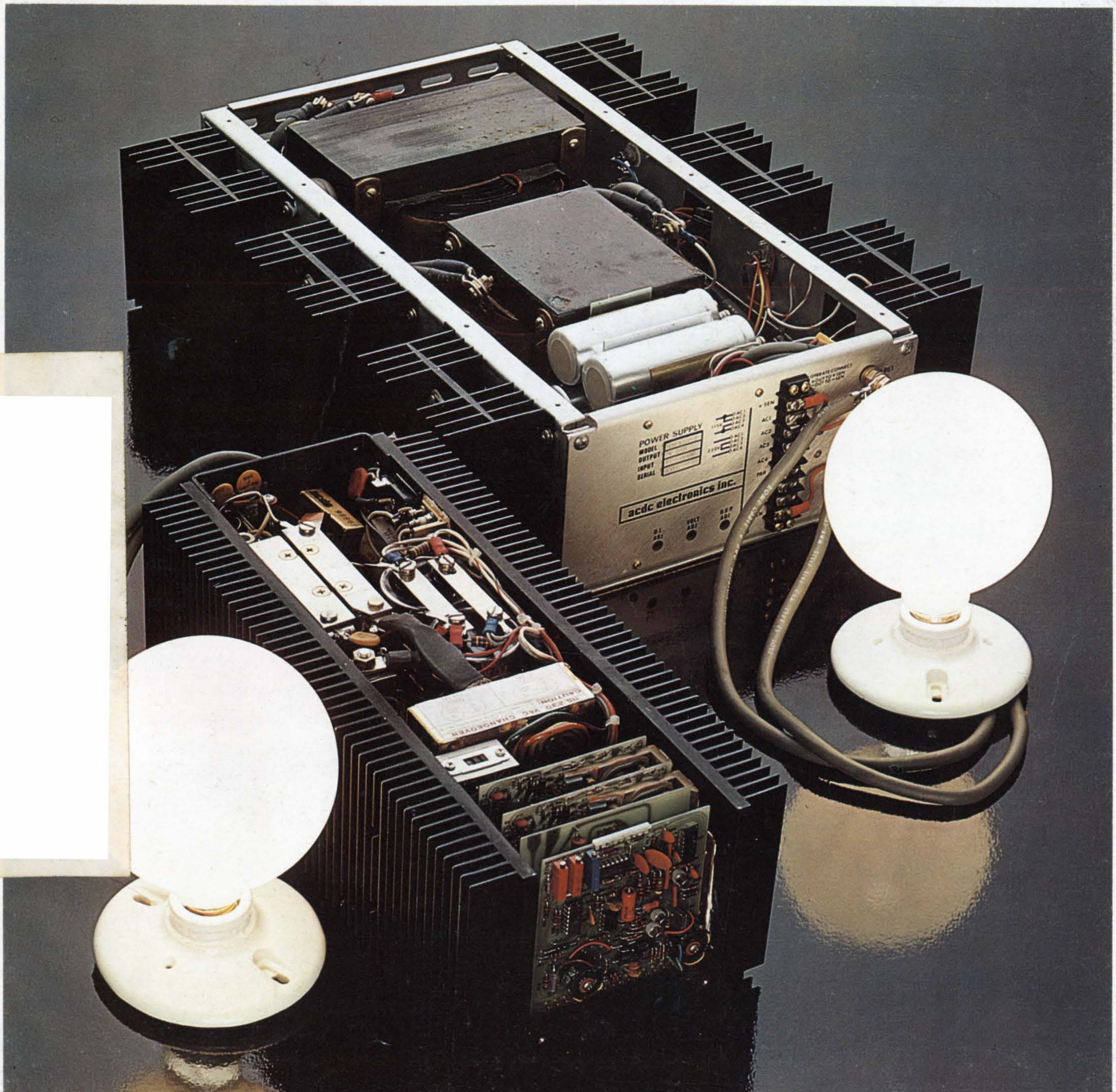
VOL. 23 NO.

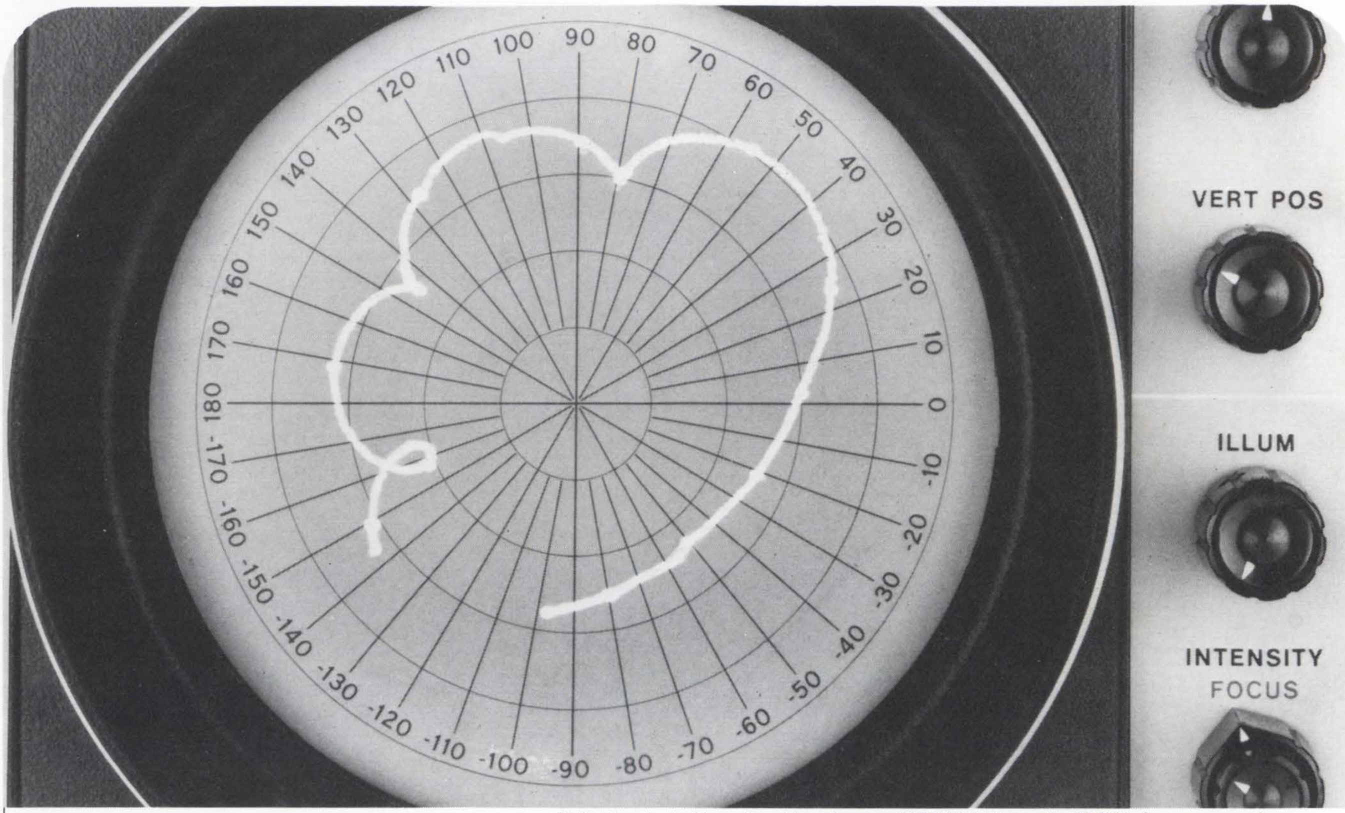
Electronic Design 20

FOR ENGINEERS AND ENGINEERING MANAGERS

SEPT. 27, 1975

Switching regulators shine with the highest efficiency, coolest operation and smallest size per watt in a regulated power supply. But you'll have to spend more and settle for higher ripple and noise. Transient performance must be relaxed, too. And then there's the big question: Are switchers reliable? Learn more on p. 52.





Reflection (s_{11}) of broadband transformer, 200-1000 MHz, with 50 MHz frequency markers.

