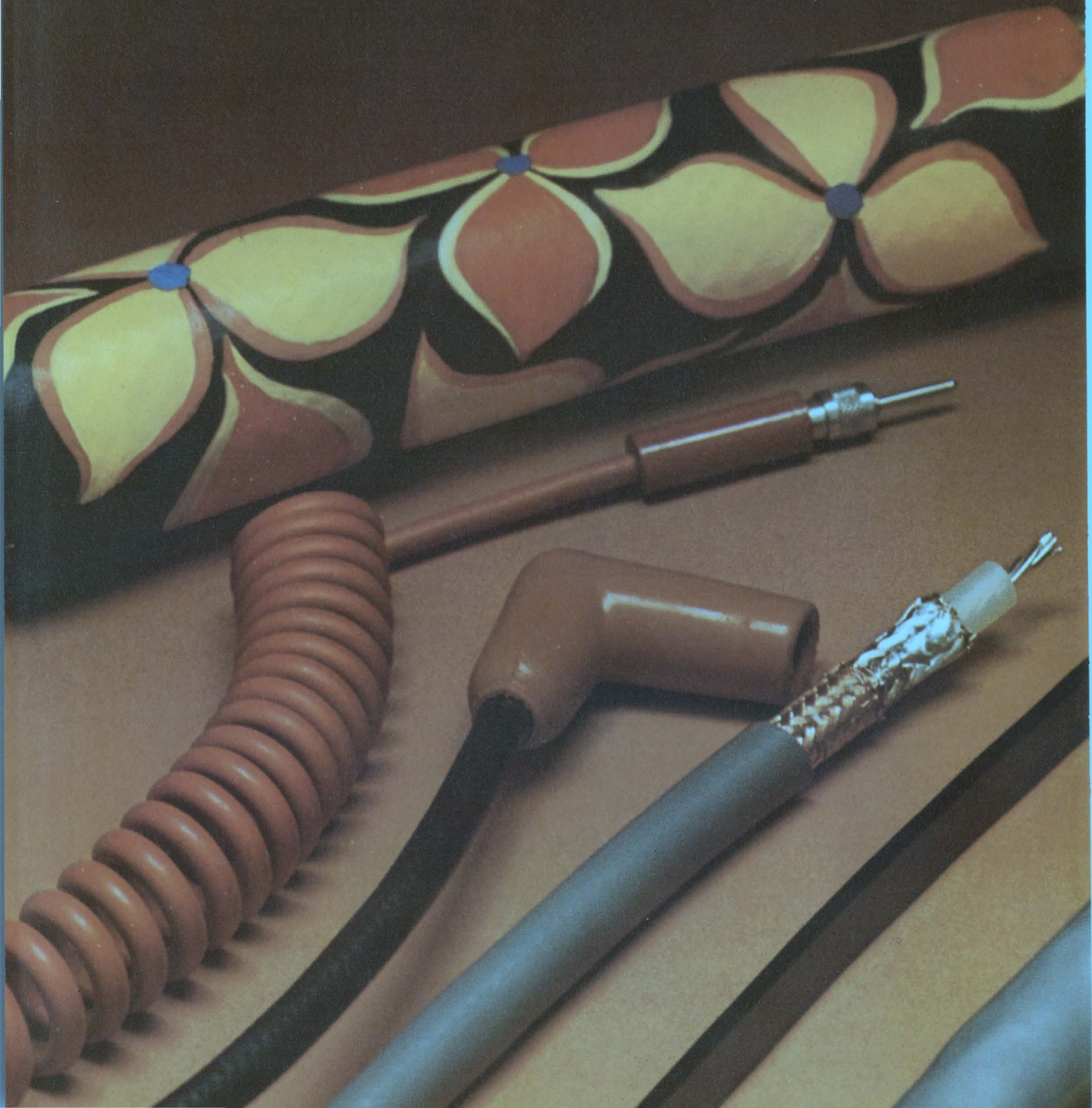
### TRAK

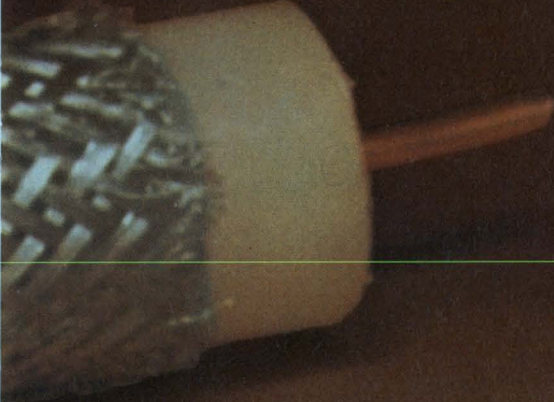
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INFORMATION RETRIEVAL NUMBER 234



# Counter look-ahead techniques – Part 1

**Stretch counter size** without sacrificing speed. Cascade simple sections and add 'look-ahead' logic to bypass critical delay paths.

*This article discusses several forms of the serial-enabling technique and how the method increases counter size and speed.*

Counting circuits are found in almost every digital system. They sequence system logic, perform mathematical operations, act as accumulators and provide digital time delays.

However, the engineer often faces a difficult design problem with such circuits—that of meeting size and speed requirements with a given power consumption. The difficulty is caused by propagation delays in the counter stages, which limit the clock rate for a given logic family. The clock period cannot be less than the time necessary for the counter state to establish itself for decoding.

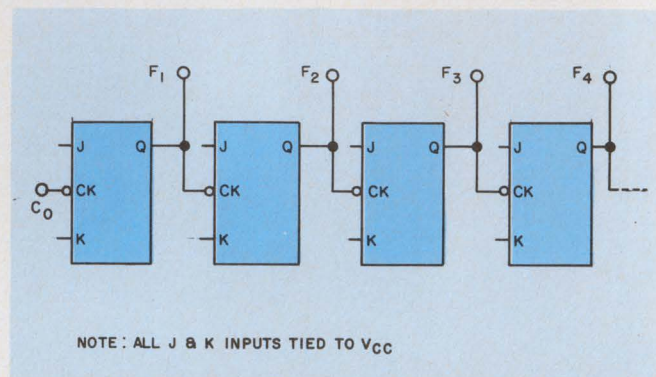
One way to reduce propagation delays in a simple binary ripple-counter is to use faster stages—and to accept the increase in cost and power consumption (Fig. 1). A better way is to use combinations of two basic "look-ahead" techniques—serial enabling or parallel enabling (often called synchronous operation) as shown in Figs. 2a and 2b.

With these techniques, each stage of the counter is enabled by the preceding stages, then toggled by the common clock line. The serial-enabled type is least complex, but the enable signal to the last stage is delayed by  $n-2$  gates. A one-gate delay is obtained with the synchronous counter, which makes it the fastest. But gate size and loading increase rapidly with the number of counter stages.

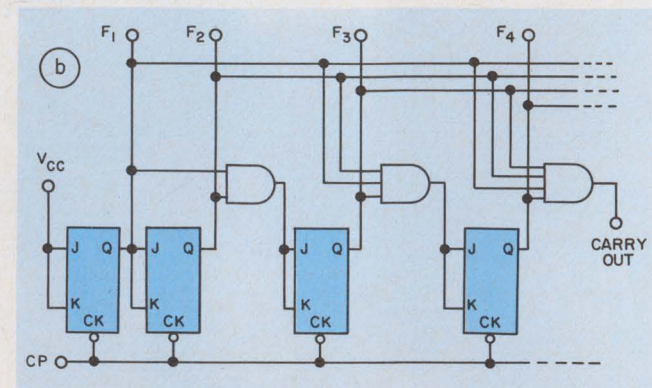
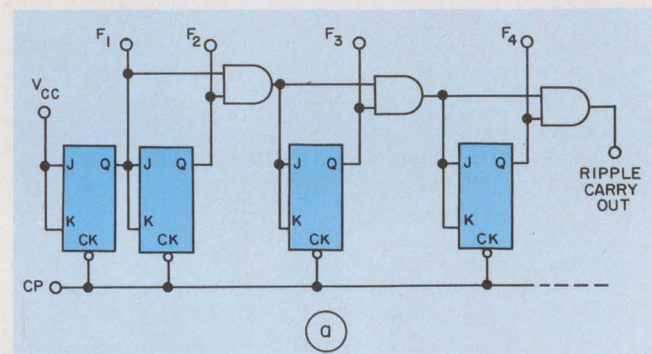
## Look at ripple-counter sections

The design procedures are simplified, and improved performance usually results, when these techniques are applied to counter sections rather than individual flip-flops. Each section is composed of individual flip-flops that are interconnected as a simple ripple-counter. When the number of flip-flops in each section becomes one, the circuits reduce to those shown in Fig. 2.

**E. Michael Meahl**, Senior Engineer, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, Calif. 91103.



1. Each stage of the ripple-counter is toggled by the preceding stage. Delays due to the individual flip-flops are cumulative.



2. Each stage is enabled by the preceding stages on the count that occurs prior to the time the stage is toggled by the clock line. The serial-enable scheme uses the fewest components (a) but has a slow count rate because of  $n-2$  gate delays. The synchronous connection (b) has the highest speed; all enable signals have just one gate delay.



## Decoding the ripple-counter

It's often said that you should use a synchronous rather than a ripple-counter if the state is to be read or decoded. You might feel that a ripple-counter will produce a multiplicity of undesired spikes on the decoded lines, while a synchronous counter won't. But neither is strictly true. All stages in a parallel-enable counter change state at approximately the same time and they do not change state instantaneously. There are finite rise-and-fall times associated with this change of state; therefore spikes will occur. It's true that the spikes may be too narrow to cause a problem, they may be filtered out easily, or they may be eliminated by "strobing" the decoding gates with the clock pulse. On the other hand, a ripple-counter will produce no spikes when decoded for some states. And the spikes produced when decoding other states are predictable. Therefore the decoding of a ripple-counter is often simpler or requires fewer inputs to the decoding gates than decoding a synchronous counter.

Counter states are decoded (recognized) by ANDing the appropriate outputs of stages of the counter. A Karnaugh map is often helpful if a single line is to decode more than one state of the counter. The figure shows a five-stage ripple-counter with states "6" and "8" separately decoded.

Consider state 1 to be the lowest-order state and state 0 to be the highest-order, with the progression of states as follows: 1, 2 . . . . 31, 0. A careful study of the circuit timing reveals the following points:

1. Spikes occur only in even-order states; odd-order states are spike-free.
2. Spikes appear only in states of a higher-order than that of the desired state. Therefore if the count is terminated—or if the counter

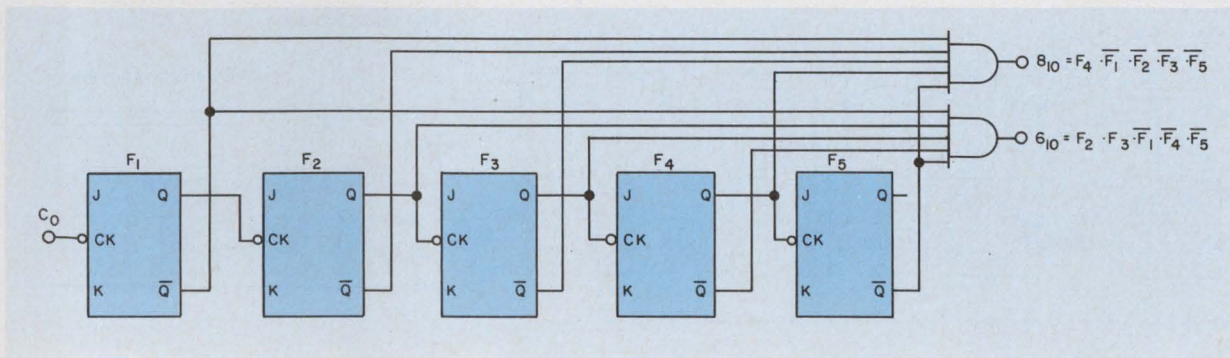
is reset when the desired state is reached (as in most variable-modulus counter designs)—no problem exists.

3. No spikes occur on any decoded line after the next higher-order stage is set. For example, spikes don't occur on any line below "8" after the state of "8" has been reached (stage  $F_4$  sets).

The following rule determines spike location: Consider state 1 to be the lowest-order state, state 2 to be the next, and state 0 to be the highest. No spikes occur prior to the desired output. After the desired output is obtained, a spike occurs in the decoded output. This spike follows the first 1-to-0 transition of each stage in the counter of order up to the lowest-order component of the sum.

For example, in terms of the "true" ("1") outputs of the counter stages, state 10 is equal to  $F_4$  plus  $F_2$ ; therefore, a spike occurs when  $F_1$  goes to zero. No spikes occur on odd-order lines because each odd-order state contains the output of the lowest-order stage ( $F_1$ ).

Can you get rid of the spikes? One thing you can do is to add into each troublesome sum the lowest-order bit of the counter—namely  $C_0$ . This is called "strobing" the output with the clock. However, with the given delays there's still trouble if you try to decode state 16 or state 0. You can eliminate the spikes on these two outputs if you narrow the clock pulse ( $C_0$ ). But as you increase the length  $n$  of the counter, you'll have trouble again soon. The width of the output terms—that are equal to a power of two—decreases as the order of the state decoded increases. In an  $n$ -stage counter, the worst case occurs in the  $2^n$  and the  $2^{n-1}$  states, because a transition must ripple down through all stages in both instances.



Propagation delays limit the maximum speed of the simple ripple counter. In general, this limit occurs when the pulse width obtained from the decoded state falls below that of the clock pulse (see box). In the case of the ripple-counter, the decoding of state  $2^n$  or  $2^{n-1}$  represents a worst case; in turn, each stage must be toggled by the stage that precedes it.

With TTL flip-flops, the 1-to-0 transition delay  $T_{PD0(F)}$  is usually greater than the 0-to-1 delay  $T_{PD1(F)}$  (see Fig. 3). Therefore the ability to decode the  $2^n$  state is usually the limiting condition. If you assume that all flip-flops in the counter have the same propagation delay, then

$$T_{CP} \geq n T_{PD0(F)} + T_{CW} \quad (1)$$

and

$$f_{\max} = 1/(nT_{PD0(F)} + T_{OW}). \quad (2)$$

In other words, the clock period must exceed the total ripple delay  $n \times T_{PD0(F)}$  by one clock pulse width. Also, for a given  $T_{CP}$ ,  $T_{CW}$  and  $T_{PD0(F)}$ , the maximum number of stages that can be decoded is

$$n \leq (T_{CP} - T_{CW})/T_{PD0(F)}. \quad (3)$$

Eq. 3 shows the fundamental limitation on ripple-counter size. For example, if a 74L73 J-K flip-flop is used with a 1.2-MHz clock, whose pulse width is 200 ns, then:

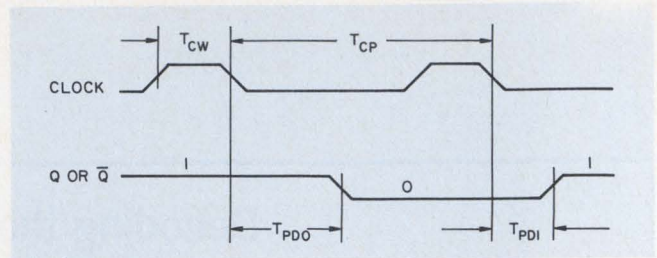
$$\begin{aligned} T_{CP} &= 833 \text{ ns,} \\ T_{CW} &= 200 \text{ ns,} \\ T_{PD0(F)} &= 150 \text{ ns (worst-case 74L73 delay),} \end{aligned}$$

and up to 4.2 (or 4) stages can be cascaded.

### Boost count capacity in sections

Suppose the basic requirements remain the same but an 11-stage—not a four-stage—counter is specified. A ripple-counter won't do the trick. But cascades of four-stage sections can—with the use of section-by-section enabling. Each section will still remain a simple ripple-counter.

Define "terminal count" (TC) as the last counter state before the all-zero state. The terminal count for the four-stage section is



3. Propagation delays are measured, with respect to the 0-to-1 transition of the system clock. With TTL flip-flops, the 1-to-0 delay  $T_{PD0(F)}$  is usually greater than the 0-to-1 delay  $T_{PD1(F)}$ .

1111<sub>2</sub>. The TC of each section provides the enabling signal for the succeeding section (Fig. 4). The terminal state is recognized (decoded) with a multiple-input AND gate.

The output of the first stage, flip-flop  $F_1$ , determines the critical delay in decoding the state; the delay is denoted as  $T_{PD1(F1)}$ . The AND gate—comprised of a NAND gate and an inverter—adds a delay of  $T_{PD0(G)} + T_{PD1(I)}$  to make the total encoding delay per section:

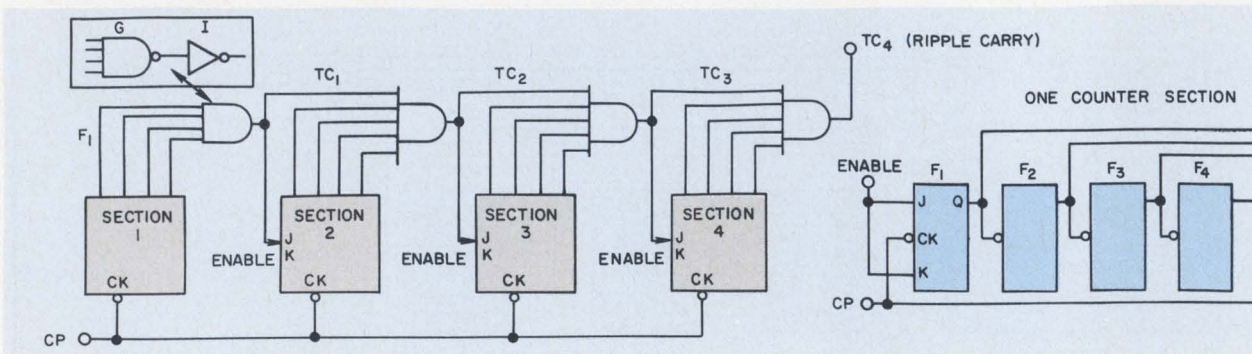
$$T_{PD1(TC)} = T_{PD1(F1)} + [T_{PD0(G)} + T_{PD1(I)}]. \quad (4)$$

When the terminal count of a multisection counter is formed at the decoder, the highest-order stage sets first, then the next highest, back to the lowest—which sets last. Just prior to the terminal count, all stages of the counter except the first stage are in the "1" state. On the next trailing edge of the clock, the first stage sets and the 0-to-1 transition ripples through the gates. If you assume that all gates in the counter are alike, then for a k-section counter:

$$T_{PD1(F1)} + (k-1) [T_{PD0(G)} + T_{PD1(I)}] + T_{CW} \leq T_{CP} \quad (5)$$

$$T_{PD0(F1)} + (k-1) [T_{PD1(G)} + T_{PD0(I)}] + T_{CW} \leq T_{CP}. \quad (6)$$

The  $T_{CW}$  term in the above equation is the setup time of the first flip-flop in the last section of the counter. With the master-slave arrangement of J-K flip-flops, the minimum setup time is equal to the width of the clock pulse  $T_{CW}$ .



4. Cascades of ripple-counter sections exceed the counting speed possible with use of a simple cascade of ripple-counter stages. The AND gates provide serial-

enabling of individual sections. The system speed is limited by the propagation delays between the  $F_1$  signal and the final stage.

Rearrangement of Eqs. 5 and 6 to solve for the maximum number of sections allowed in the counter gives

$$k_{TPD1} \leq 1 + [T_{CP} - (T_{PD1(F1)} + T_{CW})] / (T_{PD0(G)} + T_{PD1(I)}) \quad (7)$$

and

$$k_{TPD0} \leq 1 + [T_{CP} - T_{PD0(F1)} + T_{CW}] / (T_{PD1(G)} + T_{PD0(I)}) \quad (8)$$

In the case of the 11-stage counter that also uses 74L30 gates and 74L04 inverters,

$$k_{TPD1} \leq 1 + \frac{833 - (75 + 200)}{100 + 60} = 4.48$$

and

$$k_{TPD0} \leq 1 + \frac{833 - (150 + 200)}{60 + 60} = 5.02.$$

Hence up to 4 four-stage sections can be cascaded. With 7430 gates, 7404 inverters and some additional power per stage

$$k_{TPD1} \leq 1 + \frac{833 - (75 + 200)}{15 + 22} = 16$$

and

$$k_{TPD0} \leq 1 + \frac{833 - (150 + 200)}{15 + 22} = 14;$$

up to 14 sections can be cascaded. With 74LXX gates,  $T_{PD1}$  is the limiting factor; with 74XX gates,  $T_{PD0}$  is the limiting factor.

When the 1-to-0 delay is the limiting factor—as in the previous example—a small circuit addition will serve to increase the allowable number of stages from  $k_{TPD0}$  to  $k_{TPD1}$ . The 14-section counter can become a 16-section counter if the designer inserts the  $F_1$  signal into the gate at the input to section 15 (Fig. 5). The 1-to-0 transition does not have to propagate through all the preceding gates to reach the last two sections. The actual injection can be made at any or all sections between three and 15, so long as the  $T_{PD0}$  delay is decreased by at least two gate-delay times.

### Partitioning maximizes number of stages

How do you choose the balance between sections per counter and stages per section that

maximizes the allowable clock rate? Part of the answer is implied by Eqs. 5 and 6. Each additional counter section (regardless of the number of stages) increases the total propagation delay—by that of one AND gate. So the number of sections should be minimized to keep the total delay as small as possible.

And the number of flip-flop stages used in each section must be maximized—up to the maximum number allowed by the clock rate.

The ripple-counter configuration gives the smallest number of allowable stages per section (Fig. 1). The second choice—the serial-enabled configuration can count at a significantly faster rate only if the AND-gate delay is well below that of a flip-flop (Fig. 2a). The timing constraints for the serial-enabled configuration are

$$T_{CP} \geq T_{PD1(F1)} + (n-2) T_{PD1(G)} + T_{CW}$$

and

$$T_{CP} \geq T_{PD0(F1)} + (n-2) T_{PD0(G)} + T_{CW}.$$

The clock rate for the ripple-counter (Eq. 1) is:

$$T_{CP} \geq n T_{PD0(F)} T_{CW}.$$

To compare allowable clock rates, consider eight-stage sections that use 74LXX series flip-flops, gates and inverters. For the serial-enabled configuration,

$$T_{CP} \geq 75 + (6)(60 + 60) + 200 = 995 \text{ ns}$$

and

$$T_{CP} \geq 150 + (6)(60 + 60) + 200 = 1070 \text{ ns};$$

therefore the clock rate,  $1/T_{CP}$ , is

$$f_{\max} = 934 \text{ kHz.}$$

And for the eight-stage ripple-counter

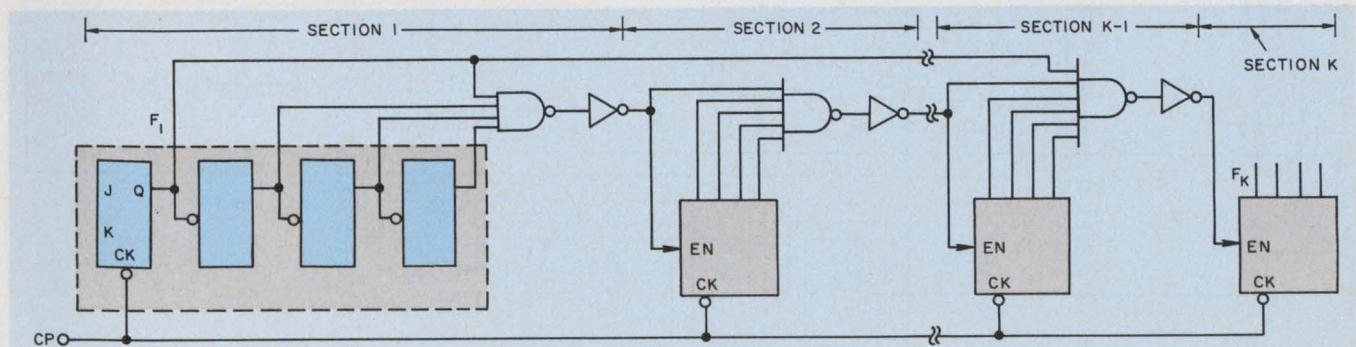
$$T_{CP} \geq (8)(150) + 200 = 1400 \text{ ns}$$

and

$$f_{\max} = 714 \text{ kHz.}$$

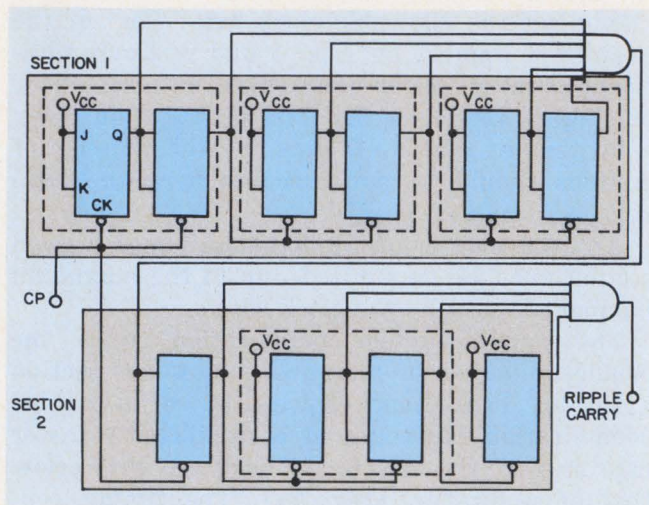
The serial-enabled counter at 934 kHz is not much better than the ripple-counter with its 714-kHz limitation.

A pairing scheme provides significant advantages over ripple-counter or serially-enabled stages. With J-K flip-flops, an additional gate is not required to enable the output of the second stage with that of the first. The same pairing can be applied to other stages of the counter to create—in effect—a cascade of serial-enabled



5. Downstream injection of the  $F_1$  signal increases the number of allowable sections provided that  $T_{PD0(F)}$  exceeds  $T_{PD1(F)}$ . The 1-to-0 transition does not have to

propagate through all preceding gates to reach the last sections. The 0-to-1 transition delay determines the maximum number of sections.



6. **Maximization of the total number** of counter stages occurs when the counter is partitioned into the least number of sections (maximum number of stages per section). Pairs of serial-enabled sections within each section permit greater clock speeds than completely serial-enabled or ripple-counter sections.

stages that are connected in ripple-counter configuration (Fig. 6).

But all sections that follow the first must contain at least one unpaired stage. The clock line must go to a single stage; otherwise an enabled second stage will also be toggled at the clock rate.

The operating restriction on the first stage is given by

$$T_{CP} \geq \text{INT} [(n + 1)/2] T_{PD0(F)} + T_{CW}, \quad (9)$$

since each pair of stages contributes the propagation delay of a single stage. The expression "INT" denotes the downward-rounded integer value of the bracketed expression. With the eight-stage counter,

$$T_{CP} = [(8 + 1)/2] \times 150 + 200 \\ = 800 \text{ ns}$$

and  $f_{\text{max}} = 1.25 \text{ MHz}$ .

The operating expression for the remaining stages is

$$T_{CP} \geq [1 + \text{INT} (n/2)] T_{PD0(F)} + T_{CW}, \quad (10)$$

and the partitioning of stages must be selected so that Eqs. 9 and 10 are satisfied simultaneously.

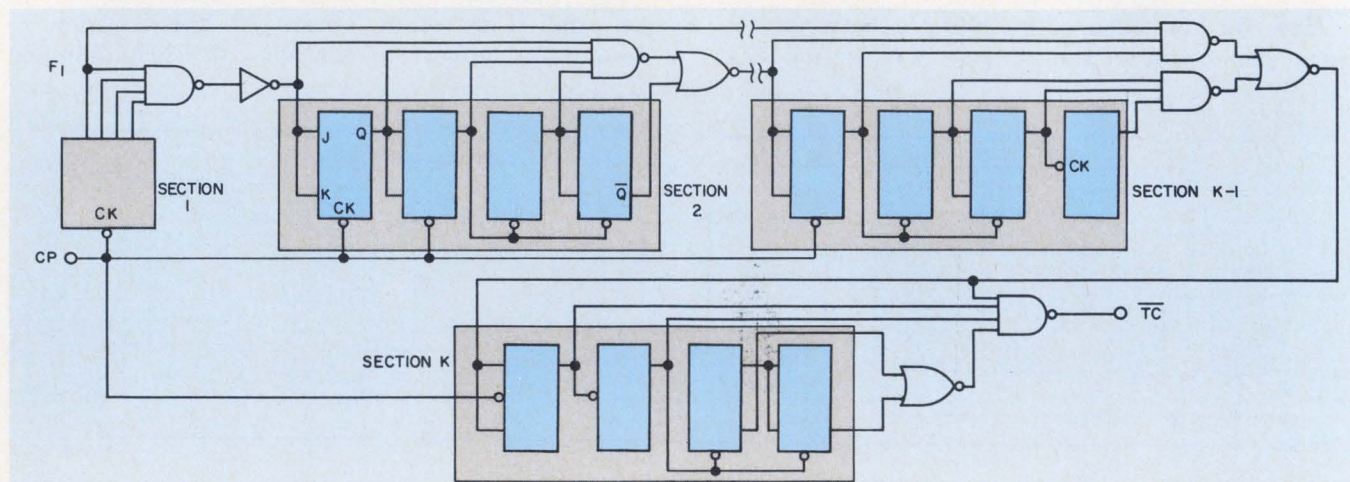
A faster flip-flop in the first counter stage reduces the contribution of  $T_{PD1(F1)}$  and  $T_{PD0(F1)}$ , and allows an increase in the number of sections.

The number of stages used per section does not limit the number of sections allowed. But the number of stages per section is limited by the need to decode them at a given clock rate.

Additional systems considerations can impose criteria other than that of maximizing the total number of stages. For example, suppose a 12-stage counter is needed and other devices are to trigger on a count of  $2^4$ ,  $2^7$  and  $2^{12}$ . The required signals are terminal counts of the first four, first seven and all 12; a natural partition of the counter could be four stages, three stages and five stages.

In choosing hardware to implement serially-enabled counter schemes, one can easily encounter gate sections that require five or more inputs. NAND gates, available as ICs, have two, three, four and eight inputs; NOR gates have two, three, and four inputs in the 74-series and two inputs in the 74L series. And there's no need to waste an eight-input package for a five-input requirement. Several solutions that use combinations of gates are shown in Fig. 7. The delay encountered by the  $F_1$  signal determines the delay in the terminal count as well as the delay to the enable of each section. As long as the logic delay of  $F_1$  is not increased, additional logic delays can be introduced in the other signal paths. ■■

*The concluding article will discuss parallel enabling techniques and the use of MSI counters.*



7. **Various practical configurations** can be used to form the multiple-input AND gates, so long as the logic-delay

path of  $F_1$  is not increased. These configurations allow efficient use of available fan-in limits.



# New digital test system... FOR systems, cards or circuits... from Kurz-Kasch

Using the new Hi-Lo pulser  
with the Kurz-Kasch logic probe  
speeds troubleshooting.

The all new Kurz-Kasch Hi-Lo pulser Model HL-582 is an in-circuit stimulator used to exercise IC's and cards. The HL-582 will pull an existing LO state to a HI state, and an existing HI state to a LO state in DTL and TTL logic circuits. By noting the change in output (or lack of change) with a Kurz-Kasch logic probe you can immediately identify troublesome logic circuits.

The basic concept of controlling the input and monitoring the output allows a wide range of use. You can check gates, counters, flip-flops, shift registers, etc. The system is ideal for field service, production checking, inspection and laboratory troubleshooting. The two pen-sized units are extremely convenient to use. The Kurz-Kasch system allows hands-free testing on the backplane, mother board or plug-in boards. Clips and adaptors are available for most commonly occurring test situations in computers, N/C and process controls, business machines and all other digital technology.

#### Specifications

### Logic Probe LP-520

**Voltage:** All logic voltage from 4.75 VDC to Vc compatible with DTL, TTL and similar families.

**Logic Voltage Level Response:** 0-0.8 VDC = logic "0" (readout white at tip).  
0.8-2.4 VDC = No Readout.  
2.4 - Vc = logic "1" (readout red at tip).

No readout in case of missing pin or unconnected wire.

**Pulse Detection Response:** High speed pulse trains, or single cycle pulse of 50 nanoseconds duration or greater = (Blue readout at tip).

**Input Impedance:** Greater than 35 K ohms for logic "1" level.

PRICE: \$69.95

### Pulser HL-582

**Pulse Voltage:** High level 3.0 VDC min.  
Low level 0.6 VDC max.

**Pulse Width:** 1  $\mu$  Sec nominal in both 1-shot and continuous modes (5Hz).

**Power:** Derived from circuit/system under test.

Power leads are over voltage and reverse voltage protected.

**Tip:** Protected to  $\pm 35$  volts.

PRICE: \$89.00

Send for complete details and specifications. For a 15 day FREE TRIAL pulser and/or logic probe, contact Tom Barth, General Manager, Kurz-Kasch Electronics, 2876 Culver Avenue, Dayton, Ohio 45429. Telephone: (513) 296-0330.



**Kurz-Kasch, Inc.**

ELECTRONICS DIVISION

2876 Culver Avenue

Dayton, Ohio 45429

Telephone 513/296-0330

# Texas Instruments announces for the 980A minicomputer interactive terminal processing

DX980 is a general purpose operating system that supports the 980A computer in various applications including batch processing, interactive terminal processing, and real-time processing. It can support all of these applications simultaneously or each one individually.

The Memory Protect/Privileged Instruction feature of the 980A provides a "hardware protected" environment so that an executing program cannot destroy the operating system or another job.

DX980 features a modular organization. Executive functions common to several application environments are included in the nucleus, while executive functions unique to specific environments are embodied in subsystems.

The nucleus is partially memory resident and partially disc resident with the disc resident portions called into memory as required using a dynamic allocation technique. The nucleus provides for such functions as: **Job Management** – to provide the facilities for job submission, resource allocation, job initiation, execution management, and job termination. The number of jobs active is limited only by available resources.

**Task Management** – for task creation, scheduling, synchronization, and termination. Multi/tasking is supported both across several programs and within a single program.

**Memory Management** – for dynamic memory allocation and release.

**I/O Management** – to provide I/O functions from programs to peripherals on a device independent basis.

**File Management** – to provide a device independent interface from a program to data stored on disc. Three file types are supported:

Linked Sequential File – has an



*Multi-terminal 980A System*

access interface identical to that used for the various sequential devices (magnetic tape, line printer, card reader, etc.). Consistency between sequential device and disc is achieved with the Linked Sequential File.

**Relative Record File** – provides a low overhead direct disc access to a contiguous section where I/O transfers may be either blocked or unblocked.

**Indexed File** – provides a directory-supported random access method based on a record identifier whose size is user specified. File operations include record addition, insertion, modification, deletion, and retrieval using either a random or sequential access method. A multiway balanced tree directory provides random access with extremely low disc access for search.

**Operator Communications** – provides an extensive command language that may be used from the system

operator's console. Subsystems are individually activated and deactivated by the systems operator as needed. When active, a subsystem operates in privileged mode and is essentially part of the operating system. Main memory is allocated to the subsystem only when it is active so a user who is not interested in a particular operating environment does not pay a penalty for the ability of DX980 to support the environment.

## **Batch Processing**

A batch processing environment is supported by three separate modules, referred to collectively as the Batch Processing Subsystem:

**Batch Input Reader** – is used to effect direct assignment of a sequential input device to a sequence of serially executed programs.

**Batch Input Spooler** – is used to effect spooled input from a sequential input device to a sequence of programs

# DX980—an operating system that supports batch processing, and real-time...simultaneously.

which may execute in parallel.

**Batch Output Spooler** — is used to effect spooled output to a sequential output device.

## Interactive Terminal Processing

DX980 provides for interactive communication between the system and local or remote terminals through the Interactive Terminal Subsystem. The features provided include:

- An interface to support multi-user interactive applications programs
- Interactive file editing
- Remote job entry
- Job status retrieval

## Real-Time Processing

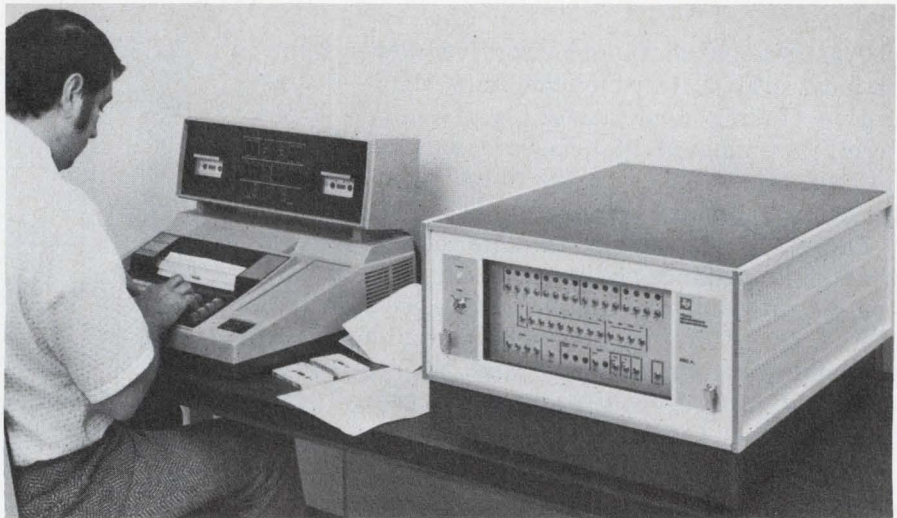
DX980 provides for multi/tasking on a priority scheduling basis. The processor may be switched from task to task by an I/O request, a supervisor call, a device interrupt or at the end of a task. It provides a roll-out/roll-in feature to insure real-time response to high priority requests.

## Other Software

DX980 supports a variety of software including FORTRAN IV, symbolic assemblers, the TI language translator and the linkage editor.

It will operate on any 980A system with at least 16K memory, an interval timer, an operator's console and a disc. The modular structure allows expansion to include:

- Multiple 3330 type disc drives
- Multiple disc cartridge drives
- Magnetic tape drives
- *Silent 700\** ASR or KSR data terminals
- Card readers
- Line printers
- Alphanumeric CRT terminals
- Paper tape readers and/or punches



*Low-cost 980A Software Development System*

- Communications interfaces
- Hardware vectored interrupts
- Up to 64K words main memory

DX980 allows users with big jobs to do their processing in an economical manner. However, Texas Instruments also offers software to support the many users who do not need a large disc-based system to solve their problems. For this class of user TI offers the Program Development System shown above. This system may be as simple as a \$9725 package of an 8K 980A with a twin cassette *Silent 700* ASR terminal. It enables fast and easy development of new software. Speed, simplicity, and reduced noise level are the major advantages over a system equipped with a 33 ASR.

Standard software includes:

- Loader
- I/O support package
- Assembler
- Linkage editor
- Source editor
- Debug aids
- A wide variety of additional

peripherals, plus expansion capabilities to support FORTRAN

## Hardware

This software has been designed to take advantage of the powerful features of the 980A, which include:

- Hardware multiply/divide
- Memory parity
- Memory protect
- Privileged instructions
- Power fail interrupt
- ROM bootstrap loader
- Removable control panel with keylock
- Hardware breakpoint and program sense switches
- DMA interface port, expandable to 8 ports
- Four I/O bus ports, up to 256
- Auxiliary processor port

The 980A is the price/performance leader in the computer world. Want more information? Get answers by writing or calling Texas Instruments Incorporated, P.O. Box 2909, Austin, Texas 78767; phone (512) 258-5121.



**TEXAS INSTRUMENTS**  
INCORPORATED

# Reduce system noise with CMOS circuits

that provide compensating waveshaping and level detection. The circuits are simple and use low-cost ICs.

The established favorite for low-power applications—CMOS, or complementary MOS—is finding increasing applications in systems where a significant amount of noise accompanies the required signal. The systems range from data acquisition to industrial control.

Designers are using the high power gain of CMOS—impedance ratios approach  $10^{10}$ —in various circuit configurations to reduce substantially the effects of system noise. The circuits provide compensatory waveshaping and level detection, and they can be built easily with readily available, low-cost CMOS ICs.

## CMOS switching characteristics nearly ideal

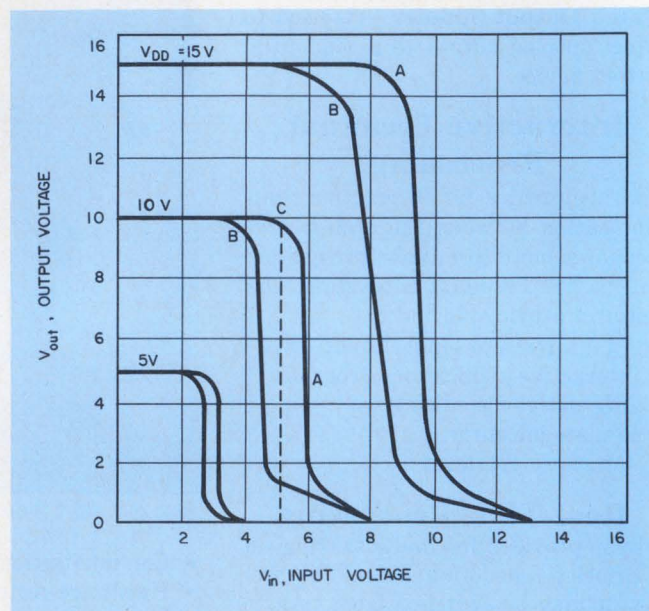
A CMOS gate typically switches at a threshold level given by

$$V_{th} = 1/2 (V_{DD} + V_{SS}), \quad (1)$$

which also varies directly with  $(V_{DD} - V_{SS})$  over the entire range of 3 to 15 V. These characteristics result in nearly ideal switching conditions that permit CMOS devices to operate over a much wider voltage range than other forms of logic circuits. Typical transfer characteristics of a two-input NAND gate are shown in Fig. 1.

Curves labeled "a" are the characteristics with both inputs tied together. Curves labeled "b" are the characteristics with one input connected to  $V_{DD}$ . Curve "c" is the characteristic of a double-buffered gate. Such buffered gates (Fig. 2) can be used as squaring circuits when system noise falls below specified noise margins—typically 40% of  $V_{DD}$ , as shown in Fig 3.

With reference to Figs. 1 and 2, when inputs A and B are tied together, the input signal must exceed the thresholds of the two series, n-channel devices before the output can begin to move. This requirement accounts for the shape of the "a" curves in Fig. 1. However, with one input tied high—to  $V_{DD}$ —one of the n-channel devices remains on, thereby leaving only one n-channel threshold to overcome. This requirement accounts



1. Typical CMOS transfer curves of a two-input NAND gate exhibit nearly ideal switching characteristics.

for the shape of the "b" curves in Fig. 1. The parallel p-channel configuration in the NAND gate has no turn-on time delay.

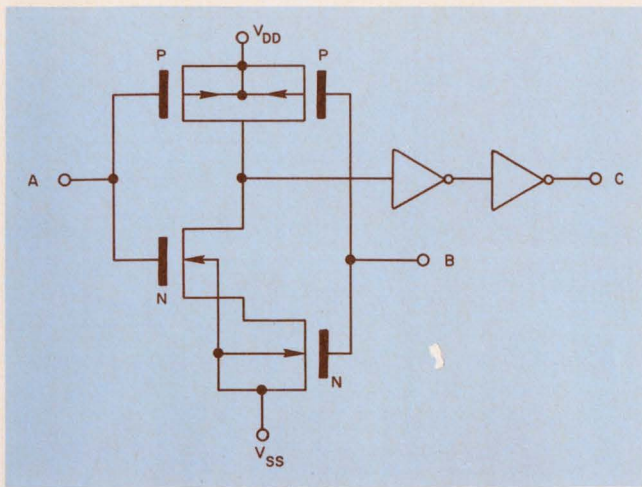
The differences between the p and n-channel thresholds can be eliminated by addition of an inverter in series with the NAND output, since the inverter has only one p-channel and one n-channel device. To keep the polarity correct, another inverter is added to form a double-buffered NAND gate. This gate not only has a symmetrical output but also increased current sourcing and sinking capability (note curve "c" in Fig. 1).

## Hysteresis reduces effects of noise

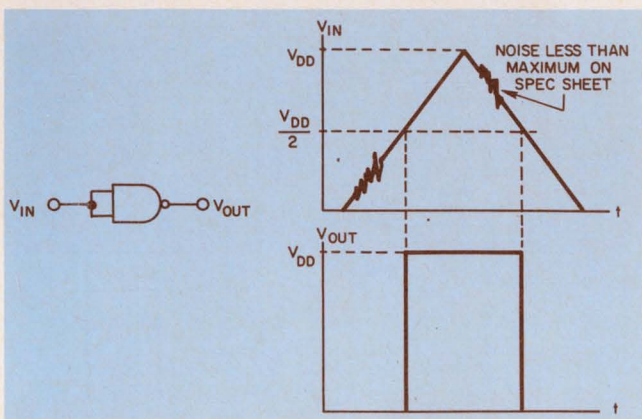
In a noisy environment the use of a wide-hysteresis amplifier as a squaring circuit offers increased protection against false triggering. Hysteresis refers to the difference between the high input triggering level and the low input triggering level of the amplifier (Fig. 4). Accordingly hysteresis voltage,  $V_{HYS}$ , can be expressed as

Robert S. Schamis, Applications Engineer, Solid State Scientific, Montgomeryville Industrial Center, Montgomeryville, Pa. 18936.





2. A double-buffered NAND gate can be used as a squaring circuit to minimize the effects of noise.



3. The double-buffered SCL 4011A forms a squaring circuit when inputs are connected together.

$$V_{HYS} = V_{HI} - V_{LO} \quad (2)$$

The effects of hysteresis in an amplifier are shown in Fig. 5.

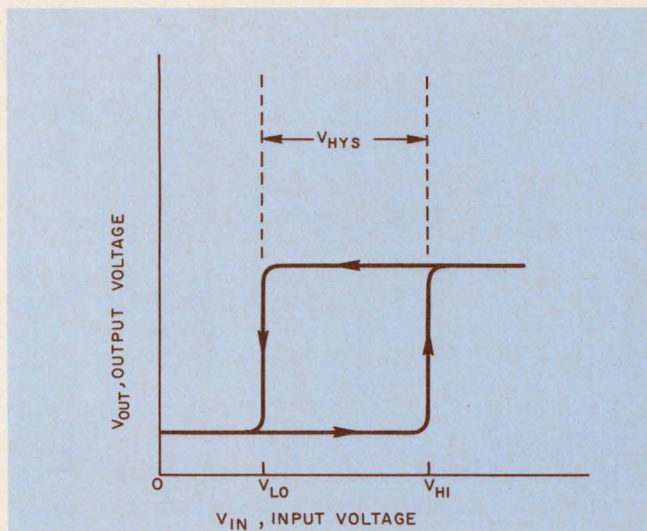
CMOS gates can be connected in configurations to exhibit varying degrees of hysteresis. For example, Fig. 6 illustrates the use of a 4011A quad two-input gate as a variable hysteresis Schmitt trigger, or squaring circuit.

Since delay time is proportional to the number of inputs, more inputs provide a wider range of hysteresis. Fig. 7 shows a 4023A triple three-input gate connected as another variable hysteresis Schmitt trigger, but with a wider hysteresis range.

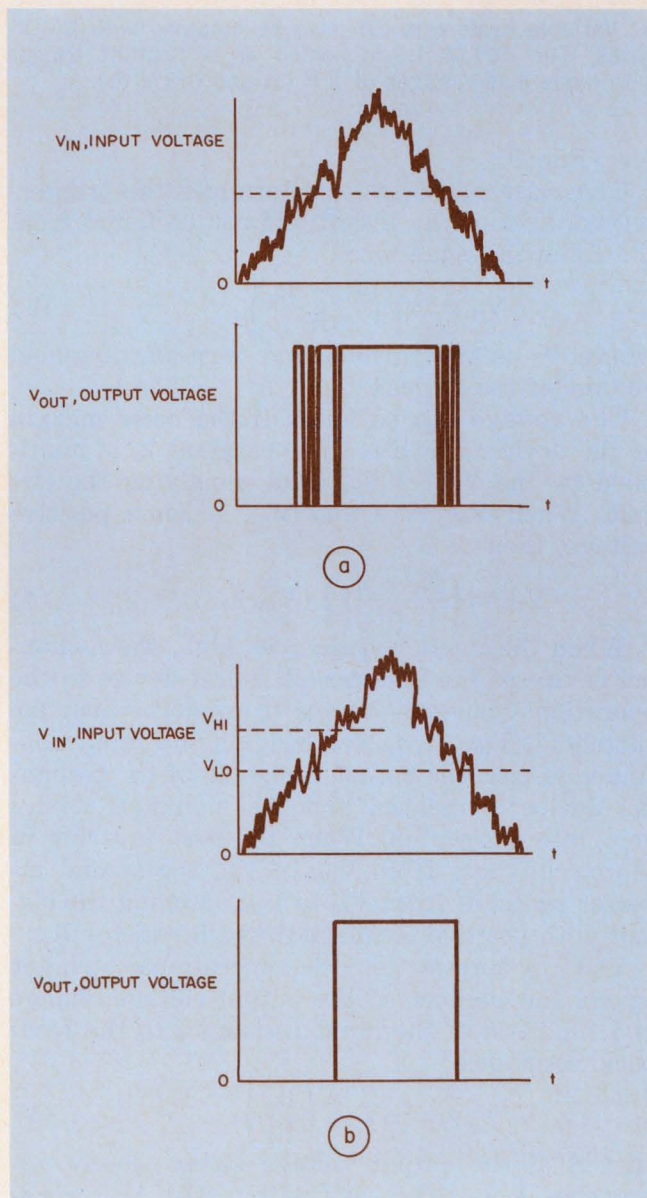
With a double-buffered gate added in series to the input signal of the variable hysteresis circuits, the minimum hysteresis level can be brought close to zero (Fig. 8).

### Operational trigger improves accuracy

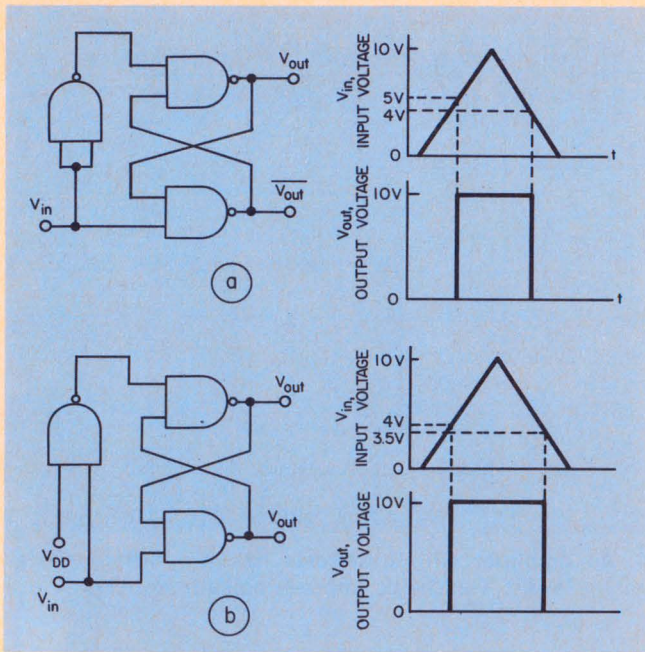
For waveshaping and more accurate level detection, an operational trigger can be constructed from CMOS with a quad true/complement buf-



4. An amplifier with hysteresis has two different triggering levels. This helps improve noise immunity.



5. Excessive output-voltage bounce (a) caused by a noisy input can be eliminated by hysteresis (b).



6. Variable hysteresis can also be obtained with CMOS gates. The 4011A is connected as a Schmitt trigger with hysteresis voltages of 1 V (a) and 0.5 V (b).

fer (Fig. 9).

The ratio of  $R_f$  to  $R_i$  determines the triggering voltages of the circuit and can be found from the following equation:

$$V_{HI} = V_T \left( \frac{R_f + R_i}{R_f} \right), \quad (3)$$

where  $V_T$  is the turn-on and turn-off threshold voltage of the device.

The voltage can be found if the noise margin of the device, which is some constant  $k$ , is multiplied by the  $V_{DD} - V_{SS}$  value supplying the circuit. When  $V_{SS} = 0$  and  $V_{DD}$  is some positive voltage, then

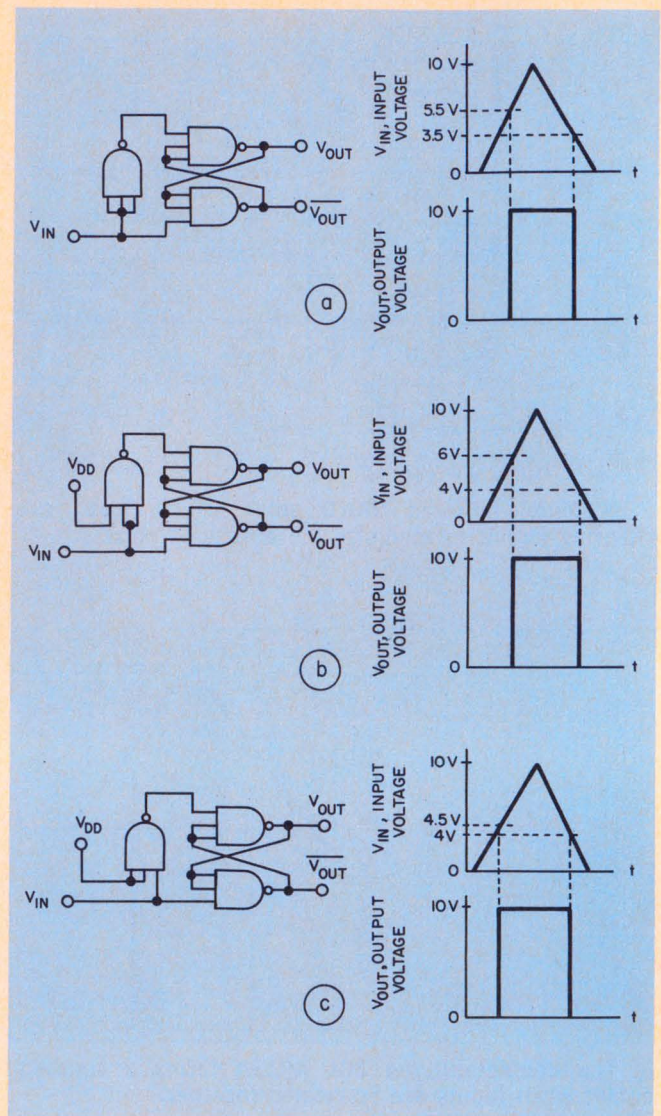
$$V_{HI} = \left( \frac{R_f + R_i}{R_f} \right) (V_{DD} k_N). \quad (4)$$

When the input voltage goes high, the n-channel device of the inverter—the first device in the operational trigger—begins to conduct when the threshold,  $V_{DD} k_N$ , is reached. As the input continues to rise, the cut-off threshold of the p-channel device is reached and the n-channel device goes into saturation. When the first inverter in the circuit goes from  $V_{DD}$  to  $V_{SS}$ , the second inverter switches from  $V_{SS}$  to  $V_{DD}$ , latching the circuit with positive feedback through resistor  $R_f$ .

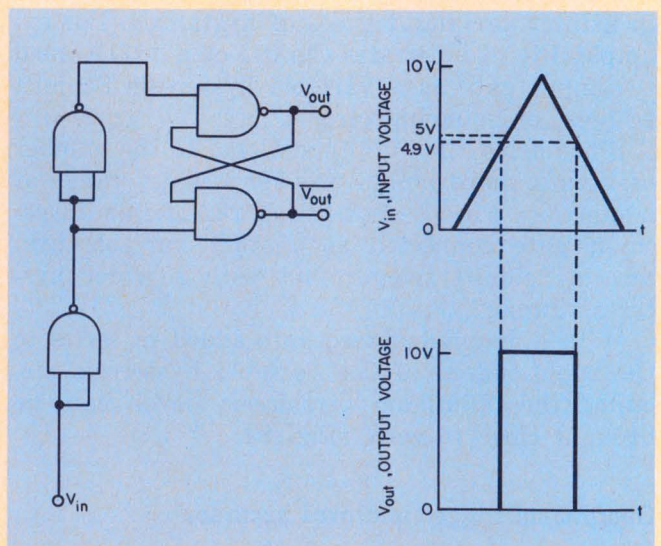
The hysteresis of the operational trigger equals the product of the output-voltage change and the ratio of the input resistance to the feedback resistance:

$$V_{HYS} = \Delta V_{OUT} \left( \frac{R_i}{R_f} \right). \quad (5)$$

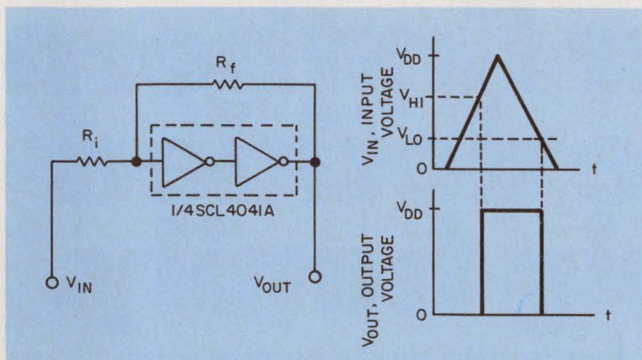
In CMOS the output voltage swing closely approaches  $V_{DD} - V_{SS}$ ; it's within 0.01 V, according to specs, but it can be as close as 0.001 V. Therefore we can say that



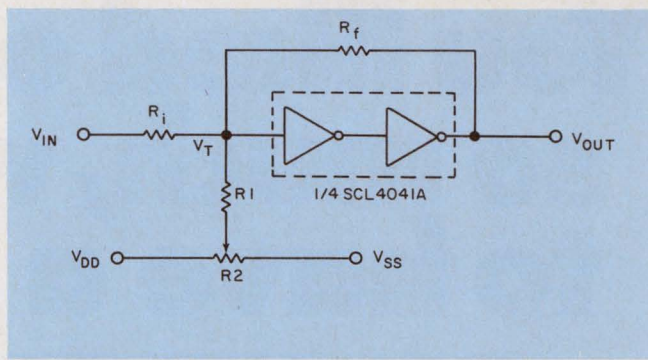
7. More inputs result in increased delay times for a still wider hysteresis range. The 4023A is connected as a Schmitt trigger, with hysteresis levels of 2 V (a and b) and 0.5 V (c).