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Electronic Design 20
FOR ENGINEERS AND ENGINEERING MANAGERS
SEPT. 27, 1975

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by Harry Chamberlain, courtesy of ACDC Electronics, Oceanside, CA

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And along with that true 12-bit accuracy, you also get: a maximum gain temperature coefficient of 10 ppm/°C, including the reference; a maximum error at +25°C of ¼ LSB; and monotonicity guaranteed over the full temperature range.

In addition, the AD563 is TTL/DTL and CMOS compatible and priced from just $27 in 100's.

AD563. A new level of integration for 12-bit DACs.

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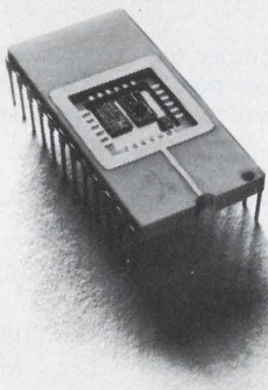

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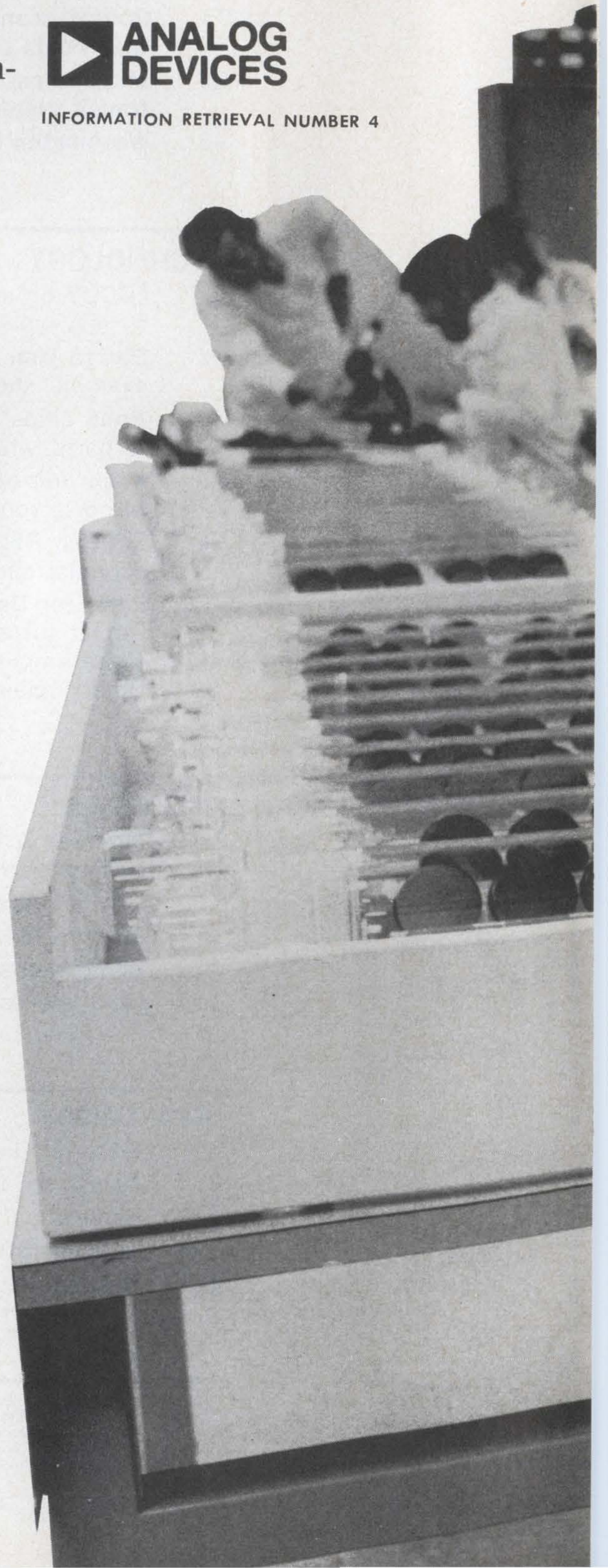
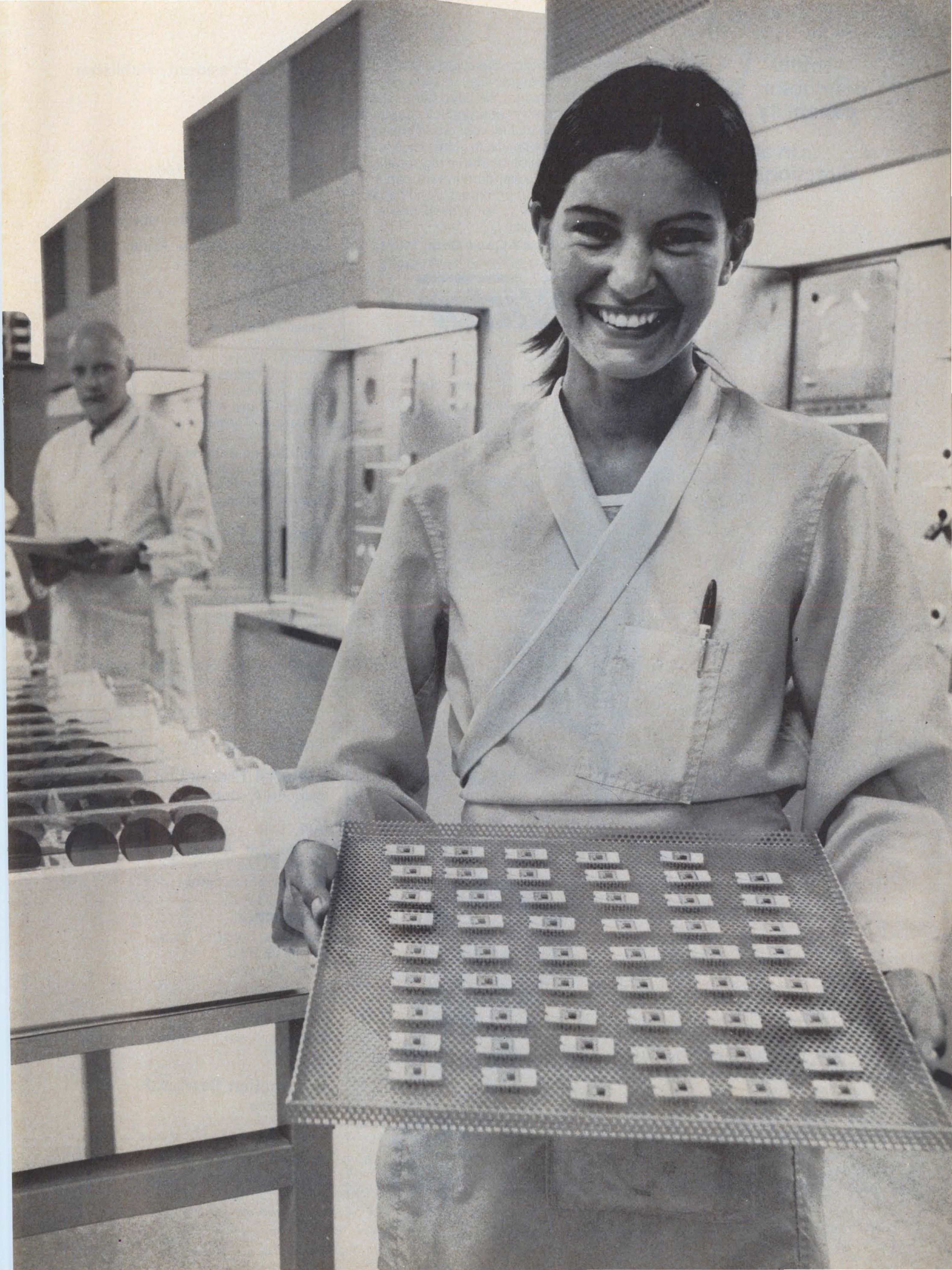
ANALOG DEVICES

INFORMATION RETRIEVAL NUMBER 4





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Across the Desk

Calculator user notes () () () () trouble

Apropos of your recent articles on RPN calculators vs algebraic notation (ED No. 2, Jan. 18, 1975, p. 50; ED No. 12, June 7, 1975, p. 8 and p. 80), I would like to point out that some of the algebraic models with parentheses make mistakes.

The problem has to do with the parentheses and the y^x function. Two examples of problems that give incorrect solutions are

$$1 + (1) = 1$$

$$((2/4)^3)^3 \cdot ((4/2)^3)^3$$
$$= 3.81469723 \times 10^{-6}.$$

The correct answer for the first problem is 2, and for the second problem, it is 1. The incorrect answers were obtained on my Bowmar MX-140, but since this calculator is now available for only $39, I suppose I shouldn't be too concerned.

The difficulty in the first example is that if you use a parenthesis without needing it—that is without doing any calculations inside it—the calculator ignores the previously stored part of the answer. Sometimes it is not entirely obvious that the problem has an unneeded parenthesis, as for example in

$$1 + (\sin 45°)^2 = 0.5.$$

The difficulty in the second problem is that the y^x key on some calculators is treated completely differently from any other function key—namely, it closes all preceding parentheses.

I believe the moral is that regardless of which scientific calculator you buy—whether it be RPN or algebraic, with or without parentheses—you will have to take time to learn its features and its quirks.

Peter A. Stark
196 Forest Dr.
Mount Kisco, NY 10549

He sharpens the focus on pulse transformers

I read with great interest "Focus on Pulse Transformers" in the June 21 issue. The first paragraph on p. 80, though—a discussion of problems that can result from the use of sine-wave inductance instead of pulse inductance—may have confused some readers. A few added sentences may help to clarify it:

To illustrate the problem . . . of less than 50%. Without consideration of the peak current drawn by the load from the transformer, the selection of a transformer with a 1-mH sine-wave inductance, instead of a 1-mH pulse inductance, may cause the core to be driven near saturation and the 50% pulse droop will be exceeded. To get a 1-mH pulse inductance for this application, you might actually need a transformer with a 2.2-mH sine-wave inductance and a larger volt-age-time product.

The ET rating of a pulse transformer is usually defined by a 20% maximum nonlinearity of the primary magnetizing current rather than by saturation-limiting of the core. Therefore both the required peak primary current and pulse inductance must be known to select a transformer with the

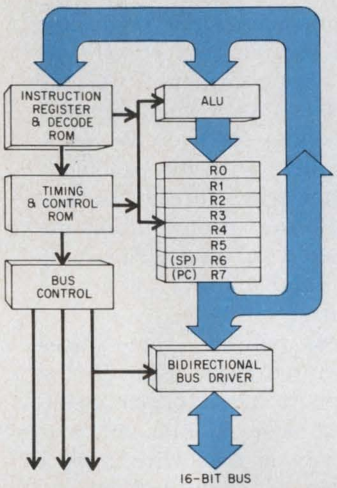
(continued on page 10)

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.

CP 1600 GENERAL INSTRUMENT'S 16-BIT MICROPROCESSOR

CP 1600 is the first single-chip 16-bit microprocessor with third generation minicomputer architecture. The only one. And, together with its powerful and continually growing support package, provides a new level of microprocessor system capability.

Let's start with the chip. It uses eight high-speed, general purpose 16-bit registers. Twice as many as the competition's 16-bit unit.

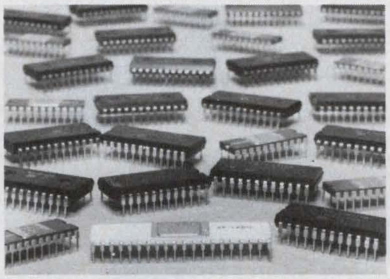


And it's twice as fast. Register to register operations take only 3.6 μs. Memory to register and Input/Output operations, only 4.8 μs. But speed is only one of the CP 1600's outstanding features. 16-bit word length and four addressing modes permit efficient access to 64K of memory—in any combination of program, data storage, or peripheral devices. So, I/O data can be manipulated just like memory. By all 87 instructions.

Regarding stack storage or program interrupts. CP 1600 has unlimited stack depth and self-identifying, nested interrupt capability with priority resolution. The competition's chip has only a 16 level stack and 4 interrupt levels.

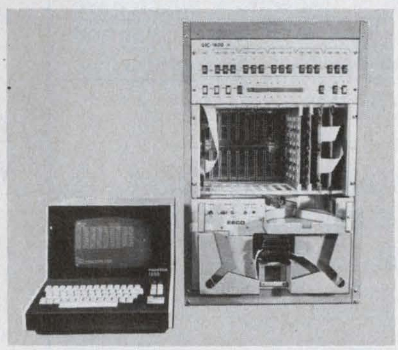
AND ALL THE SUPPORT THAT GOES WITH IT

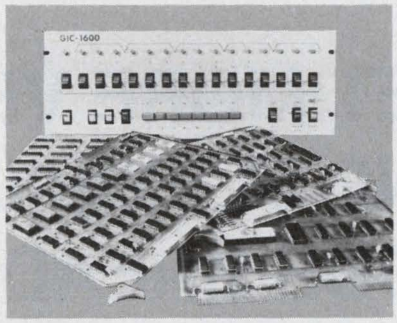
With a chip like the CP 1600, it's only right to maximize its support. So, we have a complete family of processor and memory products. ROMs from 4K to 16K... to optimize program storage efficiency and provide 16-bit computing power at 8-bit density. All fully static. All with a single 5 volt power supply. Plus static RAMs from 1K to 4K bits. And there's a continually growing family, including the Programmable Interface Controller chip, coming in January.



Development Hardware

The Series 1600 MicroComputer System will simplify your design cycle. It will provide you with a test bed for interfaces and related hardware, as well as full program preparation facility with resident on-line hardware and software debug aids. Peripheral interfaces you can use include TTY, high-speed paper tape equipment, serial line printer and magnetic tape cassettes. And all card level modules of the Series 1600 system ranging from microcomputers, memory and I/O modules, to general purpose arrays, are available on an OEM basis for further system integration.





Complete Software Support, Too

Among the Series 1600's sophisticated program preparation tools are extensive resident software and a fully compatible Cross Software package for popular minicomputers. There's the powerful, easy-to-use On-Line Debug program to aid in checkout. The Text Editor. The Assembler. The Relocating Linking Loader. The Memory Dump Program. The Monitor and Utility routines. And coming up... the Macro Processor and Language Generation package. An expanding library of application sub-routines and complete documentation are, of course, available. As are strategically located Test Centers and applications assistance.

The kind of support you'd expect for the world's most powerful microprocessor system. And the kind of support you'll get.

Please send further information on your Series 1600 Microprocessor System

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Mail to: General Instrument Corp., Microelectronics, Dept. M 13, 600 W. John St., Hicksville, N.Y. 11802

GENERAL INSTRUMENT CORPORATION MICROELECTRONICS

INFORMATION RETRIEVAL NUMBER 7

(continued from page 7)
proper ET rating. The sine-wave inductance should be used only as a reference.

Walter V. Manka
Senior Design Engineer
Delevan Div.
American Precision Industries Inc.
270 Quaker Rd.
East Aurora, NY 14052

Transformer maker 'forced to take issue'

Congratulations for a creditable job on an elusive subject, "Focus on Pulse Transformers," in the June 21 issue. As a manufacturer of those devices for over 25 years, we are familiar with the problems. We are, however, forced to take issue with you over statements that indicated it was difficult to reproduce sample units on a production basis.

Technitrol believes this places an unwarranted reservation in the mind of many transformer users or potential users. While much of what you say is true with regard to variations in cores and people, Technitrol has gone to great pains and expense to build core testing equipment and to provide manufacturing controls to prevent just such occurrences. The transformer design itself is reviewed again and again for producibility and reproducibility.