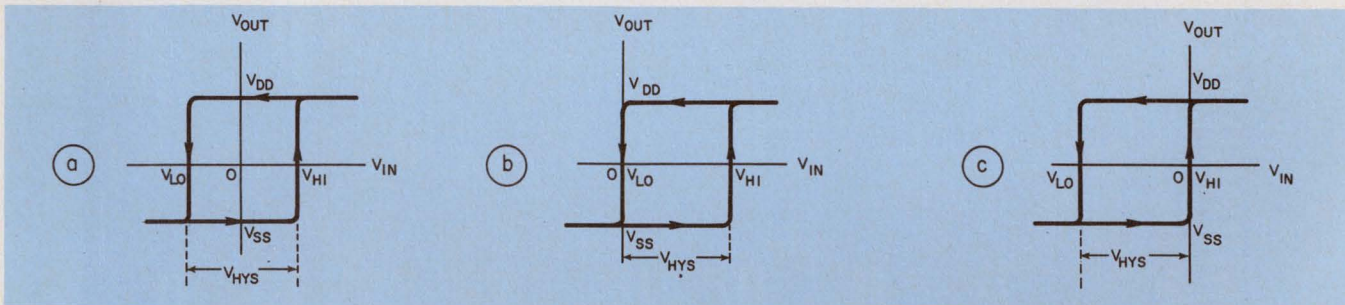
8. The minimum hysteresis level can be reduced to 0.1 V. The addition of a double-buffered gate at the input makes possible the reduction.



9. A CMOS operational trigger provides a means for waveshaping or more accurate level detection, or both.



10. The operational trigger is changed to a zero-crossing detector by the addition of simple circuitry.



11. For large hysteresis, the value of resistor  $R_2$  can be used to affect the centering of the output. Zero-crossing can be achieved with  $V_{HYS}$  centered near zero (a), or

with  $R_2$  adjusted for zero-crossing when  $V_{IN} = V_{LO}$  (b). In addition,  $R_2$  can be adjusted for zero-crossing when  $V_{IN} = V_{HI}$  (c).

$$V_{HYS} = V_{DD} \left( \frac{R_i}{R_f} \right), \quad (6)$$

when  $V_{SS} = 0$  and  $V_{DD}$  is some positive voltage.

Now, substitute Eq. 1 in the last equation for the following result:

$$V_{LO} = \left( \frac{R_f + R_i}{R_f} \right) V_{DD} k_p - V_{DD} \left( \frac{R_i}{R_f} \right). \quad (7)$$

After terms have been combined and simplified, we obtain

$$V_{LO} = V_{DD} \frac{R_i (k_p - 1) + k_p R_f}{R_f}, \quad (8)$$

where  $k_p$  is the p-channel noise-margin constant.

As an example of level detection, say you want a  $V_{HI}$  of 7.5 V and you have a 4041A that has a  $k_N$  of 0.45 and a  $k_p$  of 0.52. With  $V_{DD} = 12$  V and  $V_{SS} = 0$ , a solution of Eq. 4 yields

$$R_i = 0.39 R_f.$$

Now arbitrarily choose  $R_f$  as 100 k $\Omega$ ; then  $R_i$  becomes 39 k $\Omega$ . Finally, from Eq. 2,

$$V_{LO} = 3.99 \text{ V.}$$

#### Simple procedure finds $k_p$ and $k_N$

In this example  $k_p$  and  $k_N$  were found experimentally by means of a simple procedure. The steps are as follows:

1. Calculate the values of  $R_i$  and  $R_f$  from typical values found in the spec sheets.

2. Connect the circuit as shown in Fig. 9, tying all unused inputs to  $V_{DD}$  or  $V_{SS}$ .

3. Find  $V_{HI}$  with a variable dc supply or ramp generator.

4. Use the procedure in Step 3 to find  $V_{LO}$ .

5. Substitute  $V_{HI}$  in Eq. 2 and calculate  $k_N$ .

6. Substitute  $V_{LO}$  in Eq. 5 and calculate  $k_p$ .

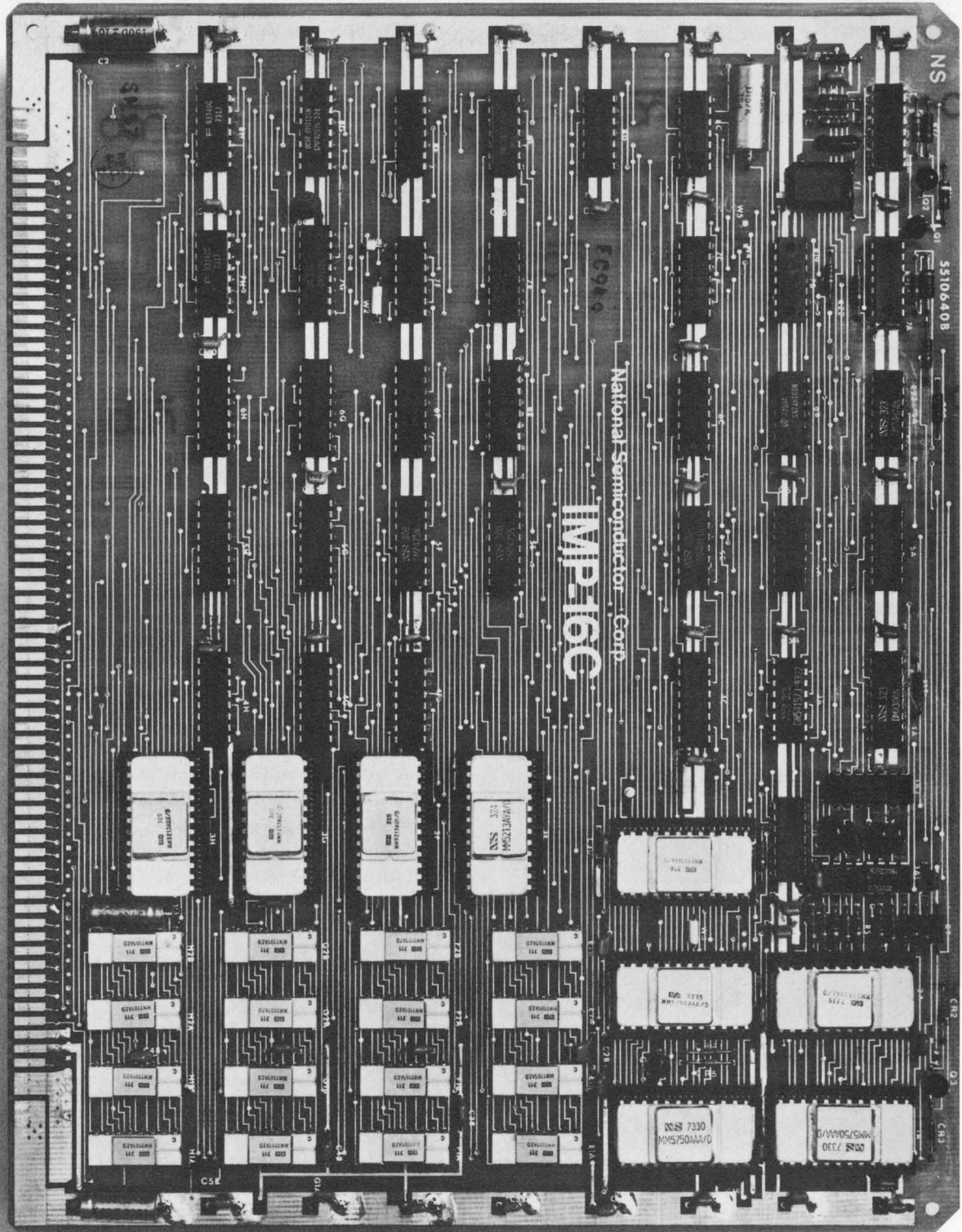
A potentiometer added between  $V_{DD}$  and  $V_{SS}$  and a series resistance connected to  $V_T$  can transform the operational trigger into a zero-crossing detector. The additional components center the hysteresis about  $(V_{DD} + V_{SS})/2$  (Fig. 10).

To obtain the zero-crossing detector, set the value of  $R_1$  equal to  $R_f$  and the value of  $R_2$  at about 0.1  $R_1$ . As the ratio of  $R_f$  to  $R_1$  increases, thereby making  $V_{HYS}$  smaller,  $R_2$  decreases in importance and the output tends to center between  $V_{DD}$  and  $V_{SS}$ . Resistor  $R_2$  becomes important when a large hysteresis is required, as in noisy systems.

The speed of operation and  $V_{HYS}$  are inversely proportional. Accordingly the operating frequency must be seriously considered when an operational trigger is designed. Of course, deviations in pulse symmetry from a square pulse—equal high and low times—decrease the frequency of operation.

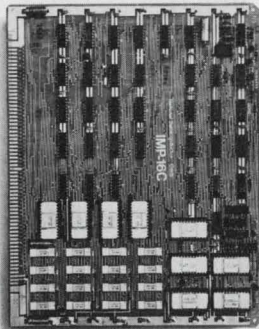
For a zero-crossing detector operating at high frequency—100 kHz to 10 MHz—the ratio of  $R_i$  to  $R_f$  should be about 1 to 1000. For lower-frequency operation and in a Schmitt trigger or level detector, the  $R_i$ -to- $R_f$  ratio can be calculated from the formulas given. ■■

# You liked our firstborn so much, we decided to have a big family.



Our IMP-16C microprocessor on a card has just multiplied into a family of microprocessors.

A full line of flexible building blocks you buy off the shelf and program to your needs. And a self-assembler to help you do it fast. It's so much better than hardwiring your own stuff that microprocessors have become the hottest thing to hit electronics



since the IC.

Our first was the IMP-16C, shown on the left.

Clock system, memory and I/O ports with bus drivers

(upper half of photo). 16-bit microprocessor (lower right-hand corner). 256 words of read/write random access memory (lower left). And provision for 512 words of ROM/pROM memory (left below center).

With its standard set of 43 instructions, IMP-16C is dandy for the control of equipment such as data terminals, test systems, communications equipment, machine tools, process control systems, and peripheral device control systems.

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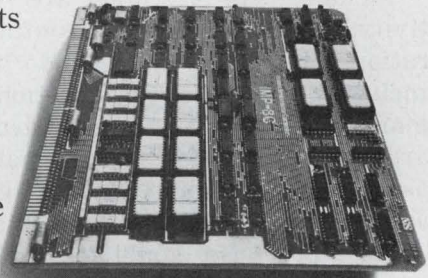
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# Calculate receiver sensitivity. But first decide which definition of sensitivity fits your system. The choice depends mainly on the type of modulation.

Before you calculate the sensitivity of your receiver system, you've got to decide how you want to define sensitivity. There's a forest of different terms from which to choose.

Included, for example, are "tangential sensitivity," "signal = noise," "output signal-to-noise ratio," "bit error rate" and "false-alarm rate, including probability of detection." And there are many more. All can be converted into terms that are related to other system characteristics, such as the required gain and noise figure of individual amplifiers and the insertion loss of components.

If you're wise, you'll make the required conversions and evaluate the results before you contract to build hardware to meet any sensitivity spec.

## Is sensitivity spec realistic?

You will want to find out the following:

1. Whether the specified sensitivity is possible to achieve. Impossible sensitivity specs have been spelled out in otherwise sensible contracts.

2. How hard it will be to meet the specification. If the spec is within a decibel of what's theoretically possible, you'd better allow for another hour or two of engineering time for component tweaking.

System sensitivity, defined as the signal strength that a properly modulated signal must have to provide an acceptable output in a receiver system, can be predicted from the following formula:

$$\text{Sensitivity} = kTB + F_s + C/N,$$

where

- Sensitivity = system sensitivity in dBm,
- kTB = thermal noise level in dBm,
- $F_s$  = system noise figure in dB,
- C/N = carrier-to-noise dB ratio required to produce the acceptable system output.

This formula does not consider antenna gain, since sensitivity is conventionally defined at the

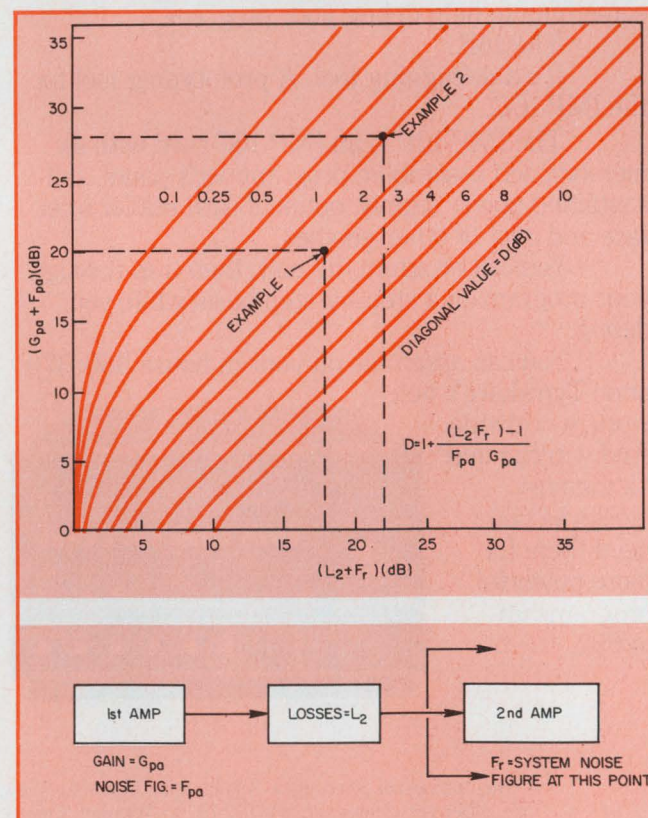
input to the receiver.

Each of the terms on the right side of this equation can be related to specific performance criteria required of the components of a receiver system. Let's look at each term.

## Every receiver has thermal noise

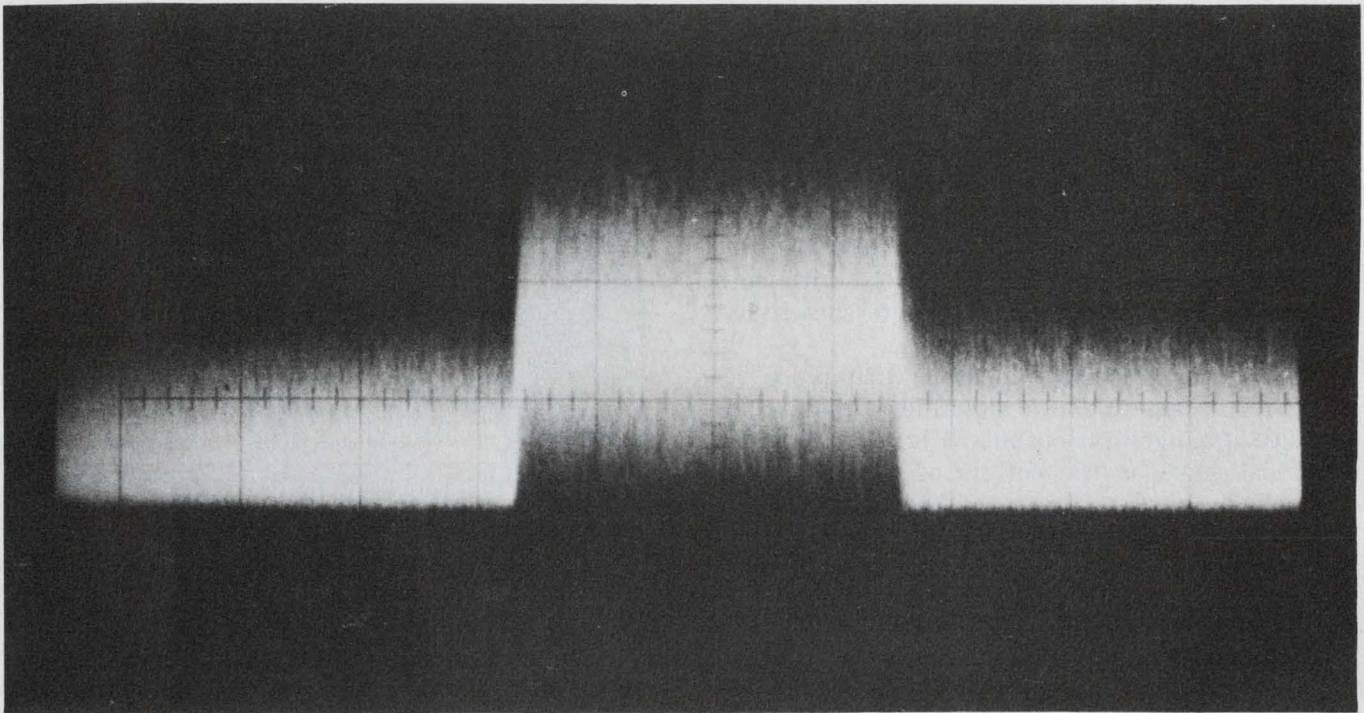
The term kTB represents the rms power level of thermal noise present in a receiver system. It is a function of both the noise bandwidth and the temperature of the system, if we neglect the effects of antenna background temperature. And the term is the same for all types of systems or modulation.

A widely used number for kTB, at room tem-



1. Degradation of noise figure of first amplifier by downstream circuitry can be calculated by equation for D, or determined from the chart.

David L. Adamy, Technical Staff Assistant, Applied Technology, Sunnyvale, Calif. 94086.



2. Scope display shows tangential output of pulse receiver, where hard noise at pulse bottom just touches

hard noise on baseline. When this happens, C/N is about 8 dB, depending on scope brightness.

perature, is “ -114 dBm per MHz” of bandwidth (B), which is more accurately expressed as:

$$kTB = -114 \text{ dBm} + 10 \log \left[ \frac{B}{1 \text{ MHz}} \right] \text{ dB.}$$

For example, in a system with 2-MHz bandwidth, the bandwidth factor is +3 dB; so  $kTB = -111 \text{ dBm}$ . Since  $kTB$  is important, it is worth a minute to calculate it for a 1-MHz receiver at room temperature:

$$kTB = \left[ 1.38 \times 10^{-23} \frac{\text{watt-sec}}{\text{°K}} \right] \left[ 290 \text{°K} \right] \left[ \frac{10^6}{\text{sec}} \right]$$

$$= 4.00 \times 10^{-15} \text{ W}$$

$$kTB \text{ (dBm)} = 10 \log_{10} \left[ \frac{kTB}{10^{-3} \text{ W}} \right]$$

$$= 10 \log_{10} \left[ 4.00 \times 10^{-12} \right] = -114 \text{ dBm,}$$

where

$k$  = Boltzman's constant =  $1.38 \times 10^{-23}$  (watt-sec)/°K,

$T$  = system operating temperature in degrees Kelvin

=  $290 \text{°K}$  at standard room temperature,

$B$  = system bandwidth (in Hz)

=  $10^6$  sec in a system with 1-MHz bandwidth. (In a system without post detection filtering, this is the bandwidth of the narrowest i-f filter.)

Note that  $kTB$  is relatively insensitive to changes in temperature; so the -114-dBm number is valid over a reasonable range of room temperature. In fact it takes a 75-C increase to

raise  $kTB$  by 1 dB.

The noise figure,  $F_s$ , is a measure of the amount of noise, above the basic thermal noise level, that a receiver system adds to incoming signals. It can be derived as follows:

$$F_s = L_1 + F_{pa} + D,$$

where

$F_s$  = system noise figure in dB,

$L_1$  = signal-strength losses in dB in circuitry ahead of the first amplifier in a system,

$F_{pa}$  = noise figure (in dB) of the first amplifier in the system (normally a preamp),

$D$  = a factor in dB accounting for degradation of the system noise figure by all circuitry downstream from the first amplifier.

This degradation factor ( $D$ ) can be easily determined from Fig. 1. To use this figure:

1. Add the gain and noise figure (in dB) of the first amplifier and find the sum on the ordinate.

2. Add the losses in dB between the first and second amplifiers to the system noise figure at the input terminals of the second amplifier and find the sum on the abscissa.

3. Find the intersection on the chart of the values found in steps 1 and 2. The diagonal-line value at this point is the  $D$  factor of the system noise-figure equation.

In a system with three or more predetection amplifiers, start from the back end and work forward to find the system noise figure looking into each amplifier. Normally the noise figure of the last predetection amplifier includes the ef-

fects of detectors or discriminators and all post-detection circuitry.

### C/N depends on receiver

The terms  $kTB$  and noise figure are common to most receivers and to all definitions of sensitivity. But the carrier-to-noise ratio required to produce an "acceptable" output varies widely with both the receiver type and the definition of sensitivity. Here are some examples:

Tangential sensitivity is used with pulse receivers. It's defined as the signal level required to produce a tangential output (Fig. 2), in which the hard noise on the bottom of the pulse just touches the hard noise on the base line. At this point the carrier-to-noise ratio is approximately 8 dB, but it can vary up to 1 dB, depending on scope brightness and pulse waveform.

Output signal-to-noise ratio is used with all types of receivers. The ratio is best determined by comparing the system output readings of a true rms voltmeter both with and without a signal.

In an AM system, the required carrier-to-noise ratio is equal to the specified output signal-to-noise ratio. However, in FM or digital systems this spec is more complicated. Some minimum carrier-to-noise ratio will be required for proper operation of the detector or discriminator, but a much higher output signal-to-noise ratio than this minimum C/N is obtained. The difference between the carrier-to-noise and the output signal-to-noise ratio is accounted for by improvement factors (see references).

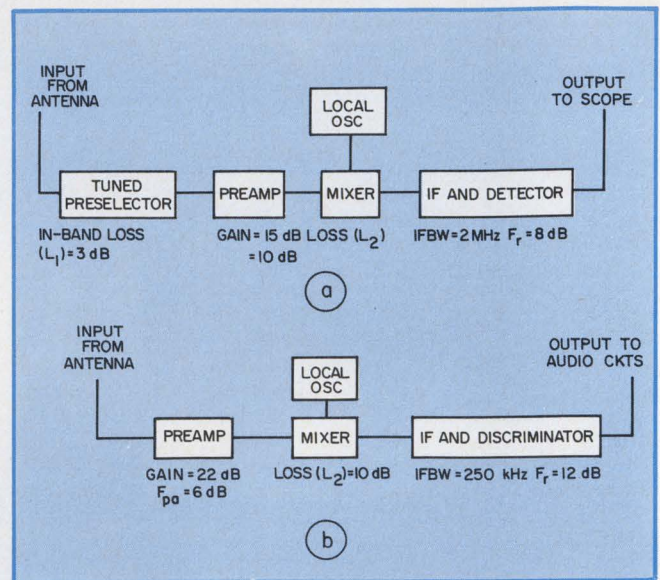
A special case of the signal-to-noise ratio spec is that for which the ratio is one (zero dB), or signal = noise.

Bit-error rate ( $= 10^{-y}$ ) is used with digital data receivers. It's defined as the signal level required to produce a digital output in which not more than one bit in  $10^y$  will be incorrect.

To convert a bit-error rate to a required carrier-to-noise ratio, you've got to know the type of rf modulation that is carrying the digital data and the type of threshold used. A graph of carrier-to-noise ratio vs bit-error rate is available for various types of modulation.<sup>1</sup> A useful generality is that bit-error rate varies about one order of magnitude for each decibel of signal-to-noise ratio over the normally specified range.

False-alarm rate ( $= 10^{-z}$ ), with probability of detection ( $= p$ ), is used in pulse systems that drive automatic processing circuitry.

At a given carrier-to-noise ratio, the level at which the detection threshold is set establishes the tradeoff between false-alarm rate and probability of detection. The relationship can be calculated. However, a graph showing the required carrier-to-noise ratio for each value of false-



3. How individual circuit blocks contribute to over-all sensitivity in a pulse receiver (a) and FM receiver (b).

alarm rate and probability of detection is also available.<sup>2</sup>

There are many more ways in which system sensitivity can be specified, but each can be expressed in terms of a required carrier-to-noise ratio, which is then used as the C/N term in the sensitivity formula.

As an example, consider a pulse receiver (Fig. 3) with an output that is monitored on a scope. To find the tangential sensitivity at room temperature, calculate:

$$1. \text{ kTB} = -114 \text{ dBm} + 10 \log \left[ \frac{2 \text{ MHz}}{1 \text{ MHz}} \right] \text{ dB} \\ = -114 \text{ dBm} + 3 \text{ dB} = -111 \text{ dBm}.$$

2. Noise figure,  $F_s$ :

$$L_1 = \text{preselector loss} = 3 \text{ dB}, \\ \text{Preamp noise figure} + \text{gain} = 5 \text{ dB} + 15 \text{ dB} = 20 \text{ dB}, \\ \text{Mixer loss} + \text{i-f noise figure} = 10 \text{ dB} + 8 \text{ dB} = 18 \text{ dB}.$$

From Fig. 1,  $D = 2 \text{ dB}$ .

$$\text{Therefore: } F_s = L_1 + F_{pa} + D \\ = 3 \text{ dB} + 5 \text{ dB} + 2 \text{ dB} = 10 \text{ dB}.$$

3. C/N = 8 dB (by definition of tangential sensitivity).

$$4. \text{ Sensitivity} = \text{kTB} + F_s + \text{C/N} = -111 \text{ dBm} + 10 \text{ dB} + 8 \text{ dB} = -93 \text{ dBm}.$$

Consider an FM receiver (Fig. 3). The received signal has a modulation index ( $\beta$ ) of 5 and a modulation bandwidth ( $f_m$ ) of 20 kHz. To find the sensitivity at room temperature for an output signal-to-noise ratio ( $S/N_o$ ) of 40 dB, proceed as follows:

$$1. \text{ kTB} = -114 \text{ dBm} + 10 \log \left[ \frac{250 \text{ kHz}}{1 \text{ MHz}} \right] \text{ dB} \\ = -114 \text{ dBm} - 6 \text{ dB} = -120 \text{ dBm}.$$

2. Noise figure,  $F_s$ :

$$L_1 = 0$$



Preamp noise figure + gain = 6 dB + 22 dB = 28 dB

Mixer loss + i-f noise figure = 10 dB + 12 dB = 22 dB

From Fig. 1, D = 1 dB

Therefore:  $F_s = L_1 + F_{pa} + D$   
 $= 0 + 6 \text{ dB} + 1 \text{ dB}$   
 $= 7 \text{ dB}.$

3. C/N: Since this is an FM receiver, the relationship between the carrier-to-noise ratio and the output signal-to-noise ratio is affected by a signal-to-noise improvement factor.<sup>3</sup> But C/N must be at least 10 dB for proper discriminator operation.

The expression for required carrier-to-noise ratio is

$C/N = S/N_o - S/N_{\text{improvement}}$  (all terms in dB)

where:  $S/N_{\text{improvement}} = 10 \log_{10} \left[ \frac{3}{2} \beta^2 \left( \frac{i\text{-fBW}}{f_m} \right) \right]$   
 $= 10 \log_{10} \left[ \frac{3}{2} (25) \left( \frac{250 \text{ kHz}}{20 \text{ kHz}} \right) \right]$   
 $= 10 \log_{10} 468 = 27 \text{ dB}$

So  $C/N = S/N_o - 27 \text{ dB}$   
 $= 40 \text{ dB} - 27 \text{ dB} = 13 \text{ dB}$

4. Sensitivity =  $kTB + F_s + C/N = -120 \text{ dBm} + 7 \text{ dB} + 13 \text{ dB} = -100 \text{ dBm}.$

#### How to increase sensitivity

Once a receiver's sensitivity has been calculated, a logical question is: If the system doesn't meet the specification, how can it be changed? If the D factor is significant—a decibel or more—more sensitivity can be obtained by increasing the preamp gain. However, more gain than required to reduce D to a small part of a decibel will only increase the cost of the system and decrease its dynamic range. The optimum gain can be easily found using Fig. 1.

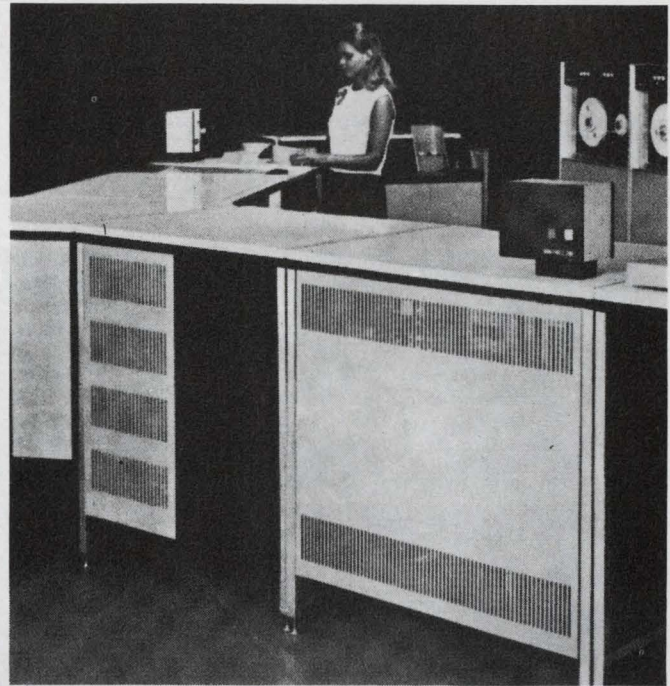
Other possible courses of action include: re-design of preselection filtering (if any), to reduce its loss, and specification of a lower-noise preamplifier, if practical.

The other factors affecting sensitivity—the losses after the preamplifier and the noise figures of downstream amplifiers—are less useful, since their effects on sensitivity are slight.

But if the D factor is low and the preselection cannot be relaxed, and if the components are the best available, then demand a change in the specification before a huge schedule slip and cost overrun occurs. ■■

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1. Schwartz, M., Bennett, W., and Stein, S., *Communication Systems and Techniques*, McGraw-Hill, New York, 1966, p. 299.
2. Skolnik, M., *Introduction to Radar Systems*, McGraw-Hill, New York, 1962, p. 32.
3. Panter, P., *Modulation Noise and Spectral Analysis*, McGraw-Hill, New York, 1965, p. 441.



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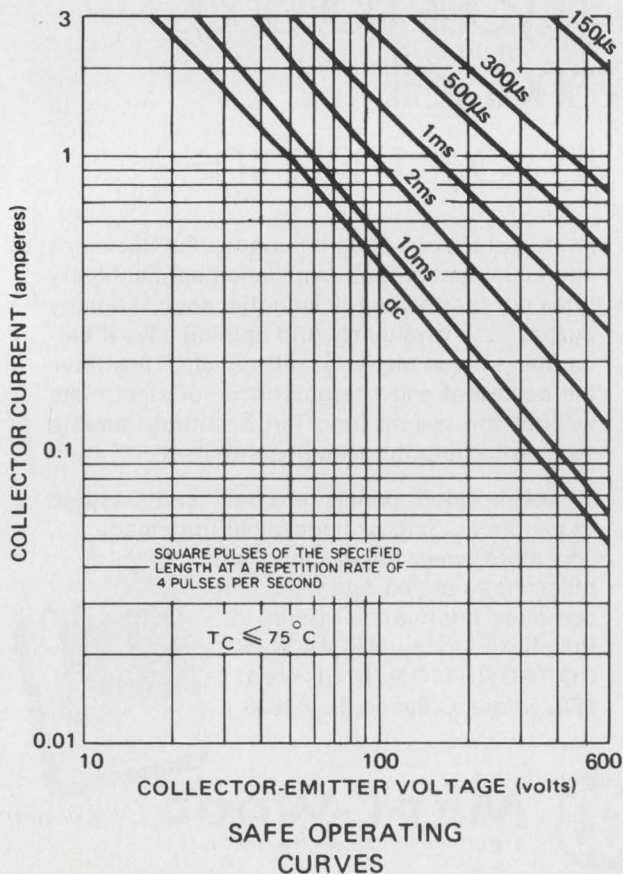
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# Single supply runs op-amp circuit if you use a four-resistor bridge. It allows full differential operation and avoids a second power bus.

If your op-amp circuit must work from a single power supply instead of the usual dual, consider a basic bridge circuit before you go to expensive techniques.

Just four resistors and a voltage source can bias the amplifier's common-mode voltage to lie near the optimum range—regardless of the input signal's dc level (Fig. 1). The bridge supply voltage makes no contribution to the output if the ratio of bridge arms is balanced. And temperature drift is minimal, since the output errors depend on the ratios of the resistances rather than their absolute value.

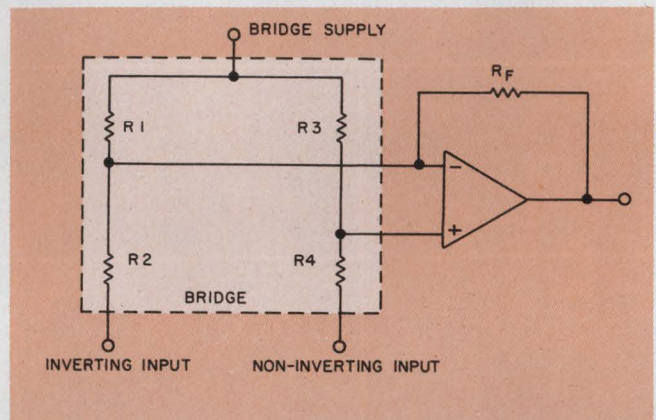
Four resistors form the bridge arms, although reactive bridge arms can also be used. The difference voltage at the bridge midpoints is also the error voltage that drives the operational amplifier (when it's in its linear region).

With an ideal amplifier, the error voltage is zero, and the two midpoints of the bridge are at equal potential with respect to ground. Each half-bridge is connected to the bridge supply at one end and to the signal input at the other. If both inputs are fed by signal sources, the bridge connection produces a differential output. With one leg grounded, the differential voltage across the bridge responds to the single-ended input.

To minimize offset effects, equalize the Thevenin equivalent resistance at both amplifier inputs. Closed-loop amplifier gains can be readily calculated. Use the effective source impedance at the amplifier's terminals—the signal source's original impedance plus the parallel combination of the related bridge elements.

## Account for internal voltage drops

The first step in the implementation of a bridge design is to determine the common-mode operating range of the operational amplifier. This range (as distinguished from the common-mode rejection ratio) is rarely listed in the amplifier's data sheet. However, most integrated-



1. Four-resistor bridge gives differential op-amp operation on a single supply. The bridge biases the common-mode voltage into the linear range of the amplifier. The bridge supply can often be the positive supply voltage.

circuit data sheets show an equivalent schematic. Usually a glance at the schematic diagrams will show the limits of common-mode operation.

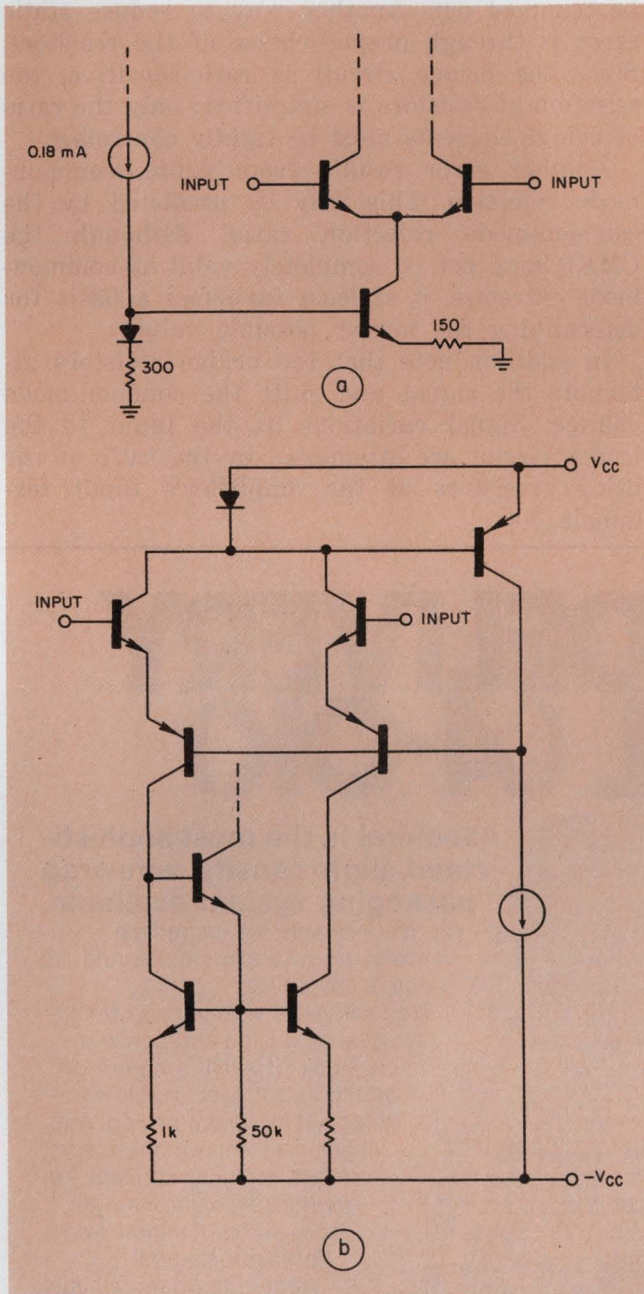
The differential-amplifier portion (simplified) of the 723 power-supply regulator is a good example (Fig. 2a). The input stage consists of a differential pair fed by a current-mirror source. With an allowance of 0.9 V per junction (to account for low-temperature, saturated-junction drops), the lowest common-mode operating voltage is 1.8 V from the negative supply bus. This value is consistent with those given in applications literature—2 V above the negative supply voltage.

A similar analysis of the 741 operational amplifier (Fig. 2b) shows at least three base-emitter junctions and one collector-emitter drop between either input and the negative supply bus. And there is at least one base-emitter and one collector-emitter drop between either input and the positive supply bus. Accordingly the expected common-mode range lies between 3.6 V above the negative supply bus and the positive supply bus (because the voltage drops cancel).

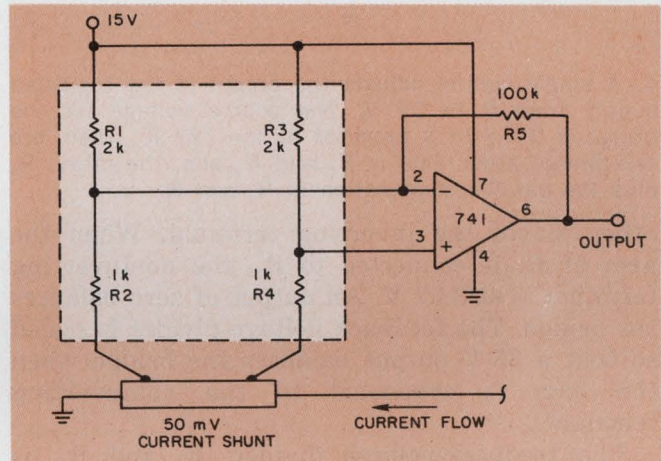
## Two examples show circuit's versatility

Two circuits illustrate the usefulness of the bridge connection. The first—a current-sensing

Steven E. Summer, Director of Product Development, Aerospace Avionics, Inc., 110 Wilbur Pl., Bohemia, N.Y. 11716.



2. **Operating limits** of the common-mode voltage are determined from simplified schematics of the input circuits. The minimum value for the 723 regulator (a) is two junction drops above the negative bus—about 1.8 V. The 741 op amp (b) has two base-emitter drops and one collector-emitter drop to the negative bus—about 3.6 V for each input signal.

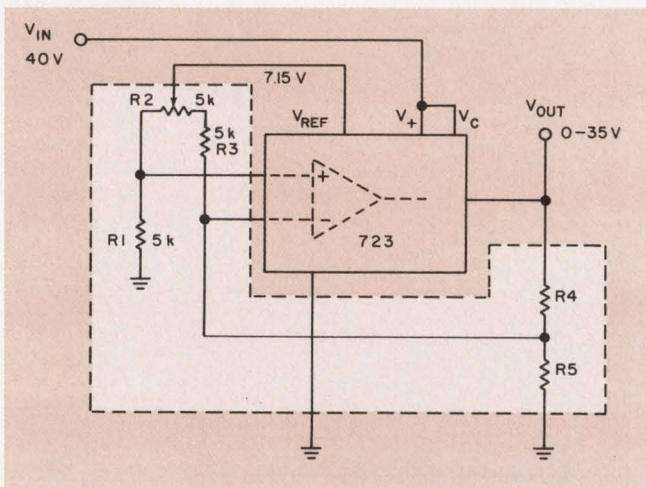


3. **Bridge connection** permits amplification of current-shunt output and doesn't require that one side of the shunt be at ground potential. The components shown provide a common-mode bias of 5 V and a gain of 100.

circuit—amplifies the voltage across a 50-mV shunt to a 5-V level (Fig. 3). The current shunt is connected near ground potential, yet only a single 15-V supply is needed. The four-wire (Kelvin) connection to the shunt is needed for maximum measurement accuracy.

Since a 741 op amp is used, a common-mode voltage of 5 V is selected by the ratios of  $R_1$  to  $R_2$  and  $R_3$  to  $R_4$ . Feedback resistor  $R_5$  is chosen to produce a gain of 100, and this takes into account the attenuation that results from the bridge dividers. A four-terminal connection to the shunt is made by connection of the end of each half-bridge to the voltage terminals of the shunt. The amplifier output is linearly proportional to the current through the shunt, except at low-output voltages, where the output stage saturates. Such a circuit is very useful in power supplies where it is uneconomical to generate negative-bias voltages.

The second circuit uses a 723 regulator IC connected in a bridge arrangement (Fig. 4). The circuit can provide output voltages from zero to 35 V with a single adjustment. The 7.15-V reference voltage drives the arm of potentiometer  $R_2$ ; the current divides into two paths. One path drives the noninverting terminal, while the



4. A single control adjusts the output of the regulated supply from 0 to 35 V. The source voltage for the bridge is the 7.15 V provided by the 723 IC. There are two bridge arms: One is  $R_1$  and  $R_2$  and, the other,  $R_3$  plus the parallel combination of  $R_4$  and  $R_5$ .

other drives the inverting terminal. When the arm of  $R_2$  is connected to  $R_3$ , the noninverting terminal is at 3.57 V. An output of zero balances the bridge. The feedback voltage-divider is scaled so that a 35-V output balances the bridge when the arm is connected to the noninverting terminal.

The feedback-voltage divider,  $R_4$  and  $R_5$ , is chosen to have the same Thevenin equivalent resistance as  $R_1$ . If the ratio of  $R_4$  to  $R_5$  is changed,

the maximum output voltage changes accordingly;  $R_2$  and  $R_3$  should have the same value, but they can be larger or smaller than  $R_1$ , so long as the minimum common-mode voltage does not go below 2 V.

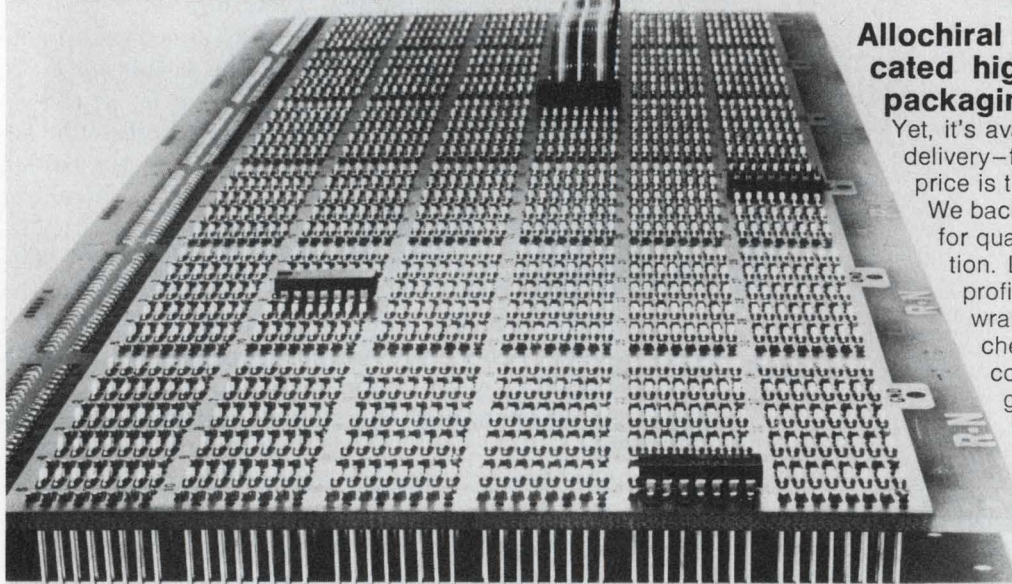
#### Beware the pitfalls

There are precautions that the designer must take, however. An obvious error source is introduced by the bridge resistors because of initial tolerances, long and short-term drifts and temperature drifts. The resulting static error may be trimmed out. Another way to reduce static error is through proper choice of the resistors. Since the bridge circuit is ratio-sensitive, the selection of resistors is simplified; only the ratio of bridge elements must be tightly controlled.

Another error results from finite, common-mode rejection. This may be predicted by the common-mode rejection ratio. Although the CMRR may not be completely valid at common-mode extremes, it at least furnishes a basis for determining the lowest possible value.

In addition note that the bridge resistors attenuate the signal and shift the common-mode voltage. Signal variations at the input to the bridge circuit are attenuated by the ratio of the bridge resistors at the amplifier's input terminals. ■■

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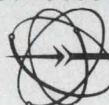


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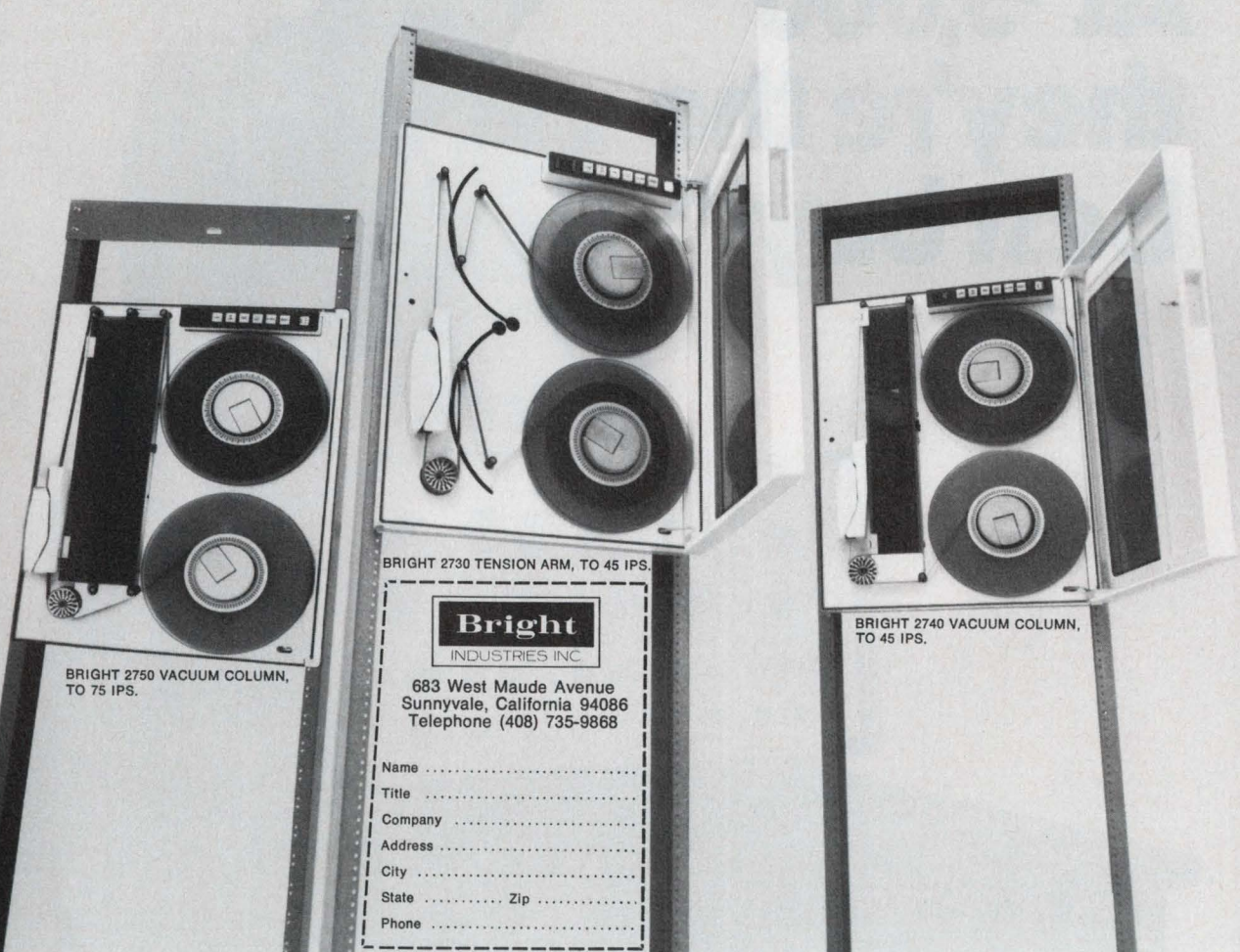
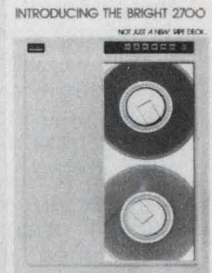
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INFORMATION RETRIEVAL NUMBER 42

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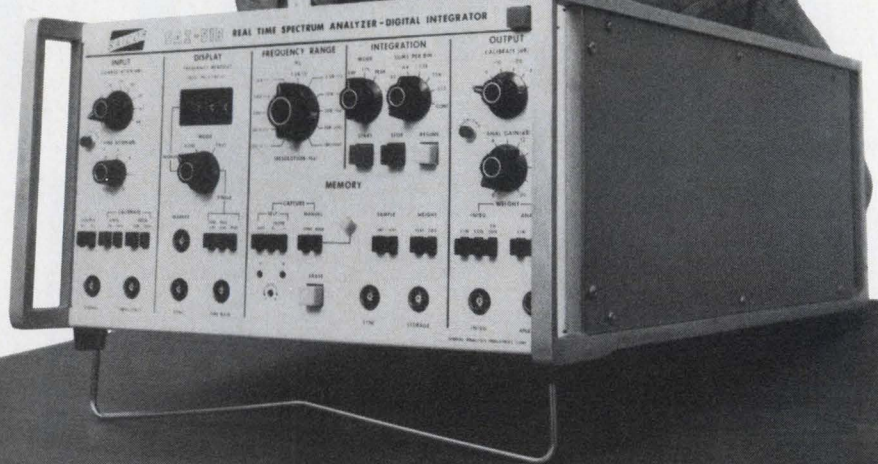
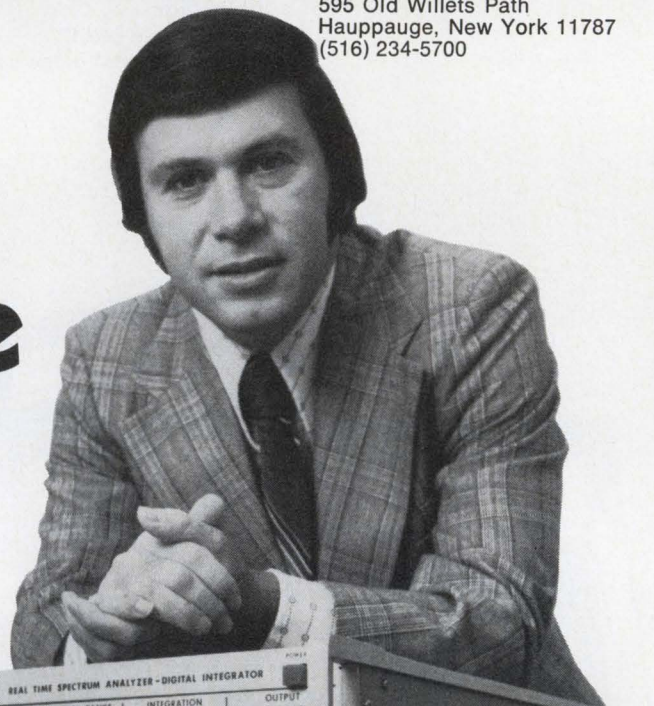
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# Stop stumbling over internal reports!

Here's a manager's guide to help you to organize your ideas and get them read by top management.

When Oliver Cromwell said "He who ceases to be better, ceases to be good," he could have been talking about some of the engineers who write internal reports. Many are less than good report writers because they would rather look in the files "to see how the report was done the last time" than take the time to improve their own.

Part of the problem is that engineers think that writing trip reports, progress reports and technical reports for customers, among others, should be accomplished at one sitting. My advice is to divide the effort into three tasks: organizing and outlining, writing, and then editing.

## Constructing the cornerstone

Before outlining your report, determine your objective, analyze your audience and choose the best approach. After discussing these points with your supervisor, agree on a sentence that summarizes the report. For example: "The purchase of a 999 computer will permit combination of our numerous semiautomated data-handling systems into an integrated, fully automated system that will supply more complete data, usable by all departments, and save approximately \$35,000 a year in reduced manpower and equipment rentals."

Quite a mouthful, I agree, but this thesis sentence should never find its way into the report. It serves as a cornerstone for the organization and outline of the report.

If you're subject to a rigid report-writing format at your company, guard against following it blindly, because the chances are it will deprive you of the opportunity that an outline provides to "think through" your material. Often you may want to plunge ahead without any outline, but that can be just as disastrous. A good outline will do the following:

- Supply a solid foundation.
- Ensure direction.
- Provide a checklist of important items.

- Help maintain proper emphasis.
- Ensure that your report doesn't become a runaway.

If you have trouble writing an outline, it may be because you're trying to write it in sequence right off the bat. A better method is to draw up a random list of items to be included, without worrying about which should come first or second. If you put the items on index cards, you can easily shuffle them into the proper order as you segregate, coordinate and subordinate your topics.

As you sort the items, you'll find that it's easy to put them in chronological order. There's a danger here that, in general, is best avoided. That kind of sequencing turns your report into a history. While this arrangement may be easy on you, it's tough on the reader, who's probably not as interested in the sequence of events as he is in what has the biggest impact on the program.

To best organize the report, put the most important item first (the cornerstone thesis), then add more and more mutually supporting information. Weave it all into an interesting and readable report. Newspapers use this format, and it's a great convenience for busy readers—like engineering managers—who may not have the time to turn to page 4, column 5, for the continuation.

An important thing to remember in organizing your report is that outlines are best made in clay, not bronze. Outlines are a working tool, subject to change like the prototype model before the production run. It's a lot easier to spot errors in organization and make changes here than it will be after the draft copy is typed.

## Take the worry out of writing

In a survey I once conducted, I asked 1000 engineers, scientists, and technicians to identify their biggest single problem in writing technical reports. Many responded, "How do I start writing?"

One way to stimulate the writing flow is to use the synoptic outline. This is a topical outline, but carried one step further. It not only lists the topics; it also provides a synopsis (key words,

---

**Terry C. Smith**, Manager of Communications, Westinghouse Electric Corp., Baltimore, Md. 21203.

## Terry C. Smith



**Education:** BS in aeronautics, St. Louis University.

**Experience:** Served as a senior engineering writer, fellow engineer, and manager of marketing communications; directed engineering and marketing personnel on various communications projects. He has written three books, including *How to Write Better and Faster*.

**Awards:** Outstanding Technical Article of the year (1972).

**Activities:** Presented in-plant seminars on technical communications for 24 corporations and government agencies.

**Employer:** The Westinghouse Defense and Electronic Systems Center (DESC) in Baltimore, Md., develops and produces aerospace, surface, and undersea ordnance systems for military, space and domestic government agency applications. The corporate investment in the Defense and Electronic Systems Center consists of land and buildings worth \$24.9 million and machinery and equipment valued at \$28.6 million. The Center employs approximately 10,000 persons.

phrases, etc.) of what you plan to say about each topic. The synoptic outline provides a good bridge between the topical outline and the first draft.

Discussing what you're planning to write with a friend often helps start the words flowing, too. Later write it as though you were telling it to yet another person. Don't feel you have to start writing your report at the beginning. Start anywhere you feel most comfortable; you can always rearrange the pieces. Many authorities suggest writing the beginning last.

Once the flow starts, be careful not to turn it off. The writer who pauses after each sentence or paragraph to inspect his writing for ways to improve it is taking a serious risk of cutting off his output. The time for inspection and polishing is during the editing process.

Don't confuse the introduction with the summary. Just as the name implies, the introduction introduces the reader to the subject. It brings him up to speed for the technical discussion that will follow. The way to write a good introduction is to ask, "What did I need to know when I came on board this project?" Or, "What would a new man need to know?"

And remember that the audience is the writer's most important consideration.

Different parts of a report have different readers. Everyone reads the summary, and top management often reads only that. So if you have a message for top management, make sure it's in the summary, and make it as straightforward as possible; the details can go in the technical discussion or appendices. Also, stress the business and financial impact along with the technical and production information. And make sure your summary has a message. Don't write it like a table of contents, telling the reader what he will find elsewhere.

### Getting rid of gobbledegook

"Editing" is a distinct process, not a part of "writing." Compare editing to reviewing an exam after the latter has been completed. It's a good way to raise your grade from a B to an A.

How can you get the most out of the time you



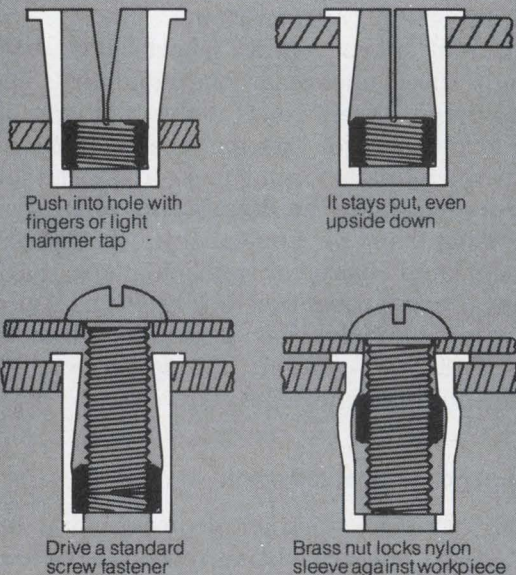
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INFORMATION RETRIEVAL NUMBER 45

## Technologists polled on writing problems

Terry Smith, the management interviewee, recently asked 1033 engineers, scientists and technicians representing 200 companies from 36 states, to list their most difficult writing problem. The response was as follows:

Problem	Percentage of respondents	Number of respondents
outlining and organizing	28%	293
lack of conciseness	19%	194
interpersonal difficulties	9%	94
writing	8%	83
lack of time	7.5%	77
audience	6.5%	67
grammar	6%	57
insufficient clarity	5%	52
poor continuity	4%	45
emphasis	3%	26
editing	2%	25
technical accuracy	1%	9
miscellaneous	1%	11

spend editing? First, put the material aside for a few days before starting, if you can. Also, have a draft copy typed. Both of these steps are aimed at encouraging editing by making the material less personal—less “yours.”

Secondly, “read” the material with your ear—how will it sound to the reader. Don’t make the mistake some people do of poking through the text, looking at each individual word and asking: “Should I change this?” Instead proceed as you would driving on an expressway, moving at a brisk pace but ready to slow when you see a danger signal. Two danger signals that appear often are: unnecessary material and lack of continuity.

Editing provides an excellent opportunity to eliminate any gobbledygook that might have sneaked in during the heat of writing. And it lets you rub out all those tangents or detailed derivations you originally thought were interesting, even though they had no direct impact on your theme.

A good vocabulary can increase clarity, but it shouldn’t encourage you to write words like “deleterious” instead of “harmful.” Another thing: Write in specific terms. Don’t say “electrical equipment” when what you really mean is “conduit.”

If you do it right, you’ll soon become one of the best-read authors in the company. ■■

# Finally:

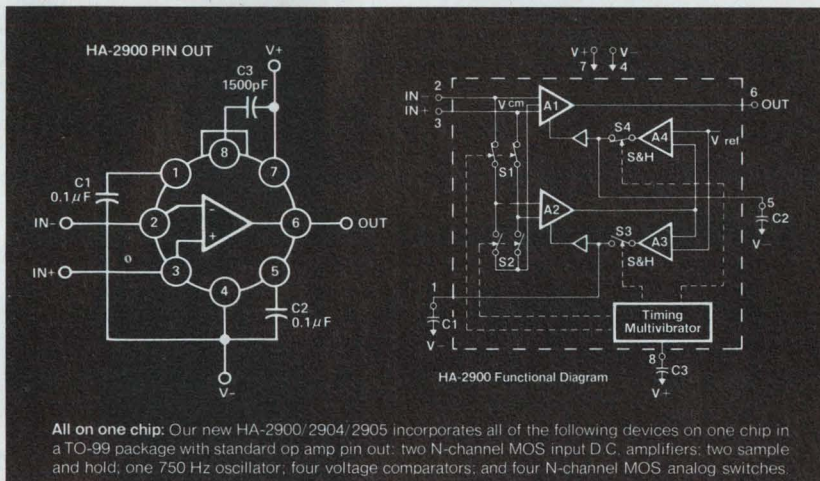
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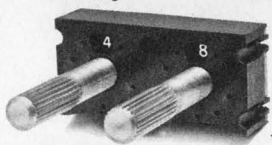
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INFORMATION RETRIEVAL NUMBER 46

# INTRODUCING THE TWO-FACED SWITCH

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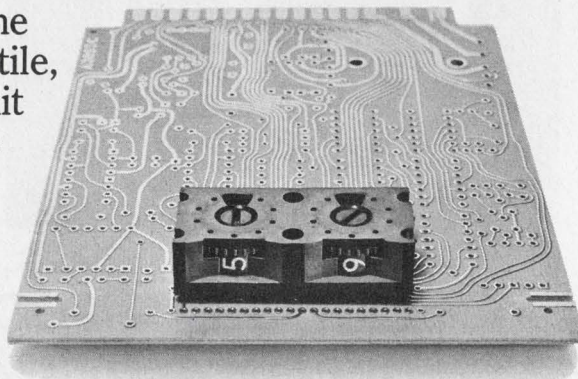
it either horizontally or vertically.

And you can wave-solder it directly to the printed circuit board.

## Saves you money

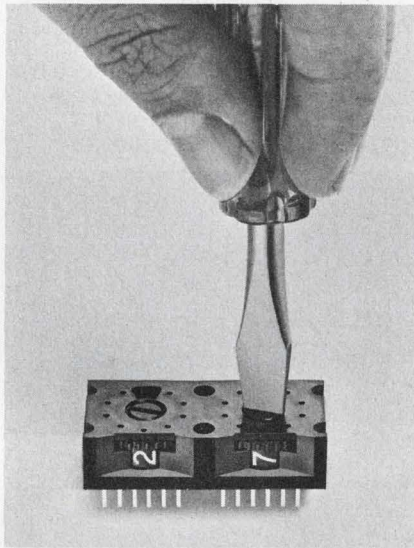
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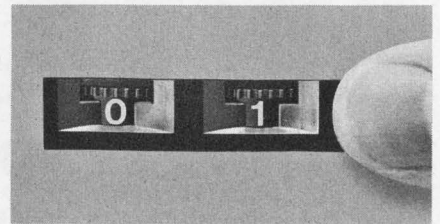


knurled wheels. Or, if you mount it behind a panel, you can actuate Stripswitch by means of a screwdriver or shaft

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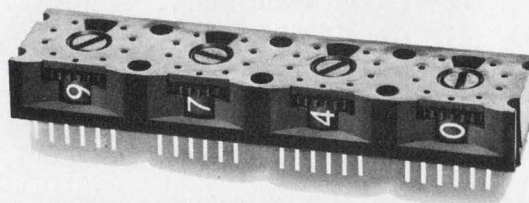
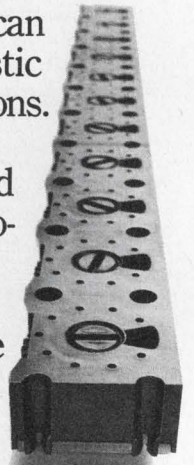
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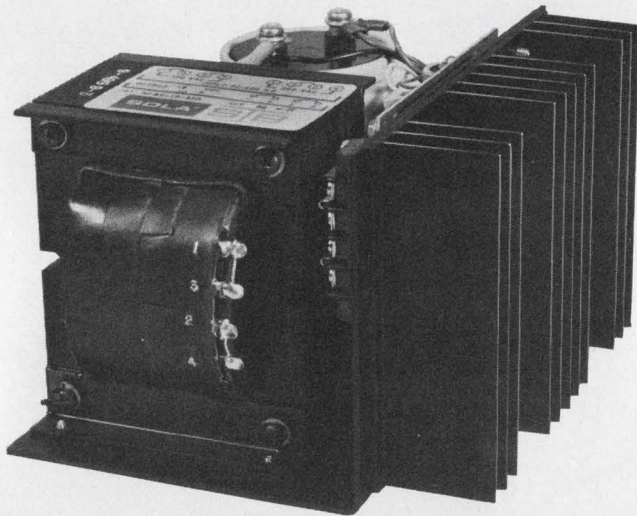
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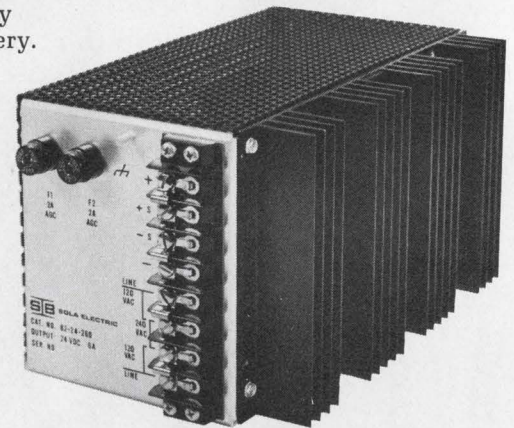
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INFORMATION RETRIEVAL NUMBER 49





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	Capacitance (mfd)	Max. ESR 120 Hz (Ohms)	Max. Ripple Current @ 120 Hz (rms amps)			Capacitance (mfd)	Max. ESR 120 Hz (Ohms)	Max. Ripple Current @ 120 Hz (rms amps)			Capacitance (mfd)	Max. ESR 120 Hz (Ohms)	Max. Ripple Current @ 120 Hz (rms amps)					
			65°C	85°C	105°C			65°C	85°C	105°C			65°C	85°C	105°C			
10	20,000	.0146	22.5	17.0	6.5	45,000	.0084	31.5	22.5	8.5	170,000	.0077	45.0	31.0	10.0			
15	14,000	.0147	22.0	16.5	6.5	32,000	.0087	31.0	22.0	8.5	110,000	.0079	45.0	30.5	10.0			
25	9,000	.0154	21.5	15.5	6.0	19,000	.0091	30.5	21.5	8.0	73,000	.0080	44.0	30.0	9.5			
50	4,400	.0168	19.5	13.5	5.0	9,800	.0101	29.0	20.0	7.0	36,000	.0087	42.0	29.0	9.0			

INFORMATION RETRIEVAL NUMBER 50

## Optical isolation of data bus simplifies logic design and eliminates noise

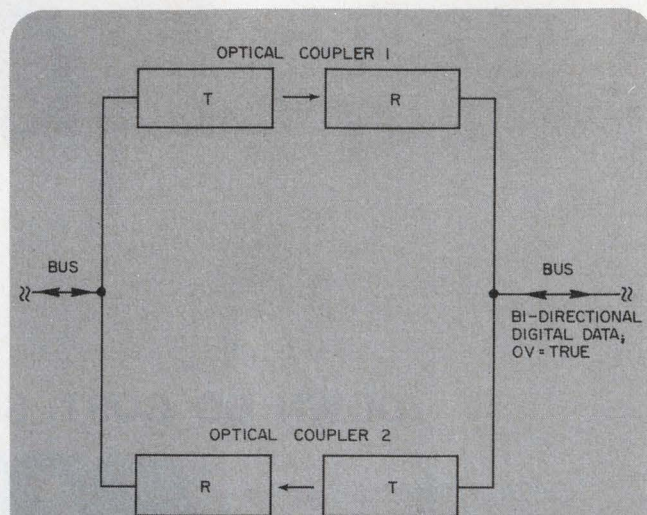
Ambient noise on two-way data busses often necessitates the use of optical coupling—which is unidirectional. A simple back-to-back arrangement is not enough—a positive feedback loop is created, which causes latch-up when a bit (data line pulled to ground) is present on either data line (Fig. 1).

You can solve the problem by inhibiting an identical response from the other optical coupler while transmitting data through the first one (Fig. 2). If either data line goes low, the signal received at the opposite end inhibits the second coupler by also being inputted to the NOR gate.

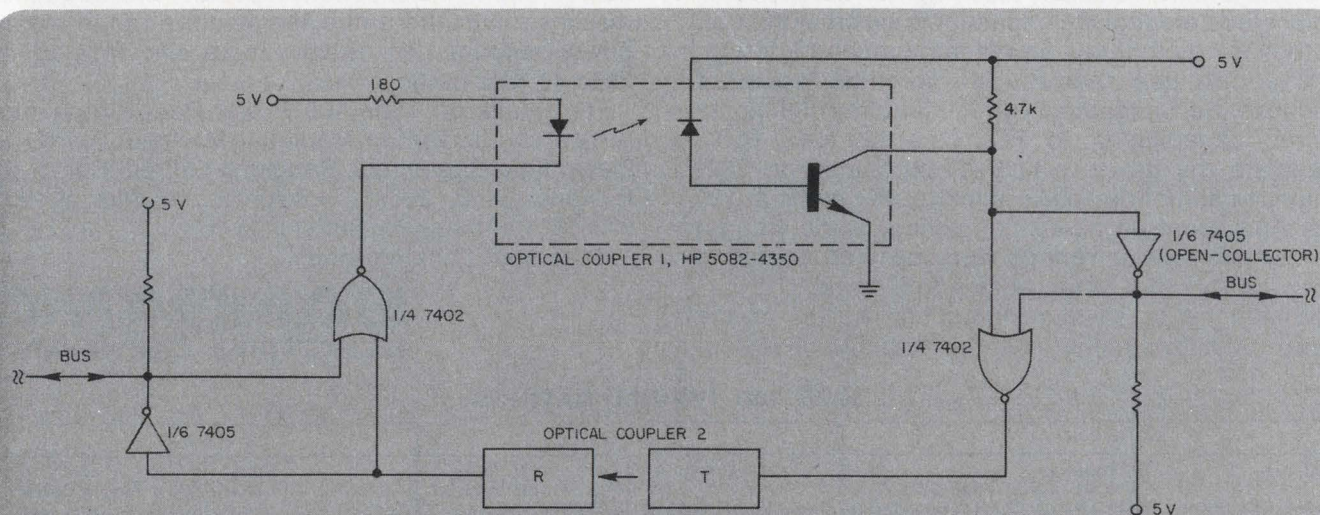
In the circuit shown, open-collector devices are used as line drivers, with a pull to ground representing the presence of a bit. Representative device numbers are given; however, other forms of logic can be used.

*Terry A. Jackson, Design Engineer, Automation Constructors, 2410 Westline Dr., Joliet, Ill. 60435.*

CIRCLE No. 311



1. **Improper optical coupling** for bi-directional data. Once the sending device releases the right-hand line, it remains low because of positive feedback through coupler 1.

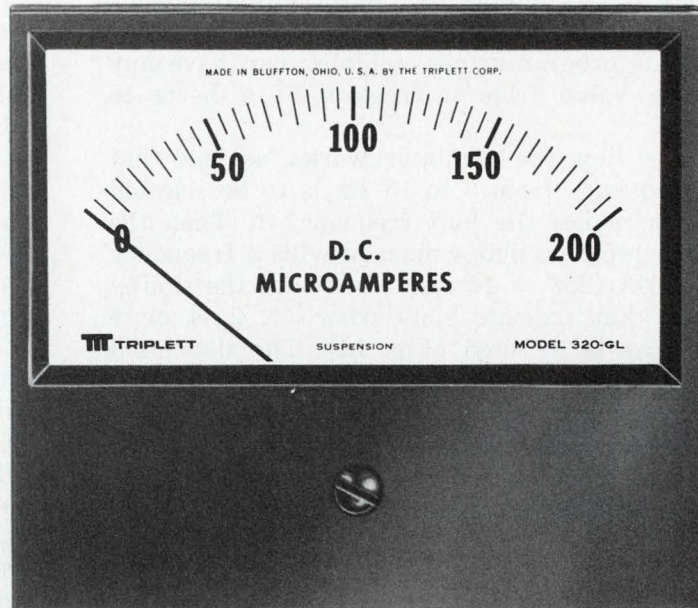


2. **Bi-directional optical coupling** without feedback is achieved when the received signal is inputted

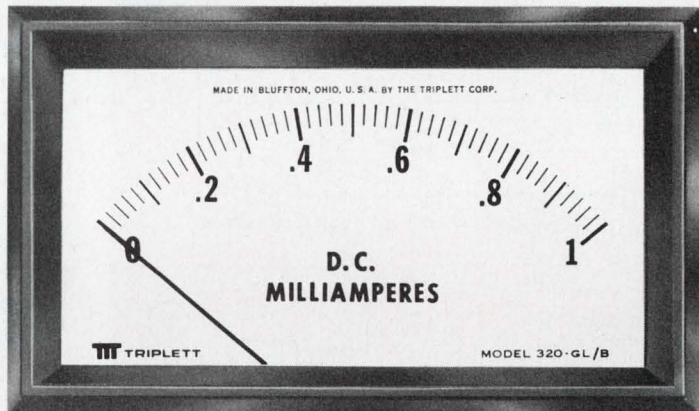
through a NOR gate to inhibit retransmission. Open-collector devices are used as line drivers.

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INFORMATION RETRIEVAL NUMBER 51

# Digitally programmable oscillator selects frequency in integer units from one to 15

Four binary inputs can select any frequency from zero to 15 units. The unit of frequency with this programmable oscillator can have any absolute value from a fraction of a hertz to 19 kHz.

To see how the oscillator works, assume that any frequency from 0 to 15 Hz is to be selected—which makes the unit frequency 1. Then the basic or input oscillator must provide a frequency of 256 Hz ( $256 = 16^4$ ). IC<sub>1</sub> provides the timing signals that indicate slots where 1, 2, 4 or 8 pulses can be selected (Fig. 1a). The slots used will depend upon which frequency-select bits are set. Four flip-flops divide the basic oscillator frequency by 2, 4, 8 and 16. Inverters A<sub>1</sub> through A<sub>3</sub> shape the oscillator pulses to eliminate spikes in the decoding circuits.

At clock pulse 0, circuit B clocks the frequency-select bits into the storage cells of IC<sub>2</sub> Fig. 1b. The outputs of IC<sub>2</sub>—W, X, Y and Z—correspond to bits 1, 2, 4 and 8, respectively.

Circuit H will receive a number of pulses equal to the binary-number representation at the input. Operation is as follows: During clock pulse 1 and with bit 1 selected, circuit C sends one pulse. With clock pulses 2 and 3, circuit E sends two pulses if it's enabled by bit 2. Circuit F sends four pulses—during clock pulses 4 through 7—if it's enabled by bit 4; and lastly, circuit G sends eight pulses—during clock pulses eight through 15—if bit eight is set.

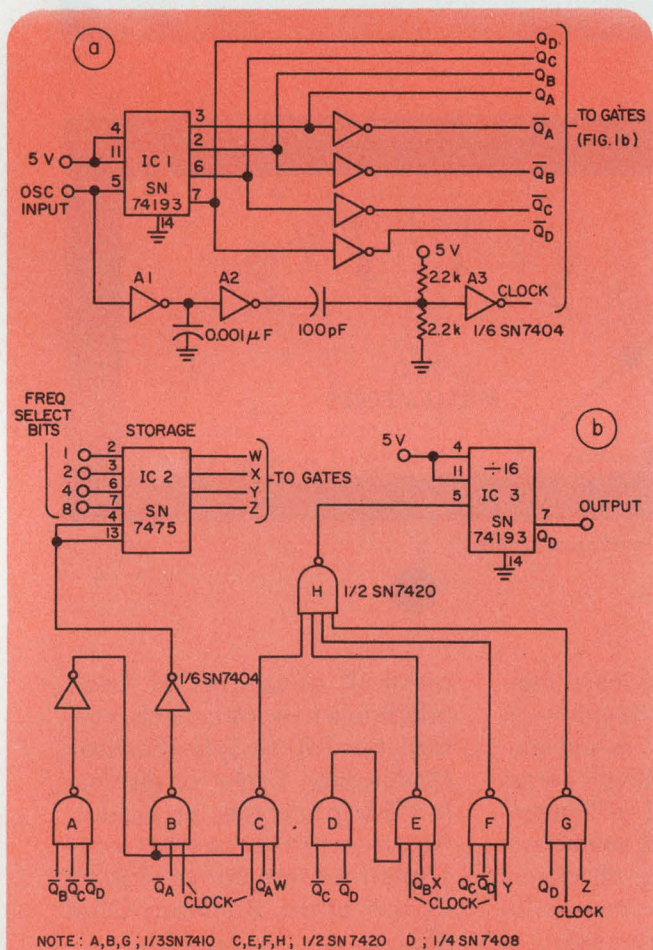
Circuit H—in turn—passes the pulses received to IC<sub>3</sub> where a division by 16 occurs to generate the output. If, for example, bits 1 and eight are set, every 16 pulses of the oscillator will pass nine pulses to circuit H—one pulse from C and eight from G. This amounts to  $9 \times 16 = 144$  pulses for every  $256 = 16 \times 16$  pulses from the oscillator. Since IC<sub>3</sub> divides the input by 16, nine pulses are outputted.

The input oscillator should have a frequency equal to 256 times the unit frequency. And the circuit output will have equal spacing between pulses at any selected frequency.

The circuit can be expanded to select any frequency so long as the input-oscillator frequency does not exceed 5 MHz.

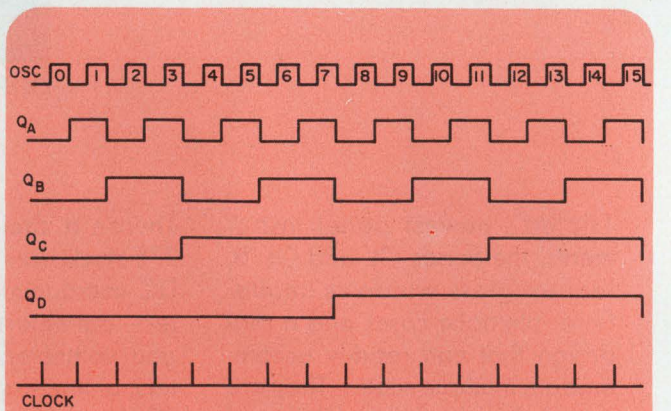
John Shakib, Design Engineer, IBM General Systems Div., 2000 51st St., Boca Raton, Fla. 33432.

CIRCLE NO. 312



NOTE: A, B, G; 1/3SN7410 C, E, F, H; 1/2 SN7420 D; 1/4 SN7408

1. Circuit provides binary programmable output frequencies. Gates generated by divider chain in IC<sub>1</sub> (a) allocate clock pulses equal to the binary number on the select lines (b). The basic cycle repeats every 16 oscillator pulses; hence the use of division by 16 in IC<sub>3</sub>.



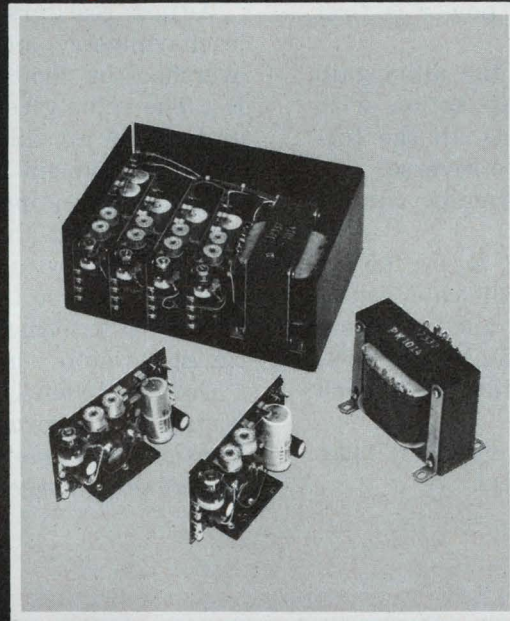
2. Gate outputs Q<sub>A</sub> through Q<sub>D</sub> define the duration for passing clock pulses to the counter. The time slot of Q<sub>A</sub> allocates one pulse, Q<sub>B</sub> two pulses, Q<sub>C</sub> four pulses and Q<sub>D</sub> eight pulses. These numbers correspond to the binary weights of the input lines.

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22AA	.40A	.35A	.25A	.20A	.23A	.20A	.19A	.18A	.17A	.16A	\$ 15	\$ 10
22A	1.0A	.875A	.725A	.625A	.575A	.500A	.475A	.450A	.425A	.400A	23	15
22B	3.0A	2.5A	2.2A	1.9A	1.7A	1.5A	1.4A	1.3A	1.2A	1.1A	30	20
22C	6.0A	5.2A	4.4A	3.8A	3.4A	3.0A	2.8A	2.6A	2.5A	2.3A	45	30
22D	12.0A	10.4A	8.8A	7.6A	6.8A	6.0A	5.6A	5.2A	5.0A	4.7A	60	40
22E	18.0A	15.6A	13.2A	11.4A	10.2A	9.0A	8.4A	7.8A	7.5A	7.1A	75	50
22F	24.0A	21A	17.25A	15A	13.7A	12.2A	11.2A	10.7A	10.0A	9.4A	105	70
22G	36.0A	31.5A	26.0A	22.5A	20.6A	18.2A	16.8A	16.0A	15.0A	14.1A	145	95
22H	50.0A	43.8A	35.9A	31.3A	28.5A	25.3A	23.3A	22.3A	20.8A	19.6A	190	125
22J	75.0A	65.6A	53.9A	46.9A	42.8A	38.0A	35.0A	33.4A	31.3A	29.5A	265	175

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# Bi-directional interval timer includes snap-action trip points

A pocket-sized, elapsed-time indicator can display up to 20 min. in two directions. Meter movement is pegged safely at the end of the interval by a regenerative limit switch.

FETs  $Q_1$ ,  $C_1$  and  $C_2$  provide the main timing mechanism. FET  $Q_1$  provides adjustable constant current, which can be varied by potentiometer  $R$  to charge  $C_1$  and  $C_2$ . Two microswitches— $S_1$  and  $S_2$ —commute the current to provide needle movement in two directions. Series connection of  $C_1$  and  $C_2$  helps to zero the meter.  $V_c$  assumes a value of approximately zero when power is first applied.

Transistors  $Q_2$  and  $Q_3$  comprise the unity-gain buffer that drives the meter. Snap action with hysteresis is provided by  $Q_4$  and  $Q_5$  in the forward direction and  $Q_6$  and  $Q_7$  in the reverse.

Transistors  $Q_4$  and  $Q_5$  are normally cut off when

$$V_m = V_s \cdot (R_6 + R_m) / (R_5 + R_6 + R_m) < 0.5V.$$

When  $V_m$  exceeds 0.5 V (near full-scale deflection), regenerative action occurs and increases  $V_{BE(Q4)}$  by about 25% to give a safe, but definite, meter overshoot. The -0.5-V limit is handled in similar fashion by  $Q_6$  and  $Q_7$ .

The buffer section,  $Q_3$  and  $Q_4$ , operates near unity gain because the drain current

$$I_{D(Q2)} \approx \frac{V_{BE(Q3)}}{R_3}$$

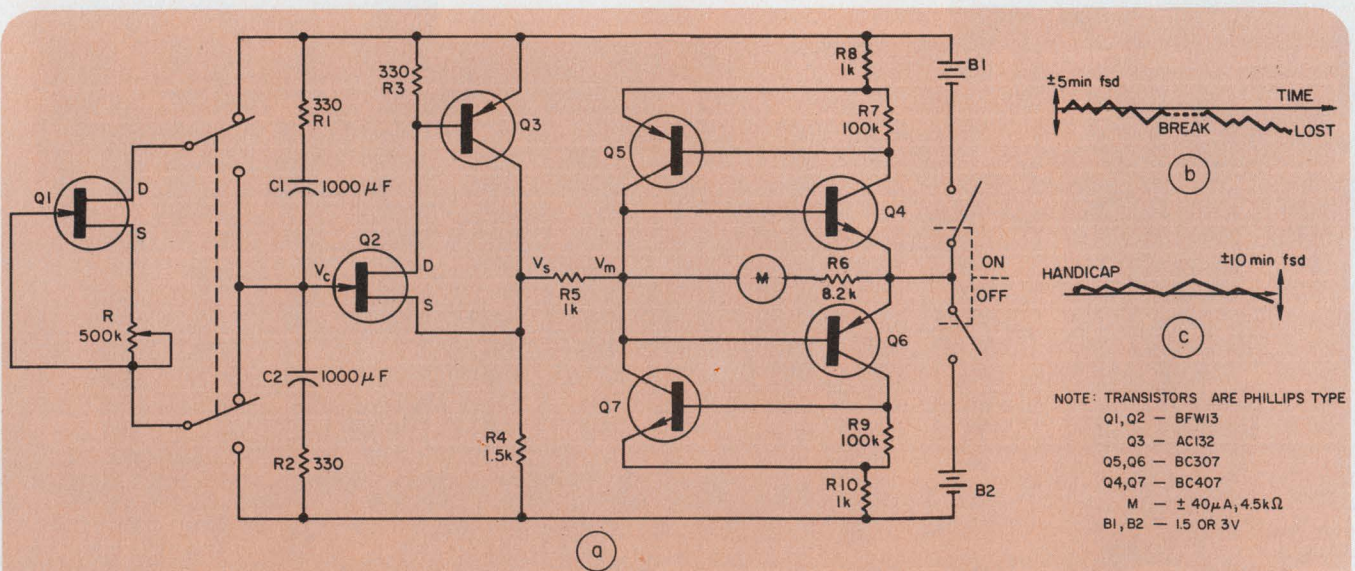
is practically constant. To keep the offset voltage ( $V_s - V_c$ ) low—say, 0.1 V—select  $Q_2$  to have a pinch-off voltage of about 0.5 V.

Select a germanium transistor for  $Q_3$  if 1.5-V batteries are used. A low value of  $V_{BE(Q3)}$ —about 0.1 V—is required because of the 0.55-V signal swing and the minimum requirement of  $V_{DS(Q2)}$ . Use of 3-V batteries gives wider latitude in selection of  $Q_2$  and  $Q_3$ .

Adjust resistors  $R_7$  and  $R_9$  for desired trip-level symmetry, and adjust the percentage meter-overshoot by choice of the values of both  $R_8$  and  $R_{10}$ . The value given for  $R_4$  accommodates meters up to  $\pm 250 \mu A$  full scale.

The instrument is convenient to use as a chess clock, if it's equipped with a cantilever arrangement of two pushbuttons. The user sets a desired time interval with  $R$  (b, c), and the players alternately reverse the needle movement after each move. An intermediate switch position permits timing to stop when a break is desired.

*Geert J. Naaijer, Research and Development Engineer, Laboratoires, d'Electronique et de Physique Appliquée, 3 avenue Descartes, Limeil-Brévannes, France 94450.* CIRCLE NO. 313



Elapsed time up to 20 min in either direction are shown visually by meter movement  $M$ . The circuit (a) includes a snap-action out-of-limit cir-

cuit ( $Q_4$  to  $Q_7$ ) to eliminate meter damage. The circuit can be used in differential timing applications (b, c) as between two chess opponents.



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# Diode bridge and current source provide current limiting for bipolar supplies

An open-loop system consisting of a four-diode bridge and a unipolar current source provides rapid current limiting for bipolar power supplies.

The circuit (Fig. 1a) limits the output current to the generator value,  $I_C$ . If the load resistance becomes abnormally low or shorted, diodes  $CR_1$  and  $CR_4$  cut off and  $I_L$  equals  $I_C$ . Current flows out of the positive terminal of the supply through  $CR_3$ , the generator,  $CR_2$ ,  $R_L$  and back to the negative supply of the terminal.

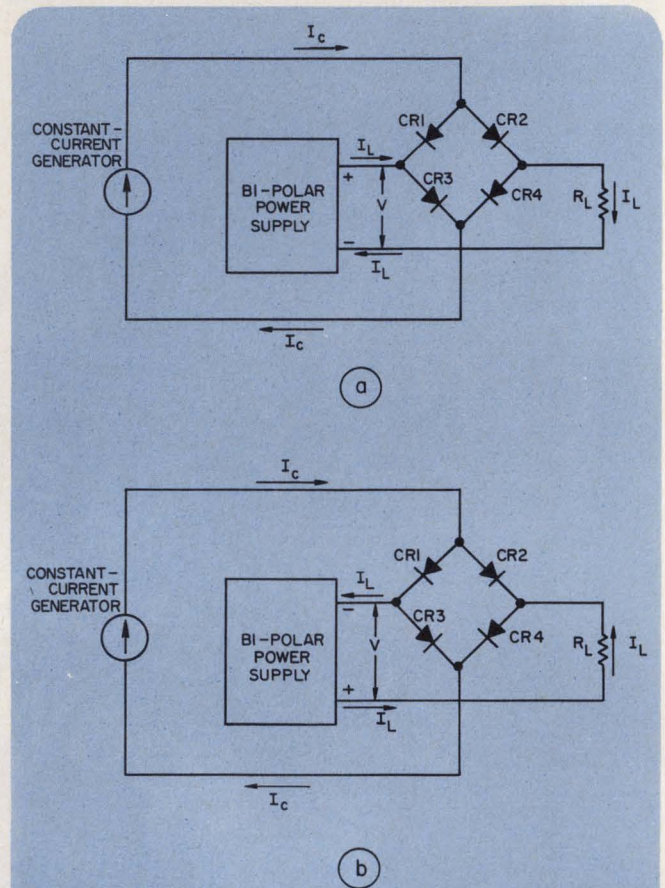
Fig. 1b shows the current-flow path with the supply polarity reversed. Diodes  $CR_2$  and  $CR_3$  are back-biased. Current flows from the positive terminal of the supply through  $R_L$ ,  $CR_4$ , the constant-current generator,  $CR_1$  and back to the negative terminal.

The constant-current generator dissipates little power unless  $I_L = I_C$ . With the load short-circuited, the dissipation (neglecting diode drops) is  $V \times I_C$ . Fig. 2 shows a practical constant-current source capable of supplying 10 to 100 mA, depending on the value of  $R_3$ . The Darlington circuit,  $Q_1$  and  $Q_2$ , provides the current regulation.

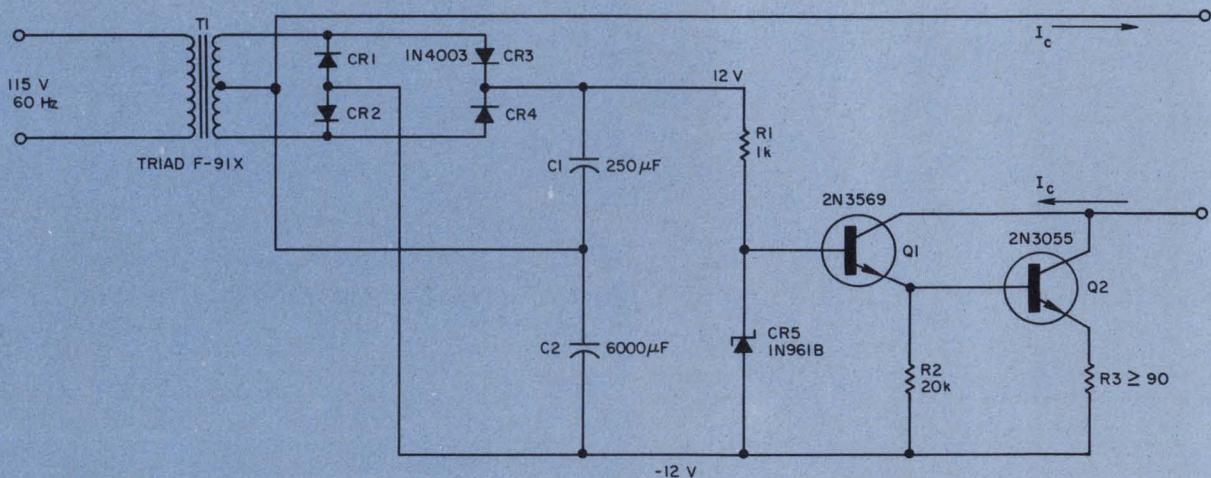
With the components shown and with  $I_C = 100$  mA, the circuit responds to a short-circuit in less than 200 ns. Limiting accuracy is less than that of a closed-loop system. However, the speed is greater, since there are no amplifier-bandwidth limitations.

*Richard W. Hofheimer, Project Manager, Non-Linear Systems, Inc., P.O. Box N. Del Mar, Calif. 92014.*

CIRCLE NO. 314



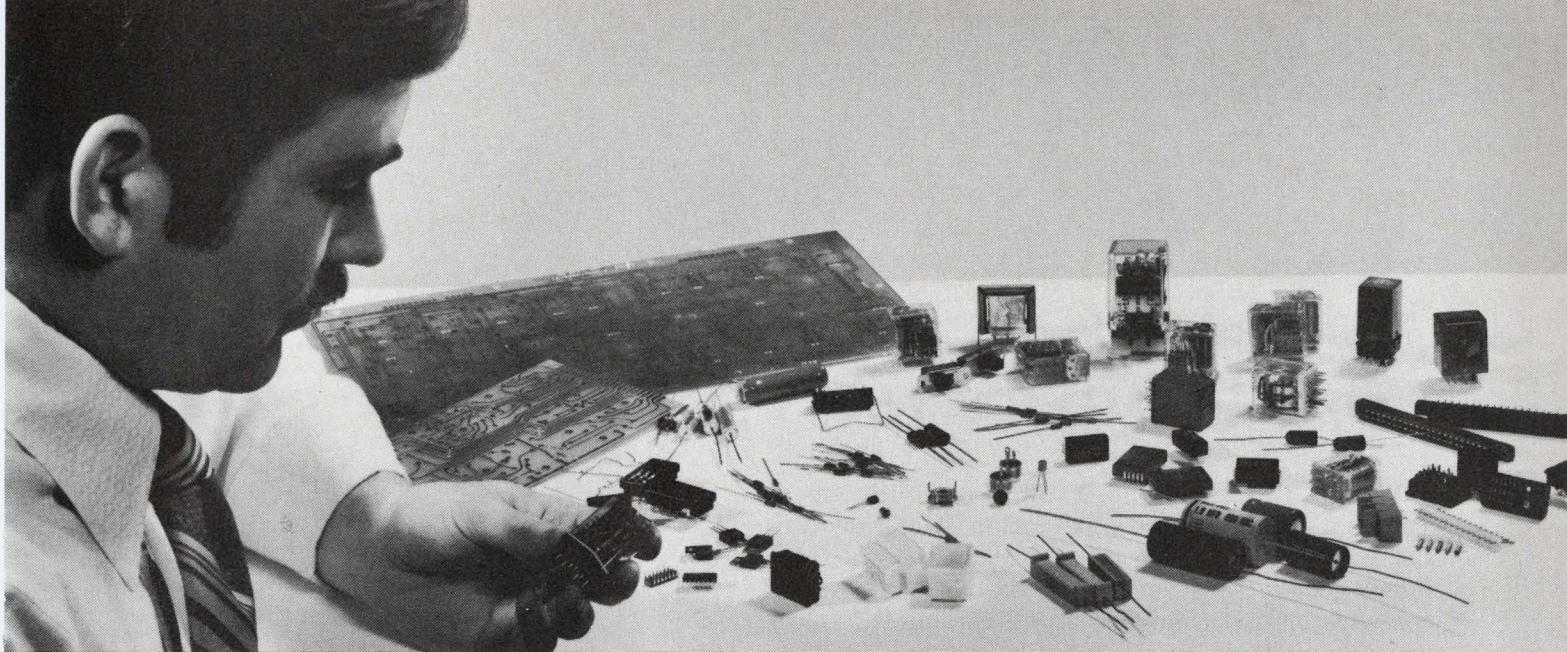
1. Diode bridge and current generator limit the output current to  $I_C$  for positive-supply polarity (a) or negative polarity (b).



2. Practical constant-current generator uses a Darlington connection of transistors to provide

regulation. Resistor  $R_3$  determines the output current. A value of  $90 \Omega$  makes  $I_C = 100$  mA.





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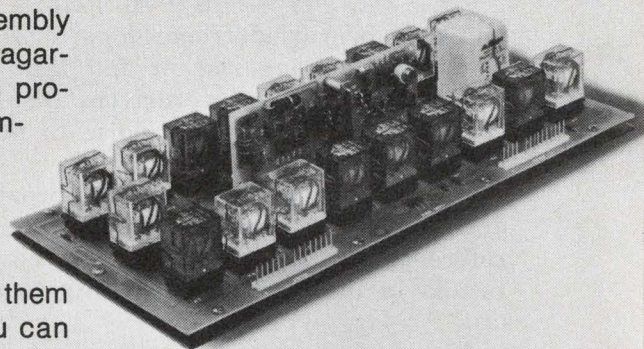
**building your own special assemblies can be a very costly decision.**

Costly indeed. Especially when you consider the attendant costs of any do-it-yourself production effort. Additional labor, training, supervision, procurement, capital equipment, floor space, production scheduling, inventory, tools, fixture and jigs—all contribute to final costs and make them hard to control.

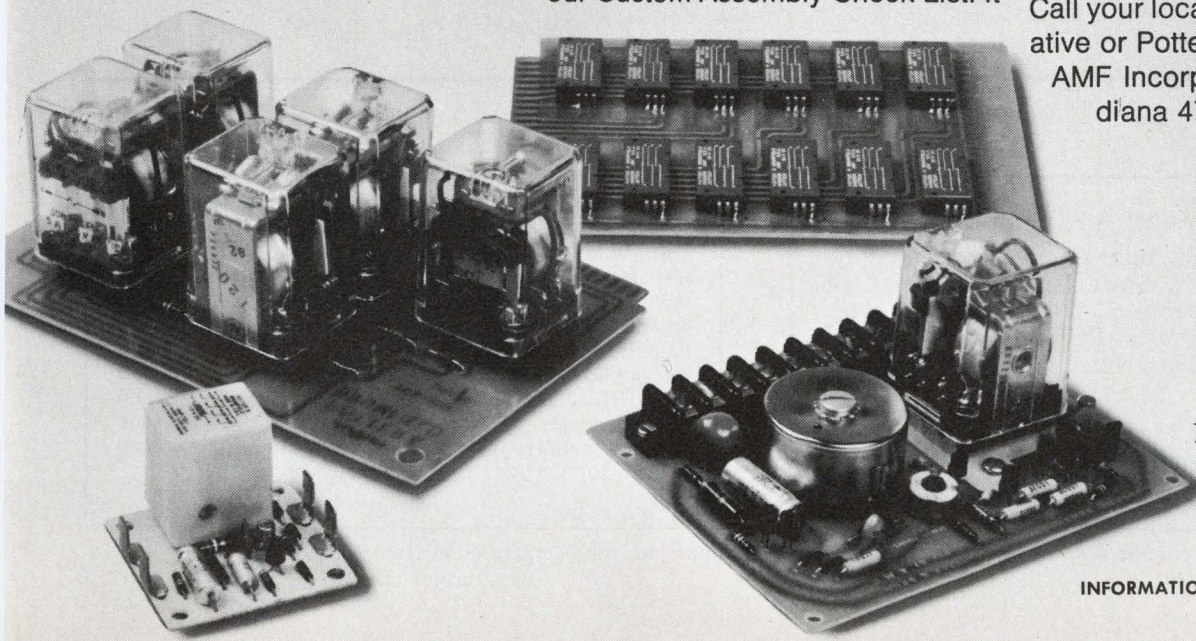
When you consider the alternative, the opportunities for savings are obvious. Perhaps more to the point, with Potter & Brumfield you

know exactly what each assembly will cost. You eliminate all the vagaries associated with in-house production. You see, Potter & Brumfield has all the people and facilities to produce special assemblies and test them to your exacting specifications. And, chances are we'll make them faster and cheaper than you can yourself, and give you a superior product.

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# Adjustable logic-delay circuit covers 40 $\mu$ s to 375 ms with one control

Where TTL logic must interface with slow (manual) data sources, it's often necessary to delay the leading edge of a logic pulse by a few microseconds to several milliseconds. A voltage comparator that compares an adjustable RC voltage decay with a dc reference level furnishes the necessary delay range.

Voltage comparator  $A_1$  offers negligible loading of  $C_T$  and  $C_1$  when compared with  $R_T$ . The capacitors charge rapidly when the output of  $I_1$  is a logic ONE and discharge exponentially through  $R_T$  during a logic ZERO. The comparator is set to trip at 1.0 V, thereby generating the delayed pulse.

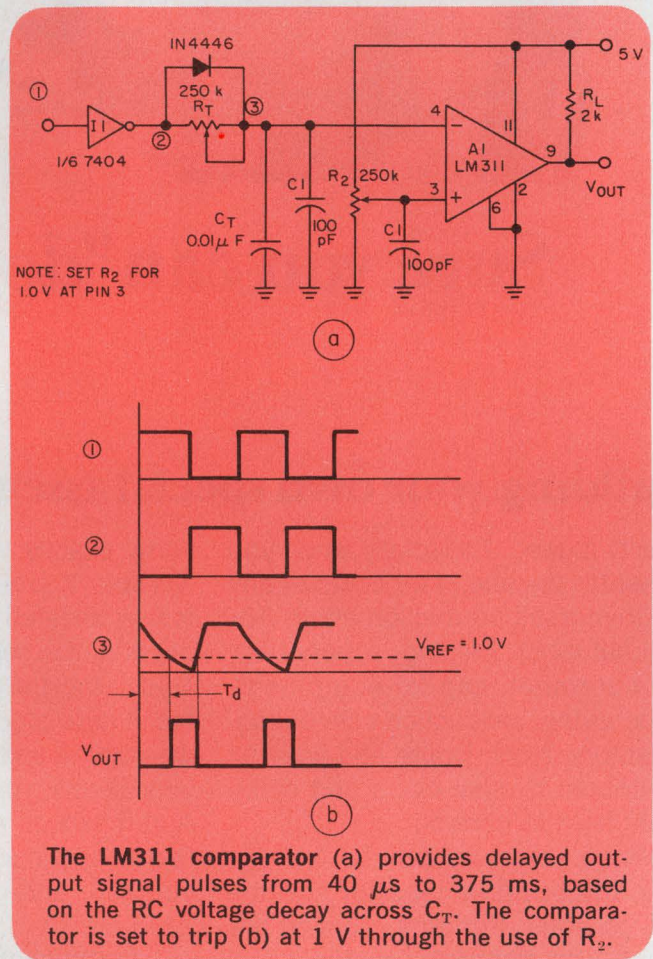
With the components shown, the delay is given by

$$T_d \approx (1.5 \times 10^{-8}) R_T$$

and may be varied from 40  $\mu$ s to 375 ms. The worst-case voltage rise or fall time is 0.4  $\mu$ s, since the LM311 is overdriven. Disc capacitors  $C_1$  bypass high-frequency noise to prevent output-signal chatter.

An increase in  $C_T$  to 0.47  $\mu$ F provides longer delays—up to four seconds. Reduction of the reference voltage also increases the delay, but results in increased susceptibility to noise pick-up.

Raymond T. Zipagan, *Advanced Retail Systems, Litton Industries, Park Ave. and Columbia Rd., Morristown, N.J. 07960.* CIRCLE NO. 315



### IFD Winner of August 2, 1973

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# The best things always come in small packages.

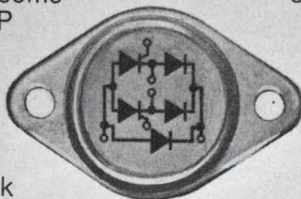


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is inspection, inventory and purchasing time. TO-3 PACE/paks are available now in seven standard circuits, in both 120 and 240 Volt RMS ratings.

The complete PACE/pak line includes ratings to 50 Amps, in configurations such as AC switches, centertap assemblies, and both single and 3-phase SCR and diode bridges. And now it's time for another old saying: Seeing is believing. Call your IR sales office, rep or distributor and get the full story. *International Rectifier, 233 Kansas St., El Segundo, CA. 90245 (213) 678-6281*

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## 'Super' phone cable to carry 100,000 simultaneous calls

Europe's highest-capacity telephone cable is to be laid soon over a 100-mile route linking Birmingham and Manchester, England. The British Post Office is asking manufacturers to submit bids for the cable, which is to carry nearly 100,000 telephone calls at once.

The Birmingham-Manchester project is the first stage of a scheme to provide a "supercable" communications network to link London, Birmingham, Manchester and Leeds by 1980. The cable will carry twice as many telephone calls as all existing transmission systems on the route.

The new cable is to have 18 co-

axial pairs and to be equipped with 60-MHz systems, in contrast with the present 12-pair and 12-MHz systems. Two coaxial pairs in the new cable—one for each direction—is to carry up to 10,800 telephone conversations, or an equivalent mix of telephony, telex, computer data and TV.

The 60-MHz line system will use frequency-division multiplexing between 4 and 60 MHz, thereby allowing 12 broadbands of 900 circuits each to be assembled. This will give the 10,800 telephone circuits on two coaxial pairs—four times the capacity of a 12-MHz system.

## Acoustic holography is used for testing

A new method of surface non-destructive testing that uses one-dimensional acoustic holography has been developed at University College, London. The holographic system can resolve a simulated defect 0.5 mm in diameter and 1  $\mu$ m thick.

A one-dimensional hologram of the acoustic-surface-wave field is constructed on the sample surface. A reconstruction of the hologram then shows up the entire acoustic-surface-wave field, including defects. The reconstruction can be carried out optically or by a computer.

The frequency used is 60 MHz, and the amplitude and phase of the waves are recorded with a phase-sensitive laser probe. The acoustic phase modulates the brightness of a cathode-ray tube beam, which is then photographed to form the hologram.

## Electronic dart game devised in England

The traditional English game of darts has been computerized by a group of apprentices at the British Aircraft Corp.

Their system, developed as part of a pre-university course organized by BAC's Guided Weapons Div. at Bristol, consists of a dartboard with sensing devices and a computer-controlled display unit that acts as the scoreboard. The system was built with 120 integrated circuits, and it shows the running totals for competing teams and totes up each individual score as well.

Each segment of the dartboard is internally divided and wired to the display unit. The impact of the dart on each segment provides an electrical signal to the computer in the display unit.

The conclusion of an individual three-dart score is signaled by the removal of the darts from the board. The system is then reactivated by the next player when he stands on the throwing mat. A proximity indicator under the mat lights a bulb on the display unit, showing that the system is ready to accept the next score. ■■

## For VIP meetings: The Electronics Room



One of Europe's most advanced conference room complexes opened recently at the York Theater at London's Heathrow Airport. Each of the 262 seats in the auditorium is equipped with a built-in console that incorporates a nine-inch television monitor, microphone, computer-controlled delegate response facility, simultaneous translation earphones, folding desks and other electronic aids. The pictures on the monitor originate from a closed-circuit TV camera (upper left). The audio-visual electronics equipment was designed by EMI Sound and Vision Equipment Ltd., Hayes, Middlesex, England.



**Color enhances the legibility of your CRT displays and substantially speeds comprehension of the information being viewed.**

Four clearly distinguishable colors are obtained on the viewing screen of a CRT display by controlling the voltage of a single beam through a multiphosphor screen. These multiphosphor screen CRT's are particularly well suited for sophisticated displays (airborne, tactical, spaceborne, shipboard, etc.) where severe environmental conditions as well as high performance requirements are imposed.

HV (kV) TYPE	7	9	11	13	15	17
E 20		Red	Orange	Yellow		Green
E 21		Red		Orange		Yellow
E 11		Red				White
Multi-persistent		Green	short			long

Penetration CRT's manufactured by THOMSON-CSF provide very high brightness and outstanding picture contrast together with the good resolution of high quality monochrome displays. Multiphosphor techniques developed by THOMSON-CSF have been adapted to multipersistence penetration screens to add variable persistence capability to radar presentation.



**THOMSON-CSF**

THOMSON-CSF ELECTRON TUBES, INC. / 50 ROCKEFELLER PLAZA / NEW YORK, N.Y. 10020 / TEL. (212) 489.0400

France - THOMSON-CSF Groupement Tubes Electroniques / 8, rue Chasseloup-Laubat / 75737 PARIS CEDEX 15 / Tél. 566 70.04

Germany - THOMSON-CSF Elektronenröhren GmbH / Am Leonhardsbrunn 10 / 6 FRANKFURT/MAN / Tél. 70 20.99

Italy - THOMSON-CSF Tubi Elettronici SRL / Viale degli Ammiragli 71 / ROMA / Tél. 638 14.58

Japan - THOMSON-CSF Japan K.K. / Kyosho Building / 1-9-3 Hirakawa-cho / Chiyoda-ku / TOKYO / 〒102 / Tel. (03) 264.6341

Sweden - THOMSON-CSF Elektronrör AB / Box 27080 / S 10251 STOCKHOLM 27 / Tél. (08) 22.58.15

United Kingdom - THOMSON-CSF Electronic Tubes Ltd / Bilton House, Uxbridge Road, Ealing / LONDON W 5 2TT / Tel. (01) 579.1857 / Telex : 25 659

1B20

We think of our enclosures as silent salesmen. The first ten seconds of display for an electronics unit focus simply on the package. Its color (and the other colors available), its finish and style. It won't *break* a sale—the equipment inside does that. But it sure can help *make* one. Our award winning designs and

total color range have proved it.

Does a client need a ventilating grille? A blower? What about writing surfaces, drawers, casters? We have them in production, on line and ready to go—offering the access, flexibility and mobility your clients require. We even paint our units inside and out, and assemble

them for final inspection—including most options and accessories—at the plant.

We're ready with all this, and more. Ready right now.

Write Optima Enclosures, 2166 Mountain Industrial Blvd., Tucker, Georgia 30084 or call (404) 939-6340.

**OPTIMA**

# Before you choose your next enclosure, show this ad to your salesmen.

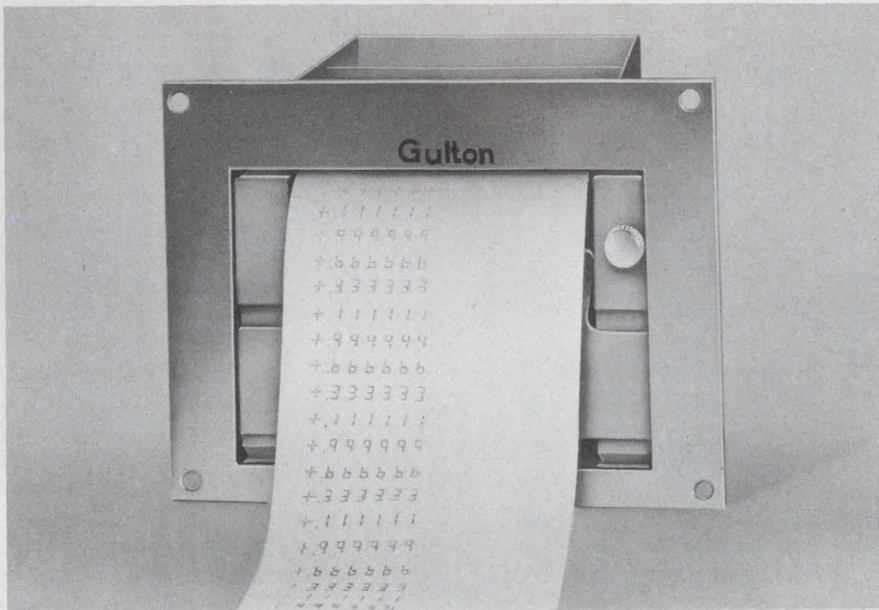


Other Scientific-Atlanta Inc. Divisions are • Cable Communications • Instrumentation • Electro-Systems • Southern Tool and Machine • Security

INFORMATION RETRIEVAL NUMBER 57

## new products

# Thermal printer upstages mechanical units for long, unattended operation



*Gulton Industries, Inc., Gulton Industrial Park, East Greenwich, R.I. 02818. (401) 884-6800. See text; 3 to 4 wk.*

A thermal printer, with its inherent lack of mechanical parts, is an excellent choice, when the application calls for long periods of unattended operation. But until a few months ago only mechanical print mechanisms were available. The GP 12 is a thermal column printer with a rated life of 10-million lines of print. The use of thermographic paper eliminates the need for ribbons and ink pads.

The 12-column, 5-line/s printer, with a \$180 quantity tag, is price-competitive with mechanical units but not with Hycom's DC-2016 electrostatic printer, which has 21-column, 6-line/s capacity and sells for \$100 in quantity. And Hycom expects to have a \$34 unit by February.

The Hycom unit, however, requires the user to supply all interface electronics, whereas Gulton's GP 12 is equipped to handle parallel TTL or DTL data. The print

head of the Hycom DC-2016 is a  $5 \times 7$  dot matrix that mechanically sweeps across the paper; the print head of the GP 12 is a stationary thick-film resistor matrix.

The GP 12 uses the resistive heating effect to print on thermal paper. Each character consists of seven resistors in a standard seven-segment array, with an eighth resistor for the decimal point. The standard head consists of six characters, each with decimal point and a plus/minus sign as the seventh column.

Two print heads provide the 12-column capacity. A character (column) is printed by appropriate selection of the segment lines and application of 34 V for about 20 ms to the character line.

The printer accepts parallel BCD inputs at TTL/DTL logic levels. The internal circuitry multiplexes these, one at a time, to the character columns, beginning with the receipt of the print command. The print time per character is 20 ms. With both heads operating simultaneously, the print cycle time

equals 140 ms.