W. A. Chamberlin
General Sales Manager
Technitrol, Inc.
1952 E. Allegheny Ave.
Philadelphia, PA 19134

Ending ambiguities when calculating

In "Another Counting Idea for Pocket Calculators" (ED No. 14, July 5, 1975, p. 7), David W. Thompson notes an ambiguity when the count ends in zero. This can be easily overcome on calculators that are not equipped to add a constant to the accumulator, if one additional step is added to the programming. The
(continued on page 15)

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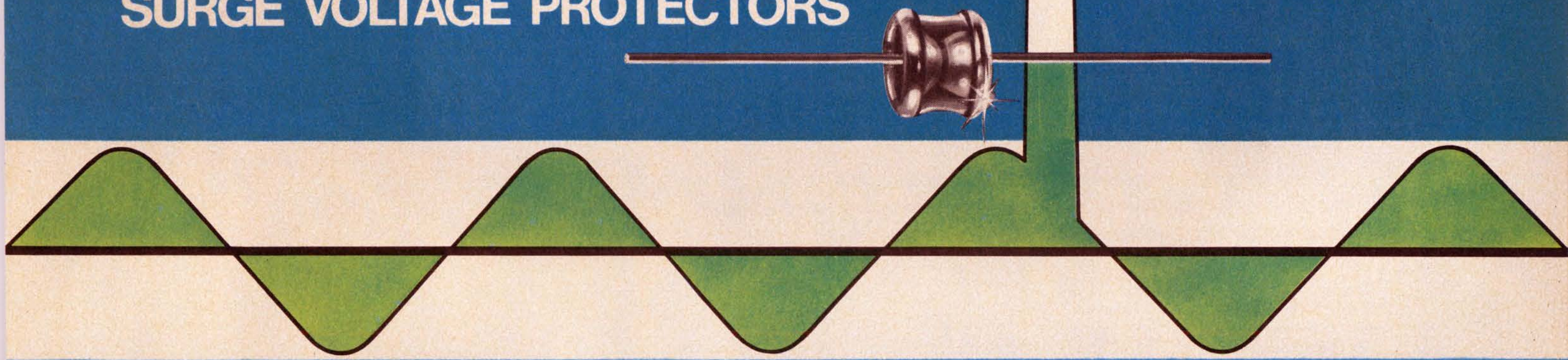

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INFORMATION RETRIEVAL NUMBER 9

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Power/Mate's answer to the switching power supply.

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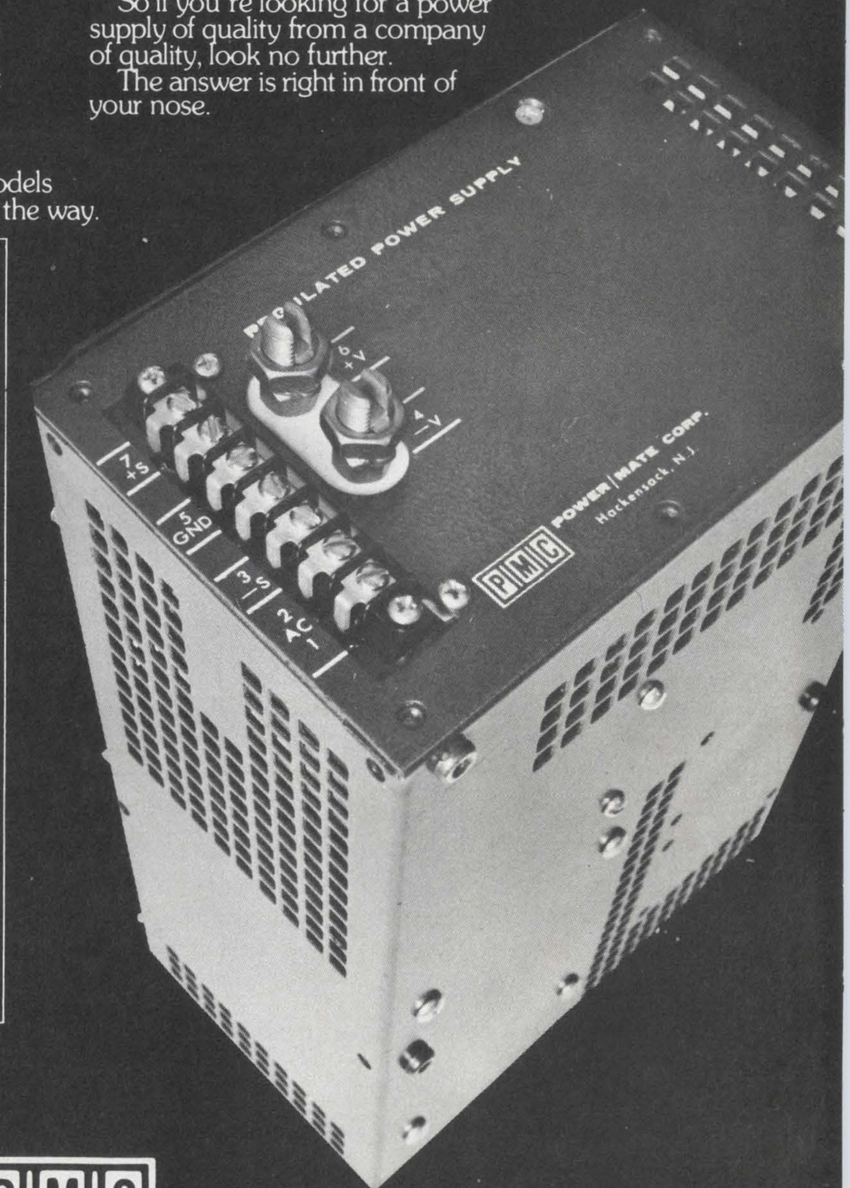
Because they're good for certain jobs and totally wrong for others.
Well, we at Power/Mate decided to find an alternative.
(We didn't get to be a leader in the field just by sitting back.)
After a year of intensive development and testing our engineering managers found the answer.
The uniquely unusual Unswitcher.
The Unswitcher is the perfect alternative for two reasons.

First, it's simpler.
A lot fewer working parts make it a lot more reliable.
And when it comes to looking at power supplies, reliability is one thing you should never overlook.
How did we make it so simple?
Our engineers will be glad to tell you.
Second, it's priced competitively.
Which means it'll make you happy while making our competition unhappy.
So if you're looking for a power supply of quality from a company of quality, look no further.
The answer is right in front of your nose.

Right now the Unswitcher comes in two models (specs shown below) with additional models on the way.

CF–5-G/50A
Input 100V–130 VAC, 57-63HZ
Output Voltage 4.5–5.5V Adjustable
Load Regulator ± 10MV
Line Regulator ± 25MV
Ripple:Less than 50MV RMS
Response Time: (50–100% Load Change) 100 milli seconds
Stability (8 hr): Less than 1%
Temperature Coefficient: 0.05%/°C
Ambient Operating Temperature: –20°C to +55°C
Storage Temperature: –40°C to 85°C
Cooling: Convection Cooled
Overload Protection: Current Limited
Isolation Voltage: 600 volts to chassis
Overvoltage Protector: Built in
Efficiency: 70%
Case Size: 50A 10½W x 6½H x 12L
Price: Only $345.00

CF–5-J/100A
Input 100V–130 VAC, 57-63HZ
Output Voltage 4.5–5.5V Adjustable
Load Regulator ± 10MV
Line Regulator ± 25MV
Ripple:Less than 50MV RMS
Response Time: (50–100% Load Change) 100 milli seconds
Stability (8 hr): Less than 1%
Temperature Coefficient: 0.05%/°C
Ambient Operating Temperature: –20°C to +55°C
Storage Temperature: –40°C to 85°C
Cooling: Convection Cooled
Overload Protection: Current Limited
Isolation Voltage: 600 volts to chassis
Overvoltage Protector: Built in
Efficiency: 70%
Case Size: 100A 10½W x 6½H x 16L
Price: Only $395.00