A solenoid-clutch combination is needed for the 5-line/s rate; an ac motor is used for the continuous rate of 3 lines/s. The maximum speed is permitted only in 10-line bursts.

The GP 12 uses either NCR LT-2 or 3M Type 161 thermographic paper—which is 3.5-in. wide and comes in 150-in. rolls. The user must furnish 25-to-34-V print power at 28 W peak per character. The same supply also drives the solenoid, if it is used. Operating temperature range of the printer is 10 to 40 C.

Gulton  
Hycom

CIRCLE NO. 250  
CIRCLE NO. 251

## EaROMs replace core in industrial controllers

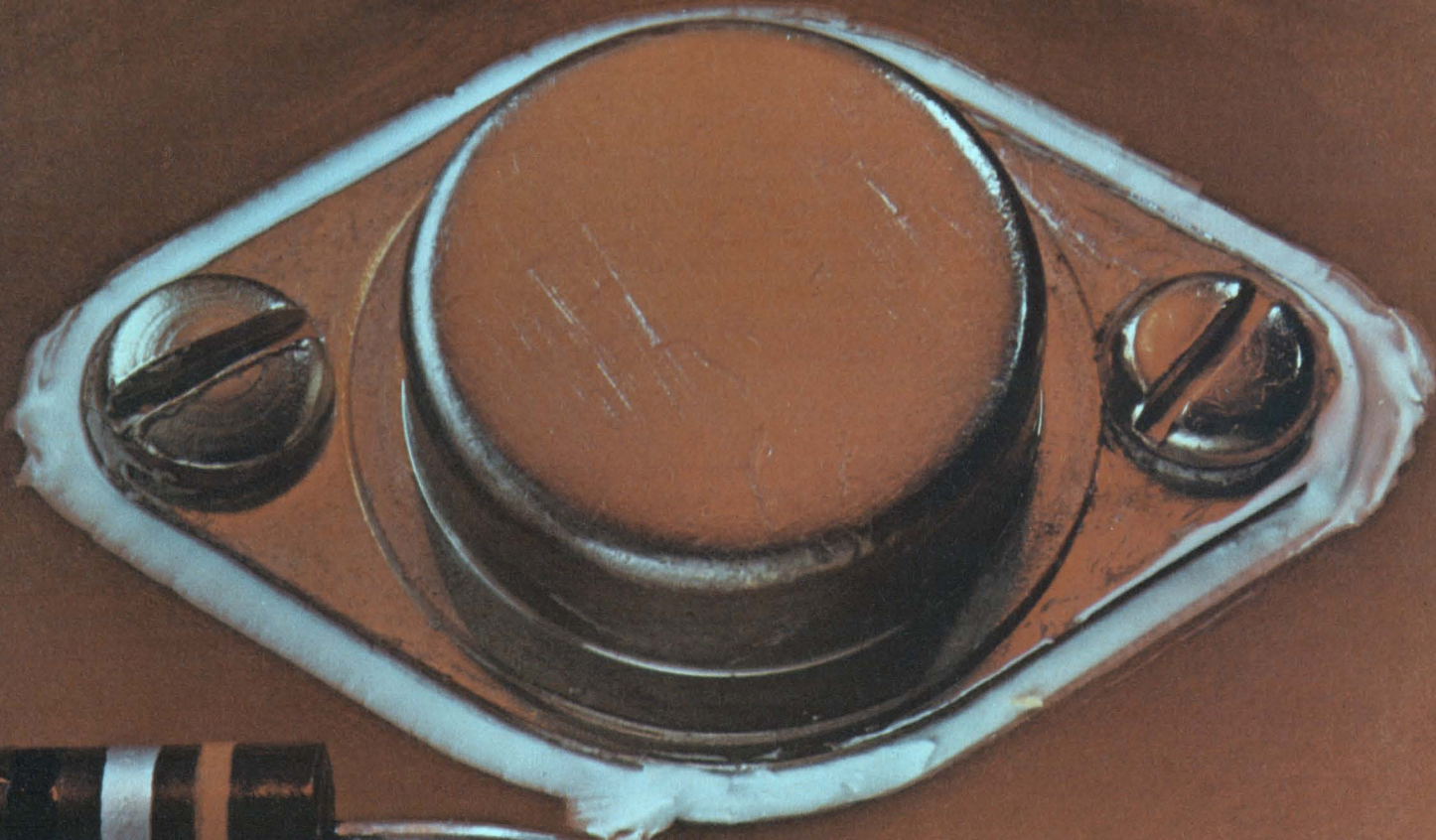
*FX Systems Corp., Mount Marion Rd., Saugerties, N.Y. 12477. (914) 246-9571. See text.*

A complete line of industrial controllers designed with electrically alterable ROMs is now available. Four basic series are offered: MC-A, MLC, SPC and PMT. The MC-A series replaces relay logic and comes with as few as eight inputs and eight outputs to 256 total lines. The MLC series (from \$225) provides more sophisticated processing. The units can check any of 126 possible inputs and outputs and cause an output change in accordance with the present conditional statement. The SPC series (from \$2350) advances from sequence step to sequence step as initiated by an external event. They handle up to 15 load controls per step. The PMT series (from \$2400) advances in time steps that range from 10 ms to 24 hours. Up to 15 load controls can be altered at one step.

CIRCLE NO. 257

**We've got a remedy  
to stop the bleeding.**

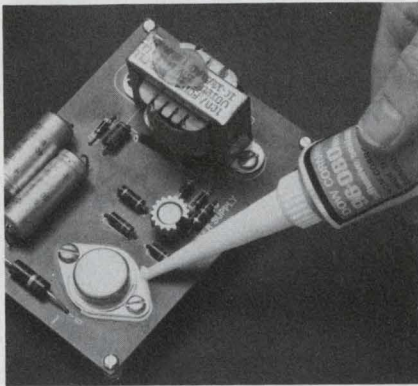
POWER SUPPLY



— 8



## A curable silicone heat sink.



New from Dow Corning: a silicone adhesive/sealant which is perfect for small areas that get hot. Just squeeze it on. It'll flow into the smallest spots and cure in place. And it never bleeds.

It has high thermal conductivity. It's noncorrosive with excellent dielectric properties.

This silicone adhesive/sealant will handle temperatures from  $-65^{\circ}\text{F}$  to  $500^{\circ}\text{F}$  continuously. The range can even extend to  $600^{\circ}\text{F}$  for short periods of time.

Add to this no mixing, no toxic fumes. It comes as one component, in collapsible tubes. And it cures at room temperatures, on exposure to atmospheric moisture.

Dow Corning's new adhesive/sealant utilizes a curing system which does not evolve corrosive by-products. That makes it perfect for use on corrosion sensitive electronic equipment and devices where rapid heat transfer is required.

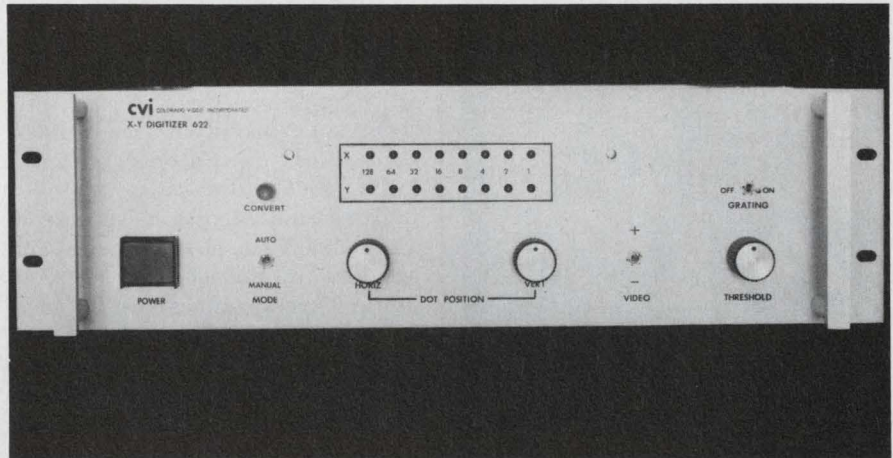
For a free sample and our Self-Curing Heat Sink Adhesive literature, write Dow Corning Corporation, Dept. C-3324, Midland, Michigan 48640.

Silicone adhesives from

# DOW CORNING

DOW CORNING

## Digitize the X-Y coordinates of video signals into 8 bits



Colorado Video, Inc., Box 928, Boulder, Colo. 80302. (303) 444-3972. \$4500; 90 day.

Information on a standard TV monitor can be digitized to 8-bit precision with the CVI 622 from Colorado Video, Inc. Video signals from either a television camera or tape recorder can be coupled to the 622.

There are two modes of operation: manual and automatic. In the manual mode, a small dot of light appears on the screen. By use of either X-Y potentiometers, a joystick, a track ball or a "mouse," the operator positions the dot over the point on the screen to be digitized. Then he gives the command for digitization and moves the light spot to the next desired point.

In the automatic mode, information from the video signal itself can be used to initiate the conversion process. Either a light object on a dark background or a dark object on a light background may be tracked and digitized. In either instance the video amplitude of the target must be substantially greater than that of the background. Once the operator selects either positive or negative video polarity (dark on light or vice versa), the video threshold control is adjusted

so that only the desired target appears on the TV screen. Data reduction is then automatic, and 8-bit X and Y words are generated every 1/60th of a second. This allows for the tracking and digitizing of moving objects on the screen.

Typical applications of the automatic mode include aircraft tracking, eye-movement studies and laser-beam location.

An internal reference grid in the 622, a self-calibrating feature, can be superimposed over the input video image to provide both simplified geometric alignment and a quick check of converter performance. In the automatic mode the output of the video quantizer is also shown on the TV screen for fast adjustment of the video threshold.

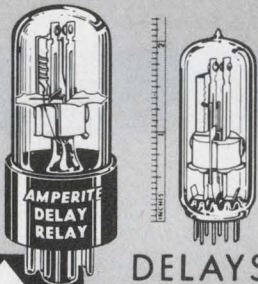
The unit stands  $5\text{-}1/4 \times 19 \times 12$  in. high, fits a 19-in. rack and accepts a 1-V pk-pk video signal in accordance with US 525 line standards. The digitized output is TTL-compatible and the maximum conversion rate is 60 points per second.

The front panel contains two rows of lights to display the digital representation of the X and Y positions of the reference dot of light on the screen.

CIRCLE NO. 253

# TOP QUALITY Still at LOW PRICE

## Thermostatic DELAY RELAYS



DELAYS:  
2 to 180  
SECONDS\*

Actuated by a heater, they operate on A.C., D.C., or Pulsating Current... Being hermetically sealed, they are not affected by altitude, moisture, or climate changes

... SPST only — normally open or normally closed... Compensated for ambient temperature changes from  $-55^{\circ}$  to  $+80^{\circ}$  C... Heaters consume approximately 2 W. and may be operated continuously. The units are rugged, explosion-proof, long-lived, and inexpensive!

TYPES: Standard Radio

Octal and 9-Pin Miniature. . . . List Price, \$4.00  
\*Miniatures Delays: 2 to 120 seconds.

All Amperite Delay Relays are recognized under component program of Underwriters' Laboratories, Inc. for all voltages up to and including 115V.

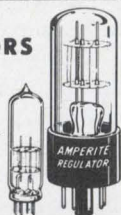
PROBLEM? Send for Bulletin No. TR-81.

### AMPERITE BALLAST REGULATORS

Hermetically sealed, they are not affected by changes in altitude, ambient temperature ( $-50^{\circ}$  to  $+70^{\circ}$ C.), or humidity... Rugged, light, compact, most inexpensive.

List Price, \$3.00

Write for 4-p. Bulletin No. AB-51.



# AMPERITE

600 PALISADE AVE., UNION CITY, N.J. 07087

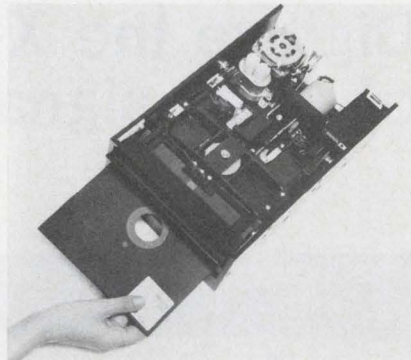
Telephone: 201 UNion 4-9503

In Canada: Atlas Radio Corp., Ltd.,

50 Wingold Ave., Toronto 10

## DATA PROCESSING

### Diskette drive stores up to 4.9 million bits



Orbis Systems, Inc., 3303 Harbor Blvd., Suite K8, Costa Mesa, Calif. 92626. \$600; 90 days.

The Orbis 74 disc drive accepts an unmodified IBM diskette and provides a storage capacity 2.46 Mbits. Access times are 10 ms/track, 10 ms settling time and 83 ms latency. The data transfer rate is 250-k bits/s. The maximum capability of the unit is 4.9 M bits with a transfer rate of 400-k bit/s.

CIRCLE NO. 258

### Microprocessor handles 32 CRT terminals

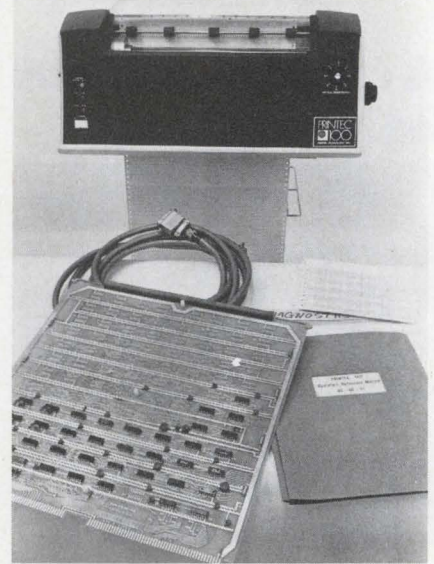


Sanders Associates, Daniel Webster Highway, Nashua, N.H. 03060. (603) 673-5432. See text; Jan.

System 8170 meets a variety of on-line alphanumeric display requirements. The terminals are plug-compatible with 2260 or 3270-type terminals. A microprocessor controller, capable of handling up to 32 terminals, adds local computing and error-checking capabilities. A cluster of five, 1920-character CRTs, keyboards, a microprocessor and a modem interface cost \$29,600 or \$740/mo on a one year lease. Optional equipment includes printers, upper and lower-case character sets and a variety of screen sizes.

CIRCLE NO. 259

### Printer packages afford 100 char/s throughput



Printer Technology, Sixth Rd., Woburn Industrial Park, Woburn, Mass. 01801. (617) 935-4246. \$3995-\$4895; 8 wks.

Three plug-compatible printer systems; series 800, series 1100 and series 1200 provide 100 char/s operation with PDP-8, PDP-11 and Nova minicomputer families. The package includes an impact printer, interface board, 25-ft. cable, a diagnostic program and instruction manuals. The printer offers a 132-column line, printed serially. Base price options include a 96-character set (upper and lower case) that prints at 70 char/s and a forms-control unit. The printer handles nine-part forms and can be equipped with a variety of special typefaces.

CIRCLE NO. 260

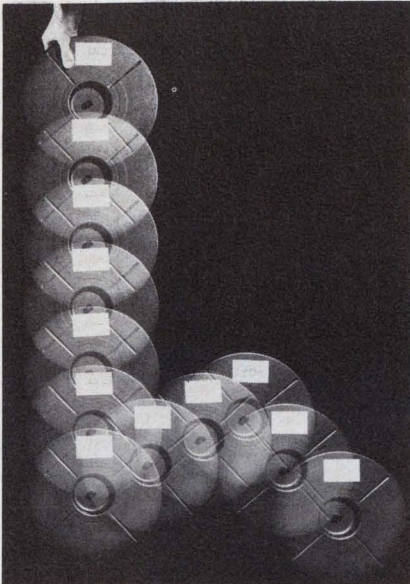
### Floppy-disc system can have RS 232C interface

Digital Associates Corp., 1031 Post Rd., Darien, Conn. 06820. (203) 655-2222. From \$2950.

Capable of storing 262-k bytes on each drive, the DISC-8 system consists of up to four "floppy-disc" drives, a formatter and an interface. The data are recorded on 64 tracks, each with 32 sectors that contain 128 bytes. And the transfer rate is 31.2-k byte/s. Head motion and settling time require 10 ms each; disc speed is 375 rpm. Interfaces are available for all popular minicomputers or as an RS 232C communications interface.

CIRCLE NO. 261

## Tape container wards off shock and magnets



*Ad-Vance Magnetics, Inc., 226 E. 7th St., Rochester, Ind. 46975. (219) 223-3158. See text; stock.*

Containers that protect irreplaceable data recorded on magnetic tape must provide magnetic as well as physical protection. Container Model TDP-116-R15P can be dropped four feet onto concrete without tape damage, and it can also ward off magnetic fields from electrical storms, aircraft power-generating equipment and permanent magnets.

Each container incorporates a centering hub to hold reels in place. Physical ruggedness is achieved by a hydroforming process and stiffening ribs. A simple twist-lock secures the tape firmly in place on the centering hub, even under the aforementioned shock conditions.

Every container holds a single 12-in.-diameter, 1-in. tape reel or two 0.5-in. reels.

Price is \$19 each in 100 quantities or \$28 in 10 to 15. Similar containers—without the hub or twist-lock feature—cost \$26 each in 100 quantities.

In addition Ad-Vance Magnetics offers carrying cases, Models TDP-2 and TDP-5. Both provide the same magnetic shielding as the container and carry two or five EDP tapes, respectively. The cases cost about \$70 in small quantities.

CIRCLE NO. 252

From out of the West . . .

## Switchlight combinations that just don't quit!

In the old days, the Western general store seemed to handle everything, and the price was right. When it comes to modern, reliable switchlights, think of us the same way. Gang switch assemblies . . . snap in adapters . . . special military switchlights . . . Monoform . . . switchlights so compact you could mistake them for shucked peas . . . some others so new they aren't on the shelf yet. But, unlike the general store, we deliver . . . and in a hurry! Just tell us what you need, and depend on Clare-Pendar.

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Phone 208-773-4541

P.O. Box 785 Post Falls, Idaho 83854  
Telex 32-6448



# Dialight sees a need:

(**Need:** Single source supply for all indicator lights.)

# See Dialight.

Dialight has so many kinds of indicator lights—approximately 1,500,000 on our shelves—that we have set up a special magic eye seek-out system to help you find the one you need in a wink. Whether it's a flasher, placard, press to test, oil tight, water tight, dust tight, dimmer, or nondimmer, we have them all, some with incandescent, neon or LED lamps, from 1.35 to 220 volts. Sizes vary from small indicators (mount in 0.120" clearance holes) to large indicators (mount in 1 $\frac{3}{16}$ " clearance

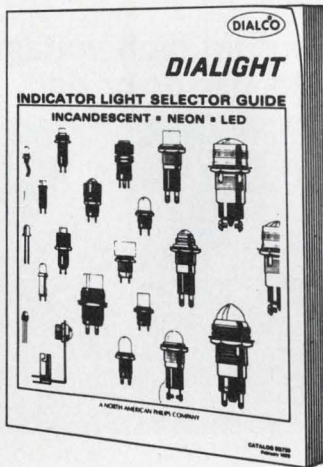


holes), and are available in a variety of terminations and finishes, lens-cap shapes and colors with or without hot-stamped, engraved or film legends. We've developed a 14-digit code number that tells any of our 120 stocking distributors in the U.S. and Canada just what indicator you want for off-the-shelf prompt delivery. If you would like to see for yourself how our code works, just write for your free copy. At Dialight it's a designer's choice because we see your need.



Dialight is a company that looks for needs . . . and develops solutions. That's how we developed the industry's broadest line of indicator lights, readouts, and LED light sources. No other company offers you one-stop shopping in visual displays. And no one has more experience in the visual display field. Dialight can help you do more with indicator lights than anyone else because we have done more with them. Talk to the specialists at Dialight first. You won't have to talk to anyone else.

And also be sure to send for your free copy of our latest 56-page Indicator Light Selector Guide. It will show you how easy it is to quickly find your way to the indicator light you need. This handy guide describes in detail the many indicator light choices — shapes and colors of their lens caps, available terminations, mounting data, available finishes, and LED, incandescent and neon light sources for which they are compatible.



Please send me INDICATOR LIGHT SELECTOR GUIDE.

NAME \_\_\_\_\_

TITLE \_\_\_\_\_

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ STATE \_\_\_\_\_

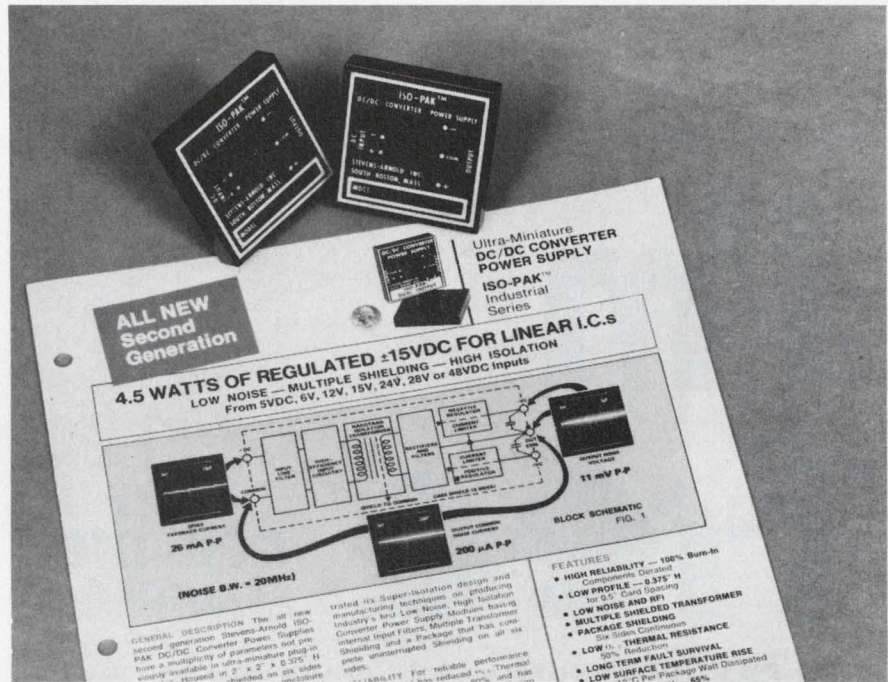
**DIALIGHT**

Dialight Corporation, A North American Philips Company  
60 Stewart Avenue, Brooklyn, N.Y. 11237 (212) 497-7600

INFORMATION RETRIEVAL NUMBER 61

POWER SOURCES

# Dual-output dc-to-dc supplies have 1 mV max output noise



Stevens-Arnold Inc., 7 Elkins St., South Boston, Mass. 02127. (617) 268-1170. P&A: See text.

Problems caused by noise in dc-to-dc converter outputs are practically eliminated by the Iso-Pak Series of dual-output switching supplies made by Stevens-Arnold. These supplies have a true-rms output noise voltage of only 1 mV max or 40 mV pk-pk max.

The converter switching frequency is greater than 20 kHz, and the unit is completely shielded on all six sides by insulated solid-copper ground planes. Output voltages are  $\pm 15$  V dc with a  $\pm 0.5\%$  max tracking error. Rated output current is  $\pm 150$  mA (both sides simultaneously), and the outputs are current limited at 150% of rated current.

Load regulation from no load to full load is  $\pm 0.07\%$  max with a load transient recovery time of 50  $\mu$ s max. The 30 minutes required for warm-up cause an initial drift of  $\pm 30$  mV, with a temperature coefficient of  $\pm 0.01\%/^{\circ}$ C max and a voltage stability after warm-up of  $\pm 0.05\%/24$  hrs.

Modules are available that can operate with inputs from 5, 6, 12, 15, 24, 28 or 48 V dc. The  $\pi$  input filter helps keep the electromagnetic interference low. All models have an operating temperature range of  $-25$  to  $71$  C, with no derating, and are short-circuit protected for an eight-hour dead short at  $71$  C. Full-load efficiency for the units is 65%.

Another company, Datel, makes a dual-output model of equivalent rating. Its BPM-15/150-D5 competes with the Stevens-Arnold A5/D15/150/Z. Over-all, the Datel unit is very similar, except that it requires derating above  $35$  C at a rate of  $1.3$  mA/ $^{\circ}$ C, and a heat sink is also recommended. It has a more restricted operating temp range of  $0$  to  $70$  C and a typical load regulation of 0.1%.

Both units cost \$79 each in 1-to-9 quantities and are approximately the same size—2 in. square by 0.4 in. Delivery for the A5/D15/150/Z is from stock to 6 wk.

Stevens-Arnold  
Datel

CIRCLE NO. 254  
CIRCLE NO. 255

**Dc-to-ac inverters deliver up to 4 kW**

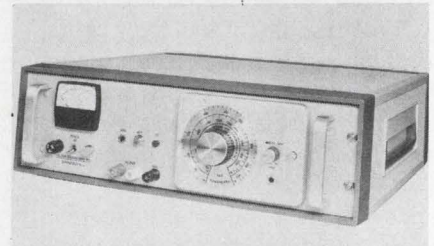
*Creative Electronics Inc., 221 N. LaSalle St., Chicago, Ill. 60601. (312) 726-0993. MV-100C: \$850, MV-200C: \$1200, MV-300C: \$1500, MV-400C: \$1800.*

Sine wave dc to ac inverters, the

MV Series, deliver 115 V, 60 Hz, sine wave power. Frequency regulation is  $\pm 0.1$  Hz in models ranging from the MV-100C, 1000 W unit to the MV-400C Model that delivers 4 W. The surge capacity is five times the continuous output rating. The MV-100C and 200C accept inputs of 11 to 14 V, while the MV-300C and 400C accept inputs of 23 to 28 V and 31 to 36 V, respectively.

CIRCLE NO. 262

**Solid-state power source runs loads to 4500 VA**



*American Vector, Inc., 59W Brown Ave., Springfield, N.J. 07081. (201) 379-7800. From \$595; 1 to 10 wk.*

The units in the S-series are solid-state ac power sources. There are 78 standard plug-in oscillator options, featuring both fixed (50/60/400/800 Hz) and variable frequencies ranging from 45 Hz to 10 kHz. The units deliver multiple output voltages, full power from 45 Hz to 10 kHz, regulated output which is settable to zero, and have short-circuit protection. The output may be grounded or floated, with terminals provided at both the front and rear of the unit. Three phase units can be used in one, two or three phase configurations. Power outputs are available from 130 to 4500 VA.

CIRCLE NO. 263

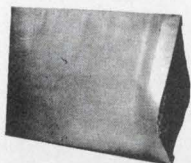
**i'm free**



**I'M A MAIL-LITE SHIPPER**

**1 CASE of Mail-Lite FREE when you buy my \$50 table model heat sealer.**

**2 CASES of Mail-Lite FREE when you buy my \$100 floor model heat sealer.**



MAIL-LITE



FLOOR MODEL \$100 OFFER



TABLE MODEL \$50 OFFER

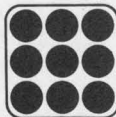
*Labor Savings: Can be heat sealed closed in 2 seconds  
Waterproof • Pilferproof • Lightweight • Clean*

**THIS SPECIAL OFFER EXPIRES DECEMBER 31, 1973**

I AM INTERESTED IN THE  \$50 OFFER  \$100 OFFER

PLEASE FORWARD ADDITIONAL INFORMATION ON;

MAIL-LITE SHIPPERS  MAIL-LITE HEAT SEALING SYSTEM



COMPANY \_\_\_\_\_

NAME \_\_\_\_\_ ADDRESS \_\_\_\_\_

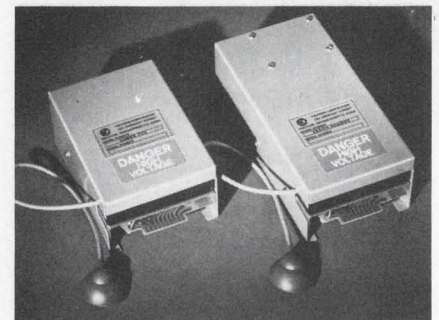
CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_

PHONE \_\_\_\_\_

**Sealed Air Corporation**

19-01 State Highway 208. Fair Lawn, New Jersey 07410

**Lone output high voltage supplies use ac or dc**



*Keltron Corp., 225 Crescent St., Waltham, Mass. 02154. (617) 894-0525. Model 710: \$125 (10 up); stock to 3 wk.*

The Series 700 and 800/900 high voltage supplies offer fixed outputs of 10, 12, 15, 18 or 20 kV  $\pm 5\%$ . Loads can vary from zero to 10 W max. Input voltage is 24 V dc  $\pm 3$  V or 115 or 230 V ac. Regulation is 0.1%, ripple is 0.05% pk-pk and full load transient response is 0.3% of peak with less than 2 ms recovery. All units are short-circuit and arc proof, factory repairable and guaranteed.

CIRCLE NO. 264

# New from MOSTEK—a low cost clock circuit with 4 or 6 digit display, 24 hour alarm and more!

MOSTEK's new MK50250N MOS Clock Circuit makes the low-cost, multi-function electronic alarm clock practical today.

It's packed with features . . . 4-or-6-digit display plus AM/PM indication, 24-hour alarm function with "snooze" feature, power failure

indicator, intensity control and display blanking.

The activity indicator allows use of a more economical 4-digit display (hours and minutes) and still verifies circuit functioning with a single pulsating LED. Operation is from standard 50 Hz (24-hour operation) or 60 Hz (12-hour operation) input. The new circuit is compatible with gas discharge or LED displays with minimal interface circuitry.

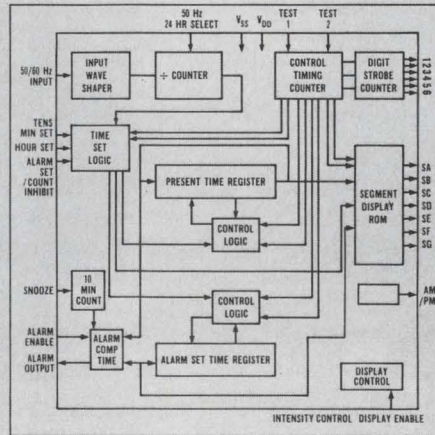
The MK50250N is available in an easy to use 28-pin production package fully stocked for immediate delivery.

If you're making the move to electronic alarm clocks, contact MOSTEK. Whether your requirement is for evaluation circuits or volume production quantities, you can count on MOSTEK to perform . . . on time.

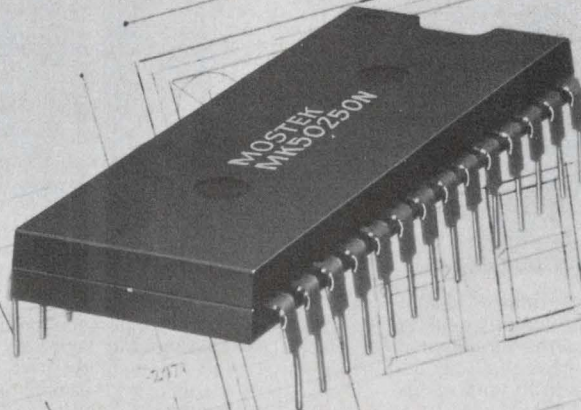
Call your local MOSTEK representative or contact MOSTEK, 1215 West Crosby Road, Carrollton, Texas 75006, (214) 242-0444.



INFORMATION RETRIEVAL NUMBER 63

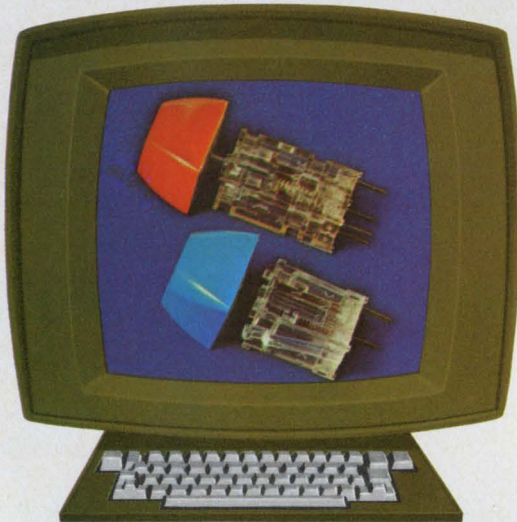


**MOSTEK moves forward...in time.**



# Oak presents a short course in keyboard switch selection you can't afford to miss.

Our course could be called "Basic Economics in Keyboard Switch Design." It sums up more than 40 years of leadership in switch design and manufacture at Oak. Take a look at our course:

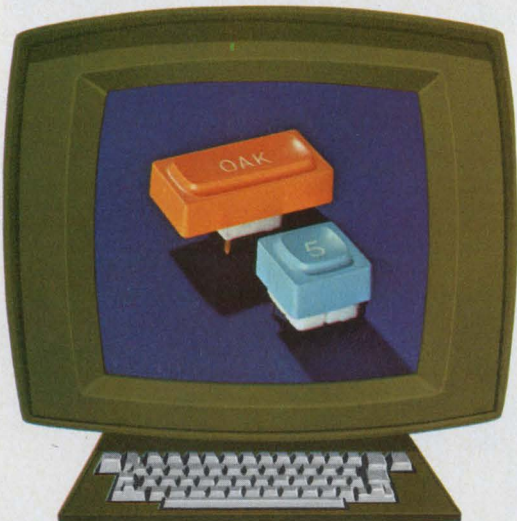


At the top: the Oak Series 400 Standard Keyboard Switch. It's what you're looking for if you want economy plus reliability. Millions are in use today in every kind of keyboard application.

And our Series 475 Compact Keyboard Switches (bottom) are about the shortest premium quality units you can buy. And, like the Series 400, they're ultra-reliable and economical.



We make so many types and sizes, you can specify Oak across the keyboard. Call on us for complete assemblies to your specifications or standard key-pads. The most frequently used 10, 12 or 16 button arrays are stocked in quantity by Oak distributors.



Next subject: Oak Series 415 Low-Profile Keyboard Switches designed for calculators, security devices and data entry equipment. Note the streamlined silhouette. Select colors, custom caps and legends,  $\frac{5}{8}$ " or  $\frac{3}{4}$ ", single and double keys to fit your needs exactly.

**OAK Industries Inc.**

SWITCH DIVISION / CRYSTAL LAKE, ILLINOIS 60014  
TELEPHONE: 815 • 459 • 5000 ■ TWX: 910 • 634 • 3353 ■ TELEX: 72 • 2447

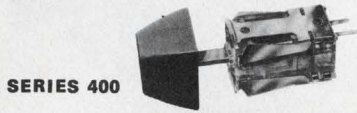


We can say that because our automated manufacturing and test equipment ensures quality. And we design our keyboard switches with the operator feel, reliability, and economy it takes for such applications as data terminals, calculators, business machines, and more.

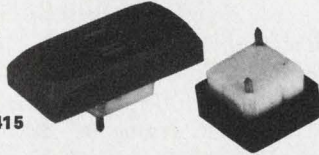
That's it. Just be sure to follow up on what you've learned. Write for Oak Keyboard Bulletins. Class dismissed.



# Who to call for fast delivery on Oak Keyboard Switches



SERIES 400



SERIES 415

Oak Series 400 and Series 415 Keyboard Switches are available from a distributor near you. He'll supply your desired quantities and ship standard 10, 12 and 16-button keypads as well. It's the way to get Oak quality switches fast!

## DEMAMBRO ELECTRONICS

MASSACHUSETTS, Boston.....(617) 787-1200

## DRW

MASSACHUSETTS, Watertown....(617) 923-1900  
NEW YORK, Farmingdale.....(516) 249-2660

## EDMAR ELECTRONICS

ILLINOIS, DesPlaines.....(312) 298-8580

## FEDERATED PURCHASER

NEW JERSEY, Springfield.....(201) 376-8900

## GRAHAM ELECTRONICS

INDIANA, Indianapolis.....(317) 634-8486

## G. S. MARSHALL

ALL BRANCH LOCATIONS—HOME OFFICE:  
CALIFORNIA, El Monte.....(213-686-1500)

## HALL-MARK

ALL BRANCH LOCATIONS—HOME OFFICE:  
TEXAS, Dallas.....(214-231-6111)

## HERBACH & RADEMAN

PENNSYLVANIA, Philadelphia....(215) 426-1700

## INDUSTRIAL COMPONENTS

MINNESOTA, Minneapolis.....(612) 831-2666

## MILGRAY/WASHINGTON

MARYLAND, Hyattsville.....(301) 864-1111

## OHM/ELECTRONICS

ILLINOIS, Palatine.....(312) 359-5500

## RADAR ELECTRIC CO.

WASHINGTON, Seattle.....(206) 282-2511

## SCHOMBURG SALES

NEW YORK, Rochester.....(716) 244-0920

## SOLID STATE ELECTRONICS

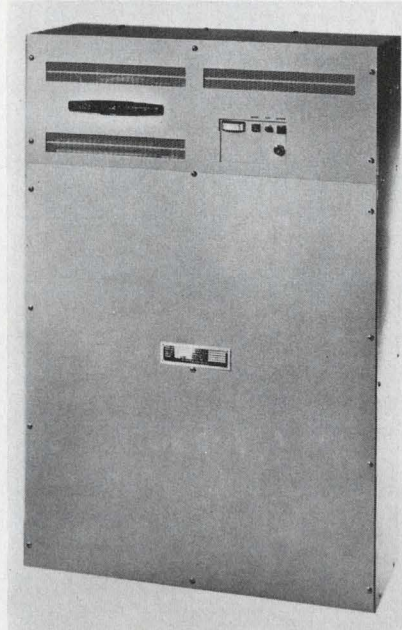
TEXAS, Dallas.....(214) 352-2601

**OAK Industries Inc.**

SWITCH DIVISION / CRYSTAL LAKE, ILLINOIS 60014

## POWER SOURCES

### UPS can provide up to 1350 W of ac power

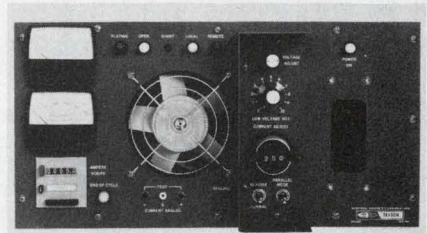


Lightguard Div., ESB Inc., 431 Pike Rd., Huntington Valley, Pa. 19106. (215) 355-0580.

The Lightguard uninterruptible power supply (UPS) automatically feeds no-break ac power to selected critical ac loads as well as to emergency fluorescent lighting systems. A single bookcase-sized cabinet houses the entire system, including the 12-cell lead-acid battery, the various controls and the electronic static inverter that converts dc to ac. The single-phase static inverter changes the battery's dc power to either 120 or 277 V ac, depending on the model of console selected for use. Inverter voltage supplied to the emergency ac loads is held within  $\pm 5\%$  during the battery's standard discharge period of 1.5 hrs. Switch-over from normal ac power feed to battery/inverter ac power is automatic and occurs within 0.5 s. Four capacity ratings are available for use with either the 120 or 277 V ac systems. These include 350, 750, 1050 and 1350 W. To prevent excessive battery discharge during a prolonged power outage, a drop-out circuit in the UPS console monitors the battery output voltage. When the cell voltage drops below 1.75 V per cell, the circuit automatically disconnects the battery from the load.

CIRCLE NO. 265

### High current dc supply offers dual control

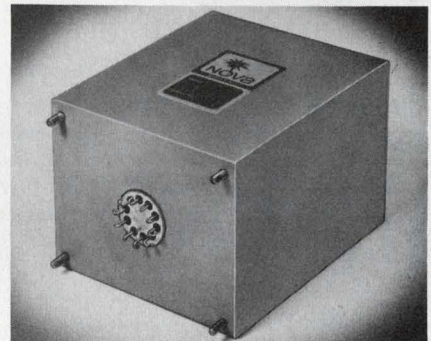


Trygon Electronics, 1200 Shames Dr., Westbury, N.Y. 11590. (516) 997-6200. \$3200; 90 day.

The Model M8C15-250S electroplating power supply can be manually operated or programmed by a computer. Features include front panel manual controls and computer interface control, true ampere-hour front panel totalizer, polarity reversal and a three-digit decade-dial current adjust. Power output is 3 kW with output voltage and current adjustable from 0 to 15 V dc and 0 to 250 A, respectively. Regulation is 0.1%, ripple is less than 15 mV pk-pk and stability is 0.2% of set value.

CIRCLE NO. 269

### Mini dc/ac inverters supply up to 120 VA



Nova Electric Manufacturing Co., 263 Hillside Ave., Nutley, N.J. 07110. (201) 661-3434. From \$254; stock to 4 wk.

The Minitron dc to ac inverters for either 400 or 60 Hz operation are available in power ratings of 30, 60 and 120 VA. They comply with MIL requirements for shock, vibration, humidity and altitude. Typical electrical specifications include: dc input voltages of 12, 24 or 48 V, output voltage regulation of  $\pm 1\%$  for line and load, distortion of less than 4%, operating temperature range of  $-20$  to  $55$  C and input transient protection of 80 V dc for 0.1 s.

CIRCLE NO. 270

# The Hickok challenge: match our features, beat our price.

Most people know that the Hickok line of Digital Multimeters is one of the best performing on the market. The hard fact is, you can spend a lot more for a Multimeter and still not get all the features we offer. That's why, spec for spec, Hickok is your best all-around dollar investment.

All of our 3400 series Digital Multimeters come with  $4\frac{3}{4}$  digits, an optional 300% overranging that enables you to read to 39999 on all five functions, an accuracy of .01%, a front panel control to vary the reading rate from 2 per second to one reading every five seconds and a solid 3-year warranty.



**The Standard 3400 Multimeter** is priced at just \$595. It's a rugged, non-tempermental, hard-working tool with a  $10\mu\text{V}$  resolution built-in. It handles DC voltage from  $10\mu\text{V}$ -1200V; AC voltage from  $10\mu\text{V}$ -1000V RMS; resistance from  $10\text{m}\Omega$ -20M $\Omega$  and DC/AC current from 10nA-2A.

**The 3410 Microvolt Multimeter** is priced at \$695. It offers full Multimeter capability with  $\mu\text{V}$  and  $1\text{m}\Omega$  resolution. It has 10 times more sensitivity for low-level measurements. A built-in guard box virtually eliminates errors due to ground loops and power line hum and provides for additional operator safety.



**The 3420 Multimeter/Counter** costs \$750. There is enough measurement capability in this one compact unit to replace a four-digit multi-meter as well as a five-digit frequency counter. Time base is from 100 seconds to 10 milliseconds; 100 mV sensitivity at 20 MHz.



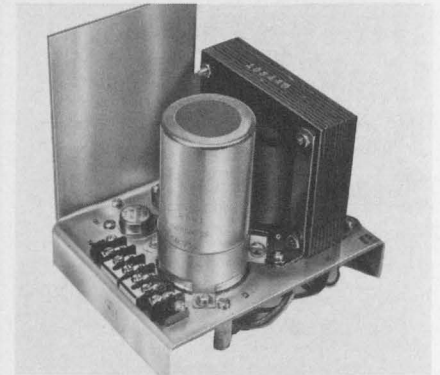
So remember, with Hickok your dollars will go as far as they can. Send for our 3400 Series Data Sheet for complete specifications on our digital Multimeters.

**HICKOK**  
the value innovator

Instrumentation & Controls Division  
The Hickok Electrical Instrument Co.  
10514 Dupont Avenue - Cleveland,  
Ohio 44108  
(216) 541-8060 - TWX: 810-421-8286

## POWER SOURCES

### High current dc supply is mini in size



Tele-Dynamics/Wanlass, 524 Virginia Dr., Fort Washington, Pa. 19034. \$75 (1 to 9); stock.

An open frame dc power supply provides 8 A at 5 V dc in about the same size as most 5 A units. Model C656 accepts inputs of 105 to 125 or 210 to 250 V, 50 to 63 Hz. Both line and load are regulated within  $\pm 1\%$ . Automatic fold-back current limiting provides built-in overload and short-circuit protection. Overvoltage protection can be provided as a low cost optional addition. It weighs 5.5 lb and measures  $5 \times 6 \times 6\frac{1}{8}$  in.

CIRCLE NO. 271

### Dual tracking supply needs single control

WORTEK, 5971 Reseda Blvd., Tarzana, Calif. 91356. (213) 881-1644. \$29.50 (100 to 249); stock to 4 wk.

Model PRT4A dual tracking dc supply eliminates the need for separate output voltage adjustments. Continuous coverage from  $\pm 12$  to  $\pm 15$  V dc (24 to 30 V dc in the differential mode) is achieved by means of a single adjust control, while maintaining 1% or less output balance error. Key specifications are as follows: Each output is rated for 1 A load (30 W total),  $\pm 0.05\%$  line/load regulation, less than 1% tracking error, 1 mV rms ripple,  $\pm 0.25\%$  long term dc stability, 0 to 40 C operating temperature range and 115 V ac, 47 to 63 Hz operation. Thermal shut-down and current fold-back limiting are standard protection features of the PRT4A. It is designed with an open frame configuration and the case dimensions are 6.875 by 4.25 by 2 in.

CIRCLE NO. 272

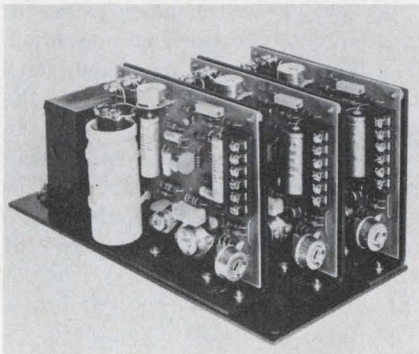
## Dual output supply gives $\pm 15$ V at 25 mA

Polytron Devices, Inc., P.O. Box 398, Paterson, N.J. 07524. (201) 523-5000. \$14 (1 to 9); stock.

The P31 dual output dc power supply delivers  $\pm 15$  V at 25 mA. Regulation is 0.1% (line and load) while the ripple and noise is 0.5 mV. Input voltage range is 95 to 125 V ac, 50 to 400 Hz. The operating temp range is  $-25$  to  $+71$  C and the size is 2.5 by 3.5 by 1 in.

CIRCLE NO. 273

## Open frame dc supplies have multiple outputs



ERA Transpac Corp., 311 E. Park St., Moonachie, N.J. 07074. (201) 239-3000. Dual output: \$82; triple: \$125; 30 day.

The OE-2/3 Series of multioutput open-frame dc power supplies is intended for IC op amp, computer and general applications. The units include such features as logic inhibit circuitry, adjustable outputs, built-in overvoltage and overcurrent protection, remote sensing, parallel operation and automatic thermal cut-outs. Input is 105 to 125 V ac, 47 to 63 Hz or 380 to 410 Hz. Outputs deliver either dual 12 or 15 V dc with current ratings up to 6.5 A. Triple outputs include dual 12 or 15 V dc and  $+5$  or 6 V dc supplies with current ratings up to 12 A. Input/output regulation is better than 0.05% and ripple is less than 1 mV rms for each output. Response time is less than 50  $\mu$ s for a full load change. The operating temperature is  $-20$  to  $+71$  C with a temperature coefficient of better than 0.01%/C. A typical dual output unit is 3.75 by 4.75 by 4.75 in. and weighs 2.5 lb and a typical triple output model is 5.75 by 10.75 by 5 in. and weighs 9 lb.

CIRCLE NO. 274

# When your machine has more to say...



**IEE Readouts provide the vocabulary.**

When your machine has more to say, IEE rear projection readouts let it speak out with an eloquence that make other display systems seem taciturn.

For instance, just one IEE rear projection readout will improve the vocabulary of your machine with up to 64 new phrases expressed in any combination of alphanumeric, in any language, accompanied by the symbols of any discipline, all displayed in a variety of colors and in the type styles that go best with your panel decor.

No gas discharge tube, or LED or what have you, can make that statement.

**IEE units communicate—loud and clear!**

Our big Series 80 rear projection readout lets your machine shout in huge 3 $\frac{3}{8}$ -inch characters. Or we can say things discretely

with our fit-anywhere  $\frac{1}{2}$  x  $\frac{3}{4}$ -inch Series 345 model.

All with single-plane viewing, variable brilliance, and the capability to change vocabularies right in the field. To assist, we have a powerful new low-cost hybrid driver/decoder for any of the readouts. Plus a host of other driver/decoders... all, competitively priced... purchased separately or customer mounted.

Rear projection readouts give you an order of display versatility a world apart from other techniques, and IEE builds more of them than anybody. Send today for our Short-Form Catalog on units that are long on talk. Industrial Electronic Engineers, Inc., 7740 Lemona Ave., Van Nuys, California 91405. Telephone: (213) 787-0311 • TWX 910-495-1707



Industrial Electronic Engineers, Inc.



INFORMATION RETRIEVAL NUMBER 66

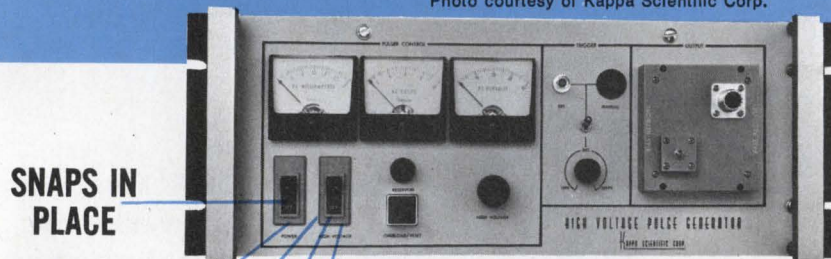
“...switch, indicator, and circuit protector *all in a single compact package.*”

## AIRPAX™ TYPE 203 Electromagnetic Circuit Protector

Airpax Type 203 Electromagnetic Circuit Protectors offer a choice of many mechanical and electrical configurations for maximum versatility. Series, shunt, and relay trip internal circuits are available and can be combined in single, two and three-pole versions. Current ratings from 0.02 to 20 amperes at 120V ac and 0.02 to 10 amperes at 250V ac. Inverse time delay or instant trip.



Photo courtesy of Kappa Scientific Corp.



SNAPS IN PLACE

SAVES SPACE

STYLISH DESIGN

REDUCES COST

LOW MAINTENANCE

Here's why Kappa Scientific selected Airpax Type 203 Circuit Protectors for their new High Voltage Pulse Generator.

We quote: "... because it features a switch, indicator, and circuit protector all in a single compact package. This is an advantage because we require switching, indication, and protection for both input power and high voltage. Especially important is that total cost is competitive with individual switch, light, and fuse components. This approach eliminates unsightly fuseholders and fuse replacement, but better, prevents the not-uncommon practice of substituting high amperage fuses (the penny-in-the-fusebox remedy) with subsequent circuit damage."

**Shouldn't your next design include a Type 203?**

Write for full specifications.

Airpax Electronics / CAMBRIDGE DIVISION / Cambridge, Md. 21613 / Phone (301) 228-4600

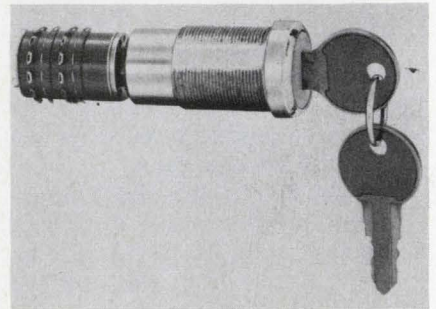
# AIRPAX™

25 YEARS OF PROGRESS

INFORMATION RETRIEVAL NUMBER 67.

## COMPONENTS

### Lock secures rotary switch operation



RCL Electronics, Inc., 700 S. 21st St., Irvington, N.J. 07111. (201) 374-3311.

A keylock switch permits operation only by authorized personnel. The lock mounts nearly flush with the front panel and is secured by nuts to prevent loosening or dismounting the unit from the panel front. This security feature may be adapted to many of RCL's extensive line of miniature rotary switches, including most of the more popular types. The lock has eight tumblers, is double-bitted and it uses a double-sided flat key.

CIRCLE NO. 275

### Qualify for free precision-pot kit

Amphenol Controls Operations, 2801 S. 25th Ave., Broadview, Ill. 60153. (312) 345-9000. \$3.83 (500-999).

A new line of low-cost, 10-turn, precision, wirewound potentiometers will be officially introduced in early 1974. Designated Scot Pots, the Model 4200 line is 3/4-in. long, 7/8-in. diameter, has a resistance range of 100  $\Omega$  to 100 k $\Omega$ , an independent linearity of  $\pm 0.25\%$  and a TC of  $\pm 20$  ppm/ $^{\circ}$ C maximum. The power rating is 2 W at 70 C, derated to zero at 125 C. Over-all operating temperatures range from  $-55$  C to 125 C. Amphenol offers engineers a free five-pot preview kit in any combination of resistance values for testing and evaluation purposes. Offer ends December 31, 1973. Obtain a qualification/application form by circling the bingo number. Kit shipments will be made in February, 1974.

CIRCLE NO. 276

Do you face  
a make or buy  
decision on  
power supplies?

# BUY LAMBDA'S LT SERIES 25 MODELS, 3 PACKAGE SIZES, ALL 5-YEAR GUARANTEED.

**\$80**

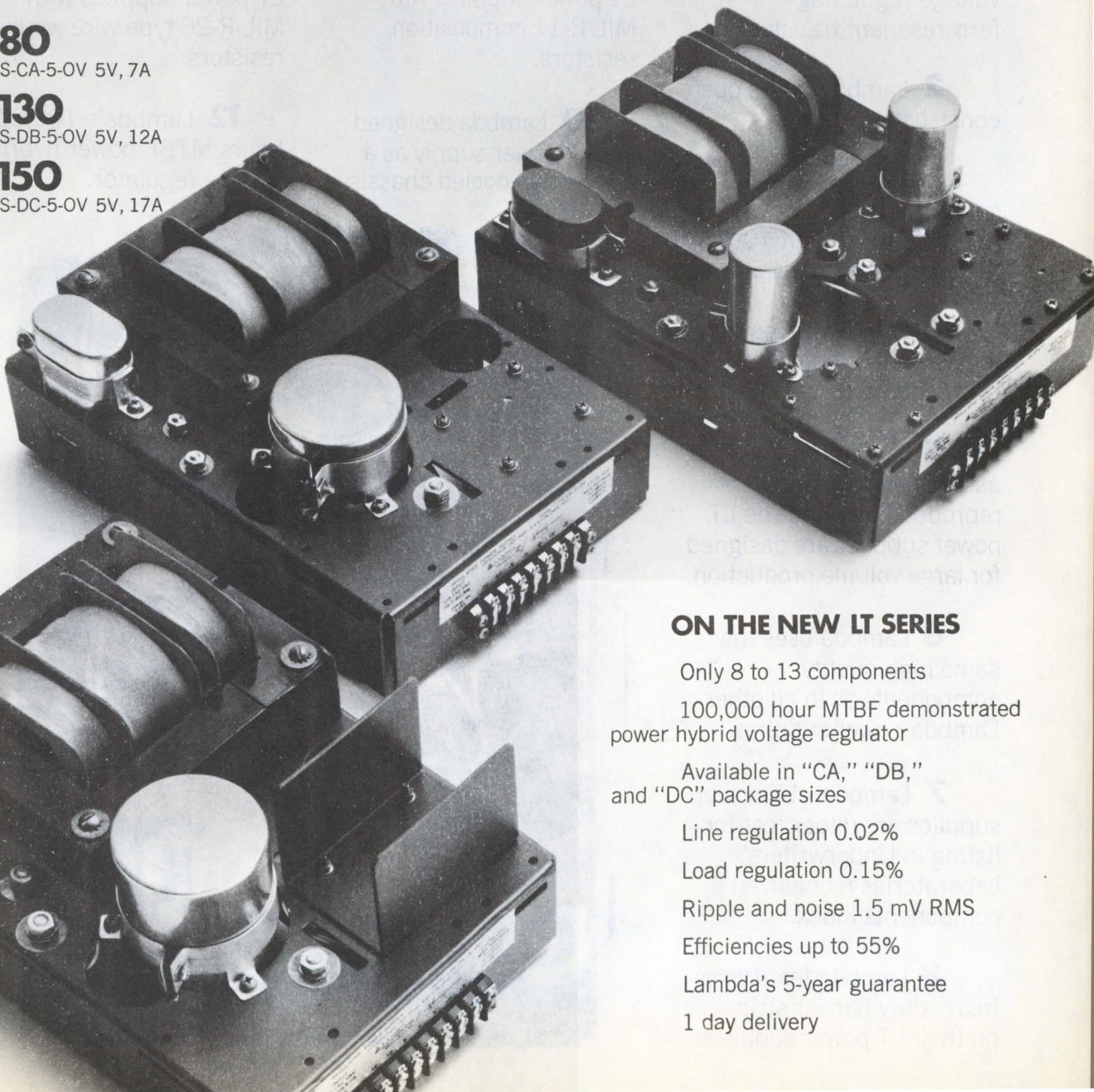
LTS-CA-5-0V 5V, 7A

**\$130**

LTS-DB-5-0V 5V, 12A

**\$150**

LTS-DC-5-0V 5V, 17A



## ON THE NEW LT SERIES

Only 8 to 13 components

100,000 hour MTBF demonstrated  
power hybrid voltage regulator

Available in "CA," "DB,"  
and "DC" package sizes

Line regulation 0.02%

Load regulation 0.15%

Ripple and noise 1.5 mV RMS

Efficiencies up to 55%

Lambda's 5-year guarantee

1 day delivery

# 12 REASONS WHY ONLY LAMBDA CAN GIVE YOU A MEANINGFUL 5-YEAR GUARANTEE...LT SERIES

**1** Lambda's long life voltage regulating ferroresonant transformer.

**2** Lambda offers open construction.

**3** Lambda uses computer grade hermetically sealed 10-year life electrolytic capacitors.

**4** Lambda LT power supplies have only 8 to 13 components.

**5** Lambda engineering assures performance reproducibility and the LT power supplies are designed for large volume production.