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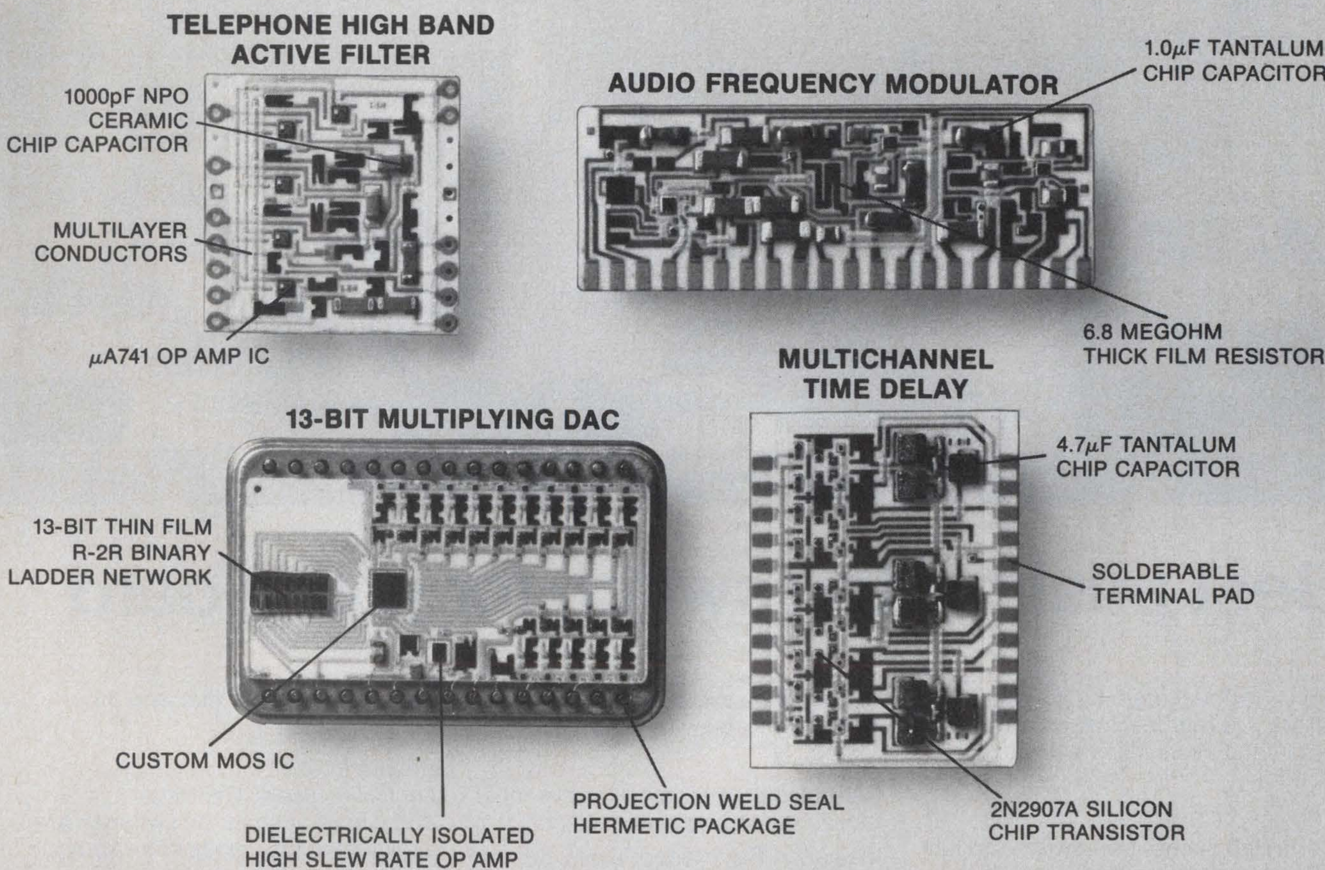

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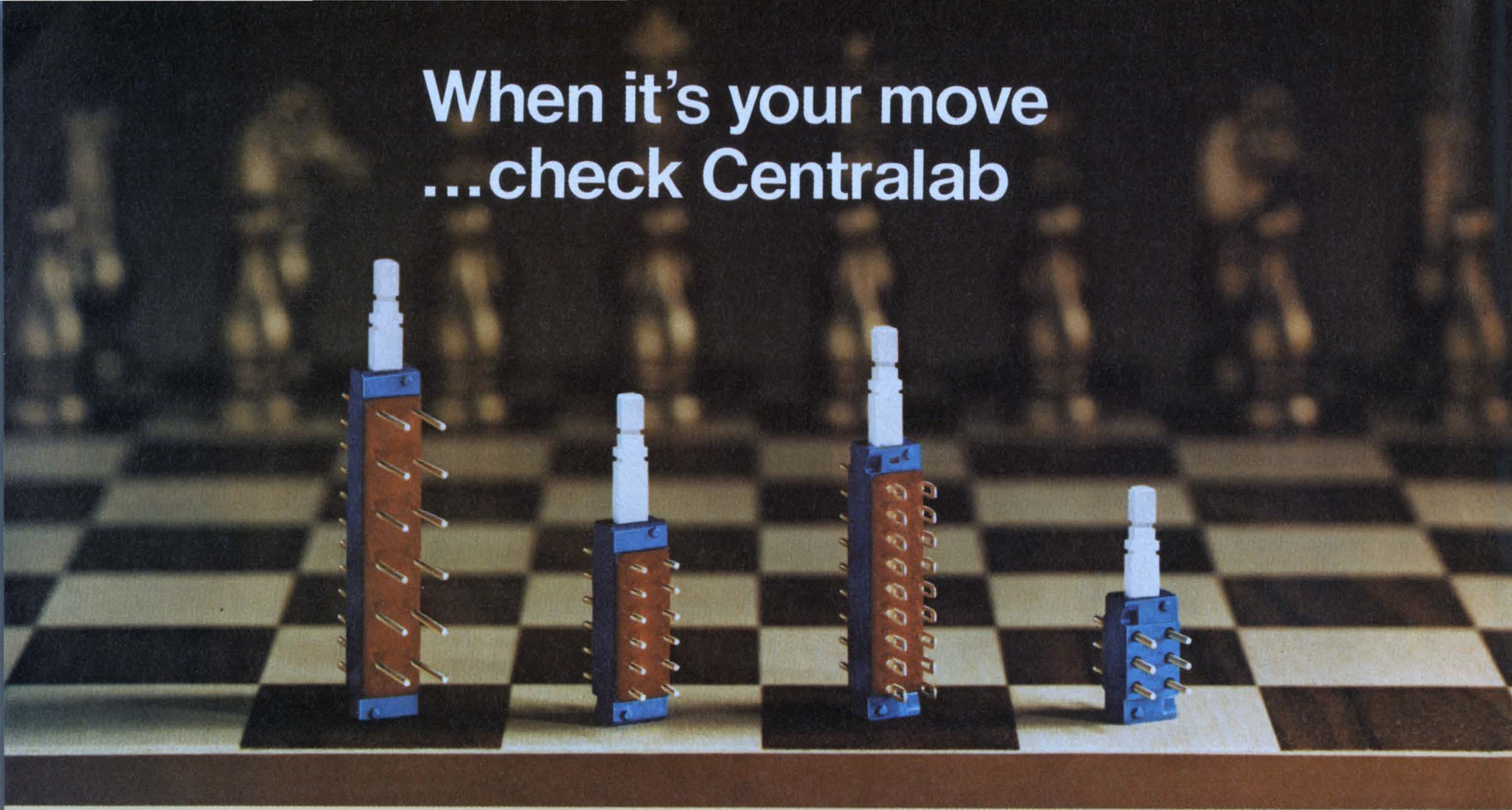
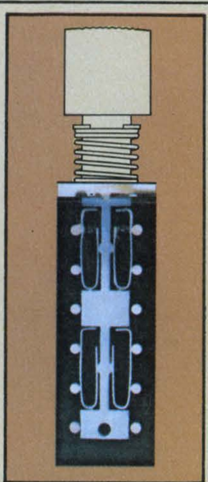


Best pushbutton switch for your board

Don't be checkmated. Only Centralab offers you the best low-cost switch module, plus so many extra-quality options.

THE BEST SWITCH—The basic Centralab pushbutton switch module is unique because of its inherently simple and rugged construction. High speed machinery produces the parts and performs assembly operations simultaneously, ensuring that the parts always fit the assembly perfectly. Stationary and movable contacts are enclosed in a high-dielectric thermoset housing to protect the smooth, positive wiping action of the slider bar and contacts. And Centralab switches are 100% tested.