**6** Lambda uses the same high quality components as in all other Lambda power supplies.

**7** Lambda's LT power supplies are under test for listing in Underwriters' Laboratories recognized components index.

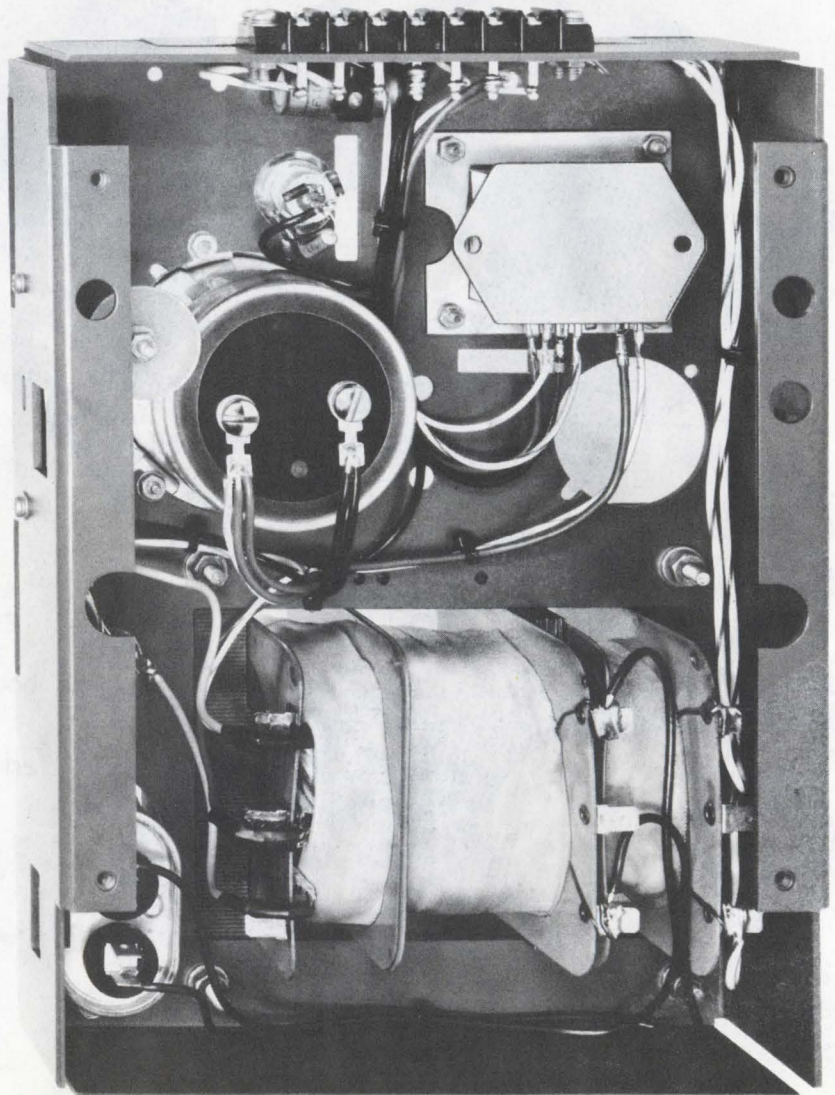
**8** Lambda features a heavy duty barrier strip on their LT power supplies.

**9** Lambda builds the LT power supplies with MIL-R-11 composition resistors.

**10** Lambda designed the LT power supply as a convection cooled chassis.

**11** Lambda builds the LT power supplies with MIL-R-26 type wire wound resistors.

**12** Lambda's 100,000 hours MTBF power hybrid voltage regulator.



# Why Lambda is the world's largest manufacturer of standard power supplies

Lambda maintains the industry's largest stock inventory of standard-power supplies with one day delivery on 90% of all models.

Lambda is its own distributor with a total inventory of over 10,000 power supply units located in Los Angeles, Chicago, Montreal, New York, France, Germany, and England.

Lambda has the most comprehensive power supply 5-year guarantee in the industry . . . in effect for over 20 years.

Lambda has a DIRECT field sales organization for world-wide sales and service.

Lambda maintains regional calibration and repair centers for servicing customers.

Lambda has the largest in-depth engineering department of any power supply manufacturer.

Lambda has a completely integrated facility with products thoroughly engineered from

the original concept to the shipping container.

Lambda has its own transformer plant for specialized production of all magnetic components.

Lambda power supplies are listed in Underwriters' Laboratories Recognized Component Index.

Lambda fulfills military specification requirements.

Lambda guarantees reproducibility of design, unit after unit.

Lambda is the RECOGNIZED leader in power supply design, engineering, manufacturing and quality assurance.

Lambda builds its own Power Hybrid Voltage Regulators—from basic material to finished product.

Lambda produces all its own metal parts from sheet . . . coining, drawing, and bending.

## Lambda's 5-year guarantee in effect for 20 years now includes entire LT series

Lambda's 5-Year Guarantee has proven itself four times over. It has covered Lambda manufactured power components, power instruments and power systems sold since the year 1953. It is another proof of Lambda's high caliber engineering, product design, quality control and production techniques which result in exceptional reliability.

### Labor and materials

The Lambda Five-Year Guarantee covers labor and all materials (except fuses) when returned to the factory. It also includes all semi-conductor components. It does not include non-magnetic components supplied with power kits, the LZ Series low cost power supplies or the Power Hybrid Voltage Regulator when purchased as a separate component.

### Components free of charge, if you repair

If the customer chooses to perform the maintenance, Lambda will supply all replacements for defective components without cost.

### Performance to published specifications

The Lambda 5-Year Guarantee covers the operation of the power unit for five years to published specifications. If, at any time during the five-year period, a power product does not meet the published specification when used within specified ratings, it can be returned to the factory for calibration. Contact the factory or the nearest Lambda office before returning equipment. Shipments must be prepaid and include reason for return.

### Transferable if you sell unit

If the unit is sold to a manufacturer who is using it in a system, which he is reselling, the complete guarantee is transferable—as long as the Lambda power product is sold as original equipment.

### All Lambda modifications

The 5-Year Guarantee covers most Lambda products, including units which have been modified by Lambda to fit customer's specific requirements.

## Models of LT series

### Power hybrid voltage regulator

All models have Power Hybrid Voltage Regulator providing complete regulation system.

### Overload protection Electrical

external overload protection; automatic electronic current limiting circuit limits the output current to a preset value, thereby providing protection for the load as well as the power supply.

### Thermal

Thermal overload protection is incorporated in Power Hybrid Voltage Regulator.

### Remote sensing

provision is made for remote sensing to eliminate effects of power output lead resistance on DC regulation, except for LT-CA units.

### Storage temperature range

-40°C to +85°C

### Overshoot

no overshoot on turn-on, turn-off or power failure.

### Input and output connections

through terminal block on chassis

### Convection cooled

no external heat sinking or forced air required.

### Mounting

two mounting surfaces, two mounting positions for LT-CA units; one mounting surface; two mounting positions for LT-DB and LT-DC units.

### Physical data Weight

LTS-CA— 6 lbs. net— 7 lbs. ship  
LTS-DB—12 lbs. net—14 lbs. ship  
LTS-DC—17 lbs. net—19 lbs. ship

### Size

4<sup>29</sup>/<sub>32</sub>" x 4<sup>15</sup>/<sub>16</sub>" x 9<sup>5</sup>/<sub>16</sub>"—LT-CA; 4<sup>29</sup>/<sub>32</sub>" x 7<sup>1</sup>/<sub>2</sub>" x 10<sup>1</sup>/<sub>2</sub>"—LT-DB and LT-DC units.

### Finish

gray, FED. STD. 595 No. 26081

### Accessories

rack adapters blank panels. Overvoltage protectors, are available for all models except 5V single output models which have built-in fixed overvoltage protection at 6.8 volts ±10%.

### LTS-CA SINGLE OUTPUT MODELS

4<sup>29</sup>/<sub>32</sub>" x 4<sup>15</sup>/<sub>16</sub>" x 9<sup>5</sup>/<sub>16</sub>"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:				PRICE
		40°C	50°C	60°C	71°C	
LTS-CA-5-OV*	5±1%	7.0	6.5	5.8	4.8	\$80
LTS-CA-6	6±1%	6.6	6.2	5.5	4.6	80
LTS-CA-12	12±1%	4.4	4.1	3.8	3.2	80
LTS-CA-15	15±1%	4.0	3.7	3.4	3.1	80
LTS-CA-20	20±1%	3.1	2.9	2.7	2.4	80
LTS-CA-24	24±1%	2.6	2.4	2.2	2.0	80
LTS-CA-28	28±1%	2.2	2.2	2.0	1.8	80

\*Includes fixed overvoltage protection at 6.8V±10%

### LTD-CA DUAL OUTPUT MODEL

4<sup>29</sup>/<sub>32</sub>" x 4<sup>15</sup>/<sub>16</sub>" x 9<sup>5</sup>/<sub>16</sub>"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:				PRICE
		40°C	50°C	60°C	71°C	
LTD-CA-152	±15±1%	2.0	1.8	1.7	1.5	\$110
LTD-CA-122	±12±1%	2.0	1.8	1.7	1.5	110

### LTS-DB SINGLE OUTPUT MODELS

4<sup>29</sup>/<sub>32</sub>" x 7<sup>1</sup>/<sub>2</sub>" x 10<sup>1</sup>/<sub>2</sub>"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:			PRICE
		40°C	50°C	60°C	
LTS-DB-5-OV*	5±1%	12.0	10.8	9.0	\$130
LTS-DB-6	6±1%	11.0	9.9	8.2	130
LTS-DB-12	12±1%	7.6	6.7	5.7	130
LTS-DB-15	15±1%	7.2	6.4	5.4	130
LTS-DB-20	20±1%	6.0	5.3	4.5	130
LTS-DB-24	24±1%	5.5	4.9	4.1	130
LTS-DB-28	28±1%	4.0	4.0	3.7	130

\*Includes fixed overvoltage protection at 6.8V±10%

### LTD-DB DUAL OUTPUT MODEL

4<sup>29</sup>/<sub>32</sub>" x 7<sup>1</sup>/<sub>2</sub>" x 10<sup>1</sup>/<sub>2</sub>"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:			PRICE
		40°C	50°C	60°C	
LTD-DB-152	±15±1%	3.8	3.2	2.6	\$160
LTD-DB-122	±12±1%	4.0	3.4	2.8	160

### LTS-DC SINGLE OUTPUT MODELS

4<sup>29</sup>/<sub>32</sub>" x 7<sup>1</sup>/<sub>2</sub>" x 10<sup>1</sup>/<sub>2</sub>"

MODEL	FIXED VOLT. RANGE VDC	MAX. AMPS AT AMBIENT OF:			PRICE
		40°C	50°C	60°C	
LTS-DC-5-OV*	5±1%	17.0	14.5	12.0	\$150
LTS-DC-6	6±1%	16.0	14.0	12.0	150
LTS-DC-12	12±1%	11.0	9.7	8.6	150
LTS-DC-15	15±1%	10.0	8.8	7.7	150
LTS-DC-20	20±1%	8.0	7.1	6.0	150
LTS-DC-24	24±1%	7.1	6.4	5.4	150
LTS-DC-28	28±1%	6.0	6.0	5.0	150

\*Includes fixed overvoltage protection at 6.8V±10%

## OVERVOLTAGE PROTECTOR ACCESSORIES

### OVERVOLTAGE PROTECTOR

MODEL	ADJ. VOLT RANGE VDC	PRICE(2)
LM-OV-2	6-20	30
LM-OV-3	18-70	30

### NOTES:

- Only one overvoltage protector accessory is required for dual outputs on LTD power supplies.
- Prices are USA list prices only. FOB Melville, N. Y.; North Hollywood, Calif.; Chicago, Ill.; Montreal, Canada. All prices and specifications are subject to change without notice.

The following charges are applicable for shipment from other than Melville, N.Y.

Value of Order**	Handling Charges*	Value of Order	Handling Charges*
up to \$50.00	\$1.00	\$181.00 to \$300.00	\$5.00
\$ 51.00 to \$180.00	\$3.00	\$301.00 to \$500.00	\$8.00

\*\*For orders with values in excess of \$500.00 add handling charges for the value(s) in the "Value of Order" list needed to cover the total value of the order being placed; for example with an order value of \$1274.00, double the \$8.00 handling charge for \$500.00 order value and add to it the \$5.00 handling charge for the \$181.00-\$300.00 order value for a total handling charge of \$21.00.

\*Not applicable when shipped from Montreal to Canadian customers.



## Specification

### DC output

voltage range: refer to tables

### Regulated voltage

regulation, line ..... 0.02%  
 regulation, load ..... 0.15% or 20mV whichever is greater  
 ripple and noise ..... 1.5mV RMS, 5mV pk-pk with either positive or negative terminal grounded  
 temperature coefficient ..... 0.01%/°C

### AC input

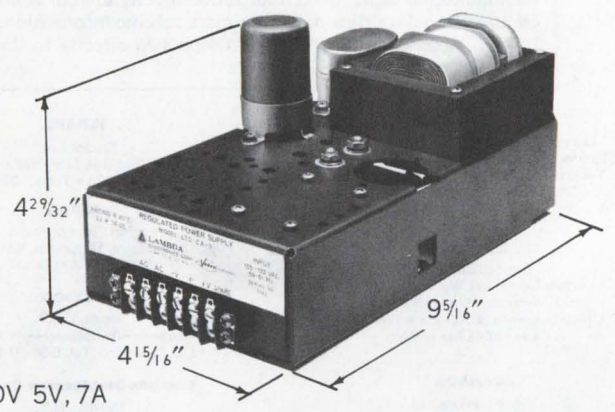
line ..... 105-132 Vac, 59.7 to 60.3 Hz. (STD. Comm'l. Line Frequency Spec.), LT-CA 125 watts max., LT-DB 225 watts max., LT-DC 300 watts max., consult factory for operation at other frequencies.

### Efficiency

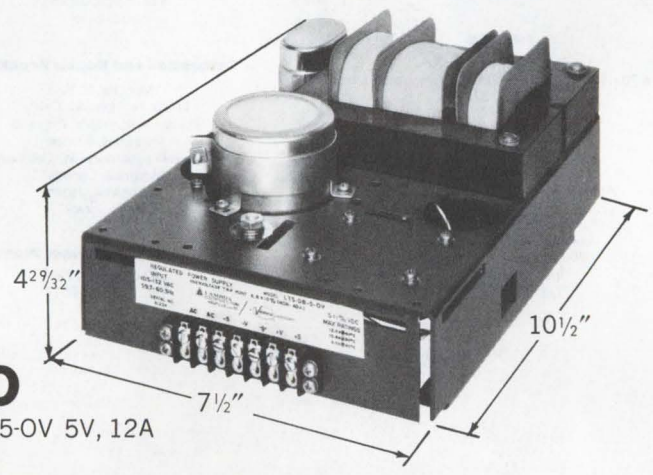
Approximately 33% for all 5 V and 6 V models  
 Approximately 48% for all 12 V and 15 V models  
 Approximately 55% for all 20 V, 24 V, and 28 V models  
 Approximately 50% for all duals.

### Ambient operating temperature range

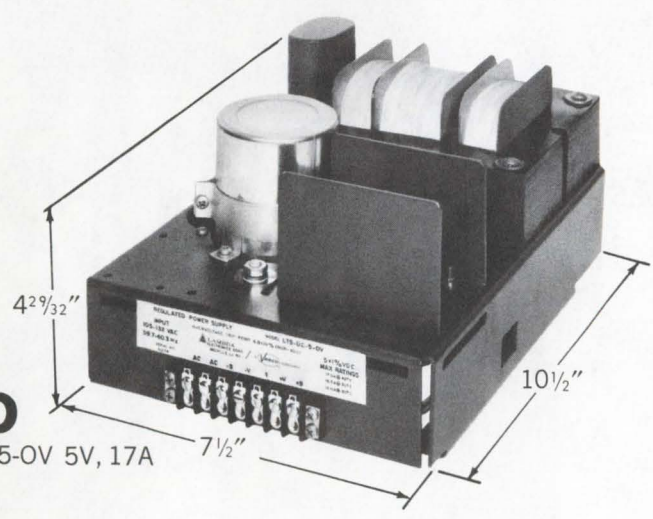
Continuous duty from 0° to +71°C for LT-CA models, and 0 to 60°C for LT-DB and LT-DC models with corresponding load current ratings for all modes of operation.



**\$80**  
LTS-CA-5-OV 5V, 7A



**\$130**  
LTS-DB-5-OV 5V, 12A



**\$150**  
LTS-DC-5-OV 5V, 17A

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Electronics Corp.  
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**How To Order**

All information necessary to order a power supply is given on each individual page. Send your order directly to your nearest Lambda sales office or call for more specific information. In U.S., orders may be mailed or telephoned directly to the main office in New York.

**1 MID-EASTERN REGION**  
**Melville, New York 11746**  
 515 Broad Hollow Road  
 Tel. 516-694-4200 • TWX: 510-224-6484

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 Tel. 716-454-6770

**Norristown, Pennsylvania**  
 Tel. 215-279-5644

**Greensboro, North Carolina**  
 Tel. 919-274-5745

**McLean, Virginia**  
 Tel. 703-356-0141

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 Tel. 713-464-6554

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**4 CENTRAL REGION**  
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 2420 East Oakton St., Unit Q  
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 TWX: 910-222-2856

**Minneapolis, Minnesota**  
 Tel. 612-935-6194

**Cleveland, Ohio**  
 Tel. 216-771-7447

**5 FAR-WESTERN REGION**  
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 7316 Varna Ave.  
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 599 N. Mathilda Ave., Suite 260  
 Tel. 408-738-2541 • TWX: 910-339-9243

**International**

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 515 Broad Hollow Road, Melville, N.Y. 11746  
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 Cable: Lambdatron, Melville, N.Y.

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Elscont Ltd.  
 Post Office Box 5258 Haifa, Israel  
 Tel. 724314, 722925 • Telex: 004-774 Haifa

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Pan Electron Inc.  
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 Tel. 045-471-8811

**MEXICO**

Mexitex, S.A.  
 Eugenia 408, Departments 1 & 5  
 Mexico 12, D.F. Mexico Tel. 5-36-09-10 or 5-43-03-77

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 Tel. 514-697-6520 • TWX: 610-422-3029

Veeco Lambda Ltd.  
 P.O. Box 501, Postal Station K  
 Toronto 12, Ont., Canada • Tel. 416-486-0794

**FRANCE**

Lambda Electronique, S.A.  
 64 a 70 rue des Chantiers, 78004, Versailles, France  
 Tel. 950-2224

**After Jan. 1, 1974**

Lambda S.A.  
 Route de Grivery  
 91 Gometz le Chatel  
 Address Postale: BP 77 91403 Orsay

**GERMANY**

Lambda Netzgerate GmbH  
 759 Achern-Fautenbach  
 Im Holzbosch 14  
 Tel. 078-41-5527

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Name \_\_\_\_\_ Title \_\_\_\_\_

Name \_\_\_\_\_ Title \_\_\_\_\_

Application \_\_\_\_\_

Regulation Requirements \_\_\_\_\_

Please have Field Sales Engineer Call.

Name \_\_\_\_\_ Title \_\_\_\_\_

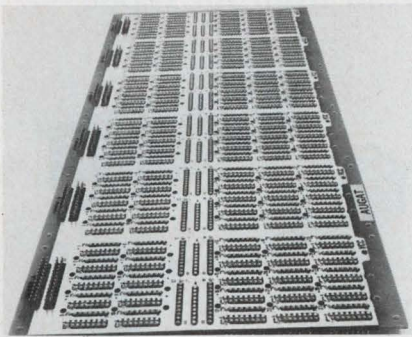
Company \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

Phone \_\_\_\_\_

## ECL can be packaged on wire-wrappable panels



Augat Inc., 33 Perry Ave., Attleboro, Mass. 02703. (617) 222-2202. See text.

Two new wire-wrappable ECL panels enable logic designers to avoid the layout time required for PC and multilayer boards. With ECL 5 and ECL 6 panels, to package a family of ECLs, the designer need only partition the logic functions and generate a wire list. Data rates of 100 MHz do not require any special wiring precautions. The tailoring or dressing of leads or the trimming of load resistors is not necessary, according to Augat. The secret lies in the control of the line-termination impedance. And unlike for PC or multilayer methods, it is not necessary to calculate the path impedances.

The panels are layered in several planes to distribute the supply voltages. And provisions for decoupling each voltage plane every 2-1/2 DIP locations are provided. These separate planes buss all the required voltages, -5.2 V, ground, and the -2 V that powers the down or line-loading resistors. Carbon, 1/8-W resistors that range from 100-120  $\Omega$  are recommended. They are wrapped directly to the receive pin of a signal line.

Wire wrapping is more flexible than PC construction, because it allows more rapid logic and circuit changes. And standard off-the-shelf panels make possible almost instantaneous circuit fabrication for experimenting, prototyping, breadboarding and even final production.

The ECL 5 panel can accommodate a mix of 24-pin logic, such as the 10181, four-bit, high-speed arithmetic unit and the 16-pin, 10179 look-ahead carry unit and many of the high-speed shift registers that are in 24-pin packages.

The new ECL 6 panel can handle a mix of ECL and TTL logic and TTL/ECL translators such as the 10124 and 10125 converters. A separate planar buss provides the positive voltage needed for the TTL circuits. The ECL 6 panel design minimizes ground-loop effects between peripheral TTL equipment and the ECL circuits. And the panel, with slight modification, can in addition also support CMOS logic.

Prices range from \$1.50 to \$2.50 per IC pattern, depending on style and quantity.

CIRCLE NO. 277

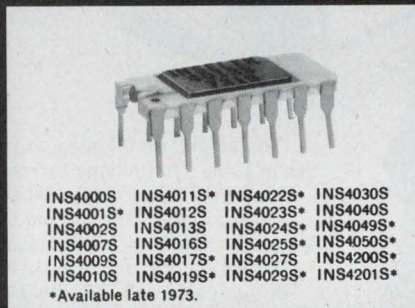
## Green LEDs rival red units in light output

Xciton Corp., Shaker Park, 5 Hemlock St., Latham, N.Y. 12110. (518) 783-7726. \$0.49 to \$0.79 (1000 up); stock.

Xciton's line of 20 green, light-emitting diode lamps and indicators produces light output that ranges from 0.4 to 6 mcd at forward currents of 10 mA. The units accommodate the three popular bulb styles—T-1, T-1-1/4 and T-1-3/4. Front-panel-snap-in and PC-board mounting styles are offered.

CIRCLE NO. 278

# WHEN YOU MAKE THE BEST CMOS IC'S IN THE BUSINESS, IT'S HARD TO BE MODEST.



INS4000S INS4011S\* INS4022S\* INS4030S  
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INS4007S INS4016S INS4025S\* INS4050S\*  
INS4009S INS4017S\* INS4027S INS4200S\*  
INS4010S INS4019S\* INS4029S\* INS4201S\*  
\*Available late 1973.

Who says we make the best? We do and our customers do. What's more, we can prove it. Only Inselek offers you C/MOS with the most optimum combination of higher speed (3 times faster than monolithic C/MOS) and lower power dissipation (typically less than 10 nW) than any other logic family. Pin-for-pin compatible with the CD4000 series too!

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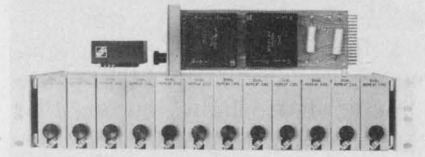


INFORMATION RETRIEVAL NUMBER 68 ▶

DISTRIBUTORS: WEST COAST—WESTATES (213) 341-4411  
NEW ENGLAND—GREEN SHAW (617) 969-8900  
MID-ATLANTIC—WILSHIRE ELECTRONICS (609) 786-8990

COMPONENTS

**Small repeat coils replace standard units**

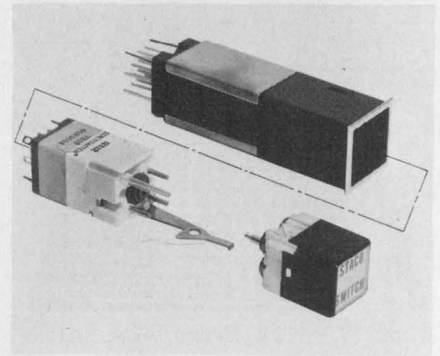


ADC Products, 4900 W. 78th St., Minneapolis, Minn. 55435. (612) 929-7881. \$9.75 (1000 up).

Though small in size, ADC universal repeat coils provide almost the same performance as larger standard units. Their multitap design enables them to replace four different standard repeat coils. The user can select 600:600, 900:900, 600:900 or 900:600-Ω impedance values. The new coil replaces a variety of WECO 120 Series coils. And unlike many other PC-mounted coils, they can handle up to a 150-mA-dc load.

CIRCLE NO. 374

**PB switch comes apart from front for repair**



Stacoswitch, Inc., 1139 Baker St., Costa Mesa, Calif. 92626. (714) 549-3041. \$13.65 (100 up); 1 to 4 wks.

The model 49 Staco lighted push-button switch provides a fast and easy method of changing switch modules in event of a malfunction. Both the display and switch module can be removed from the front of the panel for servicing. Displays can be quickly relamped. The switch comes with 2PDT or 4PDT contacts and momentary or alternate-action mechanisms. Contact ratings are 2-A resistive at 28 V dc or 115 V ac. Life expectancy is in excess of 50,000 cycles. A choice of solder or wrap-type wiring terminations is available.

CIRCLE NO. 375

**This Christmas give your car a Mark Ten B Capacitive Discharge Ignition. You and your car will enjoy it all year.**



The Mark Ten B keeps your car in tune. That means increased mileage, less maintenance and a better running car. A well-tuned car also decreases emission contaminants. All this adds up to more driving enjoyment for you. Mark Ten B, the perfect gift—for cars—and their owners.

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Please send: \_\_\_\_\_ Mark Ten B assembled @ \$59.95 ppd. \_\_\_\_\_ Mark Ten B Kit @ \$44.95

ppd. 12 volt negative ground only • \_\_\_\_\_ Standard Mark Ten, assembled, @ \$44.95 ppd.

\_\_\_\_\_ 6 Volt: Neg. Ground Only \_\_\_\_\_ 12 Volt: Specify \_\_\_\_\_ Pos. Ground \_\_\_\_\_ Neg.

Ground • \_\_\_\_\_ Standard Mark Ten Deltakit" @ \$29.95 ppd. (12 Volt Positive or Negative Ground Only)

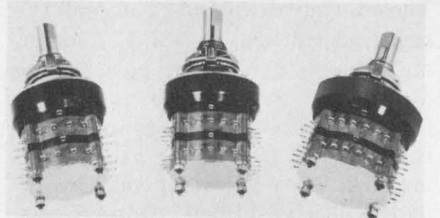
Car Year \_\_\_\_\_ Make \_\_\_\_\_

Name \_\_\_\_\_

Address \_\_\_\_\_

City/State \_\_\_\_\_ Zip \_\_\_\_\_

**Rotary enclosed switch meets military specs**

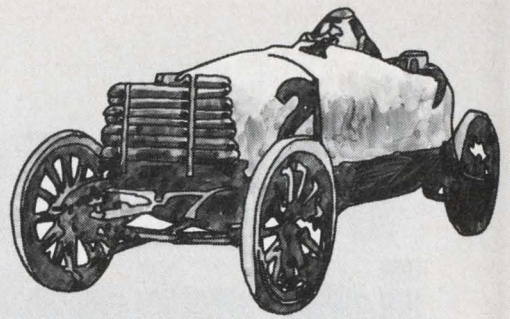


Grayhill, Inc., 561 Hillgrove Ave., La Grange, Ill. 60525. (312) 354-1040.

Series 53/57/59 rotary switches are the only military-qualified, enclosed 16, 20, and 24-position switches, according to Grayhill. They are qualified at 125 C with shaft and panel seals and with five or less decks that have eight or less poles per deck. Over 1100 such switch combinations are now qualified. The maximum diameter over the terminals of these switches is 1.350 in. Make and break load capabilities are as high as 150 mA.

CIRCLE NO. 376

The CRT display  
isn't really obsolete.  
DIGIVUE® just makes  
it look that way.



**And Design Adaptability Is One Reason Why . . .**

Digivue is the plasma display device from Owens-Illinois that delivers computer-generated alphanumeric and graphic displays at microsecond speeds. Digivue provides drift-free images, selective write/erase, inherent memory, hard copy printout potential, rear-projection capability.

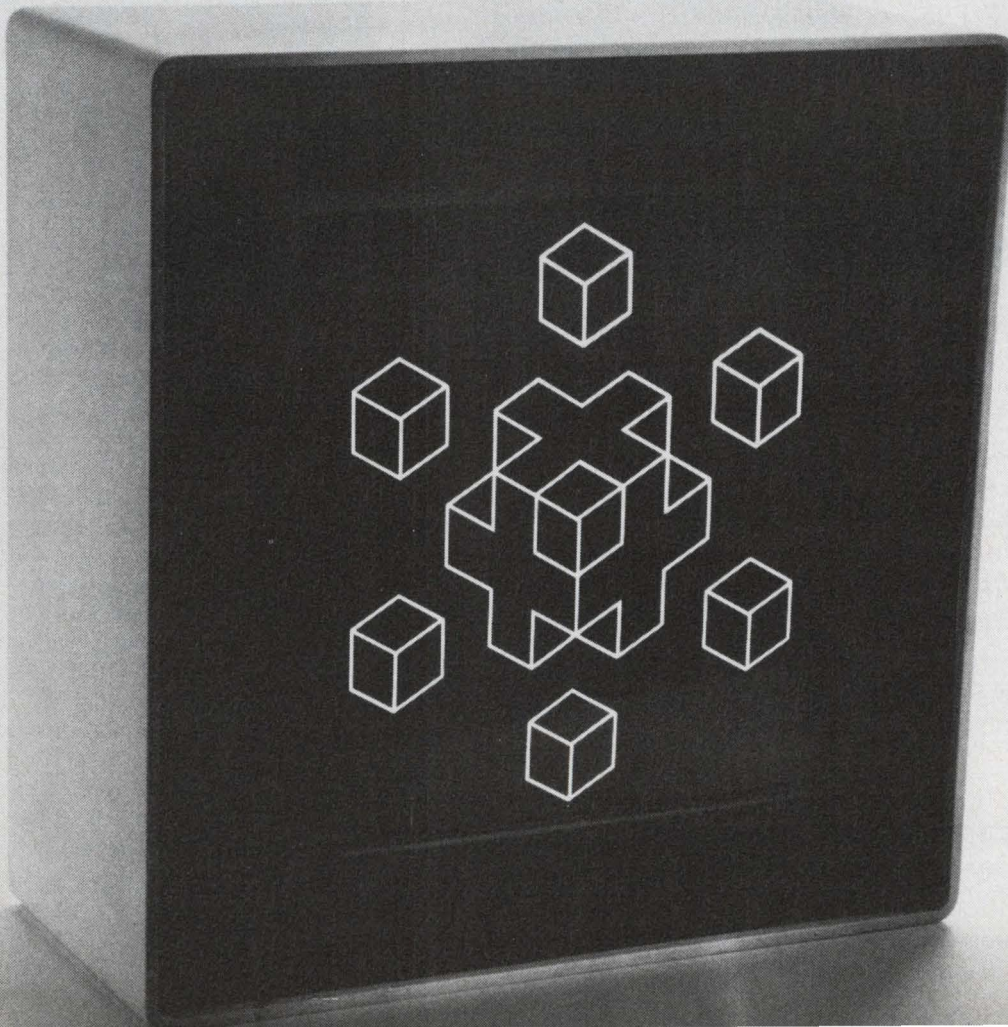
Digivue units are flat panel devices with panel depth independent of display size. Depth of panel and case for the 512-60 Digivue unit is a slim 7 inches, allowing for a variety of installation possibilities—in desks, drawers, walls, and physical compatibility with a variety of drive systems.

The bulky, boxy CRT display just can't match that kind of style.

If you'd like to know more about the next generation in display systems, take a look at tomorrow—take a look at Digivue.

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Electro/Optical Display Business  
Owens-Illinois, Inc.  
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INFORMATION RETRIEVAL NUMBER 70



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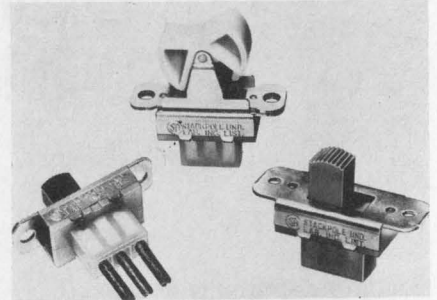


**POWERCUBE CORPORATION**  
214 CALVARY STREET, WALTHAM, MASS. 02154 (617) 891-1830  
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INFORMATION RETRIEVAL NUMBER 71

## COMPONENTS

### Slide and rocker switch accepts push-in leads

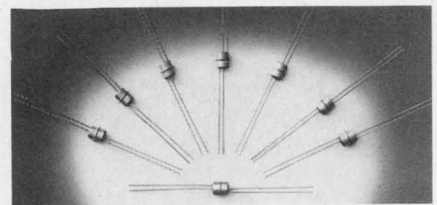


Stackpole Components Co., P.O. Box 14466, Raleigh, N.C. 27610. (919) 828-6201.

Push-in-lead slide and rocker switches allow the insertion of solid or tinned, stranded, copper wire leads directly into the switch base without special connectors, machines or fixtures. Available in SPST, SPDT, SPTT styles, the new units are no larger than standard switches and can handle 6-A, 125-V-ac UL and CSA ratings.

CIRCLE NO. 373

### Optocouplers isolate voltages to 1 kV



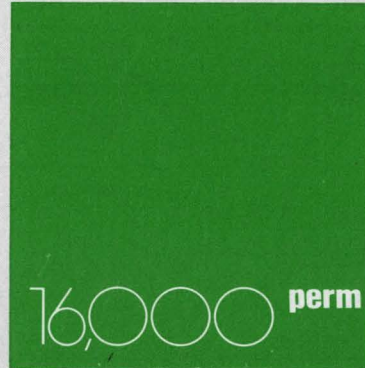
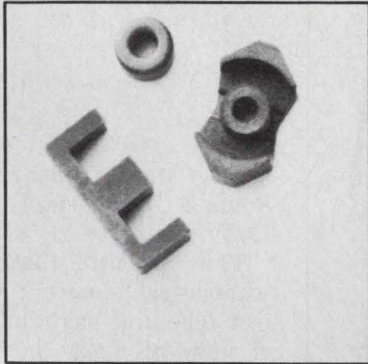
Optron, Inc., 1201 Tappan Circle, Carrollton, Tex. 75006. (214) 242-6571. \$2.95: OP 1007; \$3.50: OP 1008 (100 up); stock.

Two new optically coupled isolators feature high-efficiency gallium-arsenide emitters coupled with high-gain phototransistors. When used as replacements for pulse transformers and mechanical relays, the OP 1007 and OP 1008 isolators provide a solution for such problems as common-mode noise rejection, ground loops and voltage-level translation. The isolators provide an input-output resistance of greater than  $10^{13} \Omega$  at an isolation voltage of 1 kV and a typical coupling capacitance of 0.4 pF. Typical current transfer ratios are 10% for the OP 1007 and 20% for the higher-gain OP 1008. Both units come in a hermetic axial-lead package.

CIRCLE NO. 279

# broad band- rated™

Ferramic® components  
guarantee circuit  
performance



## New expanded line

Now you can get *Broad Band-Rated* components designed specifically for your critical bandwidth applications from 100 Hz to above 250 MHz. New shapes include mated parts in pot core, RM6 and E core configurations.

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That's us.

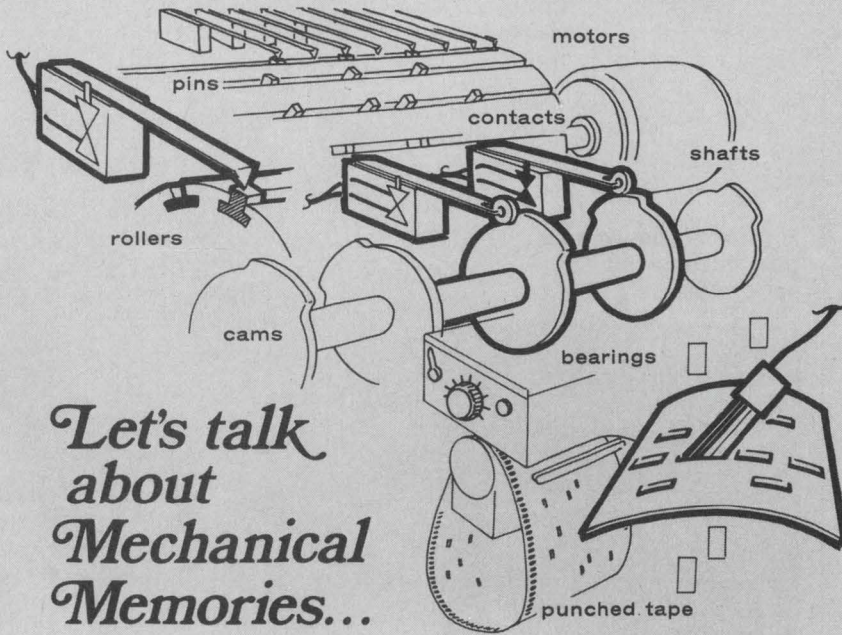
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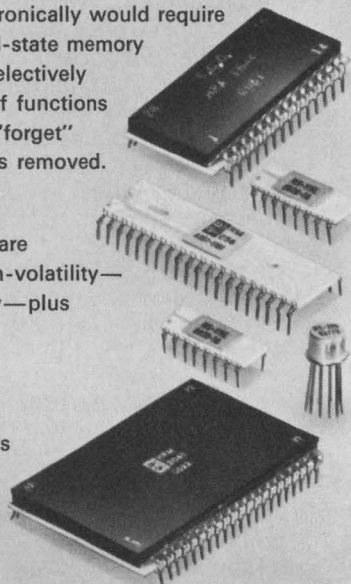
## Let's talk about Mechanical Memories...

Ever wondered why so many control systems still rely on mechanical and electromechanical components to perform "memory" functions? Why they haven't switched over to reliable solid-state electronics—yet?

It's because performing such functions electronically would require two essential characteristics in a single solid-state memory system: (1) It *must* be quickly, easily and selectively reprogrammable to accommodate a variety of functions and function changes. And (2) it *must not* "forget" what it's supposed to do every time power is removed. Then, of course, there's the matter of cost.

Now—how many semiconductor memories are there on the market today that offer true non-volatility—plus selective, repetitive electrical alterability—plus non-destructive readout—all combined in a single, low-cost, integrated array?

*Just one!* And it's available now in standard units ranging from 8-bit up to 2048-bit arrays that can readily be configured to meet your particular requirements.



### AMORPHOUS

# RMM

## Non-Volatile/Repetitively Alterable Semiconductor Memory Arrays

If you'd like to know first-hand how RMMs can be used to improve your product's reliability, versatility and cost, our Systems Engineering Group will gladly evaluate your application and submit detailed recommendations. Just call or write Howard Klausmeier at:



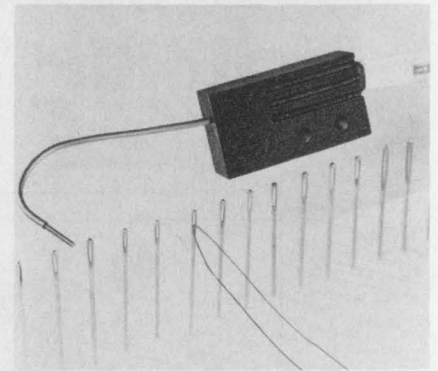
### RMM DIVISION

**Energy Conversion Devices, Inc.**

1675 WEST MAPLE ROAD • TROY, MICHIGAN 48084  
TELEPHONE: 313/549-7300

### COMPONENTS

## Fiber-optic IR scanner detects 0.001-in. object



*Skana-Matic Corp., P.O. Box S or Route 5 W, Elbridge, N.Y. 13060. (315) 689-3986.*

The S2005-3 LED fiber-optic scanner can detect a 0.001-in. object. The unit has a minimum field of view of 0.025 in. This enables the scanner to differentiate between 0.007-in. width lines that are spaced 0.007-in. apart. In indexing tests the unit has attained a repeatability of an object's position to  $\pm 0.000005$  in. The scanner's semi-rigid snout, which contains a coaxial fiber-optic bundle, can easily be bent by hand to position the tip. Infrared passes from a LED via the outer-diameter fiber optics to the target. Reflections from the target return through the center fibers to a photo-Darlington.

CIRCLE NO. 280

## Magnetic sensor output proportional to speed

*Electro Corp., 1845 57th St., Sarasota, Fla. 33580. (813) 355-8411. \$37.50 (unit qty); stock.*

Di-Mag Model 58407 is a digital magnetic sensor for synchronizing, positioning and timing applications in disc-drives, high-speed printers and other data processing equipment. The unit measures only  $1/4$  D  $\times$   $1-1/8$  L in. It produces a constant-amplitude output signal with frequency directly proportional to the speed of the sensed actuator. Signal conditioning is performed internally. The unit's specifications include: power supply, 5 to 15 V dc at 15 mA; output impedance,  $4.3 \text{ k}\Omega \pm 20\%$ ; sensitivity, min. 17 in/s with a 20 DP gear at 0.005-in. gap.

CIRCLE NO. 281



# Our Data Com Team: Champions of the MOS/LSI League.

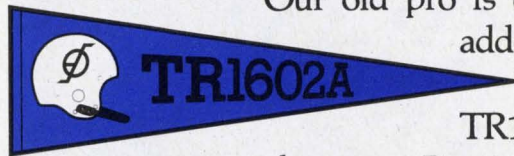
More and more systems engineers are picking the winners—Western Digital MOS/LSI. That's why we have more devices working in more data com applications than any team in the league. Look at our lineup of outstanding players:

The Rookie of the Year is our FR1502E FIFO (First-In First-Out) buffer memory. It's in a formation 9 bits wide to match your data. Features like tri-state data lines, master reset and status flags, optional 500 kHz or 1 MHz asynchronous input/output, and easy expansion with no external hardware make you stand up and cheer. It's the most cost effective method of data speed buffering available.

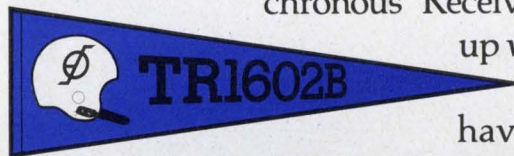
If speed is your data com game, try our Programmable Synchronous/Asynchronous Transmitter P/SAT (PT1482B) and Receiver P/SAR (PR1472B). Whatever data transmission play you are calling, this programmable duo upgrades systems with speeds to 100 kilobits/second or more. And you call signals in synchro-



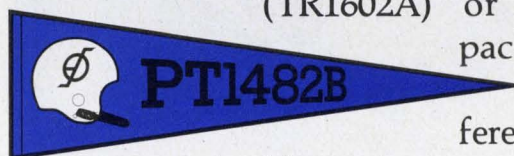
nous, asynchronous or even isochronous modes.



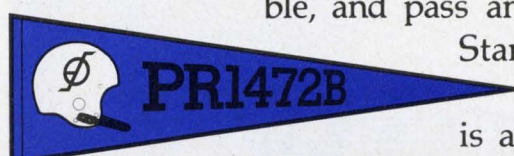
Our old pro is calling new plays. We've added 1.5 stop bits capability to our seasoned favorite



TR1402A MOS/LSI Asynchronous Receiver/Transmitter and come up with a new league standard



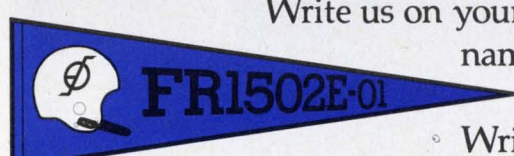
—the TR1602 series. You have the option of ceramic or hermetic plastic cavity packages (TR1602B). These



compatible, double-buffered devices are programmable, and pass and receive simultaneously.



Start and stop bit generation is automatic. Delivery is as fast as you can call it.



**Free NFL Pennant**

Our data com devices are champions of the MOS/LSI League. Find out why.

Write us on your letterhead and tell us the name of your favorite National Football League team.

Write before January 5, 1974, and we'll send you an NFL pennant for your favorite, along with literature on our winning team.

Write Western Digital Corporation, 19242 Redhill Ave., Newport Beach, California



92663. Tel: 714/557-3550. TWX: 910-595-1139.



## Go with the action...Go Western Digital!

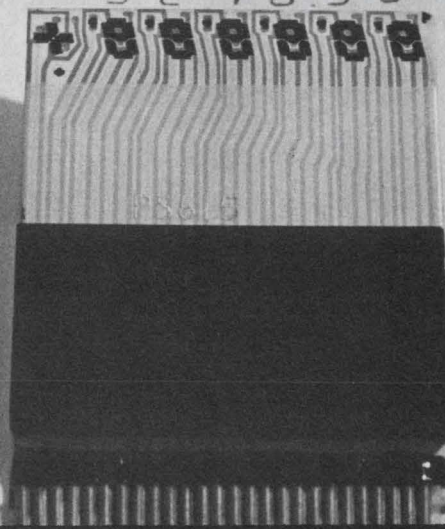
INFORMATION RETRIEVAL NUMBER 74

Especially designed for your data logging applications, to give you . . .

- quiet, reliable, non-impact printing
- simplified mechanical design — no moving printing parts
- highly legible 155-mil characters
- expandability to any number of digits
- speeds to 8ms per character
- multiplexed operation

# PUT IT ON PAPER WITH GULTON'S NEW LOW COST THICK FILM THERMAL PRINTHEADS

Part Number	Description	Unit Price (25-99)
PS4151	4-Digit with ± symbol	\$28.00
PS5150	5-Digit Expander	\$32.50
PS6151	6-Digit with ± symbol	\$37.50
PS6153	Multichannel ± 4-Digit	\$37.50
PS7150	7-Digit Expander	\$45.30



coming soon—special calculator and alphanumeric printer configuration

Industries Inc.

# Gulton

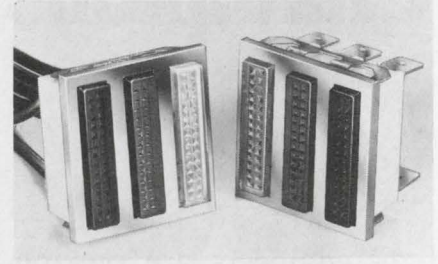
Electronic Components Division

- PRECISION MULTILAYER SUBSTRATES • THERMISTORS •
- PIEZOCERAMIC ELEMENTS • CERAMIC EM FILTERS

212 Durham Ave., Metuchen, N.J. 08840 — (201) 943-2600, Ext. 202 — TWX: 710-998-0592

## COMPONENTS

### Indicator lights sport triple colored lenses

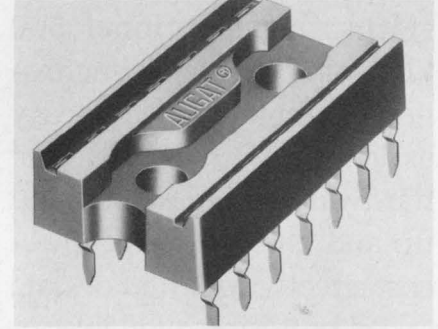


Sorenson Lighted Controls, Inc., Suite 810, 1428 Brickell Ave., Miami, Fla. 33131. (305) 358-6112.

The RT series indicator light features three separate nylon or Lexan lenses. Any three of the six available lens colors may be specified: clear, red, amber, white, blue and green. The unit snap-fits into a 1.28 × 1.234-in. mounting hole in panels from 0.09 to 0.30-in. thick. Black-plastic, 105-C leads 6-in. long, with their ends stripped and tinned, are standard. Though a chrome-plated bezel is normally supplied, decorative bezels in black or bright brass are also available.

CIRCLE NO. 282

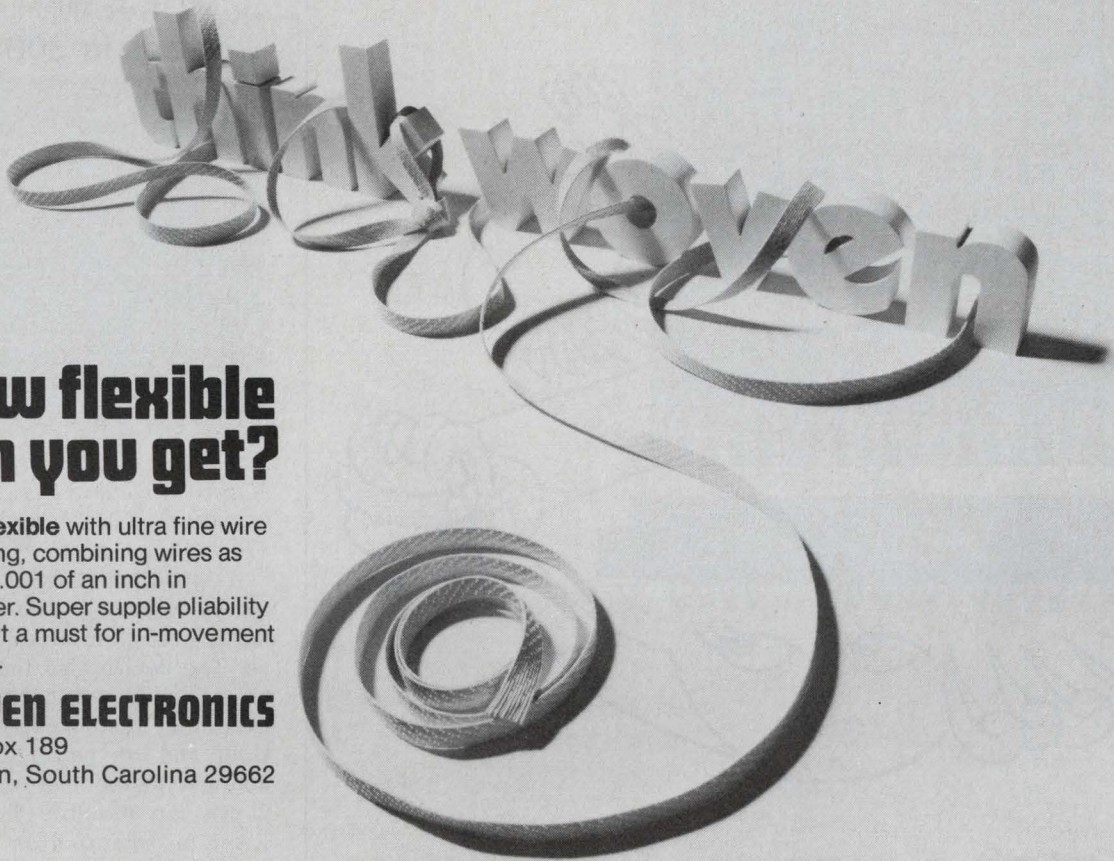
### DIP socket holds self for wave soldering



Augat Inc., 33 Perry Ave., Attleboro, Mass. 02703. (617) 222-2202. \$0.15 to \$0.38 (OEM qty).

Augat's new low-profile DIP socket provides positive retention in 1/16-in. PC board, with a special "dap" in the contact tails. The socket, designed for automatic board insertion, simply snaps into position and holds itself in place until soldering is completed. The sockets are available in either 14 or 16-contact configurations. There is a 0.020-in. standoff between the insulator and the PC board to allow circuit clearance and flux cleaning.

CIRCLE NO. 283



## How flexible can you get?

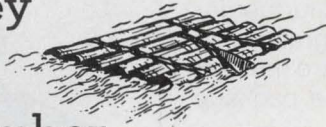
**Ultra-flexible** with ultra fine wire stranding, combining wires as slim as .001 of an inch in diameter. Super supple pliability makes it a must for in-movement service.

### WOVEN ELECTRONICS

P.O. Box 189  
Mauldin, South Carolina 29662

INFORMATION RETRIEVAL NUMBER 76

you'll remember  
**OTHER TRIMMERS**  
because they  
**DRIFT...**  
you'll remember  
**OURS** because they  
**DON'T!**



*Stay-put Trimmers by VISHAY feature:*

- Tempco to 10ppm/°C
- 0.05% setability
- Low noise (3Ω ENR typical)

VISHAY Accutrim™ Trimmers are available in a variety of 1¼" rectilinear and ¼" square styles

**WRITE FOR APPLICATION BULLETINS**



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a division of Vishay Intertechnology, Inc.  
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TELEPHONE AREA CODE (215) 644-1300

INFORMATION RETRIEVAL NUMBER 77

ELECTRONIC DESIGN 25, December 6, 1973

## HIGH PERFORMANCE ENCODERS USING DECTRAK®



Whether your requirement is incremental or absolute, English or metric, DECTRAK can provide a high performance, reliable encoder at a reasonable price.

- Absolute BCD Output to 999999
- Incremental range to 2000 pulses/rev.
- Rugged heavy-duty industrial design
- Requires only 5 VDC for operation

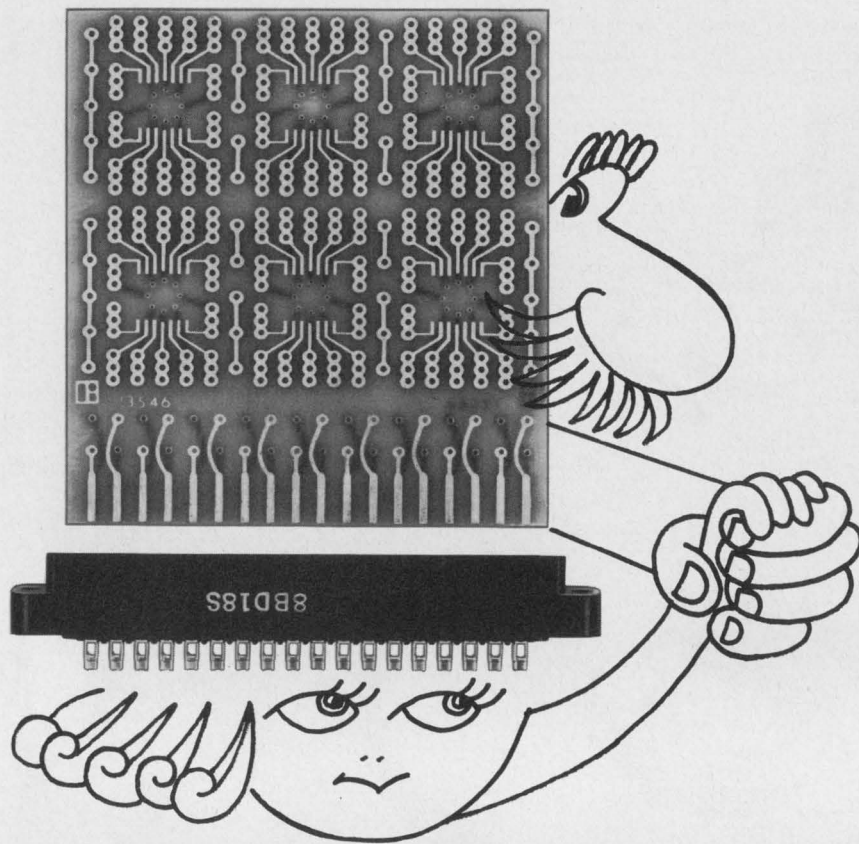
Have a systems problem? THETA can solve that too.

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Phone: 201 - 227-1700

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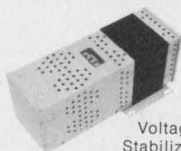


## We call them an engaging couple

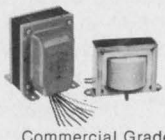
Get acquainted with this well-matched pair. No need to look further for the right connector to use with Triad's versatile line of integrated and universal circuit cards. If you put a "CO" prefix ahead of the card number, you'll get the applicable Winchester connector in the same package with the card — ready for you to put together.

Triad has many low-cost, fast-delivery cards for breadboarding and testing use: cards for flat packs, TO-5's and dual in-line packages — with or without connectors; plug-in terminal cards, extender cards, solder training cards.

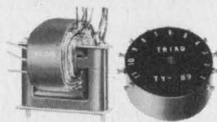
So, if you want to meet an engaging couple, call your nearest Triad distributor. He can also help on your transformer, inductor and filter requirements — we're big in these components, too. Triad-Utrad Distributor Services, 305 North Briant Street, Huntington, Indiana 46750.



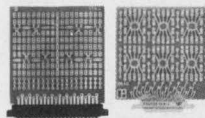
Voltage Stabilizer Transformers



Commercial Grade Powers and Audios



Transistor Power Supply Transformers

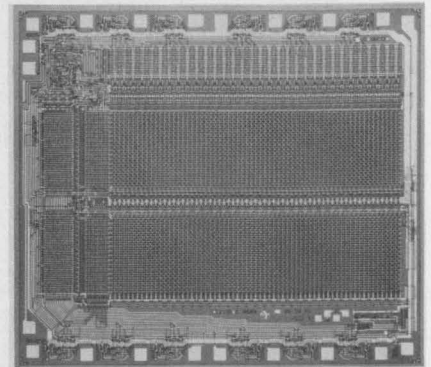


Integrated Circuit Cards

 **TRIAD-UTRAD**  
Litton Distributor Services  
INFORMATION RETRIEVAL NUMBER 79

### ICs & SEMICONDUCTORS

## 4k MOS RAM accesses in 300 ns

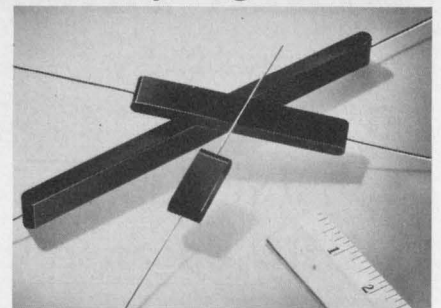


Texas Instruments, P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. TMS4030JL: \$26.35 (100-999); 6-8 wk.

A 4096-bit MOS/LSI random-access memory—the TMS4030—has a maximum access time of 300 ns. The device also features a 470-ns maximum cycle time, a 710-ns maximum read/modify/write cycle time, and low power dissipation of 400 mW in the operating mode and 2 mW at standby. The n-channel RAM is organized as 4096 one-bit words, and uses a one-transistor cell design.

CIRCLE NO. 284

## High voltage rectifiers can carry large currents

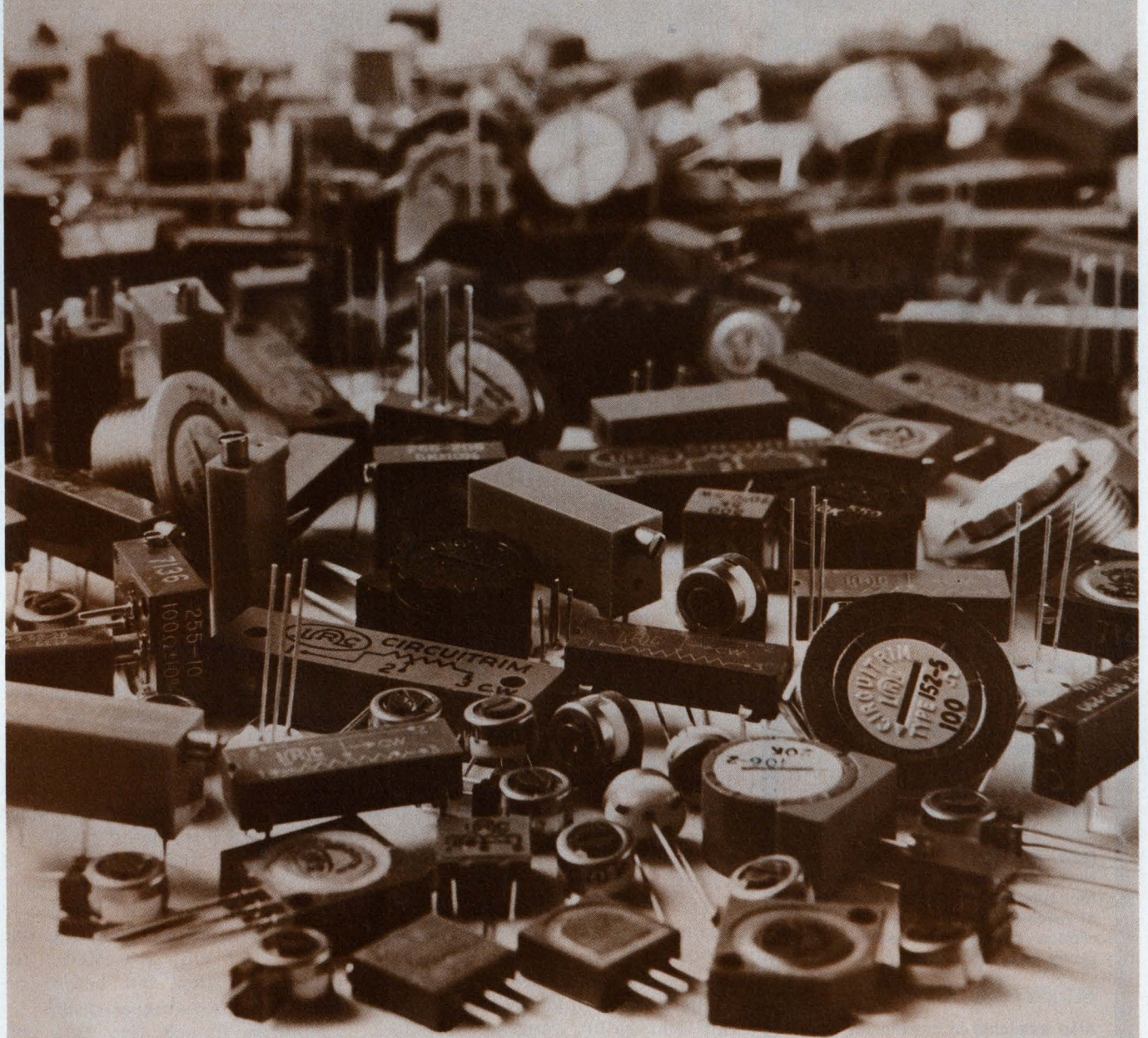


Sarkes Tarzian, 415 N. College Ave., Bloomington, Ind. 47401. (312) 467-1326. From \$6 to \$46.

The HVS Series of high voltage silicon rectifiers is available in seven PIV ratings, from 2500 to 20,000 V, with a one cycle surge current rating of 300 A. They can also handle continuous currents of 2 A at 55 C. The rectangular, molded plastic cases have a 0.375 by 0.687 in. cross-section, with lengths varying from 1.5 to 8.5 in. depending upon PIV rating. Leads are silver plated copper wire with diameters of 0.051 in.

CIRCLE NO. 285

# We're everything you need in cermet trimmers. We're TRW/IRC Potentiometers.



These infinite resolution pots cover the complete size range from 1/4" round to 1 1/4" rectangular in the industry's widest selection of mounting configurations.

The exclusive Metal Glaze® element results in a cermet trimmer with higher power rating and wider temperature range than other manufacturers' units of the same size. Maximum temperature coefficients

of  $\pm 100$  ppm/°C. are standard, with TCs of  $\pm 50$  ppm available on most types.

For fast delivery, from stock, call any TRW/IRC Potentiometer distributor. For information of the complete line, contact your distributor of TRW/IRC Potentiometers, an Electronic Components Division of TRW Inc., 2801-72nd Street North, St. Petersburg, Fla. 33733; phone (813) 347-2181.

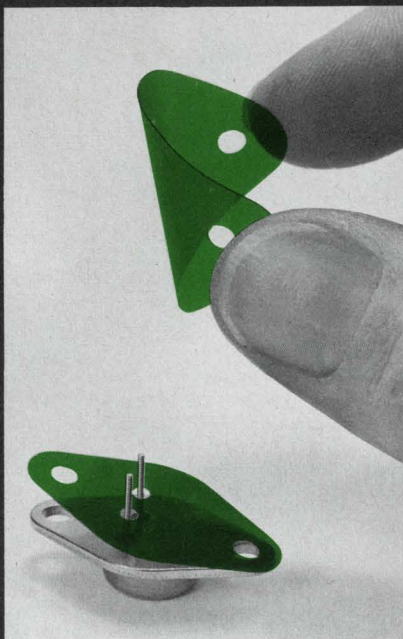
## TRW<sup>®</sup> IRC POTENTIOMETERS

CPI-7305

INFORMATION RETRIEVAL NUMBER 80

# NEW LOW-COST THERMAFILM II

Easy-to-handle  
insulating washers  
cost less than mica



- No chipping
- No peeling
- No breaking
- Bright green color identification
- Interface thermal resistance .6°C/W
- 1000 V/mil dielectric strength
- For case temperatures to 125°C

Now available from Thermalloy: New, low-cost Thermafilm II with the superior electrical properties of original Thermafilm. Helps you reduce rework and rejects, improve product reliability.

## MOUNTING KITS

Also available in convenient, low-cost mounting kits for TO-3 and TO-66 packages.

**FREE SAMPLES**

Circle reader service number

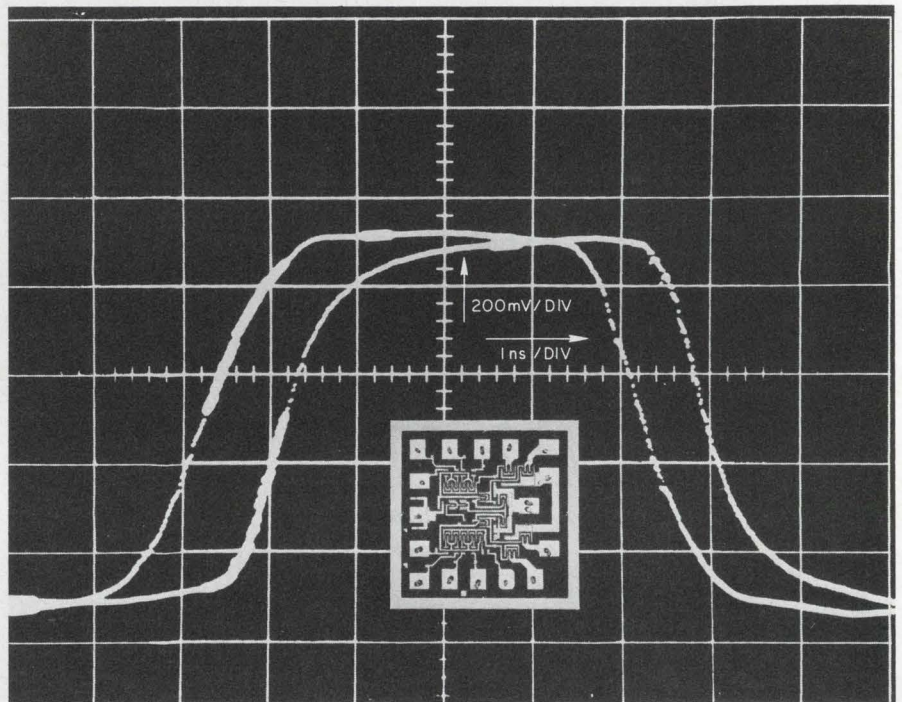


**Thermalloy Inc.**

P.O. BOX 34829

2021 VALLEY VIEW LANE/DALLAS, TEXAS-75234  
TELEPHONE (214) 243-4321/TWX 910-860-5542

## ECL-gate propagation delay cut to 0.91 ns or less



Motorola Semiconductor Products, Inc., 5005 E. McDowell Rd., Phoenix, Ariz. 85008. (602) 244-6900. P&A: See text.

Get propagation delays of less than 1 ns with off-the-shelf dual OR/NOR gates. The Motorola MC1688F MECL III circuit has a maximum propagation delay of only 0.91 ns (0.8 ns typical). Rise and fall times to the 10 and 90% points are both 1.7 ns.

The MC1688F dual gate will interface with both the MECL 10,000 series and the other MECL III devices. It comes in a 16-pin ceramic flatpack and has an operating temperature range of -30 to +85 C. The circuit consists of two independent OR/NOR gates, one with four inputs and one with five. All inputs are internally terminated by a 50-k $\Omega$  resistor that is tied to the  $V_{EE}$  pin. This eliminates the need to tie unused inputs low.

With the nominal supply voltages of  $V_{EE} = -12$  V,  $V_{CC1} = +4$  V and  $V_{CC2} = +5$  V, the no-load power dissipation of the unit is typically 125 mW. About 60 mW of this is dissipated by each gate

and the remainder by the bias regulator circuit. At 25 C, the typical power-supply current drain,  $I_E$ , is 24 mA.

Input current at room temperature varies from 350  $\mu$ A max for  $I_{in}$  (high) to 0.5  $\mu$ A min for  $I_{in}$  (low). Output voltages vary from 0.98 V min for  $V_{OH}$  to 1.6 V max for  $V_{OL}$ . Outputs match 50  $\Omega$  lines to minimize interfacing problems.

To measure the performance of circuits like the MC1688F, sampling oscilloscopes must be used to capture the fast rise and fall time traces. Each chip is tested after wafer separation, but before assembly, for grading purposes.

Motorola uses a very thin epitaxial layer and extremely rigid process control to obtain the sub-nanosecond gate delays.

A number of other high-speed circuits are under development by Motorola. These include a 1-GHz divide-by-10 counter, and gates with other configurations.

The MC1688F sells for \$22.50 (1 to 24), \$18.75 (25 to 99) and \$15 (100-up). It is available from stock in small quantities.

CIRCLE NO. 256

Dear Gabby: \_\_\_\_\_

"How can I display the most messages for the least dollars?"



Shelly's Girl Gabby



Try Shelly. This is the actual size of their SR-90 multi-message module. You get a 20% larger image in a 20%

smaller housing. Just imagine. 12 different messages in black & white or color from decimal or BCD inputs at only \$2.50 per message. That's one way to beat inflation. Better send for our free brochure.

*Gabby*

**shelly/datatron**

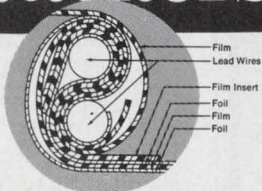
1562 Reynolds Ave., Santa Ana, California 92711  
(714) 540-9330

INFORMATION RETRIEVAL NUMBER 82



New Era in film capacitors!

POLYESTER MICROMATIC® CAPACITOR\*



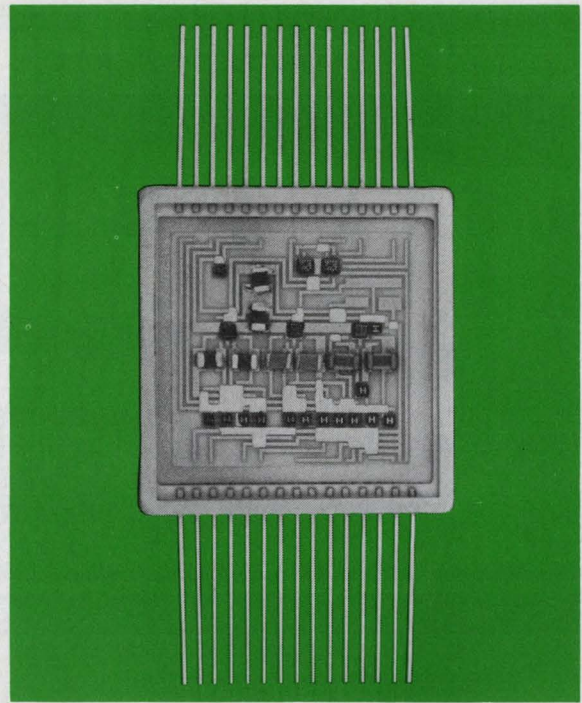
The Polyester Micromatic Capacitor provides another film capacitor design breakthrough from ITW Paktron. Here's a new polyester film capacitor smaller in size than comparable wrap and fill polyester units. And competitive with shrink-tube and/or conformal coated axial lead products presently marketed. Completely self-encased and wound on its own leads. No outside wrapping, no separate lead attachment needed. Capacitance tolerances are a low  $\pm 5\%$ . Capacitance value range .001 to 0.15mfd. Up to 600 volts. Ideal for PC board insertion due to lead concentricity. Also available in polypropylene dielectrics. Phone or write: Paktron, Division Illinois Tool Works Inc., 900 Follin Lane, S.E. Vienna, Virginia 22180. Phone (703) 281-2810. TWX 710-833-0682.

**PAKTRON**

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\* Patent No. 3638086  
Other Patents Pending



Custom Hybrids from the custom shop.

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They call us "The Specialists" with good reason when it comes to custom hybrid integrated circuits.

Dickson has over 7 years solid experience in manufacturing custom hybrids to the most exacting Government and customer specifications. In addition to our knowledgeability in thick film techniques, we offer you extensive experience in hermetically sealed packaging for special needs.

Reliability? Dickson custom hybrids are manufactured to Mil-STD 883.

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INFORMATION RETRIEVAL NUMBER 83

ELECTRONIC DESIGN 25, December 6, 1973

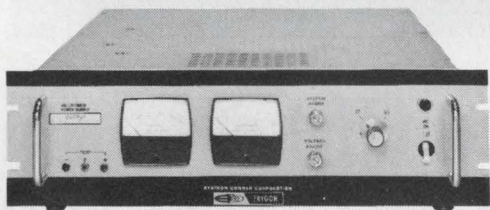
INFORMATION RETRIEVAL NUMBER 84

your best value is a

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## SYSTRON-DONNER POWER SUPPLY

QUALITY/RELIABILITY/SERVICE



VP Series  
**\$595**

A high power, economical systems supply that powers and protects critical and sensitive IC circuits.

Up to 30VDC    Up to 135AMPS  
in your choice of ranges

- Adjustable current limiting
- Low Noise
- Meters and Overvoltage Protection optionally available

**FEATURES** • Standard ratings are 5V/135A, 12V/90A, 15V/85A, 24V/60A, 28V/50A • automatic load share paralleling • low output impedance • remote sensing and programming • 0.02% line regulation • 0.05% load regulation • less than 1mV RMS ripple . . . all for only \$595.

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The Systron-Donner Instruments Group:

Concord Instruments  Computer Systems  Datapulse  Kruse Electronics  Microwave  Trygon Electronics

INFORMATION RETRIEVAL NUMBER 85

ICs & SEMICONDUCTORS

### Divide by N with CMOS counter

RCA Solid State Div., Route 202, Somerville, N.J. 08876. (201) 722-3200. \$20 (sample quantities).

A COS/MOS 4-decade divide-by-N counter, the TA6006, can be programmed to divide a system clock frequency by any number from 3 to 15,999. The single output from this device has TTL drive capability. The counter is preset by 16 "jam" inputs and is programmed by three mode-select control inputs. The TA6006 comes in a 24-lead dual-in-line ceramic package.

CIRCLE NO. 286

### FIFO memory buffers asynchronous systems

Advanced Micro Devices, 901 Thompson Pl., Sunnyvale, Calif. 94086. (408) 732-2400. Am2841DC: \$15.60 (100 up).

A first-in first-out (FIFO) memory, the Am2841, can be used for buffer-type applications. Since it offers independent read and write operations, the IC can buffer two pieces of digital equipment that operate at different clock rates. The Am2841 is organized as 64 four-bit words and offers a guaranteed data rate of 1 MHz. The circuit has a master reset that completely clears the unit, and has internal circuitry to provide TTL compatibility.

CIRCLE NO. 287

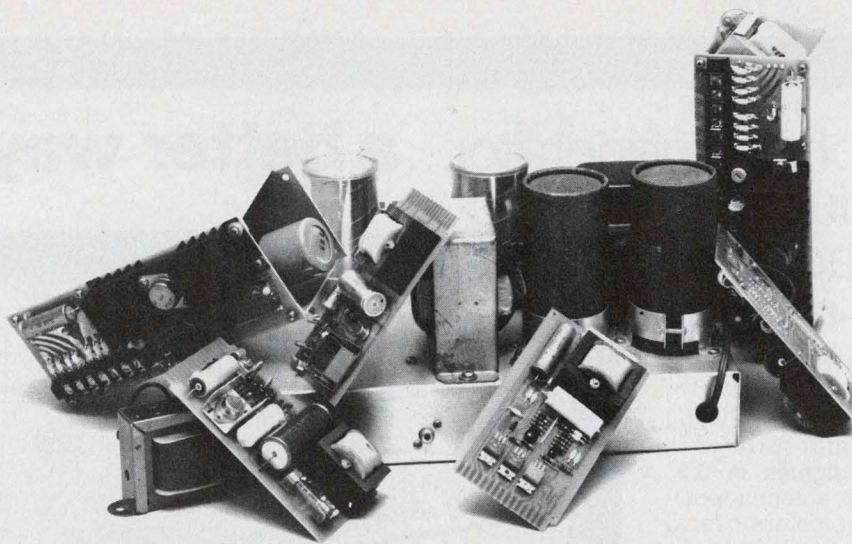
### ECL multiplexer/latch has low propagation time

Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700. \$4.80 (100 up).

Two dual clocked D-type ECL latch circuits Models 10132 and 10134, come with 2-to-1 data multiplexing. They have propagation delay times of 2.5 ns for data, 3.7 ns for select, 3 ns for reset (10132) and 4 ns for clock. Typical power dissipation is 225 mW per package with no load. Both devices can drive 50-Ω lines and the inputs have built-in 50 kΩ pulldown resistors. Both devices are housed in 16-pin ceramic DIPs and are rated for normal operation over a temperature range of -30 to +85 C.

INQUIRE DIRECT





## Retire the Relics.

Unless you're going into the antique electronics business ... now's the time to replace those open-frame power supplies with today's space-saving, encapsulated power modules.

Our miniature power modules are "triple-tested" for reliability. And backed with a 2-year warranty. Because they're easy to replace, downtime is significantly reduced. And if that isn't enough ... we provide a lower cost per watt than the relics of past generations.

Delivery? Five days from receipt of order. Right from the stocking shelves of the largest manufacturer of encapsulated power supplies, Computer Products, Inc. So don't save the relics — save money, save time, and save space. Write or call

us for more information today. As for the relics, maybe the Smithsonian will take them off your hands.

STOCKING DISTRIBUTION CENTERS: Gordon V. Peck Co., Garland, Tex., (214) 341-8311; B.J. Wolfe Ent., North Hollywood, Calif., (213) 877-5518; and Pen-Stock, Inc., Los Altos, Calif., (415) 948-6533.



**COMPUTER PRODUCTS**  
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 TWX (510) 956-9895

INFORMATION RETRIEVAL NUMBER 86

a better way...

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**RUB... IT'S TRANSFERRED**

**PERFECT REGISTRATION** because you position patterns first, then rub them down.

**CORRECTIONS ARE EASY** because you can lift patterns with a knife and reuse them.

**TOUGHER THAN STICK-ONS** because the ink is underneath a hard plastic over-coat.

Try the JotDraft Sampler and convince yourself. It's an assortment of 746 patterns and pads (2X scale) for \$4.50. Or write for a free sample and catalog. You'll be glad you did!

The **DATAK Corporation**

65 71st St.

Guttenberg, New Jersey 07093

INFORMATION RETRIEVAL NUMBER 87

ELECTRONIC DESIGN 25, December 6, 1973

## SUB-MINIATURE TWO-CIRCUIT PCB SWITCHES

... IDEAL FOR SUB-CHASSIS CHECKOUT, INTERLOCK CIRCUITS AND FIELD SERVICE

- **NO MOUNTING HARDWARE**  
Specifically designed for solder pin insertion into 1/16, 3/32 and 1/8" PC Boards
- **IMPACT AND FLAME-RESISTANT CASE**  
Available in a variety of colors
- **GOLD PLATED CONTACTS**  
Ideal for low level operation—500,000 cycles minimum

2 & 3 Position Toggle (Actual Size)

Screwdriver Slot Pushbutton (Actual Size) Snap-On Button (Actual Size) Each type Momentary Action or Latch-Down

**WRITE FOR PORTFOLIO OF TOGGLE AND PB APPLICATIONS BULLETINS**

## CONTROL SWITCH INC.

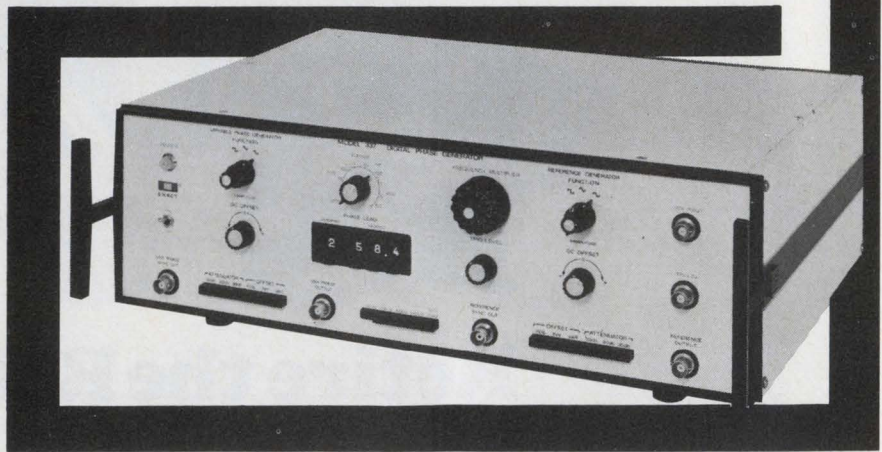
A SUBSIDIARY OF CUTLER-HAMMER INC.  
 1420 Delmar Drive • Folcroft, Pa. 19032 • (215) LU-6-7500  
 Representatives and Stocking Distributors Throughout the United States, Canada, and Europe

INFORMATION RETRIEVAL NUMBER 88

# digital phase generator... a better way to produce highly accurate, phase-related signals

Exact's new Model 337 Digital Phase Generator produces phase-related signals in 0.2° increments for antenna positioning, phase motors, servo motors and other applications requiring great accuracy.

Two generators, one with a reference output and the other with a variable phase output, generate sine, square, triangle, pulse and ramp waveforms for both phase and general purpose applications. Digital techniques are employed for 0.2° phase lead accuracy, 0.05% frequency stability and 0.02% amplitude stability.



This accuracy makes the Model 337 ideal for phase calibration in phase meters, network analyzers and radar systems.

Price \$2,495 f.o.b. Hillsboro, Oregon.

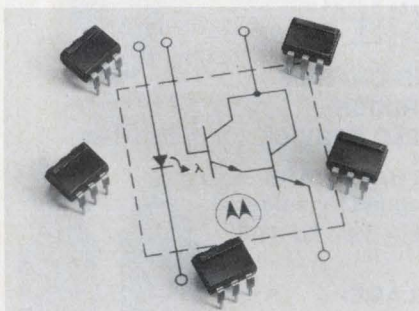


(A Subsidiary of Danalab, Inc.)  
 BOX 160, HILLSBORO, OREGON 97123  
 (503) 648-6661 TWX 910-460-8811

INFORMATION RETRIEVAL NUMBER 142

## ICs & SEMICONDUCTORS

### Opto-couplers are JEDEC registered



Motorola, P.O. Box 20924, Phoenix, Ariz. 85036. (602) 244-3466. \$1.90 to \$2.20; stock.

Five optical coupler/isolators with Darlington output transistors are available with JEDEC registration. Called the 4N29 through 4N33, the opto-couplers feature isolation voltages as high as 2500 V and collector currents of 50 mA (for 10-mA input). Speeds reach 30 kHz.

CIRCLE NO. 368

### Timer IC yields precise delays

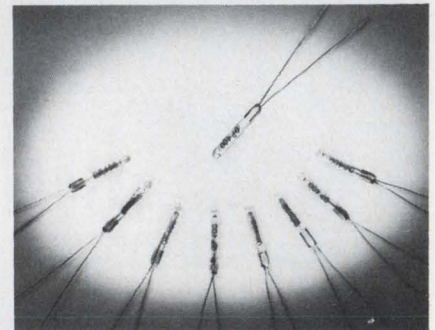


Texas Instruments, P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. SN72555P: \$1.50 (100); 12 wk.

The SN52/72555 monolithic timing circuit, a pin-for-pin replacement for the NE/SE555, can produce accurate time delays or oscillation. It features adjustable output pulse width in astable or monostable operation, TTL compatible output and adjustable duty cycle. The output circuit can source or sink currents up to 200 mA. In the time-delay or monostable mode of operation, the timed interval is controlled by a single external resistor and capacitor network.

CIRCLE NO. 369

### Npn phototransistor uses hemispheric lens

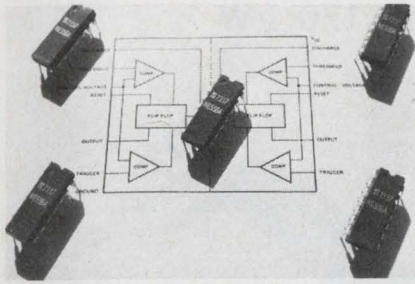


Optron, Inc., 1201 Tappan Circle, Carrollton, Tex. 75006. (214) 242-6571. Stock.

A high sensitivity npn phototransistor features a hemispheric lens to provide high collimation and uniformity of sensitivity with rotation. Called the OP 400, the new phototransistor has a collector-to-emitter breakdown voltage of 50 V, dark current of 25 nA and typical photocurrent of 3 mA with an irradiance of 20 mW/cm<sup>2</sup>. It is housed in an .080-inch diameter hermetically sealed glass package.

CIRCLE NO. 370

## Dual timer offers delays of 1 $\mu$ s to 1 h

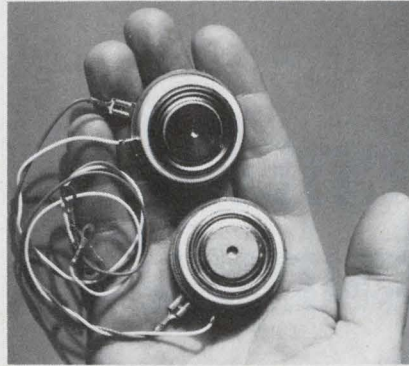


Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700. NE556: \$1.25 (100).

Both halves of the NE/SE556 dual timer IC can operate independently as well as together. They produce fully controllable time delays between one microsecond and one hour. Timing is adjustable over a ratio of 10 to one. The dual timer can also be connected to run free, in which case each half can be set to oscillate at any frequency between 300 kHz and less than one pulse per hour. Duty cycles are adjustable from 50% down to 0.01%. One NE/SE556 can replace two 555 timers.

INQUIRE DIRECT

## 275-A inverter SCR offers speed, low loss

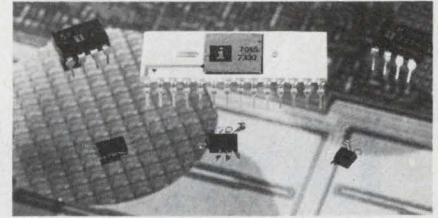


General Electric, Electronics Park, Bldg. #7, Mail Drop 49, Syracuse, N.Y. 13201. (315) 456-2021. P: See below.

A high-current inverter SCR is said to combine low switching losses with a 10- $\mu$ s turn-off time. Rated at 275 A rms with forward and reverse blocking voltage to 600 V, the C364/C365 SCR is primarily intended for power switching in the 1-to-10-kHz range. Prices start as low as \$22 for the C364 and \$19 for the C365 in 10-to-99 quantities.

CIRCLE NO. 371

## CMOS IC contains clock/timer circuitry



Intersil, 10900 N. Tantau Ave., Cupertino, Calif. 95014. (408) 257-5450. \$42.55 (100).

The ICM7045 CMOS IC contains the basic circuitry for a precision digital timer/stopwatch and a 24-hour clock. Oscillator circuitry, 15 frequency divider stages, multiplexer, decoder, segment and digit-output buffers are all included on the chip. The complete circuit interfaces directly with a fully multiplexed seven-segment/eight-digit common-cathode LED display. The nominal supply voltage is 3.6 V. Oscillator input is from a 3.2768-MHz quartz crystal. Output current from each of the seven segments is 18 mA peak at a 12.5% duty cycle.

CIRCLE NO. 372

## materials testing generator... a better way to drive mechanical test systems

Whether your materials testing system is checking relatively rapid fracture mechanics or extremely slow fatigue characteristics, Exact's new Model 336 can provide highly stable waveforms for programming the test.

For many types of tests, the generator provides both dual slope and ramp-and-hold modes. Ramp functions have periods ranging from 500 milliseconds to 500,000 seconds, and long-term hold modes at a stability of 0.02% permit programming of extended materials tests.

The digital design of the Model 336 offers superior accuracy and stability as well as long



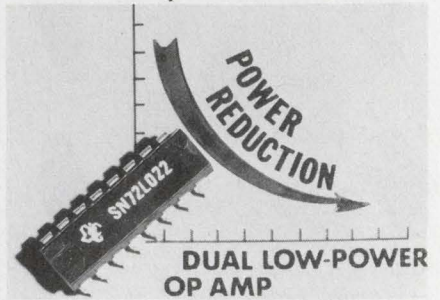
term holding ability. The instrument can also be used as a general purpose waveform generator at frequencies up to 1 kHz.

Price \$1,495 f.o.b. Hillsboro, Oregon

 **EXACT**  
electronics, inc.

(A Subsidiary of Danalab, Inc.)  
BOX 160, HILLSBORO, OREGON 97123  
(503) 648-6661 TWX 910-460-8811

## Dual op amp dissipates low 170 $\mu$ W

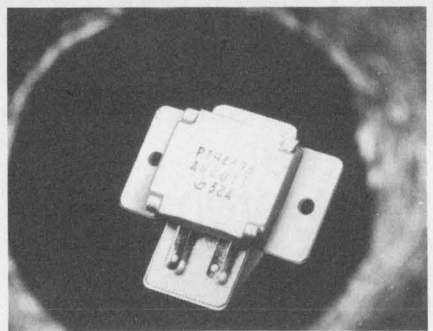


Texas Instruments, P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. SN72L022P: \$2.41 (100); 12 wk.

A dual low-power op amp, the SN52L022/72L022, features a low power consumption of 170  $\mu$ W at  $\pm 2$  V, low supply current of 0.13 mA for both amplifiers at  $\pm 15$  V and low equivalent input noise voltage of 50 nV/ $\sqrt{\text{Hz}}$ . Other features include internal frequency compensation, absence of latch-up and short-circuit output protection. The SN72L022 operates over the 0-to-70-C temperature range and comes in an 8-lead plastic DIP or metal can.

CIRCLE NO. 288

## Posistors control heat, temperature



Murata Corp. of America, 2 Westchester Plaza, Elmsford, N.Y. 10523. (914) 592-9180.

Posistors provide both the heating and temperature control function for small appliances and heating devices. These new units have ratings up to 10 W and up to 140 V rms. They can also be obtained with temperature ranges up to 200 C. Called the PTH-469 Series, Posistors have a positive temperature coefficient of resistance for both self-heating and self-controlling.

CIRCLE NO. 289

# Limited room for your power supply? See us. We'll design one to fit.

And furnish the first prototype in as little as 6 to 8 weeks.

We can do this because our past experience has given us a "library" of more than 1000 performance-proven designs from which to select—up to 60 KV and 2 KW. In high-, low- or combination-voltage configurations. And we'll work with you from start to finish—using specs you write or helping you write them.

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INFORMATION RETRIEVAL NUMBER 89



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**24-HOUR DELIVERY!**



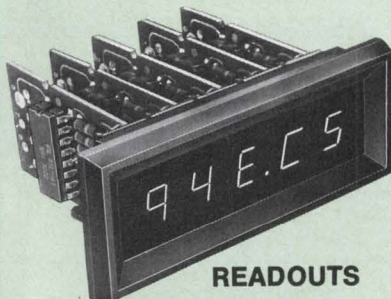
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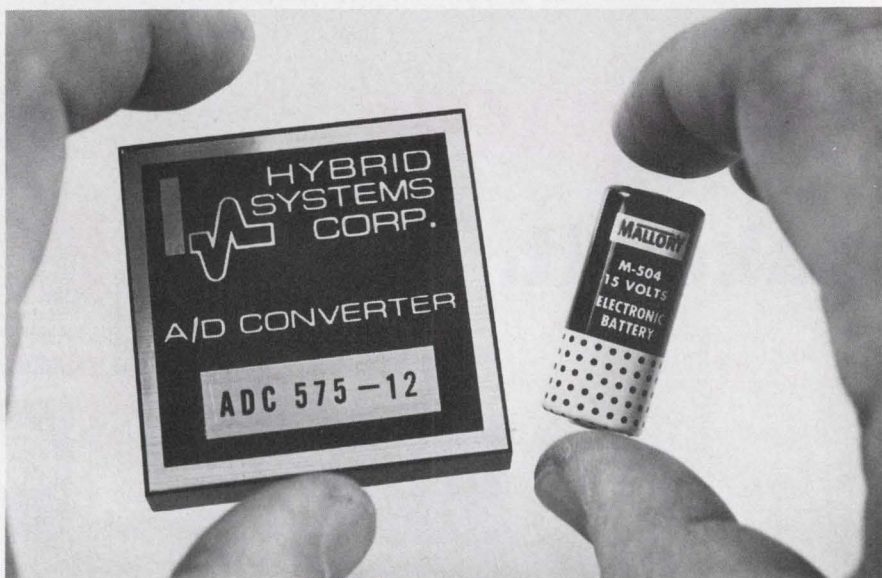
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 Tucson, Arizona 85704  
 (602) 297-1111

MODULES & SUBASSEMBLIES

# CMOS a/d is lean on power, yet it delivers 12 bits



Hybrid Systems Corp., 87 Second Ave., Northwest Park, Burlington, Mass. 01803. (617) 272-1522. P&A: See text.

Can you run an analog-to-digital converter from just one tiny battery? You bet. Hybrid Systems' CMOS a/d converter, the Model 575-12, draws only 25 mW from a 15-V supply and delivers 12-bit resolution and linearity.

The unit requires a long conversion time—100 ms—to achieve the low-power operation. Input impedance is greater than 1 MΩ when the converter is connected for unipolar (0-to-10-V) operation. The input impedance drops to 400 kΩ when bipolar operation is selected ( $\pm 10$  V), but that's still 10 times better than any other unit can do.

Accuracy and linearity errors are held to  $\pm 1/2$  LSB over the operating temperature range of 0 to 70 C. The unit also rejects both 50 and 60-Hz line noise.

Competitors are few. Analog Devices Corp. makes its ADC-12QL—a 12-bit, low-power a/d converter. Like the 575-12, it draws about 25 mW for a 100-ms conversion rate. Its input impedance, though, is smaller by at least a factor of 10, and the cost is more than triple—\$675. Size can also be a deciding factor: The 12QL is a  $4.1 \times 4.025$

$\times 0.35$ -in. circuit card, while the 575-12 is a  $2 \times 2 \times 0.4$ -in. encapsulated module.

The Analog Devices 12QL does offer advantages, though: It can deliver a serial output and it is faster—conversion time is 85  $\mu$ s—when a 15-V supply is used.

Datel Corp. also has a low-power converter, the ADC-CM12B. This 12-bit unit's input impedance is about 10 times lower than that of the 575-12. Its conversion time is a fast 100  $\mu$ s—but this is traded off for a power drain of 140 mW max from the 15-V supply. The CM12B is an encapsulated module that measures  $3 \times 2 \times 0.8$  in.—still more than double the volume of the 575-12. And the cost of the CM12B is \$249.

The Hybrid Systems 575-12 uses a patented delta-modulation circuit called the Deltaverta. This conversion technique eliminates the need for resistor ladder networks and thus permits a very simple a/d converter to be built.

Single-quantity price for the 575-12 is \$199, with delivery from stock to 2 wk. The manufacturer says all-hermetic components are used to increase reliability.

Hybrid Systems	<b>CIRCLE NO. 266</b>
Analog Devices	<b>CIRCLE NO. 267</b>
Datel	<b>CIRCLE NO. 268</b>

# the standard power supply is a minor consideration... until it fails!

OEM's are getting a little tired of 'power failures'. And many have decided it's better to pay the difference to be sure their products are powered reliably. The cost isn't that much more -- and it may save some valuable reputations.

This concept puts North Electric squarely in the picture, because reliability is our stock in trade.

We've been the leading custom power producer for more than 40 years -- and our modular power supplies follow the same quality standards . . . including rugged Life Tests, EMI analysis, shock, vibration, humidity and temperature tests -- and most are UL recognized.

Another point - if you are presently making your own power, let us show you (through a make or buy analysis) why it might be to your advantage to have North handle this specialized area of production.

When you buy power supplies, standard or custom, buy from the one big name that makes both.

MODEL	11000	12000	13000	14000	15000	16000	17000	18000
VDC	AMPERES							
5.0	3.9	5.3	11.3	13.0	20.0	32.5	49.0	82.0
12.0	2.8	4.2	8.0	10.5	15.0	23.0	36.0	58.0
15.0	2.4	3.7	7.5	9.5	14.0	20.5	27.0	47.0
18.0	2.1	3.3	6.0	8.0	13.0	18.0	26.0	40.0
24.0	1.5	2.8	4.2	7.0	11.0	15.0	21.0	33.0
28.0	1.4	2.4	4.0	6.3	9.0	14.0	20.0	29.0
36.0	1.2	2.2	3.1	5.6	8.0	11.0	14.0	23.0
48.0	.95	1.8	2.6	4.2	6.0	8.0	10.0	18.0

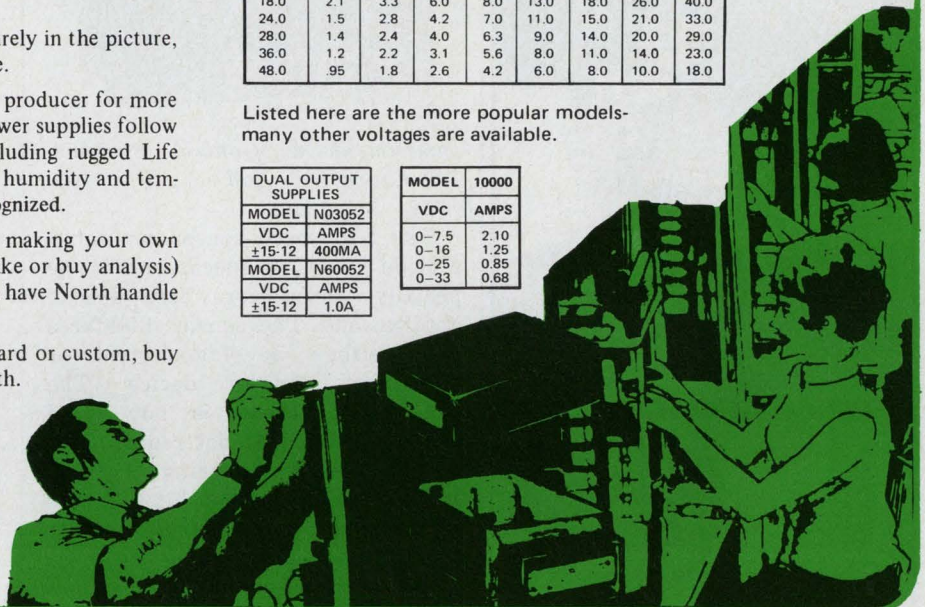
Listed here are the more popular models-- many other voltages are available.

DUAL OUTPUT SUPPLIES	
MODEL	N03052
VDC	AMPS
±15-12	400MA
MODEL	N60052
VDC	AMPS
±15-12	1.0A

MODEL	10000
VDC	AMPS
0-7.5	2.10
0-16	1.25
0-25	0.85
0-33	0.68

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ELECTRIC COMPANY

Electronics Division/Galion, Ohio 44833  
A United Telecommunications Company  
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Ask for Product Manager/Standard Power



INFORMATION RETRIEVAL NUMBER 92

## FOR THE UTMOST IN RELIABILITY



### INTERVAL TIMERS Series PAB.

This is an automatic reset interval timer with an extremely accurate timing mechanism built to stand up under hard usage in modern manufacturing processes. Due to the simplicity and reliability of its special clutch we can offer it in a range of time intervals from 1 second (1/60" dial divisions) to 3 hours (3' dial divisions), twelve in all. It is also available in a panel mount model PAF.

All of our timers are made to give you service far beyond what you'd reasonably expect. Our line consists of 17 basic types, each avail-

able in various mountings, voltages, cycles, circuits and load ratings . . . and with whatever special wrinkles you may need.

Bulletin #403 tells all about our line of reliable Interval Timers. Write for it or a catalogue of the entire line. If you have an immediate timer requirement, send us your specifications. Or for fastest service, give us a ring at (201) 887-2200.

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A UNIT OF ESTERLINE CORPORATION

Industrial Timer Corporation, U.S. Highway 287, Parsippany, N.J. 07054


INFORMATION RETRIEVAL NUMBER 93

ELECTRONIC DESIGN 25, December 6, 1973



## EMI SHIELDING WINDOWS

- ECTC Windows are highly conductive transparent coated optical display windows, 14 ohms/sq. resistivity, 75% visible light transmission
- EMC Glas Windows are fine mesh laminated optical display windows with 90+% transmission • Write for data 711.

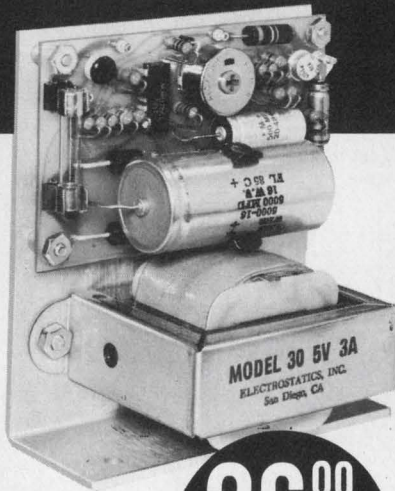
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INFORMATION RETRIEVAL NUMBER 94

DIRECT FROM STOCK

# 5V3A



**26<sup>00</sup>**  
(1-9)

\$19.90 - 100 pcs.

**Excellent regulation and ripple.**

## SPECIFICATIONS

Size: 4 x 4.5 x 2.75 overall  
 Input: 105-125V, 47-420 Hz  
 Output: Any DC voltage 3 to 30  
 Regulation: Line — 0.005%  
                   Load — 0.05%  
 Ripple: Less than 250 Microvolts  
 Temp: Operative —40 to +71°C  
       Storage —65 to +85°C  
       Coefficient —0.01%/°C Max.  
 Current Limiting: Fixed Foldback Type  
 Overvoltage: Optional

MODEL	VOLTAGE	AMPS
30-5	5.0	3.0
30-12	12.0	1.5
30-15	15.0	1.2
30-24	24.0	1.0
30-28	28.0	1.0

## ORDERING INFORMATION

QUANTITY	PRICE	WITH O.V.
1-9	\$26.00	\$31.00
10-24	24.20	28.70
25-49	22.60	26.90
50-99	21.20	25.10
100-	19.90	23.70

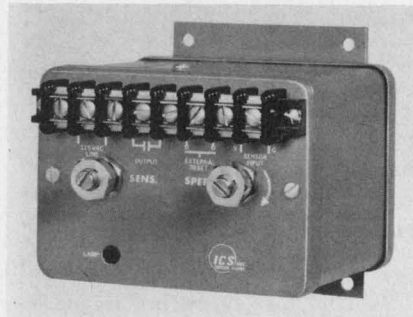
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**Electrostatics, Inc.**  
 7718 CLAIREMONT MESA BLVD. • SAN DIEGO, CA 92111

INFORMATION RETRIEVAL NUMBER 95

MODULES & SUBASSEMBLIES

## Speed sensor needs no critical alignment



Instrument & Control Systems,  
 129 Laura Dr., Addison, Ill. 60101.  
 (312) 543-6200.

The ICS speed sensor can sense a wide range of speeds and is especially useful for "zero speed" applications. The sensor interfaces with either a photoelectric or proximity pick-up device. The proximity pick-up is not speed sensitive and does not require ferrous metal for sensing. Critical mechanical alignment between the pick-up and the rotating member is not necessary. The sensor is available in 10 to 1 speed ranges from 1 to 5000 rpm and works from a power input of 100 to 130 V ac, 60 Hz. It is housed in a 2.75 by 3.75 by 3.75 in. case and weighs only 1.5 lb.

CIRCLE NO. 290

## Filter-oscillator unit provides dual function

Controlec, Inc., Box 48132, Niles, Ill. 60648. (312) 966-8435. \$19 (500-up).

The Model 22 filter-oscillator combines a stable RC active filter with an oscillator at the same frequency. Switching between the filter and oscillator modes can be done by a solid state or manual spdt switch. The unit operates from a single 5 V supply. A pre-amplifier/multiplexer/tone detector is also available as a companion unit. It will accept signals of 25 mV and up. It provides a rectified filter output at logic level which will drive up to 10 TTL gates. Filter input and oscillator output are provided on the same pair of wires, and switching between the two functions is from a logic level input.

CIRCLE NO. 291

## Rms converter offers accuracy to 0.1%

Optical Electronics Inc., P.O. Box 11140, Tucson, Ariz. 85734. (602) 624-8358. \$95 ea. (10 to 29 pieces); stock.

Model 5040 true rms converter uses logarithmic circuit techniques to handle crest factors up to 30. It is packaged in a 2 in. square by 0.4 in. high module and features:  $\pm 0.1\%$  of full scale typical error;  $\pm 0.01\%$  of full scale/°C temperature drift; dc to 100 kHz input bandwidth for rated accuracy; standard  $\pm 15$  V power supply requirements and a  $-55$  to  $+100$  C operating temperature range.

CIRCLE NO. 292

## CMOS DACs consume only 40 mW



Datal Systems, Inc., 1020 Turnpike St., Canton, Mass. 02021. (617) 828-6395. DAC-CM8B: \$99; CM10B: \$109; CM12B: \$119; stock.

The DAC-CM CMOS d/a converters offer a maximum power consumption of 40 mW at  $\pm 12$  to  $\pm 15$  V dc. They are available in word lengths of 8, 10, and 12 binary bits with a choice of straight binary or offset binary coding. The voltage output is programmable and can be either unipolar (0 to  $-5$  V FS or 0 to  $-10$  V FS) or bipolar ( $\pm 15$  or  $\pm 10$  V FS) and can drive a 5 k $\Omega$  load. All digital inputs are compatible with standard CMOS logic levels. Overall accuracy is  $\pm 0.01\%$  of full scale with a temperature coefficient of  $\pm 0.003\%/^{\circ}\text{C}$  and the unit is adjustment free over an operating temperature range of 0 to 70 C. Output settling time is 25  $\mu\text{s}$  to  $\pm 0.025\%$  of FS which allows an update rate of 40 kHz. Long term stability is  $\pm 0.01\%$  for six months.

CIRCLE NO. 293



# RCA's drift-free Master VoltOhmyst only \$135\*



It's the RCA WV-510A Master VoltOhmyst®, a solid-state VOM with all of these features:

- Excellent stability — drift-free operation
- Battery or AC operation
- Measures from 0.01 ma to 1.5 A in 8 ranges . . . 0.2 ohms to 1000 megohms in 7 ranges . . . 0.01 volt to 1500 volts DC in 8 ranges . . . 0.2 to 1500 rms AC volts in 7 ranges
- Measures peak-to-peak voltages of complex waveforms from 0.25 to 4200 volts in 7 ranges
- 21-megohm input resistance on all DC ranges
- Mirror scale meter-movement electrically protected against burnout

To buy: order from any one of the more than 1,000 Authorized RCA Distributors worldwide, or through RCA Electronic Instruments Headquarters, Harrison, N.J. 07029. (RCA will forward your order to the distributor of your choice.) Also ask for your copy of the new full-line Electronic Instruments 1Q1218F catalog.

**RCA** Electronic Instruments

\*Optional Price including probe and current leads.

INFORMATION RETRIEVAL NUMBER 96

## RELIABLE SPACE SAVERS...



Terminal guarantees a permanent seal.

NEW! IMPROVED DESIGN provides longer life and greater dependability.

LEVER STOP feature prevents "push-in" of toggle, protects internal moving parts.

HIGH TORQUE BUSHING withstands mechanical abuse.

NEW FRAME DESIGN allows use on 250VAC circuits.

GOLD FINISH on contacts and terminals for easier soldering and longer shelf life.

FINE SILVER CONTACTS and heat sinks provide a conservative 6 Amp rating.

ISOLATION BARRIERS between poles and terminals, inside and out.

CASE MATERIAL of DAP for strength, better arc and flame resistance, lower leakage.



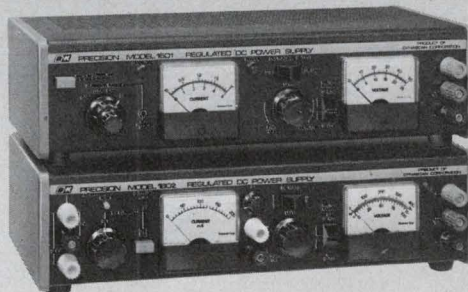
Ask for our illustrated "New Product Selection Guide" — containing a detailed listing of all series, options and pricing.

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**ALCOSWITCH**

Mfg. by ALCO ELECTRONIC PRODUCTS, INC. NORTH ANDOVER, MASS.

INFORMATION RETRIEVAL NUMBER 97

## overload protected power supplies with more filtering, line and load regulation per dollar



**B&K Model 1601 • \$159.95**  
0-50 VDC @ 0-2 Amperes  
Typical regulation:  
line-0.02%, load-0.07%  
Ripple: 5mV p-to-p

**B&K Model 1602 • \$169.95**  
0-400 VDC @ 0-200 mA  
Typical regulation: 0.1%.  
Ripple: 10mV p-to-p  
0-100 VDC @ 0-2mA  
6.3/12.6VAC @ 3.5A

The output voltages are continuously variable over full range with a single control. Foolproof fully automatic overload shuts down when current on 2 A or 200 mA supply exceeds the adjustable preset level. Pushbutton restores operation. See your distributor or write Dynascan Corporation.

**B&K** PRODUCTS OF  
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INFORMATION RETRIEVAL NUMBER 98

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GOLD  
BOOK**



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- TO EXCEED ALL CURRENTLY AVAILABLE DIRECTORIES IN COMPREHENSIVENESS AND UTILITY.

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THE GOLD BOOK will be distributed to *Electronic Design's* request-controlled and paid circulation in the U.S.A. and overseas, including 5,000 purchasing managers. More than 10,000 circulation will be concentrated in Europe. Total distribution exceeds 85,000 copies!

Employing Hayden Publishing Company's advanced publishing techniques, THE GOLD BOOK is designed to be the largest, most complete, most comprehensive one-step purchasing and reference tool ever produced in this industry.

THE GOLD BOOK contains more information and data for the specifier/purchaser; more useful listings, more detailed listings, in its directories; more directory pages; more catalog pages, divided into more product classifications than ever assembled into one convenient package.

THE GOLD BOOK is a data source where you can find what you want to find, and find it easily. If you've never used a directory before, this will be your opportunity to see how useful it can be.

### CONTENTS INCLUDE:

**Product Index Directory • Directory of Manufacturers and Sales Offices • Directory of Trade Names • Catalog Data and Technical Information Section • a massive compendium organized by Product Category. Watch for it . . . it's coming your way July, 1974.**

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Tell your top management and advertising people about this offer—but tell them soon. *They'll have to act fast.* Ad forms close February 19, 1974. For complete information they can call their local *Electronic Design* rep. or Tom Carr, V.P./Sales at 201-843-0550.



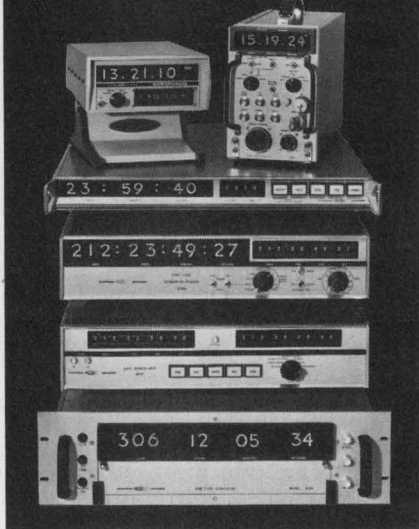
# Electronic Design



A Hayden Publication

Peter Coley, Vice President/Publisher • Tom Carr, Vice President/Sales Manager  
50 Essex Street, Rochelle Park, New Jersey 07662 • Tel: 201-843-0550

# Time coding can be simpler than you think

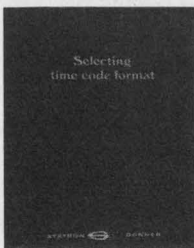


Systron-Donner can help you cut through the profusion of time code formats and equipment—to the selection of the right format and the right equipment for the job.

Our new 90-page handbook will guide you to the best technique for your application, and enable you to select appropriate equipment from the comprehensive line offered by Systron-Donner.

Systron-Donner equipment ranges from compact time code generator/readers costing as little as \$1495, through portable battery-powered generators for field use, to high-precision generator/readers with automatic tape search.

## Send for handbook sample.



Send for free copy of "Selecting time code format," Chapter 3 of our new 90-page, illustrated handbook on time coding techniques. Complete handbook: \$3.00.

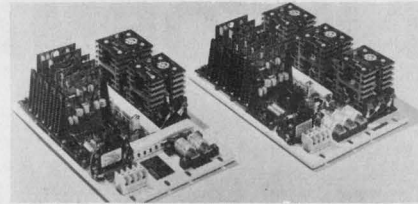
**SYSTRON  DONNER**

Data Products Division,  
Systron-Donner Corporation,  
10 Systron Dr.,  
Concord, Calif. 94518.  
Phone (415) 682-6161.

INFORMATION RETRIEVAL NUMBER 99

## MODULES & SUBASSEMBLIES

### SCR amplifiers are built for high rel



*Inland Motor Div., Kollmorgen Corp., 501 First St., Radford, Va. 24141. (703) 639-3973.*

The SP series of SCR amplifiers is available in single-phase, full-wave and three-phase, half-wave models. These units employ four-quadrant, bi-directional, fully regenerative operation and deliver continuous torques from 3 to 40 lb-ft. They can either be mated with numerical control units and run in a closed position loop with extremely high accuracies and stiffness. Or they can be used in just a closed velocity loop with speeds down to 0.1 in/min on a five pitch ball screw. The amplifier uses a modular construction throughout—from the SCR packs to plug-in PC boards. Every major circuit contact is paralleled for extra reliability. For increased machine protection an overspeed circuit automatically shuts down the drive when motor speed becomes excessive. Also provided is a torque-limiting circuit which can be used to run the motor against a hard stop.