Unretouched cutaway view of Centralab 2 PDT module showing positive spring force for superior contact wiping action.

Centralab pushbutton switches meet these demanding specifications:

Insulation Resistance: Up to 10^{12} ohms.

Dielectric strength: 1,500 volts.

Contact resistance: .004 ohms.

Life and reliability: Up to 250,000 MTBF in ganged assemblies. Over 500,000 operations on contact systems.

Shock and Vibration: 100g's and 10g's low frequency.

Electrical rating: Covers range from dry circuits to 1 ampere, and low millivolts to 120 volts.

If your requirements go beyond the basic Centralab module, consider these optional moves:

HIGHEST INSULATION RESISTANCE—Centralab offers diallyl phthalate housing material, in addition to phenolic.

BEST CONTACT RESISTANCE—Gold contacts and terminals are standard options. Best for dry circuit applications and contaminating environments.

NO INTERNAL CONTAMINATION—Epoxy sealed terminals prevent failure from solder flux and other contaminants.

Proven in use by more quality-conscious users, Centralab 2, 4, 6 and 8 pole pushbutton switches are available in four types of lockout for momentary, push-push or interlocking action. Both PC and solder lug terminals are available. PC terminals can be selectively cut to your desired lengths.

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MILWAUKEE, WISCONSIN 53201

INFORMATION RETRIEVAL NUMBER 12

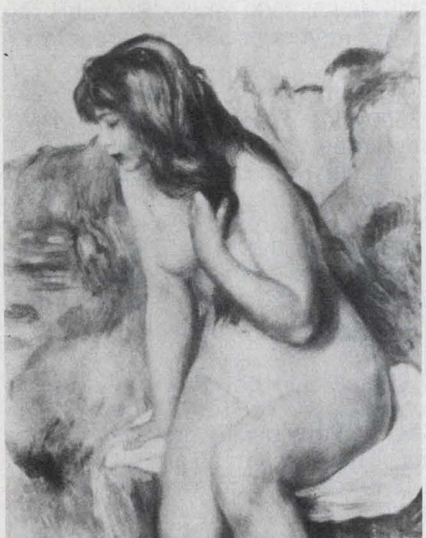
(continued from page 10)
steps are as follows:

1. Turn on "K switch."
2. Clear accumulator and constant (C).
3. Enter 1.0000001.
4. Press the multiply key.
5. Enter 10000001.
6. Successive key strokes of the (+=) key will then count events by incrementing the least-significant digits, 10000002, 10000003, etc., and there is no ambiguity when the count reaches 10000010.

When using the J.C. Penney Model MM3R, the procedure works as stated. On some models, such as the Texas Instruments TI-2500, steps 3 and 5 must be interchanged.

Daniel Barnes
Senior Design Engineer
Magnavox Co.
1700 Magnavox Way
Fort Wayne, IN 46804

Misplaced Caption Dept.



"Whew! I thought he'd never sign."

Sorry. That's Pierre-Auguste Renoir's "Bather on the Rock," which hangs in the collection of Durand-Ruel in Paris.

Thank you, thank you Elizabeth deAtley

I always admire your editorial judgment, but never more than recently when you paid me a personal compliment in the pages of your magazine. Imagine my appreciation of your abilities when I discovered on p. 14 of your issue No. 15, July 19, 1975, a verbatim copy of the "Idea Killers" that had appeared some time before in No. 15 of Stanford Research Institute's *Investment in Tomorrow*, of which I am editor.

And instead of the usual clutter at the end of the piece—such as an acknowledgment of your source—you maintained a discreet white space, classic in its simplicity.

Elizabeth deAtley
Editor
Stanford Research Institute
Menlo Park, CA 94025

Ed. Note: Your letter, with classic impact, pierces without verbiage directly to the point—somewhere between the second and third lumbar. Sorry the credit was omitted.

We flipped

In ED No. 16, Aug. 2, 1975, p. 124, the New Product photo for Electronic Engineering Co.'s microprocessor board was placed inadvertently with the product above it—Tempil's temperature-indicating coating.

Reader spots error in a design aid

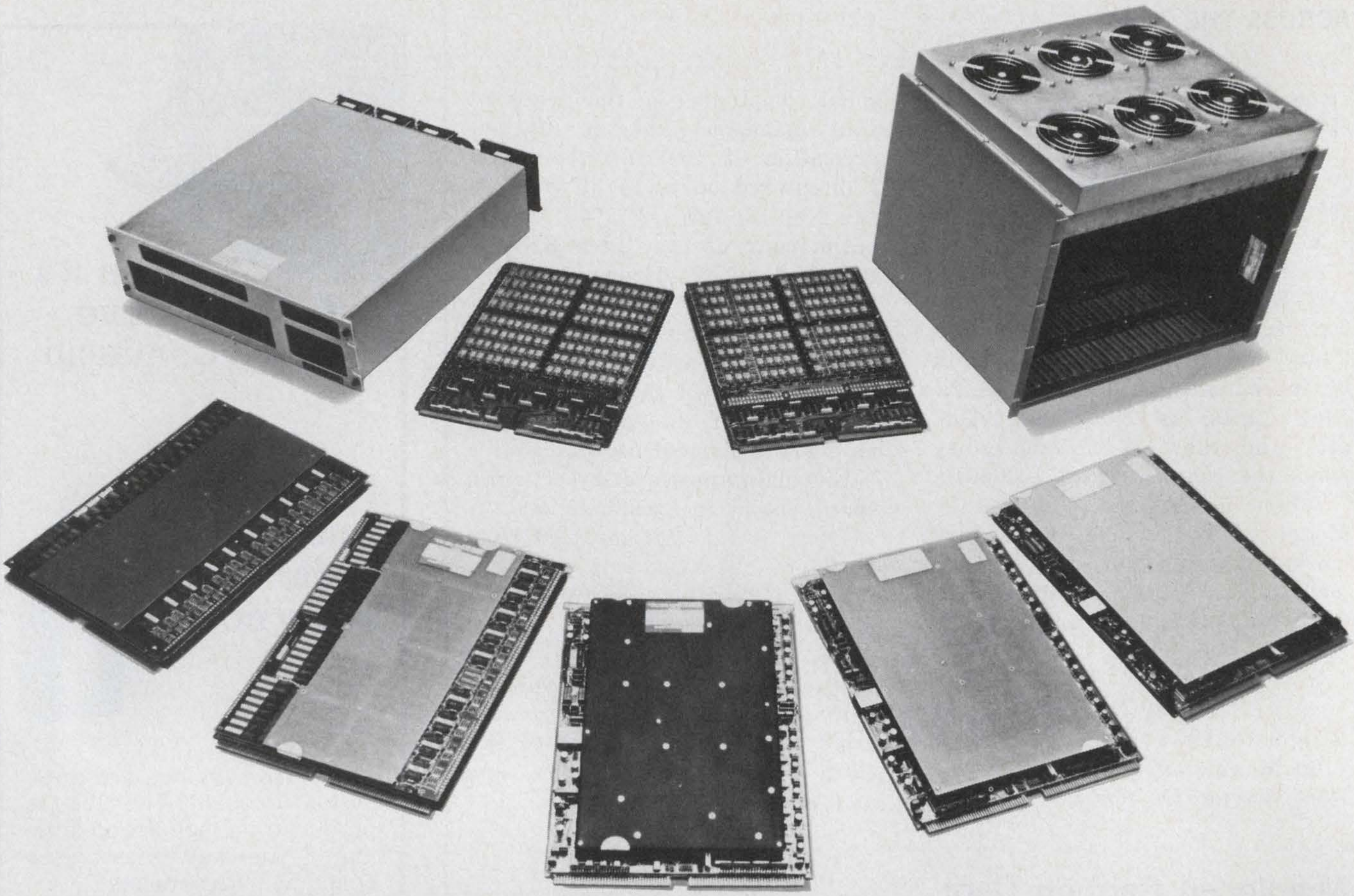
In reading your issue of July 5, 1975, I came across an error in "Design Aids" on p. 95. When following the sample program given with my HP-21, I noticed that when the number "a" is entered, then stored in the machine, a wrong answer resulted. The second line of the program should read

a	STO 2 ×

for the HP-21 calculator only.