CIRCLE NO. 294

### Digital-to-resolver circuit accepts 12-bits

*Astrosystems Inc., 6 Nevada Dr., Lake Success, N.Y. 11040. (516) 328-1600.*

The DR7000 digital-to-resolver converter accepts a 12-bit binary angle input and provides ratio-metric outputs proportional to the sine and cosine of the programmed input angle. By itself, the converter can be used with frequencies down to dc and, with its power output module, it can be used in 400 Hz systems of either 11.8 or 90 V and 1 VA power output. The input of the device is TTL/DTL compatible, positive true. The converter is housed in a 2.5 in. square by 0.8 in. high module.

CIRCLE NO. 295

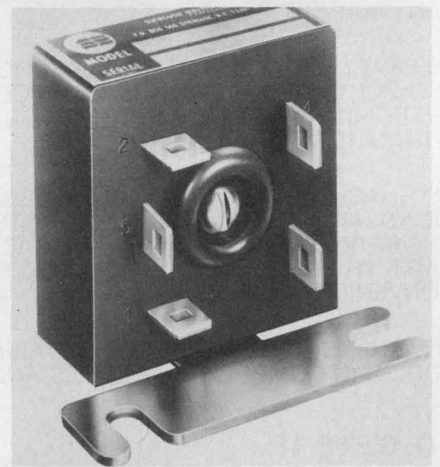
### Pulse generator works over -55 to +85 C

*Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343. (213) 894-2271.*

The Model PG-113 crystal-controlled pulse generator provides a pulse or square wave output. It operates from a nominal +28 V supply and can deliver 0.5 W of output for loads as low as 100  $\Omega$ . The output impedance is approximately 5  $\Omega$ . Operating frequencies are available from 16 to 300 kHz and operation is specified over a -55 to 85 C temp range.

CIRCLE NO. 296

### Solid state timer has long operating lifetime

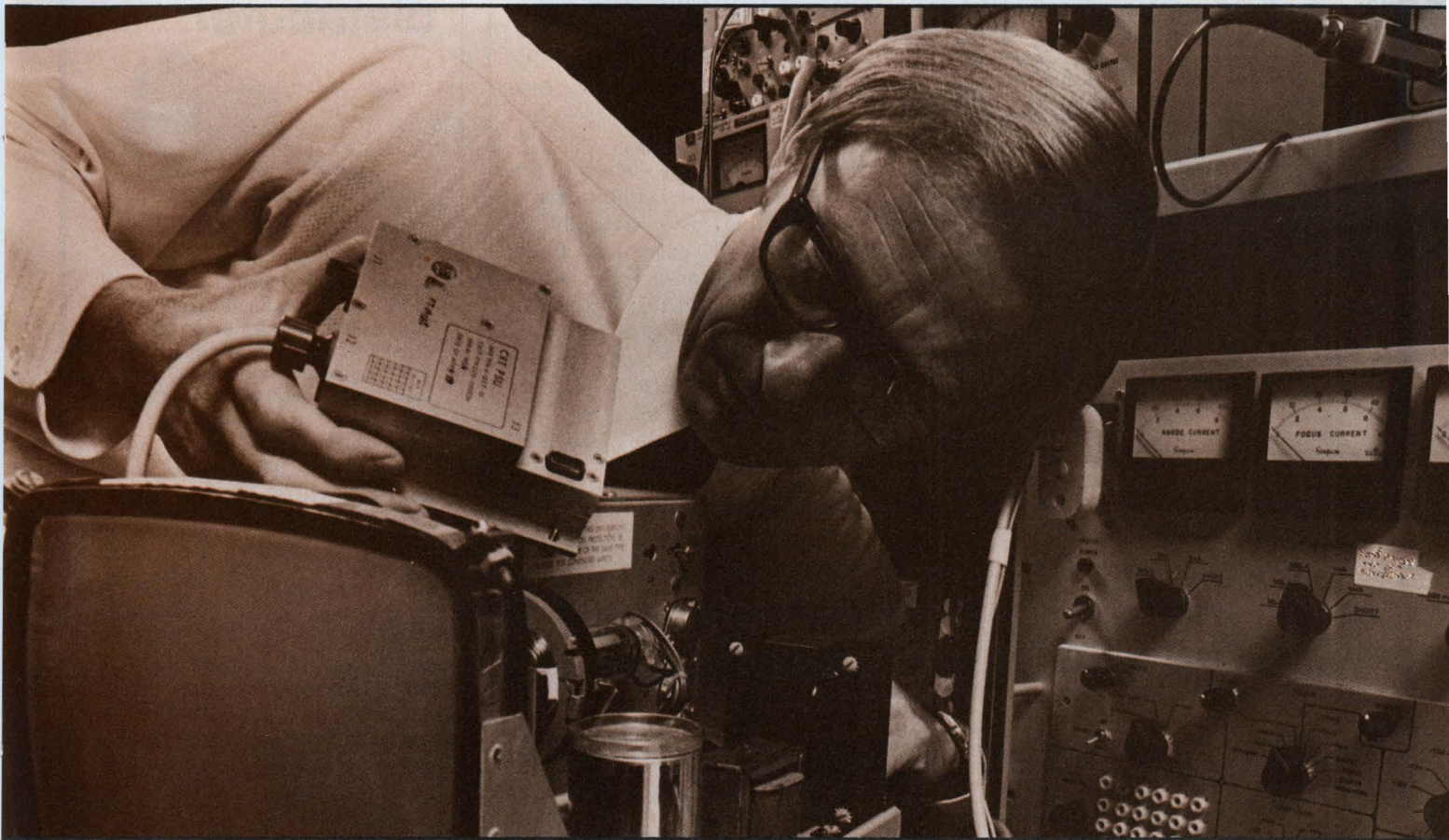


*Syracuse Electronics, P.O. Box 566, Syracuse, N.Y. 13201. (315) 488-4915. \$5 to \$7; 4 wk.*

The SDS Series of solid state timers is engineered for 100,000-000 operations. A single-shot device, the SDS offers a typical repeat accuracy of  $\pm 2\%$ . It is designed for input frequencies of 50/60 Hz and is available for line voltage values from 24 to 230 V ac or 24 to 110 V dc. The module has a reset time during and after timing of 50 ms. The unit is fully protected against transients as high as 400 V (for one full line cycle, repetitive) and against surges as high as 15 A (for one-half cycle, nonrepetitive). Inverse voltage protection is included with all units designed for dc operation. Remote and factory-fixed time delays range from 0.1 to 480 s. Operating temperatures range from -10 to +60 C. The unit is approximately 2 in. square and weighs 3 oz.

CIRCLE NO. 297

# When you need a custom high voltage power supply, ELDEC designs, packages, and builds them so you can rely on them.



Power supplies for CRT displays. Small size. Light weight. Look to ELDEC. We have years of experience combined with field proven reliability. ELDEC specializes in high voltage, custom mil-spec requirements. Air, ground, or shipboard.

Now by-pass that make or buy decision. When reliability is on the line, rely on proven experience. And ELDEC delivers. No gap between promises and prototype. High quality levels of manufacturing? You can bet on it!

We understand the custom business. Plenty of back-up documentation and service support. A successful track record you can check on. Ask for our brochure. Write me, Kevin Hall, Marketing Manager, ELDEC Corporation, 16700 - 13th Ave. W., Lynnwood, Washington 98036. Phone (206) 743-1313.



*Formerly Electro Development Corporation*  
INFORMATION RETRIEVAL NUMBER 100

# Now the famous 829 has a "G" for good measure!



Calibrate or Measure with the

## RFL Model 829G

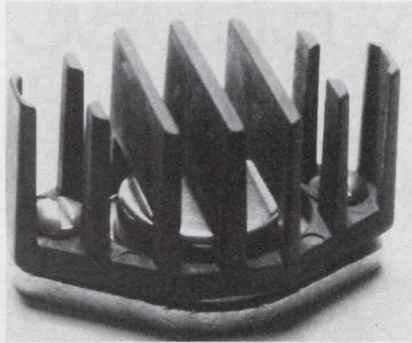
RFL's famous 829, for 15 years the industry calibration standard, now gives way to the new 829G — still the industry calibration standard. But now it's twice as useful. When functioning as a calibration source, the 829-G delivers AC or DC voltages from 10mV to 1400V; current from 10 $\mu$ A to 14A; and 10 cardinal resistance values from 0.01 ohm to 10 megohms. AC calibration is internally generated and may be selected at 50, 60, 400 and 1000Hz. Direct read-out is by a 5-digit DPM. Many other features are available. Price \$3,950.00  Write for complete data today. RFL Industries, Inc., Instrumentation Division, Boonton, New Jersey 07005 Tel.: (201) 334-3100 / Twx: 710-987-8352 / Cable: RADAIRCO, N.J.



**RFL Industries, Inc.**

### PACKAGING & MATERIALS

#### Heat sink uses no additional space



Aham, 968 W. Foothill Blvd., P.O. Box 909, Azusa, Calif. 91702. (213) 334-5135.

Aham LID-3 is a compact, finned heat sink that clamps over a TO-3 case and uses virtually no additional board space. This lightweight cooler is cast from aluminum and rated at 15 C/W thermal resistance. Much greater heat dissipation is realized with forced air. The LID-3 can also be used to enhance the performance of TO-3 devices that are already mounted to a larger heat sink.

CIRCLE NO. 298

#### Potting compound has low viscosity

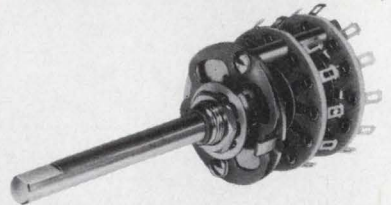
Castall Inc., Weymouth Industrial Park, East Weymouth, Mass. 02189. (617) 337-6075. \$18 per gallon.

Casting resin, Castall 305, has a viscosity of 2000 to 3000 cps, which is very low for a filled system. Low viscosity ensures good wetting and penetration of intricate circuitry. It also eliminates the need for preheating and evacuating the compound in many cases. The thermal conductivity of Castall 305 is 22.5 cal/s/cm<sup>2</sup>/C/cm<sup>10</sup>-, which is comparable to conventional casting resins of high viscosity. Shrinkage and coefficient of thermal expansion are somewhat higher and heat distortion temperature (130 C) is slightly lower than conventional resins. The cured material is a resilient black solid with good dielectric properties and excellent adhesion to most porous and nonporous surfaces. This two-part resin is available with several different hardeners for room temperature and heat cure.

CIRCLE NO. 299

◀ INFORMATION RETRIEVAL NUMBER 101

## Need rotary switches? 2-million combinations, 72-hr. delivery from your Oak Moduline™ distributor.



Quick-and-easy ordering of Oak-quality rotary switches in lots of 1 to 99. The Moduline system lets you specify switch components by number (no drawings needed). Your order is shipped within 3 days. Contact these Moduline distributors:

### DRW

MASSACHUSETTS, Watertown. (617) 923-1900\*  
NEW YORK, Farmingdale..... (516) 249-2660\*

### HALL-MARK

ALABAMA, Huntsville..... (205) 539-0691  
FLORIDA, Orlando..... (305) 855-4020\*  
GEORGIA, Atlanta..... (404) 963-9728  
ILLINOIS, Chicago..... (312) 437-8800  
KANSAS, Kansas City..... (913) 888-4747  
KANSAS, Wichita..... (316) 682-2073  
MARYLAND, Baltimore..... (301) 265-8500  
MINNESOTA, Minneapolis... (612) 925-2944  
MISSOURI, St. Louis..... (314) 521-3800  
NORTH CAROLINA, Raleigh... (919) 832-4465  
NEW YORK, New York..... (516) 293-7500  
OHIO, Dayton..... (513) 278-6963  
OKLAHOMA, Okla. City... Enterprise 50094  
OKLAHOMA, Tulsa..... (918) 835-8458  
PENNSYLVANIA, Philadelphia. (215) 355-7300  
TEXAS, Austin..... (512) 454-4839  
TEXAS, Dallas..... (214) 231-6111  
TEXAS, Houston..... (713) 781-6100  
WISCONSIN, Milwaukee..... (414) 476-1270

### INDUSTRIAL COMPONENTS

MINNESOTA, Minneapolis... (612) 831-2666\*

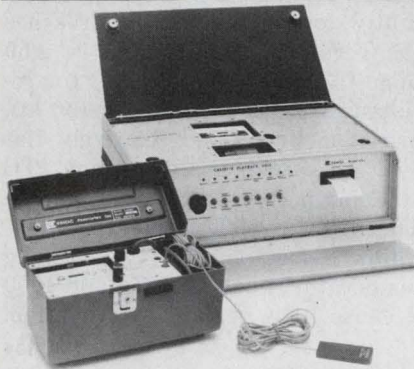
### SOLID STATE

TEXAS, Dallas..... (214) 352-2601\*  
TEXAS, Houston..... (713) 785-5205

\* Assembly Locations

**OAK Industries Inc.**  
SWITCH DIVISION / CRYSTAL LAKE, ILLINOIS 60014

**17 DAYS  
of event data  
organized and  
printed out in  
7½ MINUTES**



The new EDMAC event logging and playback SYSTEM is fast . . . simple . . . and thrifty . . . less effort, time, and money!

#### EDMAC Event Loggers

- \*Models: One-channel or two-channel
- \*Tape speed: 0.0022 inches/second
- \*Count rate: to 2 events per second
- \*Logging time: to 17 days with C-60 cassette
- \*Interface: universal to varied input sensors
- \*Time coherence: for event rate and distribution analysis
- \*Input power: 115 VAC, 60 Hz, 6 watts
- \*Size: 10 x 6 x 5½ in., self-contained

#### EDMAC Dual-Channel Playback Unit

- \*Service: one playback unit services many loggers
- \*Time compression ratio: 1700 to 1
- \*Playback time: 7.5 minutes (C-60 cassette)
- \*Paper print-out: 9-digit columnar in 36 seconds
- \*Count capacity: to 999,999 counts per channel
- \*Group size capacity: 31 event group sizes; 999,999 counts per group size
- \*Size, etc.: 22x13x6 in., self-contained, 35 lbs.
- \*Input power: 115 VAC, 60 Hz, 75 watts

MODEL 2042A (Single Channel) Event Logger  
MODEL 2043A (Dual Channel) Event Logger  
MODEL 2150 (Dual Channel) Cassette Playback

For further information about this new system, contact Roland Boisvert, Vice President (Marketing).

### EDMAC Associates, Inc.

333 West Commercial Street  
East Rochester, N.Y. 14445 (716) 385-1440

## New inks write on oily surfaces and fluoresce



Metron Optics, P.O. Box 690,  
Solana Beach, Calif. 92075. \$2.95  
(unit qty).

Created for inspection of electronic components, two kinds of ink—removable and permanent—are available in five highly fluorescent colors, (red, green, blue, orange and yellow). The inks can mark on Teflon and oily surfaces. The removable ink is nonconductive and contains no silicones. It can be flicked off with a fingernail, removed with most solvents, or wiped off with a damp cloth, yet will not stain fabrics nor damage painted surfaces. The permanent inks are waterproof, flexible when dry, and difficult to remove. Because the ink is flexible, it can be used on soft surfaces such as plastic laboratory bottles and on cloth. Ink application is by the Metron Marker pen that has a flexible, tapered body and a thin needle-like tube. You squeeze the pen body to deliver a tiny dot of color. Steady pressure permits the marker to be used like a pen. Surplus ink in the tube is returned to the body when pressure is released. Ink capacity in each pen is the equivalent of more than 12,000 dots.

CIRCLE NO. 300

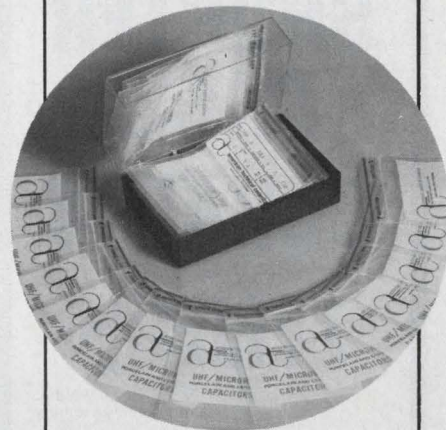
## Colloidal graphite dries to lubricant film

Huron Industries, Inc., P.O. Box  
104, Port Huron, Mich. 48060.  
(313) 984-4213.

A dry-film lubricant, Neolube, is based on colloidal graphite suspended in alcohol. In ready-to-use form, when exposed to air it dries in seconds to a slippery, lustrous, adherent film of pure graphite. It is electrically conductive, and it resists radiation damage. It has been used as an anti-sieze thread lubricant in almost every nuclear-energy plant in the U.S.A.

CIRCLE NO. 301

## ATC 100 UHF/MICROWAVE CAPACITOR KITS



- High Q thru Microwaves
- 0.1 pF to 1000 pF standard
- High R.F. current capability
- Rugged Terminations
- Absolute Retrace
- Hermetic Construction
- Close Tolerances standard
- High Reliability
- Completely Characterized:  
Full RF and DC test data

## FOR RF DESIGN ENGINEERS:

A new line of capacitor kits is available from ATC. Both Case A mini-cube® and Case B MAXI—"Q"UBE™ chips are offered in a variety of terminations and lead styles.

Three kit configurations for both case sizes are described in the new brochure:

- EVALUATION KIT—low cost assortment for evaluation purposes:
- TRIM KIT™—fixed capacity replacements for trimmers.
- DESIGNER KIT—large range of capacity values and tolerances for all your design needs.

A complimentary copy of  
THE RF CAPACITOR HANDBOOK  
is provided with each kit.

**american  
technical  
ceramics**

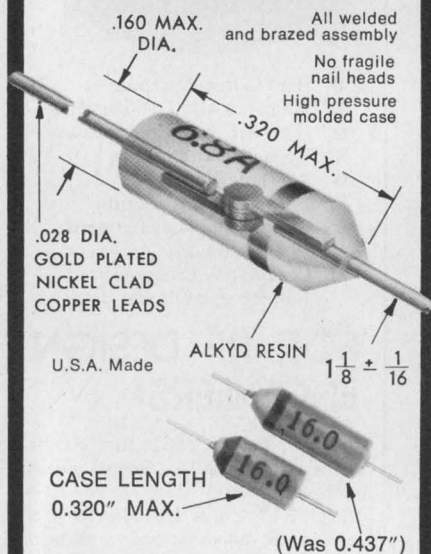
ONE NORDEN LANE  
HUNTINGTON STATION, N.Y. 11746

516/271-9600 • TWX 510-226-6993

INFORMATION RETRIEVAL NUMBER 104

199

# NEW SHORTER CASE! SCHAUER 1-WATT ZENERS



**SAME LOW PRICES FOR  
1% TOLERANCE ZENERS  
ANY VOLTAGE  
FROM 2.0 TO 18.0**

Quantity	Price Each
1-99	\$1.07
100-499	.97
500-999	.91
1000-4999	.86
5000 up	.82

**IMMEDIATE SHIPMENT**  
Send for rating data and 20%, 10%, 5% and 2% tolerance prices.

Semiconductor Division

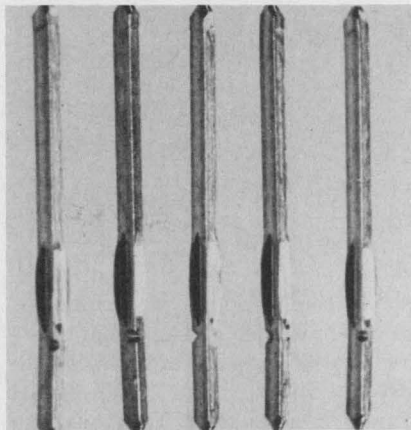
**SCHAUER**

MANUFACTURING CORP.

4511 Alpine Ave., Cincinnati, Ohio 45242  
Telephone 513/791-3030

## PACKAGING & MATERIALS

### Wrapost pins feature star-swage fit

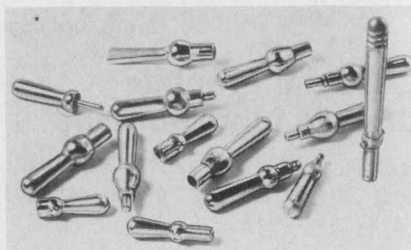


Auto-Swage Products Inc., 726 River Rd., Shelton, Conn. 06484. (203) 929-1401.

Starred wrapost pins are suitable for automatic insertion equipment. This new pin line comes with 0.025-in. square cone ends and a 0.003-in. max corner radius. The star-swage interference fit is 0.060-in. long with the star tips at 0.043 ± 0.001 in., so they will not scar, scuff or meale the hole or damage plated through holes. Pins are available in phosphor-bronze, beryllium-copper, brass, cupro-nickel, nickel-silver and other metals. Custom plating with gold, bright-acid tin and nickel is also available.

CIRCLE NO. 302

### Die-cast levers made to your specifications



Gries Reproducer Co., 125 Beechwood Ave., New Rochelle, N.Y. 10802. (914) 633-8600.

Custom-made small levers are delivered immediately ready for assembly. They are die-cast in zinc alloy in all sizes, with plain or complex designs and high part-to-part uniformity. Nickel and other plating finishes are available.

CIRCLE NO. 303

### Resistor ink allows stable laser trimming

Electro Materials Corp. of America, 605 Center Ave., Mamaroneck, N.Y. 10543. (914) 698-8434. \$50 per oz (OEM qty).

EMCA 5500 series thick-film resistor ink has stable laser-trimming, power and thermal storage properties that are comparable to the 5000 series, but with a significantly lower TC that approaches the Firon inks. The TCC is ± 50 ppm/°C from -55 to 125 C for resistance values of 100 Ω to 100 kΩ, and it is linear and relatively flat over this temperature range. TC tracking never exceeds ± 5 ppm/°C. The EMCA 5500 series also exhibits a low negative VC. Firing temperatures between 750 and 1000 C cause little resistivity variation.

CIRCLE NO. 304

### Conductive calking shields rf



Technical Wire Products Inc., 129 Dermody St., Cranford, N.J. 07016. (201) 272-5500. \$15 per lb; stock.

A new one part conductive calking system, identified as 72-00018, provides, when properly applied, in excess of 100 dB of shielding across the rf and microwave spectrum. It is a silicone-based system that maintains its soft putty-like consistency after it is applied to allow joints to be disassembled with ease. It can be applied with a calking gun, a 3/32 in. or larger syringe, a spatula or putty knife. The material is safe to handle and free of any corrosive binder. It has an operating temperature range between -80 and 400 F and provides excellent moisture resistance. The standard package of 1 lb yields 15.1 in.<sup>3</sup> and will cover 302 in.<sup>2</sup> at a 0.050-in. thickness.

CIRCLE NO. 305



# Measure temperatures anywhere.



1. Operates from self contained rechargeable batteries or line.
2. Two models provide wide temperature ranges in °F or °C.
3. Highly stable and accurate with resolution of 0.1°.
4. Six types of interchangeable probes available for air, immersion, surface and biological measurements.
5. Five selectable probe inputs.
6. Completely solid state with LED display.

Priced at only **\$395**

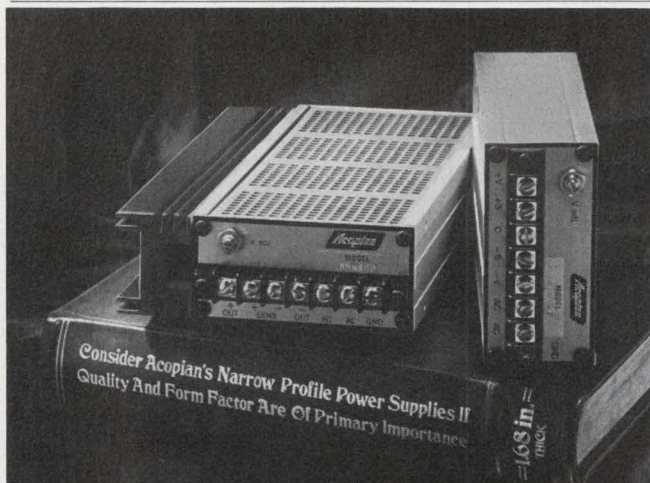
**United Systems Corporation**  
918 Woodley Road, Dayton, Ohio 45403  
Ph. (513) 254-6251—TWX (810) 459-1728  
a subsidiary of

**Monsanto**

Model 581C — 30.0° to +100.0°C  
Model 582C — 22.0° to +199.9°F

**Digitec**

INFORMATION RETRIEVAL NUMBER 106



## 5V @ 4 amp or ±15V @ 500 ma... in 1.68"

The Model A5NT400 delivers 5V @ 4A with regulation of  $\pm 2$  mv and ripple of 0.25 mv. Price, \$150. The FD15-50 provides tracking  $\pm 15V$  @ 500 ma. Regulation  $\pm 0.1\%$ ; ripple, 1.5 mv; price, \$115. Standard input, 105-125 VAC, 50-400 Hz. Other single output models to 150 volts;  $\pm 12$  and  $\pm 15$  volt duals to 1 amp. All only 1.68" thick. Three day shipment guaranteed.



Acopian Corp., Easton, Pa. 18042  
Telephone: (215) 258-5441

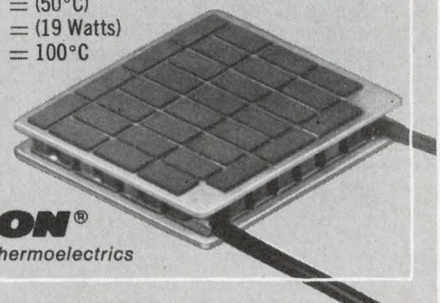
For a limited time only, Cambion's new general purpose ceramic module 801-2001-01 will be sold for 1/3 off the usual \$30 price. It can be used in water coolers, small refrigerators, hot and cold temperature sources, spot cooling for electronic components, and many other applications. You'll also get a free copy of Cambion's Thermoelectric handbook.

To order, send name and address along with \$20 check or money order. Cambridge Thermionic Corporation, 445 Concord Ave., Cambridge, Mass. 02138

**Special introductory offer**  
**It costs less to buy**  
**our new low cost**  
**thermoelectric module NOW.**

### OPERATING CHARACTERISTICS

$\Delta T$ Max. at Qc Zero	= (60°C)
Max. current	= (8.5 amps.)
Nom. Voltage	= (3.5 VDC)
Th	= (50°C)
Qc Max. at $\Delta T$ Zero	= (19 Watts)
Max. Op. temp.	= 100°C



Standardize on

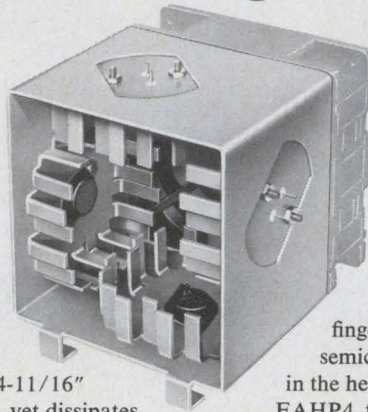
**CAMBION**  
The Guaranteed Thermoelectrics

INFORMATION RETRIEVAL NUMBER 107

ELECTRONIC DESIGN 25, December 6, 1973

INFORMATION RETRIEVAL NUMBER 108

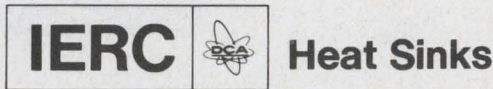
# New forced air cooling package dissipates 450 watts; costs only \$6.50\*



\*1000-pc qty.; fan not included.

Our new Series FAHP4 blower package measures only 3-3/4" x 5-3/16" x 4-11/16" and weighs only 14 ounces, yet dissipates 450 watts in a 25°C ambient with a case rise of less than 95°C. The secret to its high performance and low cost is the use of four standard IERC HP3 staggered

finger heat sinks. Since the semiconductor hole pattern is in the heat sinks we assemble the FAHP4 from standard off-the-shelf heat sinks and shrouds. Ask for our new data sheet. IERC, 135 W. Magnolia Blvd., Burbank, Calif. 91502, a subsidiary of Dynamics Corporation of America.



INFORMATION RETRIEVAL NUMBER 109

For color and monochrome television receivers

## High Voltage Diffused Silicon Rectifiers

Types H431 and H484. Designed to replace high voltage rectifier tubes in hybrid or solid state large screen color TV.

Features: 45kV (PRV); 2.2mA (I<sub>o</sub>); 250 and 300 nsec (t<sub>r</sub>). These rectifiers have a corona ring and a wide selection of A and K connecting hardware.

Also five series of versatile, low-cost rectifiers with end caps or axial leads. For half-wave rectification in B & W and small screen color TV.

Ratings: 15kV to 30kV (PRV); 1.5 and 2.2mA (I<sub>o</sub>) and 300 nsec. (t<sub>r</sub>). Mounting hardware available.

Design us in — We'll stay there



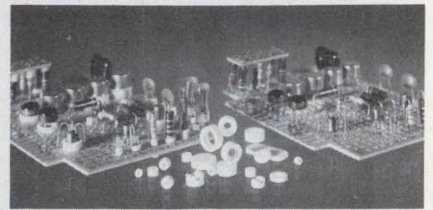
VARO SEMICONDUCTOR, INC.

P.O. BOX 676, 1000 N. SHILOH, GARLAND, TEX. 75040, 214/272-4551, TWX 910-860-5178

INFORMATION RETRIEVAL NUMBER 110

## PACKAGING & MATERIALS

### Temporary spacers wash away after soldering

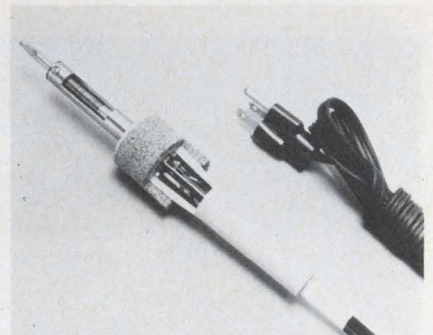


Bivar, Inc., 1500 S. Lyon St., Santa Ana, Calif. 92705. (714) 547-5832. \$10 per thousand (100,000 up); stock.

Diss-O-Pads provide accurate uniform spacing, protect components during the soldering cycle and then wash away in warm or hot running water without a trace of residue. They are available in many styles and almost any thickness. Over 400 standards are stocked. Specials can be tooled economically in less than three weeks.

CIRCLE NO. 306

### Grounded solder tip protects components



Hexacon Electric Co., 161 W. Clay Ave., Roselle Park, N.J. 07204. (201) 245-6200.

Posi-Ground is a new design feature for soldering irons that positively eliminates voltage leakage. Less than one millivolt of leakage, including noise, is measured on a sensitive oscilloscope. The standard three-wire, grounded construction does not eliminate the possibility of voltage leakage that can cause damage to voltage-sensitive components. Posi-Ground removes this hazard by providing a direct connection between the front of the element core and the ground wire of the line cord. Posi-Ground is available for a small charge on all of Hexacon's wide range of instrument irons.

CIRCLE NO. 307

Do you face  
a make or buy  
decision on  
power supplies?

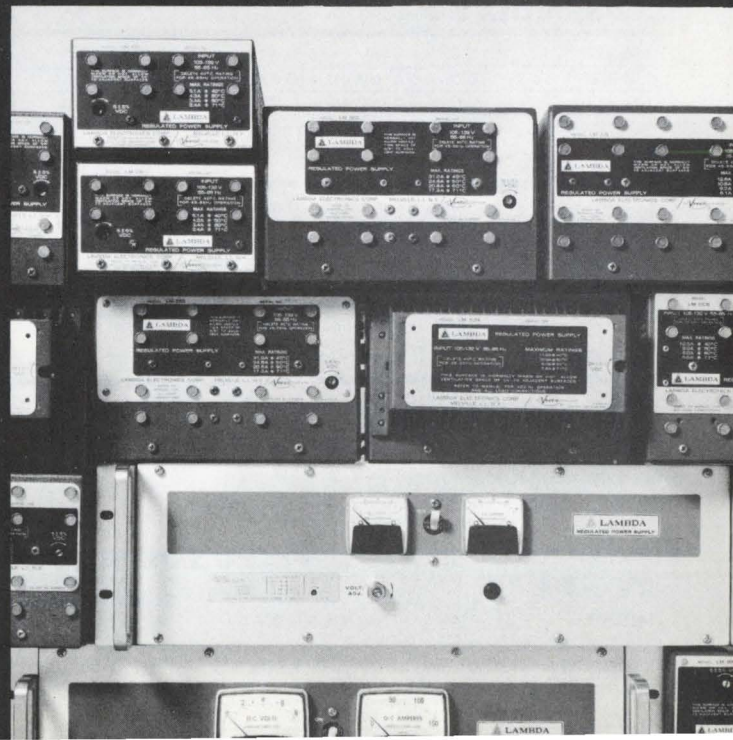
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# LAMBDA'S LM SERIES MOD RECOGNIZED COMPONENT

## WIDE RANGE MODELS — SINGLE OUTPUT

### 0-7 VOLTS

MODEL	REGULATION	RIPPLE (MV RMS)	MAX. AMPS AT AMBIENT OF:				PKG. SIZE	DIMENSIONS	PRICE
			40°C	50°C	60°C	71°C			
LM-B-0-7	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	2.8	2.6	2.3	1.5	B 3 3/16" x 4 15/16" x 6 1/2"	\$119.	
LM-225	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	4.0	3.6	3.0	2.4	C 3 3/16" x 4 15/16" x 9 3/8"	149.	
LM-234	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	8.3	7.3	6.5	5.5	D 4 15/16" x 7 1/2" x 9 3/8"	199.	
LM-E-0-7	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	12.0	10.5	8.5	6.8	E 4 15/16" x 7 1/2" x 11 3/4"	249.	
LM-EE-0-7	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	16.0	13.5	11.2	9.2	EE 4 15/16" x 7 1/2" x 16 1/2"	340.	
LM-F-0-7-OV-M (1)	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	25.0	21.0	17.0	14.0	F 3 1/2" x 19" x 16 1/2"	595.	
LM-G-0-7-OV-M (1)	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	35.0	29.0	24.0	20.0	G 5 3/16" x 19" x 16 1/2"	725.	

### 8.5-14 VOLTS

LM-217	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	2.1	1.9	1.7	1.3	B 3 3/16" x 4 15/16" x 6 1/2"	\$129.
LM-235	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	7.7	6.8	6.0	4.8	D 4 15/16" x 7 1/2" x 9 3/8"	199.

### 0-14 VOLTS

LM-B-0-14	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	1.6	1.5	1.3	1.2	B 3 3/16" x 4 15/16" x 6 1/2"	\$119.
LM-C-0-14	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	2.2	2.0	1.8	1.5	C 3 3/16" x 4 15/16" x 9 3/8"	149.
LM-D-0-32	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	4.9	4.2	3.4	2.7	D 4 15/16" x 7 1/2" x 9 3/8"	199.
LM-E-0-14	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	7.4	6.4	5.2	4.1	E 4 15/16" x 7 1/2" x 11 3/4"	249.
LM-EE-0-14	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	10.2	8.6	7.3	6.1	EE 4 15/16" x 7 1/2" x 16 1/2"	340.

### 13-23 VOLTS

LM-218	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	1.5	1.3	1.2	1.0	B 3 3/16" x 4 15/16" x 6 1/2"	\$129.
LM-227	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	2.3	2.1	1.7	1.4	C 3 3/16" x 4 15/16" x 9 3/8"	149.
LM-236	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	5.8	5.1	4.5	3.6	D 4 15/16" x 7 1/2" x 9 3/8"	209.

### 22-32 VOLTS

LM-219	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	1.2	1.1	1.0	0.8	B 3 3/16" x 4 15/16" x 6 1/2"	\$129.
LM-228	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	2.0	1.8	1.5	1.2	C 3 3/16" x 4 15/16" x 9 3/8"	149.
LM-237	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	5.0	4.4	3.9	3.1	D 4 15/16" x 7 1/2" x 9 3/8"	219.

### 0-32 VOLTS

LM-B-0-32	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	0.8	0.7	0.6	0.5	B 3 3/16" x 4 15/16" x 6 1/2"	\$119.
LM-C-0-32	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	1.1	1.0	0.90	0.80	C 3 3/16" x 4 15/16" x 9 3/8"	149.
LM-D-0-32	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	2.5	2.1	1.7	1.3	D 4 15/16" x 7 1/2" x 9 3/8"	180.
LM-E-0-32	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	3.7	3.2	2.6	2.1	E 4 15/16" x 7 1/2" x 11 3/4"	249.
LM-EE-0-32	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	5.2	4.4	3.8	3.2	EE 4 15/16" x 7 1/2" x 16 1/2"	340.

### 30-60 VOLTS

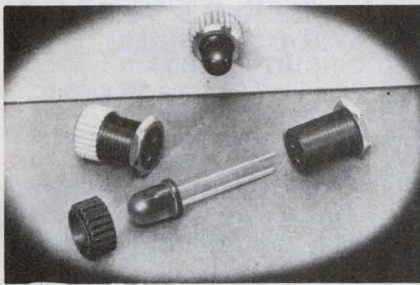
LM-220	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	0.70	0.65	0.60	0.45	B 3 3/16" x 4 15/16" x 6 1/2"	\$139.
LM-229	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	1.1	1.0	0.80	0.60	C 3 3/16" x 4 15/16" x 9 3/8"	159.
LM-238	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	2.6	2.3	2.0	1.6	D 4 15/16" x 7 1/2" x 9 3/8"	239.

## FIXED VOLTAGE MODELS — SINGLE OUTPUT

### 2V ±5%

MODEL	REGULATION	RIPPLE (MV RMS)	MAX. AMPS AT AMBIENT OF:				PKG. SIZE	DIMENSIONS	PRICE
			40°C	50°C	60°C	71°C			
LM-F-2 (3)	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	48.0	41.0	33.0	25.0	F 3 1/2" x 19" x 16 1/2"	\$475.	
LM-G-2 (3)	0.05% + 4 mV - line, 0.03% + 3 mV - load	1	95.0	80.0	62.0	45.0	G 5 3/16" x 19" x 16 1/2"	605.	
LM-H-2-OV-Y-M (2)	0.01% + 1 mV - line, 0.02% + 2 mV - load	0.5	150.0	140.0	125.0	91.0	H 7" x 19" x 18 1/2"	995.	

## LEDs installed with simple mounting kit

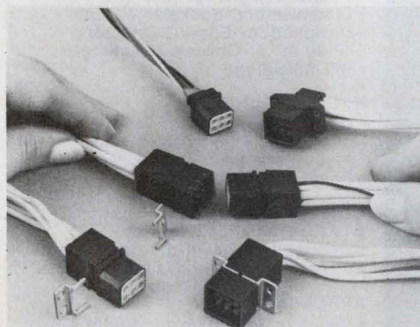


Eldema Div., Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. 90221. (213) 774-1850.

Simplified layout, assembly and installation of standard LED lamps is provided by this new low-cost, panel mounting, hardware kit. The Model Q-084-2D/3D LED hardware set can mount all T-1-3/4 LED lamps and TO-18 cases on panels up to 0.187-in. max thickness. The assembly allows either front or rear-panel lamp installation. A 1/4-in. mounting hole requires no critical tolerances.

CIRCLE NO. 308

## High-voltage connectors operate at 70,000 ft



AMP Inc., 1595 S. Mount Joy St., Elizabethtown, Pa. 17022. (717) 367-1105.

Rated 5 kV dc at 70,000 ft. from -55 to 125 C, these new high-voltage connectors require less than 0.6 in.<sup>2</sup> of mounting surface and occupy less than 0.750 in.<sup>3</sup> per mated pair of six-contact connectors. The plug and receptacle are polarized. They are molded from flame-retardant glass-filled polyester, with a silicone-rubber insert to provide an interfacial seal. Their recessed contacts are gold plated and have a 5-A rating. The connectors are supplied preassembled with shielded or nonshielded leads in a variety of housing configurations.

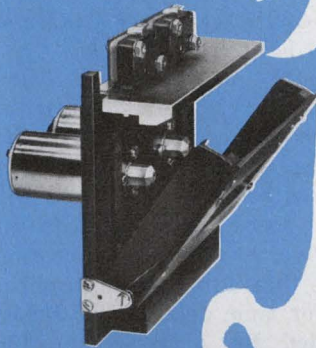
CIRCLE NO. 309

# The Non-forgettable Memory

## Why Non-forgettable?

Because a digital cassette tape recorder should not ever forget unless it is programmed to forget - and it should remember nothing extra. The things that make it forget - capstans, pinch rollers, solenoids, belts - are simply not there. The patented constant tape speed motor control system eliminates noise susceptibility. Please call or write now for all the details.

**Spend less for less . . .  
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INFORMATION RETRIEVAL NUMBER 111

## DIP REED RELAYS

Available in all standard configurations  
From distributor stock

Elec-Trol's totally encapsulated DIP REED RELAYS can be driven directly by TTL logic. Available in 1 and 2 Pole Form A, 1 Form B, 1 Form C with 5 through 24 VDC standard coil voltages. Contact ratings up to 10 watts. Available in .225" and .275" heights. Clamping diode and electrostatic shielding optional.

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INFORMATION RETRIEVAL NUMBER 112



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**TEMP-R-TAPE** of fiberglass  
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Excellent electrical properties plus most anything else you want in fiberglass tapes like high tensile and tear strength, dimensional stability, good conformability, thermal endurance, abrasion resistance, non-corrosiveness, Temperature to 180°C. Available with several adhesive systems. Low unit cost.

Find your nearest Distributor in the Yellow Pages under "Tapes, Industrial" or in Industrial Directories or write for complete specification kit and sample offer. The Connecticut Hard Rubber Company, New Haven, Conn. 06509

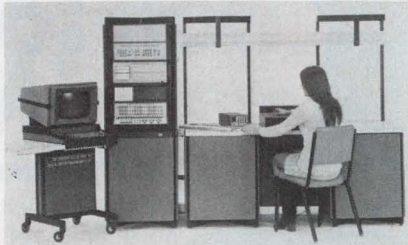


a HITCO company

INFORMATION RETRIEVAL NUMBER 113

## INSTRUMENTATION

### System tests memories to 4096 four-bit words



Teradyne Inc., 183 Essex St., Boston, Mass. 02111. (617) 482-2700. \$85,000 base price; 20 wk.

The J384 Memory Test System performs functional and parametric tests on static and dynamic MOS and fast bipolar memories of all types, with capacities up to 4096 four-bit words. A primary feature is a "vector-list autocalibration" routine that automatically compensates for time delays. The J384 is controlled by a Teradyne M365 computer, with CartriFile magnetic tape cartridges used for program storage and data logging. A Teradyne CRT terminal is also included.

CIRCLE NO. 310

### 'Smart' counters display true units



Nu-Metrics Instrumentation, R.D. #1, Box 489, Vanderbilt, Pa. 15486. (412) 638-0400. Start at \$89 (quantity); 30 days.

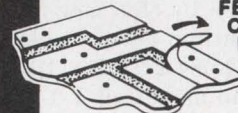
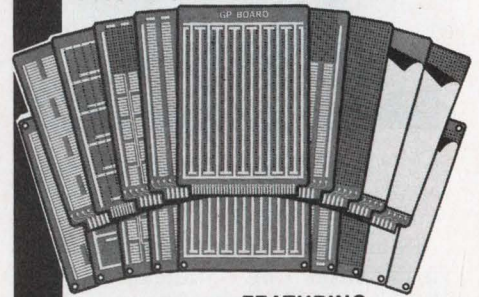
The "Smart Counters" display the true value of an input event, such as gallons, barrels, feet, inches, etc. Arithmetic circuits can be programmed to compute actual value of your measurements up to six digits. Five counters can be multiplexed for a sum total. Other features include: 30-day power-off memory with emergency display, selectable decimal point, fully programmable, high speed or mechanical filtered input, predetermining capability to four decades.

CIRCLE NO. 316

## CIRCUIT-STIK introduces

# GP BOARDS

GENERAL PURPOSE  
CIRCUIT BOARDS  
Plug-in & Chassis Mounting  
and ELECTRONIC  
PACKAGING MATERIALS



FEATURING  
CIRCUIT-STIK'S  
NEW CUT &  
PEEL BOARDS

## GP CIRCUIT BOARDS

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- Mix All Types of DIP Sockets (8 to 40 Leads)
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- Plus Space for 50 Decoupling Capacitors

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- 4 Sizes of Boards available

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- Card Pull Handles

### EPOXY GLASS BOARD MATERIALS

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Phone (213) 530-5530

Digital VOM also offers analog indicator



Simpson Electric, 853 Dundee Ave., Elgin, Ill. 60120. (312) 695-1121. \$275 (w/o battery); stock.

Model 360 is a new solid-state VOM with a 3-1/2 digit, nonblinking, 0.33-in. LED display. Polarity selection is automatic, as is over-range. A unique analog indicator is useful for quickly scanning nulls and peaks. The unit features 29 ac, dc and resistance ranges including "low power ohms."

CIRCLE NO. 317

Function generator costs just \$225

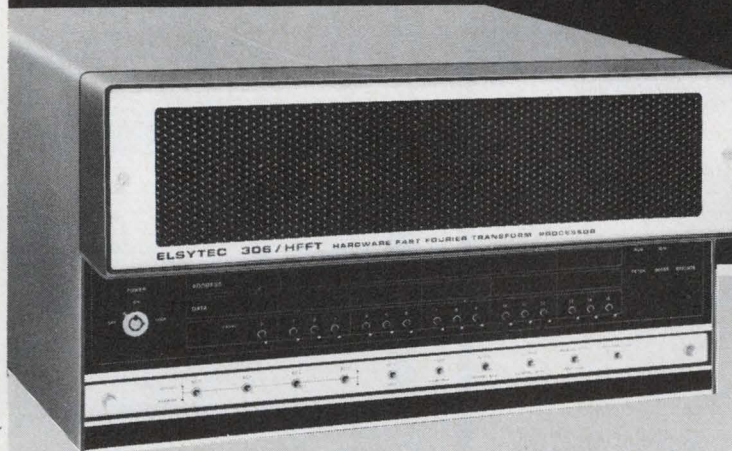


Tucker Electronics, 1717 S. Jupiter, Garland, Tex. 75040. (214) 348-8800. \$225; stock.

Model 300A is a 0.1 Hz to 1 MHz basic function generator offering 10-V pk-pk output into 50  $\Omega$  and less than 2% sinusoidal distortion. The unit provides sinusoidal, square and triangular-wave switched outputs and a corresponding sync output. Dc offset of  $\pm 2.5$  V is standard. The unit comes in either an 8 x 5 x 8-in. lab model or as a standard half-rack panel mount.

CIRCLE NO. 318

# Hardware Fast Fourier Transform Processor



The 306/HFFT is a digital processor that performs forward or inverse Fourier Transforms of time or frequency domain data. It is contained within the mainframe of its host NOVA 800 computer for efficiency, smaller size and cost saving.

## FEATURES

- Basic Fast Fourier Transform time of 9.5 ms for 512 complex points (1024 real points).
- Real-Time to 25 KHz for 1024 real input points, 18 ms total processing time including all requisite procedures.
- Transform from 16 to 16384 real points.
- Full 16 bit accuracy.
- Polar coordinate output standard.

## APPLICATIONS

- Underwater acoustics
- Speech recognition
- Biomedicine
- Mechanical vibrations
- Noise identification
- Geophysics
- Digital filtering
- Doppler radar analysis
- Nuclear physics

**EXPAND to a complete Fourier Spectrum Analyzer by field addition of:**

- A single or dual Input Channel.
- Anti-aliasing filters
- Operation oriented Control Panel
- Output displays

Delivery is 90 days ARO.

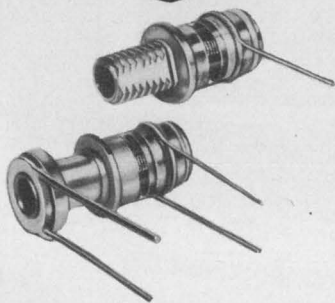
For further information, contact your local representative or the factory directly.

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electronic systems technology

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(516) 364-0560

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These highly stable capacitors all have a multi-lobed seal ring at the adjust end coupled with the new Sprague-Goodman simplified and highly reliable adjust mechanism.

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PISTONCAP trimmer capacitors are available for immediate delivery from stocking Sprague distributors.

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GOODMAN**

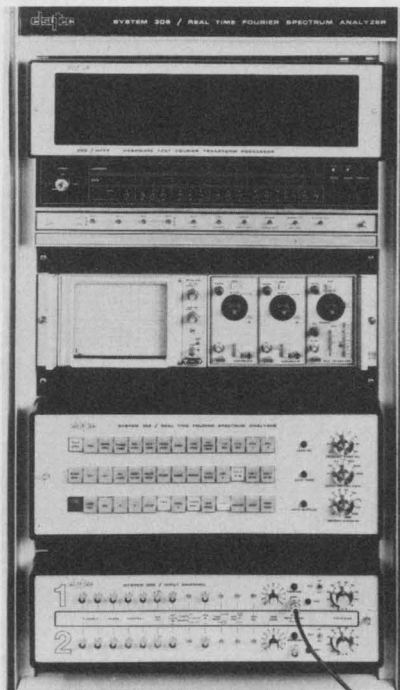
**Sprague-Goodman  
Electronics, Inc.**

(An Affiliate of the Sprague Electric Company)

371 Willis Ave., Mineola, N.Y. 11501  
516/746-1385

## INSTRUMENTATION

### Fourier analyzer correlates to 50 kHz



*Elsytec Inc., 212 Michael Dr., Syosset, N.Y. 11791. (516) 364-0560. \$32,900; 90 days.*

System 306/230 is a dual-input, Real-Time Fourier Analyzer that processes and displays two input signals from dc to 50,000 Hz simultaneously. Single and cross-functions such as FFT, Inverse FFT, Time Function, Fourier Spectrum, PSD, Auto Correlation, Cross-Spectrum, Transfer Function, Cross-Correlation, and Averaging may be selected at the touch of a button. The unit features a built-in fully programmed minicomputer, the NOVA 1200 Jumbo with 12 k of core memory.

CIRCLE NO. 320

### Add-ons allow photon counting correlation

*Signal Analysis Operation, Honeywell TID, 595 Old Willets Path, Hauppauge, N.Y. 11787. (516) 234-5700. \$6500; 30 day.*

New optional add-ons to the SAICOR line of digital correlators make them useful for laser light scattering research. The options include full four-bit by four-bit processing, single clipping with adjustable clipping levels, pseudo-random cross-correlation and probability density computations.

CIRCLE NO. 321

### EMI meter covers 10 kHz to 32 MHz

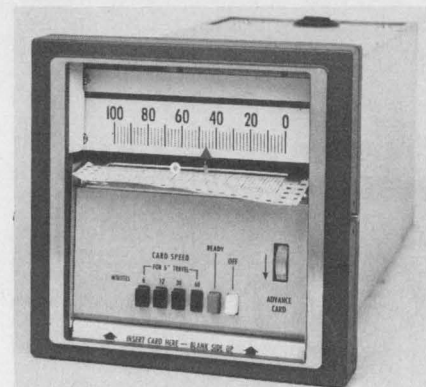


*Singer Instrumentation, 3211 S. La Cienega Blvd., Los Angeles, Calif. 90016. (213) 870-2761. \$9800, 5 mo.*

Model NM-17/27 complements the NM-37/57 EMI meter to give full rf spectrum coverage. The new meter covers the lower segment of the spectrum, from 10 kHz to 32 MHz and, apart from frequency coverage, is almost identical to the NM-37/57. The unit is fully programmable and performs precision automatic and semi-automatic testing to the stringent standards specified by MIL-STD-461A and MIL-STD-826A.

CIRCLE NO. 322

### Recorder draws on both charts and cards



*Leeds & Northrup, Sumneytown Pike, North Wales, Pa. 19454. (215) 643-2000. 1-pin: \$650; 2-pin: \$910; Feb.*

Mark III Infotrak Card-Chart Recorder offers a unique concept in curve-drawing records of periodic, cyclic, or transient measurements. You simply adjust zero and span for the signal amplitude, select the appropriate recording speed by pushbutton, feed a card into the transport and the Infotrak does the rest. The standard 5 × 8-in. card size is convenient for filing, with room on front and back for notations; the card can be edge-punched and coded for quick retrieval.

CIRCLE NO. 323



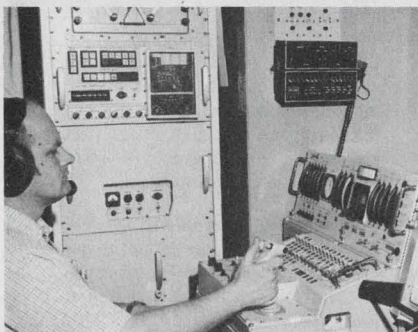
ATTENTION PROGRAM MANAGERS:

# How to win a \$10 million government contract with the new \$20,250 Rolm Ruggednova:

For \$20,250 you can meet Mil Specs E-5400 airborne environment, E-16400 shipboard environment, eliminate software and interfacing problems . . . and still buy the world's toughest computer system with 8K of memory and teletype.



If you're in the business of producing military systems, we don't have to tell you about budgets, risks, deliveries and design problems. Instead, let's talk about the Ruggednova 1602 . . . and how Rolm can help you win those big contracts.



A new technique for armchair control of RPVs (Remotely Piloted Vehicles) has been developed by Motorola Government Electronics Division for the Navy. The Ruggednova in the background helps provide either discrete or proportional control for up to six RPVs of any variety at ranges exceeding 250 nautical miles.

## SOFTWARE IS THE FIRST SAVING

You can effectively reduce the most expensive and longest lead-time item in a system's task with our wide selection of proven and documented software. You'll see your program working on the 1602 in less time because the Rolm software set includes assemblers, compilers, debugging aids, utility routines, math libraries and powerful operating systems. A significant benefit of our system is the availability of a compatible commercial equivalent. Any program written on the Data General Corporation's Nova series will operate on the Ruggednova. Our licensing agreement with Data General allows us to provide more software than any other mil spec computer.

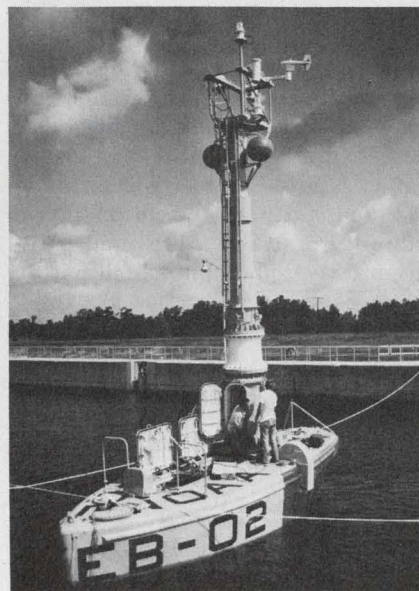
## OUR EXPANDED INSTRUCTION SET GIVES GREATER FLEXIBILITY

With the Ruggednova 1602 your applications programming task has been simplified with a new extended instruction set. For example, our file search instruction enables you to do an "in limits / out of limits" comparison on a file up to 64,000 words long with one single instruction. Other examples include 1602's stack processing capability, auto-

matic branching and nesting of interrupts, immediate mode instructions and double precision arithmetic.

## INTERFACING IS MADE EASY

Over 30 general purpose interfaces to select from gives you another edge on that contract. No design costs. No technical risks. The I/O interfaces range from series and parallel digital interfaces to communication interfaces to D/A and A/D converters all the way to NTDS interfaces. If you have your own special interface it can be placed inside the 1602 chassis. You save money by not having to design a rugged chassis or rugged power supply.



This new prototype, 30-ton buoy, built by Lockheed Missile & Space Company for the National Oceanic and Atmospheric Administration, has been placed in the Gulf of Mexico to record meteorological and oceanographic data. It is equipped with a Rolm Ruggednova for data acquisition and communications processing.

## MIL SPECS ARE ALREADY MET

We supply you with a qualification test report free. You don't have the hassle, risk, or expense of qualification testing. The 1602 meets Mil-E-5400 airborne environments, Class II; Mil-E-16400 shipboard environments, Class I; Mil-Std-461A electromagnetic interference and Mil-S-901 for high impact shock. It has

an operating temperature range of  $-55^{\circ}$  to  $+95^{\circ}\text{C}$  case temperature, at altitudes from sea level to 80,000 feet. The 1602 meets shock specifications of 15 g's with 11 ms duration and vibration tests of 10 g's, 5 to 2000 Hz.

## AND THERE'S A SUPPORT PACKAGE AT NO EXTRA COST

Rolm's program doesn't stop with just hardware and software. We also help you reduce your budget and design risk with a number of back-up items. These include detailed reliability reports, two weeks of training, complete documentation and a 90-day warranty. For software support there's also a "how-to" software manual, individual software write-ups, and full diagnostic software.

## NEW DEBUGGING FEATURE

Within the first 15 minutes of loading a program into the 1602 you can localize most program errors. A new "panel breakpoint" switch allows you to execute your program until it hits the address located on the 16 data switches. This allows you to verify good routines and identify program bugs. No more single stepping through 2,000 word subroutines or keying halts. It's a great time-saving software feature.

Now that we've told you about all the ways Rolm can help you get that multi-million dollar contract, there's no space left to describe a host of other features about the Ruggednova 1602. So, drop us a line and we'll send you complete data on the world's toughest computer. If you're interested in getting a head start on that contract . . . give us a call.

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CORPORATION

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**REGIONAL SALES OFFICES:** Los Angeles 213-784-8500; Palo Alto 415-965-2224; Washington D.C. 703-893-2696; Boston 617-237-5752; New York 914-297-9533; Cincinnati/Dayton 513-874-5406; Texas 214-661-8905.