When the sample program was worked out on an HP-35, the results were correct.

Allen R. Maslowski
Product Development Engineer
RCA
Route 202
Somerville, NJ 08876



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The beauty of it is, you can mix or match any of these in the same 5¼" chassis, and go from 4K core to 32K NMOS cards without any basic change in the support electronics. (There's even a vertical chassis which holds up to 16 cards totalling a megabyte if you need that much.)

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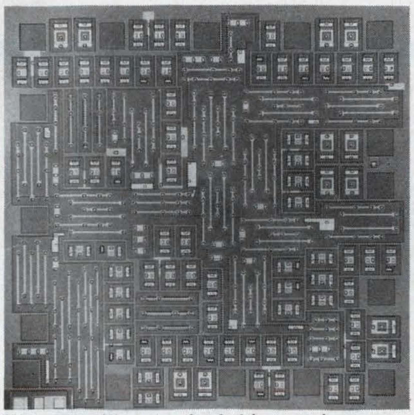
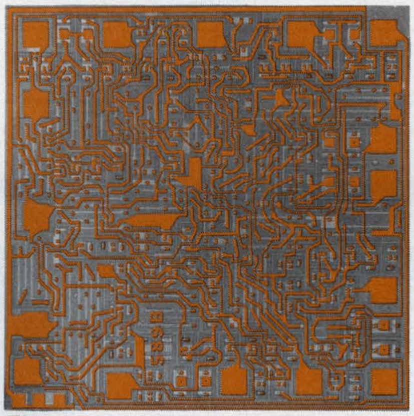
To help you get started, Interdesign provides a $39 design kit. It contains discretes corresponding to the components on our four Monochips plus a complete design handbook.



We start with a standard chip carrying unconnected components.



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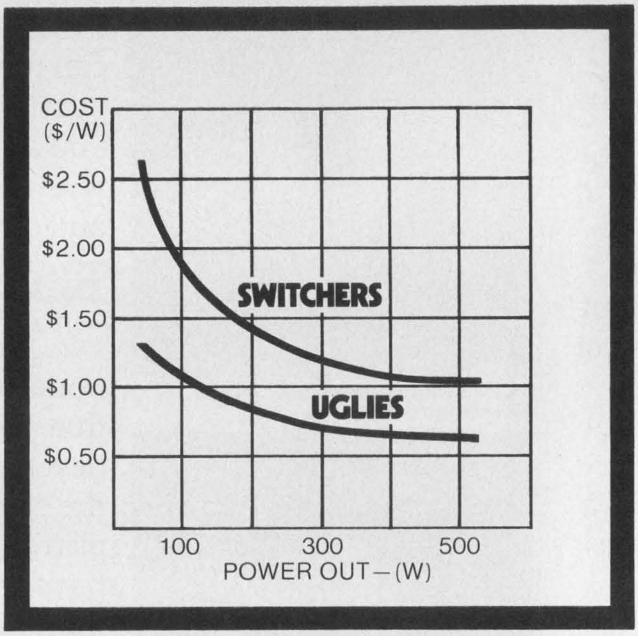
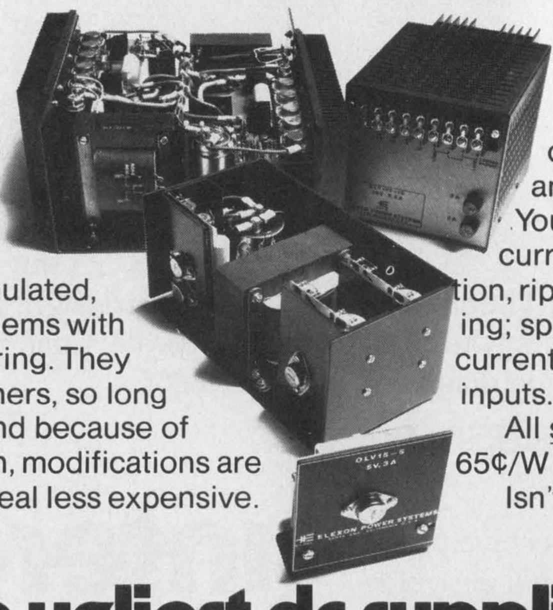
INFORMATION RETRIEVAL NUMBER 15

THE SWITCHERS VS THE UGLIES™





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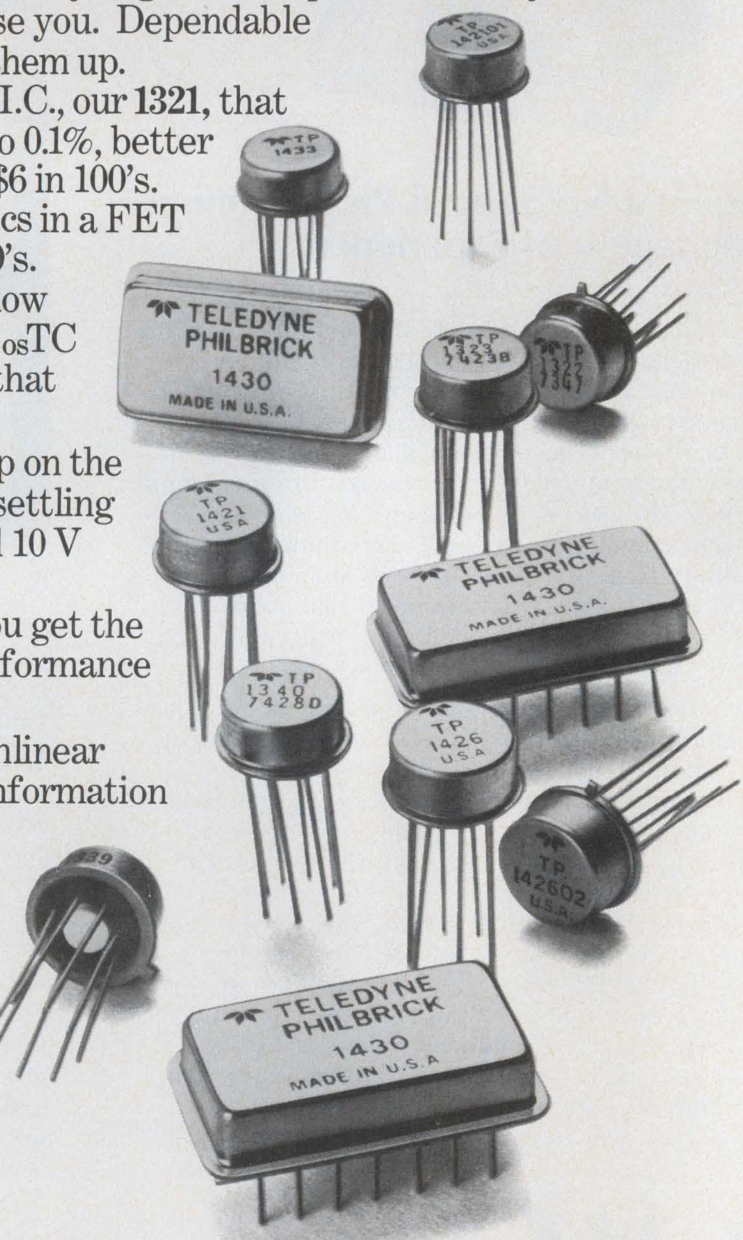