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INFORMATION RETRIEVAL NUMBER 118

# syntronic

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INFORMATION RETRIEVAL NUMBER 119

### INSTRUMENTATION

## Spotmeter spans 0.5 to 1000 fL



*Photo Research, Div. of Kollmorgen Corp., 3000 N. Hollywood Way, Burbank, Calif. 91505. (213) 849-6017. \$550; 30 days after Jan. 1.*

SPECTRA "Mini-Spot" Silicon Cell Spotmeter measures luminance (brightness). The self-contained, hand-held unit is 1° angular coverage, 21° viewing field and see-through optics, with meter reading simultaneously displayed in viewing field. Low-range sensitivity is 50 fL full-scale, with readings legible down to 0.5 fL, while the high-range value of 1000 fL may be increased to 100,000 with accessories. A silicon photodetector is said to be free from hysteresis and fatigue and to maintain stability of  $\pm 2\%$  a year and  $\pm 5\%$  accuracy. A photopic match within  $\pm 4\%$  is achieved.

CIRCLE NO. 324

## VOM measures leakage and temperature

*Triplett Corp., 2867 Harmon Rd., Bluffton, Ohio 45817. (419) 358-5015. \$130.*

This multiple-range VOM, Model 615, is designed especially for appliance, residential, industrial and commercial maintenance. As a maintenance tester, the unit measures ac or dc V, ohms, and ac-current leakage; as a temperature tester it has two compensated temperature ranges with switch selection for up to three temperature probes; and as a thermocouple tester, the 615 provides low millivolt ranges.

CIRCLE NO. 325

### MONOLITHIC CRYSTAL FILTERS



#### OF HIGHER THINGS . . .

By international convention, the VHF frequency range extends from 30 to 300 MHz. At 30 MHz a monolithic quartz crystal filter element is about .002 in. thick and typically .25 in. in diameter. Fragile? Yes indeed. Maybe that's why only a handful of manufacturers offer crystal filters in the VHF range. Of these few, one is head and shoulders above the rest. Needless to say, that's us. (If we weren't, we wouldn't be writing this ad.) Our first monolithic—way back in 1966—had a center frequency of 112 MHz. We pioneered the VHF monolithic crystal filter. And we're still pioneering. We supply production quantities of VHF monolithics at frequencies to 175 MHz. No one else can make that statement, and believe us—we're pretty high on our product.

#### NOW FOR THE LOW-DOWN

Although we're mighty proud of our VHF Monolithic Crystal Filters, much of our bread and butter is earned at lower frequencies. As low as 3 MHz in special cases. And at 10.7 and 21.4 MHz, we offer the industry's widest selection of stock model monolithic crystal filters—over 50 models in all. We can help you with all your production requirements for monolithics. More and more people are saying our low down is on the up and up.

#### . . . AND WHAT TO DO WITH THEM

Our VHF Monolithics are used as front-end filters and as up-converter filters. They're found in satellites and in commercial equipment. In the U.S. and in most other major countries of the world. In VHF two-way radios, paging receivers, and HF receivers and transmitters. And in a variety of special applications, like spectrum clean-up in frequency synthesizers.

What's your application? Whether it's one of the above or something brand-new we'll be glad to work with you. Just give us a call, or a brief note outlining your requirements. We'll take it from there.

# Pi

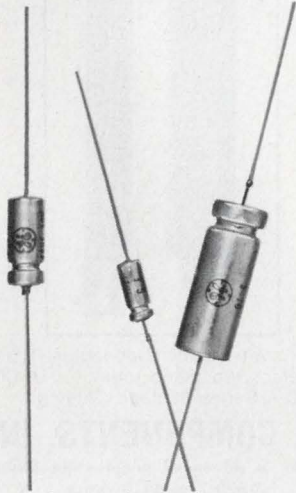
**Piezo Technology Inc.**

2400 Diversified Way Orlando, Florida 32804  
305-425-1574

The Standard in monolithic crystal filters.

INFORMATION RETRIEVAL NUMBER 120

# GENERAL ELECTRIC'S 69F MIL TYPE TANTALUM WET SLUG CAPACITOR...



Four series to choose from:

**69F** — Unique patented double O-ring elastomer seal, with proved superiority over other elastomer seal designs.

**69F2000** — Provides two-to-three times more capacitance in the same case size, with the patented double O-ring elastomer seal.

**69F3000** — Glass-to-metal hermetic seal. Fully qualified to MIL-C-3965/24, Style CL66/67.

**69F4000** — Glass-to-tantalum hermetic seal. Fully qualified to MIL-C-39006/9C, Style CLR65.

Same quality features in all four:

- High Volumetric Efficiency — for minimum size and weight.
- Low Leakage Current — for timing applications.
- Broad dual rated temperature range — from  $-55\text{ C}$  to  $+85/125\text{ C}$ .
- Thixotropic gelled electrolyte — for maximum stability throughout extreme temperature ranges.

For more information on these, or any other General Electric capacitors, call your nearest GE sales office, or write Section 430-52, Schenectady, N. Y. 12345.

# MAKE SOMETHING OUT OF IT!

GENERAL  ELECTRIC

INFORMATION RETRIEVAL NUMBER 121  
ELECTRONIC DESIGN 25, December 6, 1973

## DPMs serve as ohmmeters



Electronic Research Co., P.O. Box 913, Shawnee Mission, Kan. 66201. (913) 631-6700. \$475; 5 wk.

Series 4100 are digital panel-mountable ohmmeters. The new instruments are available with one of four different resistance ranges: 199.99  $\Omega$ , 1999.9  $\Omega$ , 19,999  $k\Omega$  and 199.99  $k\Omega$ . The meter offers front-panel, screwdriver adjustable ZERO and FULL-SCALE. Reading rate of Series 4100 Ohmmeters is four-per-second. Dimensions are: 4-1/2  $\times$  2-1/2  $\times$  7 in. Other features are: LED displays, buffered and latched TTL compatible BCD outputs, external start conversion and hold inputs.

CIRCLE NO. 326

## Color generator works on battery power

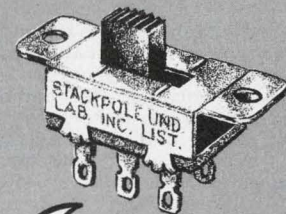
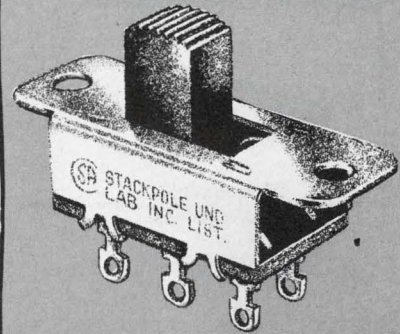


Sencore, 3200 Sencore Dr., Sioux Falls, S.D. 57102. (605) 339-0100. \$99.

The CG25 "Little Huey" is said to be the first portable, battery-operated digital color generator using CMOS ICs. The unit produces all RCA licensed patterns with pushbutton operation. Stability is guaranteed, with digital counting circuits displaying patterns that cannot jitter. Low power drain is backed up with an automatic shutoff. Operation is from 120 F to  $-20\text{ F}$ .

CIRCLE NO. 327

For five  
cents,  
I'd start  
something.



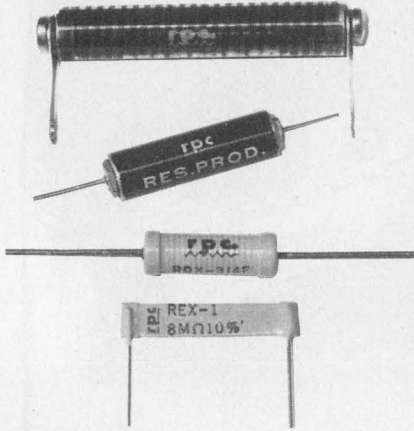
me too.

Turn on with a Stackpole slide switch. Prices start at 5¢ for this field proven standard of the industry. Available in two sizes, Regular and the new 50% smaller Miniature Series. Fully UL and CSA approved. Rated from 1 to 10 amps @ 125 and 250 volts (Miniature Series rated at 3 amps @ 125 V). Over 23 basic types, 7960 variations of slide and rocker switch adaptations. For complete details, send for Bulletin 78/79-100.

 **STACKPOLE**  
COMPONENTS COMPANY  
Raleigh, N. C. 27610

INFORMATION RETRIEVAL NUMBER 122

## WHO SAID GOOD RESISTORS HAVE TO BE EXPENSIVE?



### RPC CARBON FILM AND METAL OXIDE RESISTORS MAY COST YOU LESS

Knowing the technology involved in manufacturing resistors at RPC, you would assume that resistors are an expensive component. RPC carbon film and metal oxide resistors are the product of the best materials, research, design, and development techniques available today.

In the long run, as a supplier, RPC carbon film and metal oxide resistors may cost you less because over the years we have developed many cost saving techniques in manufacturing them. RPC resistors are designed and manufactured to meet your specifications. Our engineers use the most up-to-date technological equipment and knowledge in producing carbon film and metal oxide resistors that will meet the most stringent quality and performance requirements. **RPC's engineering facilities and research and development department are available to support your present staff**, which means RPC resistors may cost you less.

The next time you have a special application for carbon film or metal oxide resistors...think of RPC...as your research and development department. RPC carbon film and metal oxide resistors are priced competitively. For additional information write or call:

**RPC Resistance Products Co.**

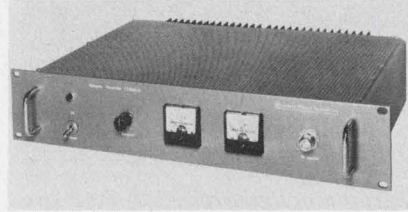
914 South 13th Street,  
Harrisburg, Pa. 17104  
Phone 717-236-5081 • TWX 510-650-4920

Export Address: 2200 Shames Drive,  
Westbury, New York 11590  
CABLE: CHURCHIN WESTBURY

INFORMATION RETRIEVAL NUMBER 123

## MICROWAVES & LASERS

### L-band telemetry xmtr outputs 25 W

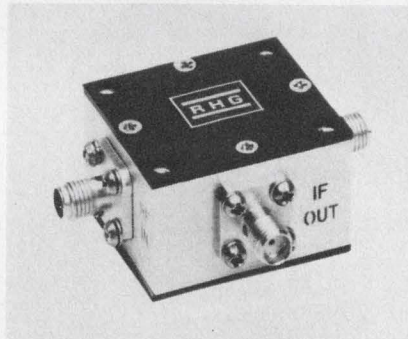


*Emhiser Rand Industries, 7721  
Convoy Ct., San Diego, Calif.  
92111. (714) 278-5080. 8 wk.*

The Model TT3620LR L-band telemetry transmitter, featuring a deviation range of 100 to 300 kHz pk-pk, has an output capability of 25 W over the 0-to-45-C temperature range. Harmonic distortion is 2% maximum over the modulation bandwidth and spurious outputs conform to IRIG 106-69. Interference and susceptibility meet MIL-STD-461 requirements. The FM unit accepts data signals in the 0-to-500-kHz range. It is factory set to any L-band frequency in the 1710-to-1850-MHz band with a frequency stability of  $\pm 0.003\%$  of preset value.

CIRCLE NO. 328

### Double balanced mixer uses 5-dBm LO



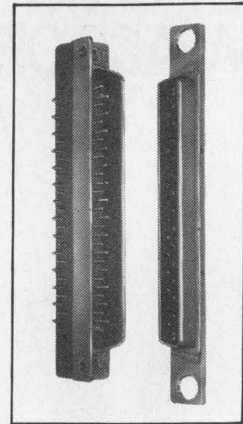
*RHG Electronics Laboratory, 161  
E. Industry Ct., Deer Park, N.Y.  
11729. (516) 242-1100. \$595; stock  
to 30 days.*

A multi-octave, double-balanced MIC mixer operates with reduced local oscillator power over the 1-to-18-GHz range. Called the Model DM1-18, the mixer's LO power requirements have been reduced from +7 to +5 dBm. The mixer has an rf-to-LO isolation of 20 dB, a noise figure of 10 dB (including a 1.5-dB i-f NF) and an i-f range of dc to 300 MHz. Both rf and LO VSWR are typically 2:1.

CIRCLE NO. 329

## USC UPCC/REPC CONNECTORS

Draw-Pull and Screwlocking. Built to MIL-C-55302 & Commercial Specifications. Printed Circuit & Related Applications. REPC Connectors are Removable, Re-Entrancy, Crimp Contact Types



1 of over 20,000 Connector Types Manufactured. Send today for UPCC-REPC-A Series 32-page Catalog

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Cable: COMPONENTS, NYK

INFORMATION RETRIEVAL NUMBER 124

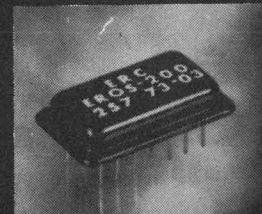
GO with

THE PEOPLE DOING  
THINGS THAT MATTER...  
IMAGINATIVELY

electronic research co. • a **ITT** div.

**erc**

In  
Hermetically Sealed  
.200 Inch High  
Crystal Oscillators



Actual Size

- 30 KHz to 15 MHz
- Ambient Range: up to  $-50^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$
- Ambient Stability: as good as  $\pm .002\%$

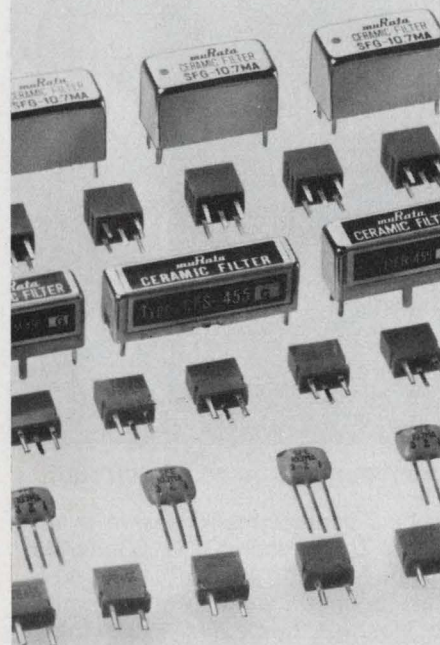
Telephone (913) 631-6700  
7618 Wedd  
Overland Park, Kansas 66204  
Mail to: P.O. Box 913, Dept. 114  
Shawnee Mission • Kansas 66201  
TWX: (910) 749-6477

# SOLID STATE IF FILTERS FOR SOLID STATE RELIABILITY

## muRata CERAMIC IF FILTERS

Whether your application includes AM and FM entertainment receivers or communications and TV receivers, Murata has a solid state ceramic IF filter that can replace those tired, wound IF cans for increased performance and reliability with reduced size and cost. 455 KHz filters, 10.7 MHz filters, 4.5 MHz filters including bandwidths for the sharpest communications receiver specifications and bandwidths to meet the "flat-top" requirements of good FM and TV are all included in this, the industry's largest, line of ceramic IF filters.

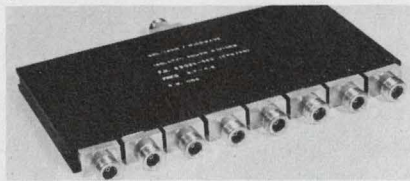
Why not add solid state reliability to your entire IF strip? Write for complete technical information today, it's yours for the asking.



# muRata

**MURATA CORPORATION OF AMERICA**  
2 Westchester Plaza, Elmsford, New York 10523  
Telex: MURATA EMFD 137332  
Phone: 914/592-9180  
A Subsidiary of  
Murata Mfg. Co., Ltd., Japan

## 8-way, 4-GHz divider provides isolated power



*Solitron/Microwave Connector Div., Cove Rd., Port Salerno, Fla. 33492. (305) 287-5000. \$500 (in quantity); 4-6 wk.*

An 8-way isolated power divider, the Model 69025-663 (with Type N connectors) covers a frequency range of 3.7 to 4.2 GHz. The power split is 9.0 dB with 0.5 dB maximum tracking. The phase tracking is less than 2° and the isolation is 22-dB minimum.

CIRCLE NO. 330

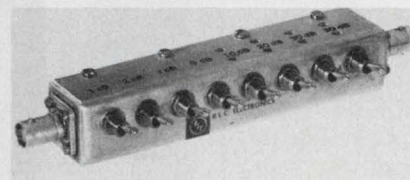
## Fixture measures S-parameters

*Wavecom Industries, 470 Persian Dr., Sunnyvale, Calif. 94086. (408) 734-8000. \$425; stock to 30 day.*

The Model 7025 microwave transistor test fixture can be used to measure S parameters and noise figures to 10 GHz. For both manual tests or computer-controlled network analyzers, the 7025 requires no soldering or tuning when configuring the device to accept the various transistors.

CIRCLE NO. 331

## Precision attenuators operate in vhf range



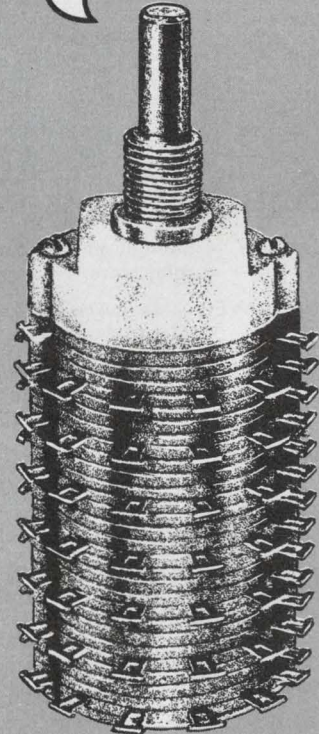
*R L C Electronics, Inc., 83 Radio Circle, Mount Kisco, N.Y. 10549. (914) 241-1334. \$100 (small qty.); stock.*

A line of vhf precision switch attenuators operate over the frequency range of dc to 120 MHz in 1-dB steps to 101 dB. The units feature low VSWR. Miniature, precision toggle switches allow the attenuation selection with reliability, according to the company. Units are available with type N, BNC, TNC or SMA female connectors.

CIRCLE NO. 332

You're a  
penny-pinching,  
up-tight, li'l  
switch with  
no spark.

True.



There's no better value than a Stackpole rotary switch. Fast delivery and quality features, but at a price you can afford. Unique design achieves a totally enclosed rotary, without sacrificing complex switching capability. Rigid construction and molded terminals produce a switch so tight it's explosion proof. Samples immediately. Production quantities in 1 to 2 weeks. Including switches with PC mounting. For details, send for Bulletin 73-103.

**STACKPOLE**  
COMPONENTS COMPANY  
Raleigh, N. C. 27610

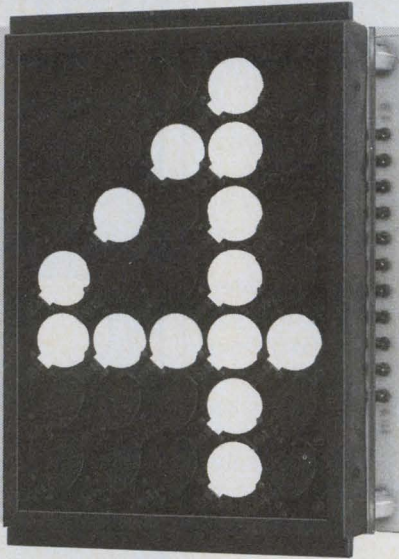
INFORMATION RETRIEVAL NUMBER 126



## Light-Reflecting Electromagnetic Display Components

### PRE-ENCODED MODULE

is made up of 35 light-reflecting discs in a 5 x 7 array — to display up to 11 different characters or symbols.



### MODULES 1 TO 18 INCHES

**MEMORY** — inherent remanent magnetism maintains the display state.

**LOW POWER** — as low as .75 joules to change data. Zero power to retain state.

**VISIBILITY** — rotating fluorescent discs provide excellent visibility over a wide range of ambient light conditions and wide viewing angles.

**RELIABILITY** — only one moving part per dot rated for over 20 million operations. No lights or mechanical linkages to wear out. Virtually maintenance free.

### FERRANTI-PACKARD DISPLAY MODULES

#### Ideal for

- Industrial Displays
- Scoreboards
- Traffic Control Displays
- TV Shows
- Paging Systems.

Fluorescent discs available in a range of colors.

Electromagnetic operation with remanent magnetism maintains display with zero energy input.

Inherent memory eliminates memory circuits and minimizes control and cabling costs. Modules can be driven from a common data bus.

A range of modules are available to display character sizes from 1 inch (2.54 cm) to 18 inches (45.72 cm) in pre-encoded and alphanumeric formats.

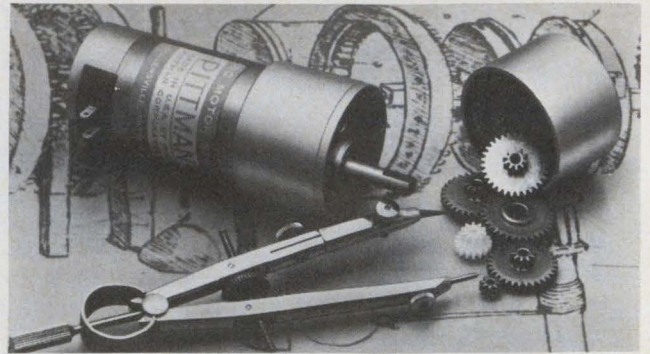
*For full information and specifications, contact the Display Components Department.*

## FERRANTI-PACKARD LIMITED

ELECTRONICS DIVISION,  
121 Industry Street,  
Toronto, Ontario, M6M 4M3, Canada.  
Telephone: (416) 762-3661  
Telex: 06-22007.

7305

INFORMATION RETRIEVAL NUMBER 127



## New Pitmo® Gearmotors

offer d-c servo motor performance combined with a rugged spur gear reducer which provides four standard ratios from 6.6:1 to 197:1. The GM8200 series, now in production, has a gearbox diameter of 1.375" and lengths from 3" to 3.4", excluding output shaft extension.

Gears are sintered iron to AGMA 9E tolerances except for the first gear after the armature pinion which is molded acetal resin to AGMA 8E tolerances. Torque limit on the gearbox is 250 oz. -in.

Three standard motor lengths combined with many possible variations in armature windings permit tailoring of outputs to a wide range of performance requirements.

©1973

For more information, write now.

114



### THE PITTMAN CORPORATION

A Subsidiary of Penn Engineering & Manufacturing Corp.

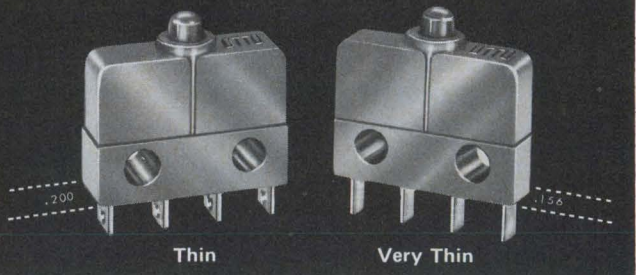
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INFORMATION RETRIEVAL NUMBER 128

## OTTO®

## Sub-subminiature Switches



**snap-action • precision • 8 A. to dry circuit!**

Less than 10 milliohms contact resistance in a ten million cycle switch! That's the OTTO B3 series with patented\* design featuring high contact force and minimal contact bounce. Commercial or military, your options include "thin" and "very thin" sizes, contact arrangements to form Z, terminals, and contact materials. Load ratings to 8 A. resistive. Actuators available, too.

*For full details including prices and local distributors, write for Bulletin B3.*

\*U.S. Pat. No. 3,612,793

## OTTO CONTROLS Division, OTTO engineering, Inc.

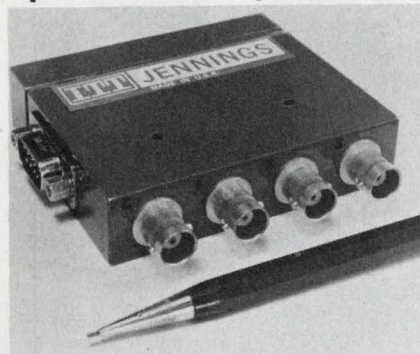
36 Main Street, Carpentersville, Illinois 60110 • Phone: 312/428-7171

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INFORMATION RETRIEVAL NUMBER 129

ELECTRONIC DESIGN 25, December 6, 1973

### 300-MHz unit starts up coaxial relay line

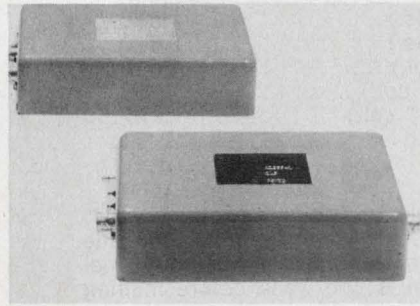


ITT Jennings, 970 McLaughlin Ave., San Jose, Calif. 95116. (408) 292-4025. RC1103A: \$100 (small qty.); 60 day.

A series of modular coaxial relays, the RC1100 series, is available for a range of applications including CATV, CCTV and telemetry. The initial offering in the series is the RC1103A, a 1X3 relay with a dc-to-300-MHz frequency capability. The unit's sealed rf contacts are said to provide a low and stable contact resistance with an extremely long life. Characteristic impedance is 50  $\Omega$  and the unit is equipped with BNC connectors.

CIRCLE NO. 333

### Rf-amp line spans 3-kHz to 300-MHz band



Aiken Electronics, 7411 50th Ave., College Park, Md. 20740. (301) 779-7600.

The company's line of rf amplifiers reportedly feature wide dynamic range and low intermod distortion, plus predicted MTBFs on the order of 100,000 hours. The amplifiers cover the frequency range of 3 kHz to over 300 MHz. Standard features include VSWR of typically less than 1.5:1, an output compression of typically +25 dBm and integral front-end protection.

CIRCLE NO. 334

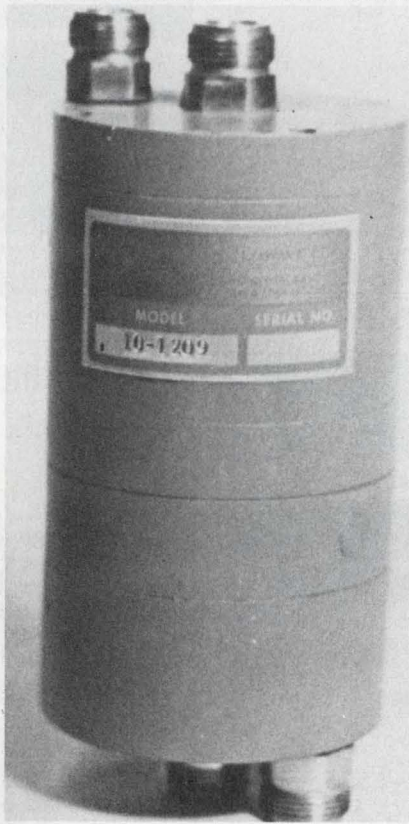
### Filter/isolator module has 10% bw in S-band

UTE Microwave, 3500 Sunset Ave., Asbury Park, N.J. 07712. (201) 922-1009. 90 day.

A four-channel S-band filter-isolator assembly, the FCF-306-0, has a 10% bandwidth and 1-dB maximum insertion loss. Intended for such multichannel applications as phased arrays and monopulse systems, the subassembly also features a minimum reverse isolation of 20 dB and phase matching of  $\pm 5^\circ$  between channels. VSWR is 1.25:1.

CIRCLE NO. 335

### Compact rotary joint covers broad bandwidth

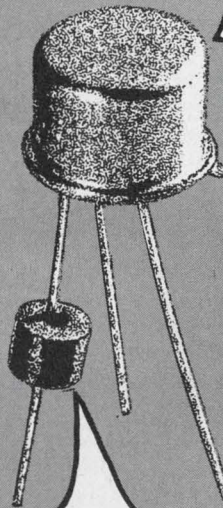


Eastern Microwave, 139 Swanton St., Winchester, Mass. 01890. (617) 729-7901.

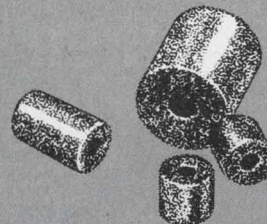
A dual-channel coaxial rotary joint, the Model 10-1209, measures only 5-1/4  $\times$  2-3/8 inches when equipped with type N connectors. The center channel can operate over the frequency range of 0.1 to 12 GHz, while the outside channel handles frequencies from 0.2 to 3 GHz. Isolation between channels is 50 dB. The VSWR is less than 1.4:1 and the insertion loss is less than 0.3 dB.

CIRCLE NO. 336

Switch on **NOISE**,  
Switch off **NOISE**,  
Switch on **NOISE**,  
Switch off **NOISE**.



Quiet!

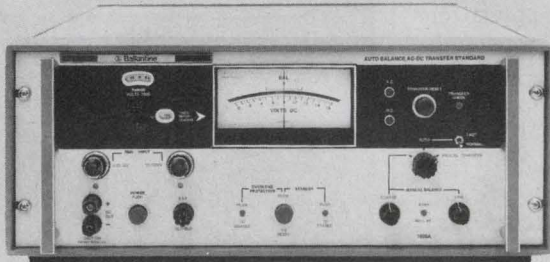


Ceramag<sup>®</sup> ferrite beads provide a simple, inexpensive means of obtaining RF decoupling, shielding and parasitic suppression without sacrificing low frequency power or signal level. Install beads by slipping one (or more) over appropriate conductor(s) for desired effect. Sizes from .020" ID - .038" OD - .050" L. Beads available with leads for PC boards. Send for samples.



**STACKPOLE**  
Electronic Components Division  
St. Marys, Pa. 15857

# automatic transfer standards



The 1600A Auto-Balance AC/DC Transfer Standard. Precise repeatable measurements every 30 seconds. Traceable to NBS. Takes tedium and guesswork out of 100 ppm transfer measurements in Lab, QA and production.

0.25 V to 1 kV rms, dc to > 100MHz: \$3950



**Ballantine Laboratories, Inc.**  
P.O. Box 97, Boonton, New Jersey 07005  
201-335-0900, TWX 710-987-8380

INFORMATION RETRIEVAL NUMBER 131

# MINIATURE BITE INDICATOR OPERATES DIRECTLY FROM LOGIC LEVEL...

BUILT-IN TEST EQUIPMENT

ACTUAL SIZE



## MI51LP

The Minelco® MI51LP BITE Indicator features a desirable combination of features for the design engineer including:

- Miniature size.
- Negligible power drain.
- Operation directly from logic level.
- Manual reset with spring return.
- Environmental sealings without "O" rings.
- Long life capability — virtually burn-out proof.

For further information ask for Bulletin M-12.



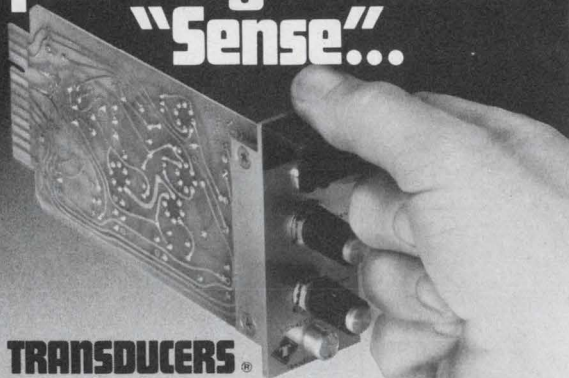
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DIVISION  
GENERAL TIME CORP.  
A Talley Industries Company

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INFORMATION RETRIEVAL NUMBER 133


# When you Plug in some "Sense"...



## TRANSDUCERS® can help.

Now available from Transducers, Inc. is a complete series of "sensible" instrumentation "building blocks" designed to provide better measurement data. In simple rack plug-in form are accurate data measurement instrument modules such as power supplies, amplifiers, analog and digital set point controllers, analog peak holds, analog meters, channel selectors, digital panel meters, and a variety of rack adapters.

Now we can give you a conditioned signal at your control point. You can free your mind for process problems with confidence in our quality building block solution to weight, force or pressure signal conditioning for high performance transducers. Ask for Bulletin 92 for more information. Write, wire or phone today!

**TRANSDUCERS, Inc.**  **Makes Sense**

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INFORMATION RETRIEVAL NUMBER 132

# Recruitment Advertising gets READ . . . in Electronic Design

## RATES

1 page . . . . .	\$2,040.
3/4 page (3 cols.) . . . . .	1,530.
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One column inch . . . . .	51.

## DATA

Four column make-up. Column width: 1-3/4". Each issue mails two weeks prior to the issue date. Closing dates for camera-ready mechanicals or film is one week before mailing date. If desired, Electronic Design will set type at no charge (closing date is 2 weeks prior to mailing date).

**84,000 DESIGN ENGINEERS AND ENGINEERING MANAGERS**

Call the Recruitment Hotline: (201) 843-0550 X209 or clip & mail this coupon to: Recruitment Manager, Electronic Design, 50 Essex St., Rochelle Park, N.J. 07662.

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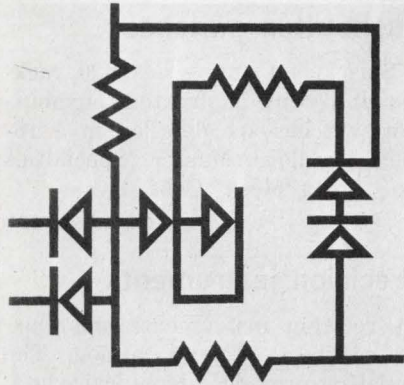
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 Name \_\_\_\_\_ Title \_\_\_\_\_  
 Company \_\_\_\_\_ Telephone \_\_\_\_\_  
 Address \_\_\_\_\_  
 City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_



## new literature

### Electronic Development Corporation

1973



### Voltage standards

A four-page selection guide to ac and dc voltage and current standards describes 21 calibrators, references and sources, and lists performance information and optional features. Electronic Development, Boston, Mass.

CIRCLE NO. 337

### Digital IC tester

Major features of the J127 Accutest circuit analyzer, a test instrument designed to perform functional and dc parametric tests on digital ICs as well as on certain discrete, linear and optoelectronic devices, are discussed in a 10-page brochure. Teradyne, Boston, Mass.

CIRCLE NO. 338

### Fault locator

Design features and specifications for the capacitor impulse fault locator, model CF25-3, are given in a brochure, along with operating instructions for the location of cable faults. Safety features, both for operators and personnel, are listed, as are mechanical design highlights. Hipotronics, Brewster, N.Y.

CIRCLE NO. 339

### Frequency synthesizers

Six programmable frequency synthesizers are described and illustrated in a 16-page short-form catalog. Adret, Lancaster, Pa.

CIRCLE NO. 340

### Self-clinching fasteners

An eight-page bulletin is devoted to self-clinching captive fasteners in ISO metric thread sizes. Penn Engineering & Manufacturing Co., Doylestown, Pa.

CIRCLE NO. 341

### Digital instruments

A digital instrument product index shows what's available in the company's digital instruments. Electronic Research, Shawnee Mission, Kan.

CIRCLE NO. 342

### Microwave circuit modules

Detailed charts and outline drawings in a four-page data sheet present characteristics, ratings and physical parameters on bulk-effect diodes suited to applications that include miniature cw doppler radar, motion-detection systems such as police radar and traffic speed controls, private and commercial security alarms and automobile safety systems. General Electric, Owensboro, Ky.

CIRCLE NO. 343

### Comparison report on FFTs

A side-by-side analysis of present Fast-Fourier-Transform systems—specification by specification—includes comparisons of speed, dynamic range, usable resolution, ease-of-use and price. Federal Scientific, New York, N.Y.

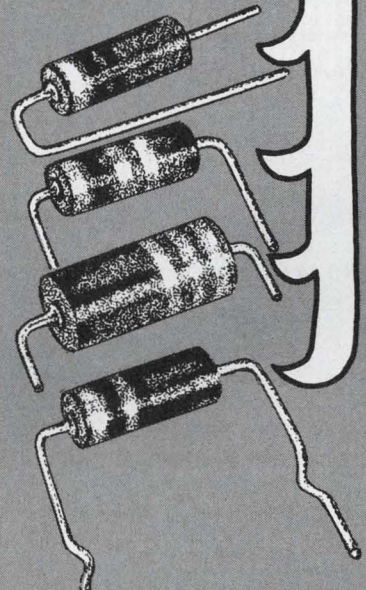
CIRCLE NO. 344

### Gas-sensing semis

Unique bulk metal-oxide semiconductors that change ac-output voltage rapidly in the presence of small concentrations of gases like hydrogen, carbon monoxide, methane, propane, alcohol (including the drinking kind), volatile oil, acetylene and "white" smoke are described in a 4-page brochure and a series of data sheets that include response curves for different gases, a circuit diagram, key specs and prices. Figaro Engineering, Osaka, Japan.

CIRCLE NO. 345

**Cut and formed leads reduce assembly costs.**



**Now that's a nice twist.**

Pre-shaped and trimmed resistor leads significantly reduce installation time. All Stackpole carbon composition resistors, 2, 1, 1/2, and 1/4 watts are available with cut and formed leads, to your specifications. Leads are coated for easy soldering. All resistors are 100% tested. Samples available. Send for Bulletin 80-100.



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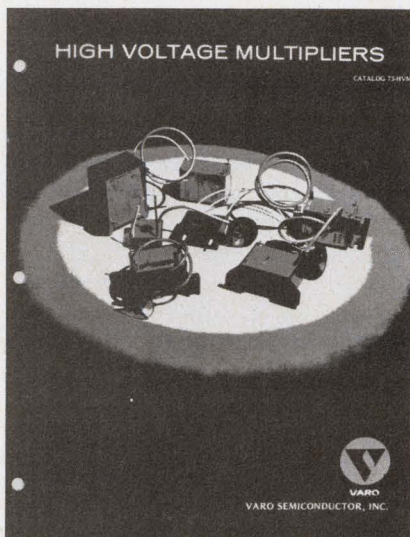


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55 Years of Measuring  
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## NEW LITERATURE



### High-voltage multipliers

A high-voltage multiplier catalog includes electrical and mechanical design considerations, circuits and typical case styles, and nine output connectors. Varo Semiconductor, Garland, Tex.

CIRCLE NO. 346

### Test equipment

One of the broadest lines of test equipment from Japan—the National brand—is covered in a 52-page catalog. Included are scopes, counters, digital multimeters, signal generators, oscillators, distortion meters, VTVMs and accessories. Matsushita Communication Industrial Co., Ltd., Osaka, Japan.

CIRCLE NO. 347

### Silicon rectifiers

Three versions of an extended series of medium-power silicon rectifiers, 1N1199, 1N3670 and 12F series, are described in a six-page data sheet. The literature contains 11 graphs, a dimensioned outline drawing and a photograph of the devices. Specifications and ratings are provided. International Rectifier, Semiconductor Div., El Segundo, Calif.

CIRCLE NO. 348

### Rubber adhesives

Typical applications of five rubber adhesives are illustrated in a two-page, two-color brochure. 3M, St. Paul, Minn.

CIRCLE NO. 349

### Recording equipment

Sound measuring, monitoring and recording equipment designed to meet OSHA and similar noise-pollution-control requirements are detailed in an eight-page, four-color brochure. Triplett, Bluffton, Ohio.

CIRCLE NO. 350

### Pushbutton switches

Series 800 and series 820 rack-mounted/plug-in lighted pushbutton switches are detailed in a 16-page catalog. Master Specialties Co., Costa Mesa, Calif.

CIRCLE NO. 351

### Precision instruments

Precision instruments are illustrated in a 12-page catalog. The bulletin provides technical data, sales and service information. General Resistance, Mount Vernon, N.Y.

CIRCLE NO. 352

### Video instruments

A literature packet includes a list of the company's video instruments and a freebie super-maze to challenge your perception. Colorado Video, Boulder, Colo.

CIRCLE NO. 353

### Pushbutton switches

Lighted and nonlighted pushbutton switches for industrial applications are described in a 24-page catalog. Specifications, dimensional drawings and ordering information are included. Centralab, Milwaukee, Wis.

CIRCLE NO. 354

### Equipment rack

The all-new "Action" rack, readily adaptable for use in large multibay systems, is described in a 16-page catalog. Optima Enclosures, Tucker, Ga.

CIRCLE NO. 355

### Digital multimeters

A short-form catalog describes a line of digital multimeters, ranging from 2000 to 20,000 counts and offering measurements capability from 10  $\mu$ V to 1400 V. Data Technology, Santa Ana, Calif.

CIRCLE NO. 356

## Emergency ac power sources

Descriptive data, application information, technical and mechanical specifications for solid-state emergency power sources are given in a two-page data sheet. ERA Transpac, Moonachie, N.J.

CIRCLE NO. 357

## Test set

A test set for the nondestructive measurement of the safe-area of power transistors under high-voltage, high-current conditions is described in an eight-page data sheet. RCA, Somerville, N.J.

CIRCLE NO. 358

## Line conditioners

A specification sheet highlights the model 478T line conditioner. Bowmar Instrument Div., Acton, Mass.

CIRCLE NO. 359

## Communication modems

A 12-page illustrated catalog contains descriptions of high-speed modems and specialized communication system accessories. International Communication Corp, Miami, Fla.

CIRCLE NO. 360

## Digital troubleshooting

Troubleshooting digital equipment in the engineering lab, on the production line or in field service is simple and easy using a new technique of capturing any section of a digital bit stream. "The Logic Analyzer" describes in detail how this method is used with the HP model 5000A logic analyzer. Hewlett-Packard, Palo Alto, Calif.

CIRCLE NO. 361

## Digital instruments

An easy-to-use 76-page catalog allows selection of mechanical, electrical and electronic digital instruments available from a single manufacturer. Contents are grouped by totalizing counters, predetermining counters, printers, input devices and custom-designed products. Included are stock items, applications, specifications, options, drawings and ordering information. Veeder-Root, Hartford, Conn.

CIRCLE NO. 362

# What you should know about SLIMSWITCHES



### SERIES 23000 SNAP-IN SLIMSWITCH

- A List prices start at \$2.50 per switch module, (or only 25¢ per switch function, avg. ...less than most toggle, pushbutton, lever, slide or rotary switches.
- B Snap-in mounting cuts installation costs by eliminating mounting holes and hardware and lets you relax your panel cut out tolerances.
- C The molded-on bezel stops installation "headaches" by covering irregular panel cut outs, chipped paint, and scratches.
- D They're only .315" (8mm) wide, so you can put more switches into a given space. That's why we call 'em SLIMSWITCHES.
- E Our unique assembly strap lets you put switch assemblies together fast, without tools.
- F Why not stock parts and build your own switch assemblies? Or we'll assemble them for you at no extra cost.
- G Plenty of output code options, too!
- H They're good for a million detent operations. Just like more expensive switches.

They're built by DIGITRAN the originators of the DIGISWITCH the first switch of its type anywhere and that's your guarantee of high quality for the price.

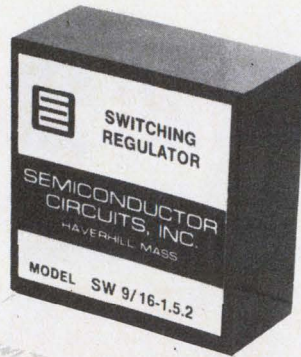
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INFORMATION RETRIEVAL NUMBER 138

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Common Mode Rejection is 140dB and interwinding capacitance is less than 1 femtofarad (0.001 pf).



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CORPORATION

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 Telephone (714) 297-4466

Fairchild Camera & Instrument Corp.'s Digital Products Div. has added 15 new device types to the line of 7400 series TTL/MSI circuits. They are available in commercial and military temperature ranges in ceramic dual-inline packages as well as in commercial temperature ranges in plastic DIP packages.

CIRCLE NO. 363

Three low-cost visible light-emitting diodes (VLEDs) have been introduced by Texas Instruments. They are designated the TIL209A, TIL220 and TIL221. At a forward current of 20 mA, minimum luminous intensity for the TIL209A is 500 microcandelas, 800 for the TIL220 and 1000 for the TIL221. Static forward voltage for each VLED is 2 V max.

CIRCLE NO. 364

Motorola Semiconductor Products Div. has introduced MMCRA thin-film resistor chips with resistance values from 0.1 Ω to 5.11 MΩ and a ±0.01% tolerance range. Operating temperatures spread from -55 to +125 C. These laser-trimmed resistors are manufactured from nickel-chrome film deposited over a silicon-oxide isolation layer grown on p-type silicon material.

CIRCLE NO. 365

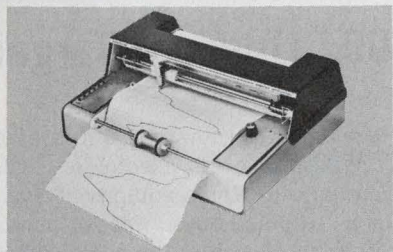
A line of D-subminiature connectors with terminals has been introduced by TRW/Cinch Connectors. These are produced in the standard 8, 15, 25, 37 and 50-contact arrangements in both plug and socket types. They are directly interchangeable with any other D-subminiature connector in the Cinch line.

CIRCLE NO. 366

Silicon General has announced the availability of the SG 1558/1458, the equivalent of two 741 op amps, in eight-pin plastic miniDIP and TO-99 metal packages. The SG 1558 is a direct replacement for the Motorola MC1558.

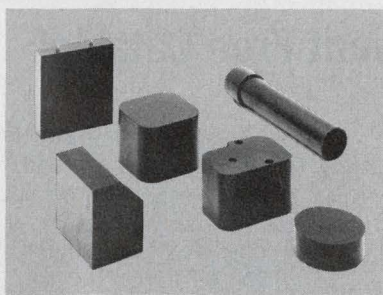
CIRCLE NO. 367

INFORMATION RETRIEVAL NUMBER 139



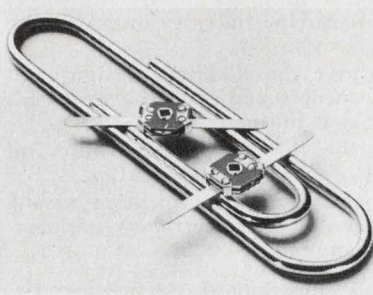
**OmniScribe™ Strip Chart Recorder** provides low cost, high quality for industrial, chemical, medical, biochemical, physiological and university laboratories. Prices start at \$395 which is half of competition. Features include multi-speed chart drive, sprocketless paper feed and a re-balance element to replace the potentiometer. Houston Instrument, 3950 Terminal Ave., Bellaire, Texas 77401. (713) 667-7403

INFORMATION RETRIEVAL NUMBER 151



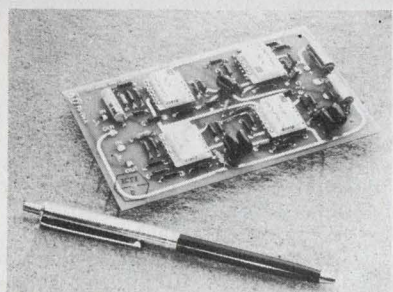
**Glass laminated epoxy 155°C cases** for component and circuit packaging are available in thousands of sizes. Thin wall tubes and headers offer optimum protection in all applications. Literature and samples available. Stevens Tubing Corp., 128 North Park Street, East Orange, New Jersey 07019. Telephone 201-672-2140.

INFORMATION RETRIEVAL NUMBER 152



**Thin-Trim variable capacitors** provide a reliable means of adjusting capacitance without abrasive trimming or interchange of fixed capacitors. Series 9401 has high Q's and a range of capacitance values from 0.2-0.6 pf to 3.0-12.0 pf and 250 WVDC working voltage. Johanson Manufacturing Corporation, Boonton, New Jersey (201) 334-2676.

INFORMATION RETRIEVAL NUMBER 153



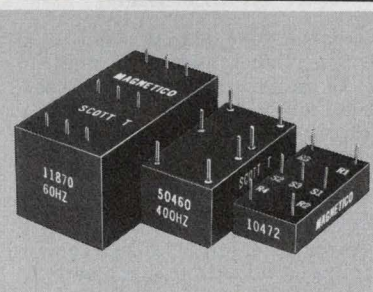
**"C"—message weighting filter** with 2800 Hz notch, KTI Model FB-194A, for use with telephone noise measuring equipment. Separate "C"—Message and Separate Notch (2800 Hz or 1010 Hz.) filters available. Brochure describing theory, design, application and options from KTI, 3393 De La Cruz Blvd., Santa Clara, Calif. 95050. (408) 296-9305.

INFORMATION RETRIEVAL NUMBER 154



**Low power time code generator** for remote, data recording systems: Outputs days, hrs, mins, and secs in IRIG-B 1000 Hz Time Code. Input 5-15 VDC <20 m watts. Accuracy .0001%. Features: Preset time of year—BCD time output for system control—provision for 45 bits of add data. Vast Inc., 1 Main St., Ivoryton, CT 06442 (203) 767-0158

INFORMATION RETRIEVAL NUMBER 155



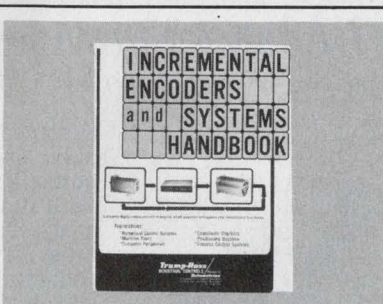
**Scott T Transformer.** 11870: 60HZ, 90v, L-L In. 1.1x2.1x1.1. 50460: 400HZ, 90v, L-L In. 7/8x1-5/8 x11/16. 50462: 400HZ, 11.8v, L-L In. 7/8x1-5/8x11/16. 10472: 400-HZ, 11.8v, L-L In. 3/4x1-1/2x3/8. All with 6v RMS sine & cosine output. MAGNETICO, INC., E. Northport, N.Y. 11731. 516-261-4502.

INFORMATION RETRIEVAL NUMBER 156



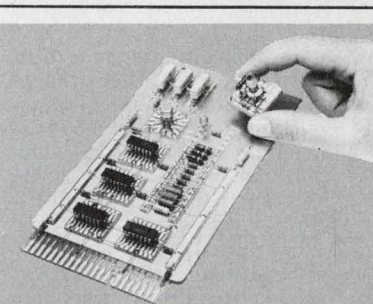
**PED-A-VAC Desoldering System**—Places all power desoldering/soldering elements in one location. Foot-controlled vacuum generator uses standard shop air. Adjustable tip temperature control. Mechanical switching won't damage circuit components. PACE, INC. 9329 Fraser St., Silver Spg., Md. 20910

INFORMATION RETRIEVAL NUMBER 157



**Free new valuable handbook** on the Theory, Selection, and System applications of Incremental Encoders. The handbook outlines the do's and don'ts on the use of incremental encoders and the ease of incorporating incremental encoders into digital systems. Trump-Ross Industrial Controls, Div. Datametrics, 340 Fordham Rd., Wilmington, Mass. 01887.

INFORMATION RETRIEVAL NUMBER 158



**Free sample** shows how you can assemble your prototype circuits in minutes even your card cage bread board. Mini-mounts, a series of etched patterns which adhere to your ground plane, mount all electronic components for prototype circuits from dc to GHz. Christiansen Radio, Inc., 3034 Nestall, Laguna Beach, Ca 92651. (714) 497-1506.

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A new 40-page short form catalog contains 17 new data conversion products from Datal Systems. The catalog has complete electrical and mechanical specifications on all of Datal Systems products with over six pages of applications information.

Modular products described in this catalog include: A/D converters, D/A converters, sample and hold amplifiers, operational amplifiers, DC power supplies, DC to DC converters, digital panel meters, analog multiplexers, and a 16 channel data acquisition system. Systems products include a 256 channel data acquisition and distribution system with minicomputer interfacing for digital signal processing and a low data logging system for remote environmental applications.

CIRCLE NO. 172

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CIRCLE NO. 173

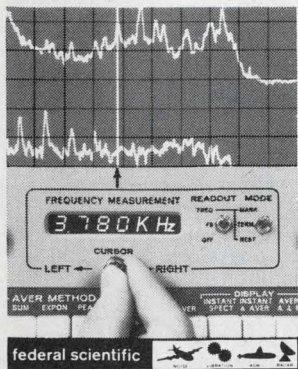
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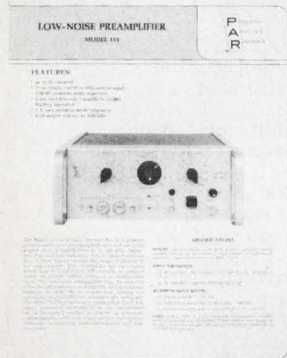
### Federal Scientific Corporation

An Affiliate of Nicolet Instrument

615 West 131st St., New York, N.Y. 10027 (212) 286-4400

CIRCLE NO. 174

## Low-Noise High-Gain Pre amplification



Complete specifications of a variable-bandwidth high-gain preamplifier are contained in the Model 113 data sheet, T-224. Included are typical noise figure contours illustrating the amplifier's exceptionally low noise, which is as low as .05 dB at mid frequencies with a 1 megohm source. Other illustrations include typical plots of the equivalent input noise and common mode rejection, which exceeds 100 dB at 60 Hz at all gain settings. The data contained in the specification sheet will be of interest to all engineers and researchers looking for a preamplifier with calibrated gain and rolloffs from dc to 300 kHz.

CIRCLE NO. 175

### Princeton Applied Research Corporation

Box 2565, Princeton, New Jersey 08540 - (609) 452-2111

## DIGILAY® push button programming . . . 4 separate operational modes . . . unbelievable accuracy, crystal controlled.

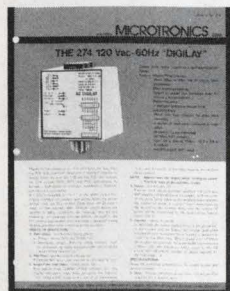
The DIGILAY is the first digitally controlled time delay relay. The desired timing, pulse, counting or flip-flop action is programmed into the unit merely by pressing one or more switches at the top of the unit.

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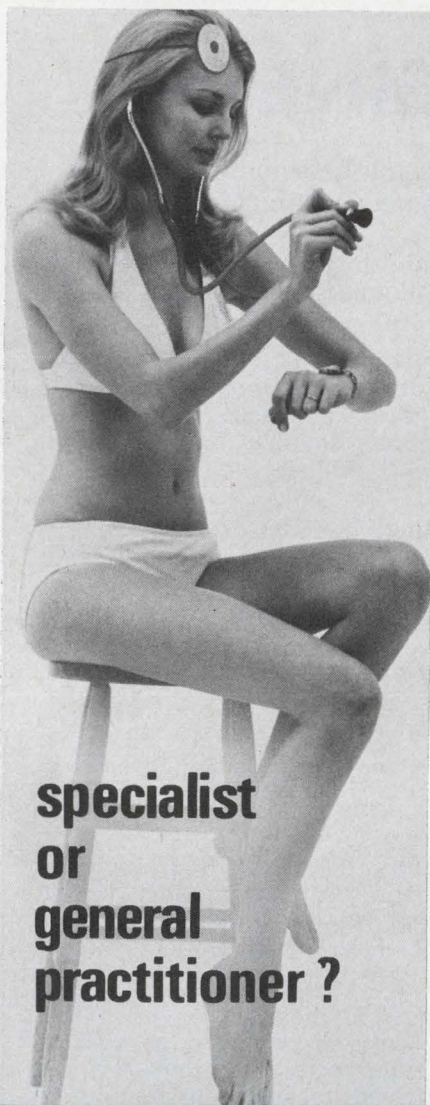
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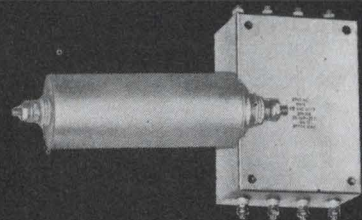
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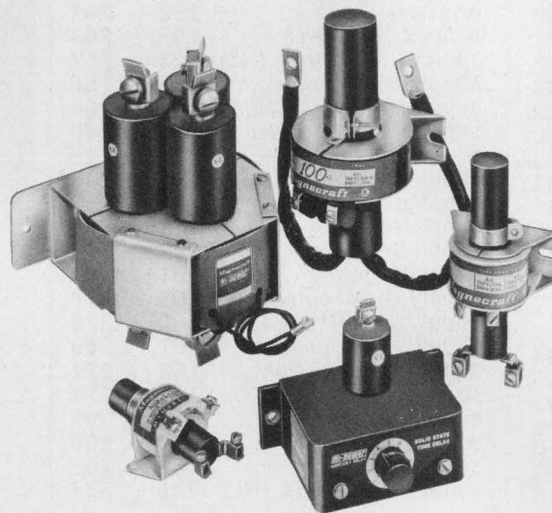
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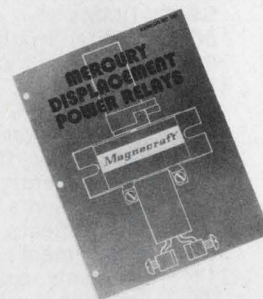
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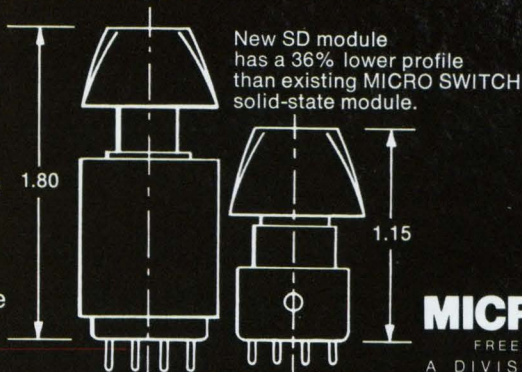
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Only Burroughs manufactures NIXIE<sup>®</sup> tubes, SELF-SCAN<sup>®</sup> panel displays and PANAPLEX<sup>™</sup> numeric panel displays.

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