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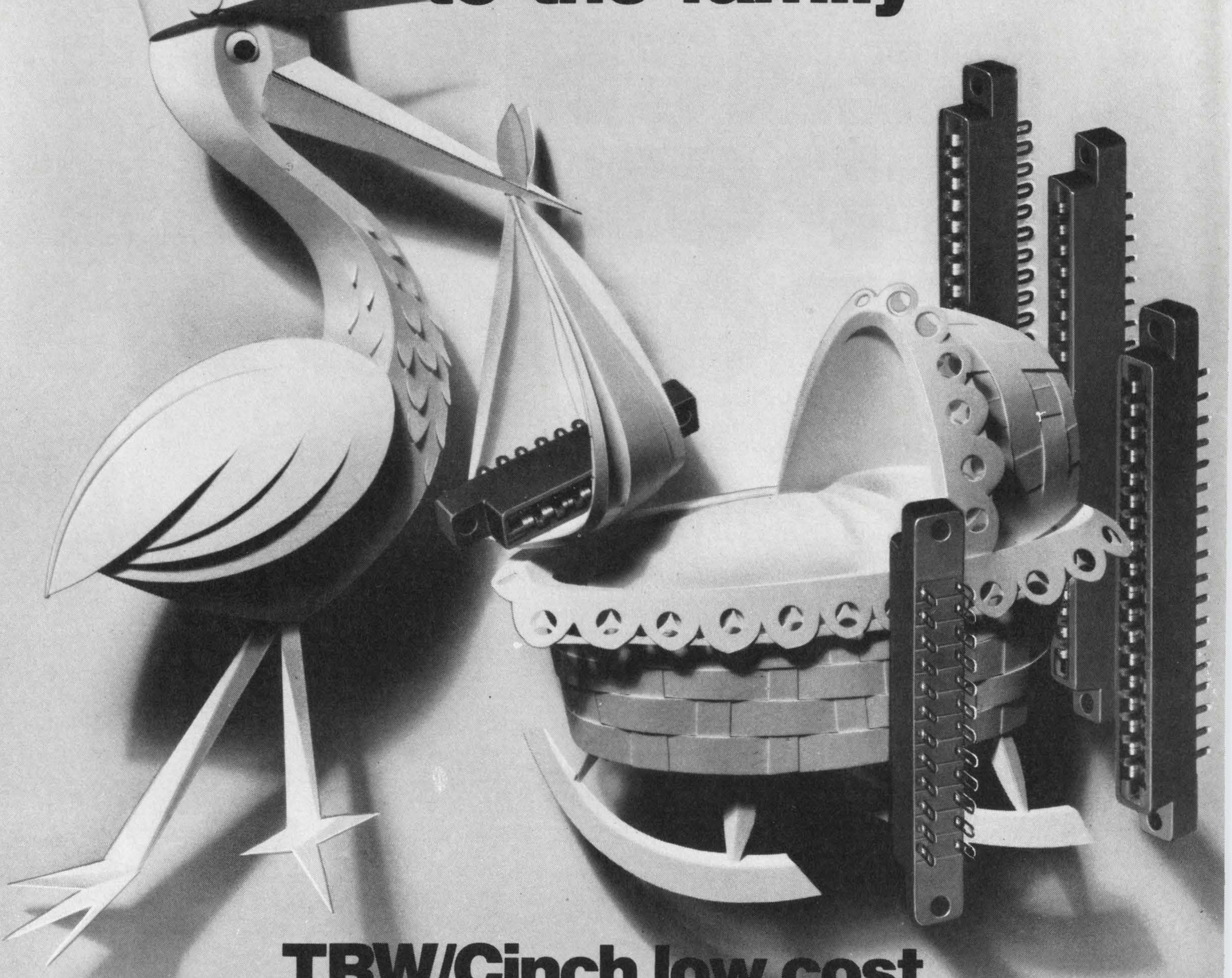


Acousto-optics pushes up laser-recording standards

Two laser recording systems—one digital and one analog—that use unique acousto-optic modulators and deflectors to achieve new standards of throughput and resolution will be highlighted in papers at the Electro-Optics/International Laser Conference at Anaheim, CA, Nov. 11-13.

The digital system is a holographic record-playback system with a present throughput of over 600 Mbits per second and a potential of several gigabits. The system, designed by researchers at the Electronic Systems Div. of the Harris Corp., Melbourne, FL, records data on, and reads it off of a vertically moving 35-mm film.

The analog system is a recorder that uses a 4-mW helium-neon laser to produce high-resolution, 875-line TV images on 8-mm dry silver film. Developed by the Isomet Corp., Springfield, VA, the system uses an acousto-optic modulator and a pair of special acousto-optic deflectors to paint the image on the film.

In the digital system, the critical design breakthrough was the development of a holographic page composer, says Anthony Bardos, head of the Harris engineering group and co-author of a paper entitled 'Multigigabit Digital Recording."

"The composer," Bardos points out, "generates the holographic data input using 128 original acousto-optic modulators, each in a glass cell. Laser light through each cell is modulated at about 6 MHz per data channel, and with 128 channels, we get over 600 Mbits of data through," Bardos explains.

"The maximum system data rate is 750 Mbits," Bardos notes, "which includes—as well as data—error-correction coding and housekeeping information.

"The incoming 600 Mbits of data are multiplexed into the 128 data channels of the composer, where they are converted to 128 optically modulated laser elements."

A reference beam is combined with the modulated elements to form the 128 holograms, which are aligned in a raster-type scan across the 35-mm film. The film moves down at 4 m/s, and exposed film is automatically developed in 30 minutes.

"This is a real-time system," Bardos points out, "in the sense that the readout rate is the same as the recording rate."

For recovery of data, the developed film is put back into the system, and the reference beam scans the film, reading out the holograms as light and dark data bits.

The holographic data come out on 128 optical channels, which feed 128 fiber-optic elements that carry the data to 128 discrete silicon diode detectors.

"The photodiode outputs are multiplexed, along with error and time-base correction signals to produce the 600 Mbit serial data stream," Bartos says.

The Harris development is sponsored by the Air Force's Rome (NY) Air Development Center, but Bartos also sees commercial applications where many channels of data are needed, as in seismic recording.

In the analog laser recording system by Isomet, the key element, says Jason Eveleth, marketing manager, is a "chirp deflector," a proprietary opto-acoustic device that solves a major problem of these systems—simple generation of a fast horizontal scan of the laser beam.

"Whereas the Isomet system is all solid state," Eveleth notes, "previous scanning systems used rotating mirrors or prism scanners with speeds up to 90,000 rpm."

With the chirp deflector, the beam is deflected with the speed of sound in the deflector-cell material. At a rate of 0.616 mm/μs, a full TV frame is scanned in 33 ms.

"The chirp deflector," Eveleth explains, "is a Bragg cell that is excited by chirp pulses—signals that start at a relatively low frequency and sweep to a high one. The chirp pulse also serves to focus the laser beam to some distant point. In this case it is on 8-mm film."

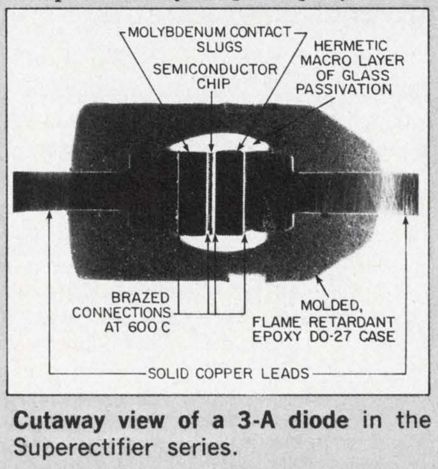
The system, which was designed as a military mission recorder for the Naval Air Development Center, Warminster, PA, is virtually real time, Eveleth explains, because the dry film requires only three seconds to develop with heat. The deflector is described in a paper co-authored by Eveleth, "Solid-State Laser Beam Recorder for 875-line TV."

Low-power rectifiers get better packages

A high-reliability method for packaging low-power rectifiers, announced by General Instrument Corp., is said to provide glass reliability and performance at plastic prices.

The packaging scheme takes the best of the two commonly used methods—molded epoxy and glass beads. According to Bob Brown, product manager for rectifier products, "the new Superectifier package looks identical to the plastic DO-41, 15 or 27 on the outside, but inside there's a world of difference."

To bypass the faults of available methods—poor hermeticity and temperature cycling in epoxy cases,



Cutaway view of a 3-A diode in the Superectifier series.

varying size and the difficulty of handling glass beads—engineers at General Instrument in Hicksville, NY, developed a five-step process:

1. Sand-blasting of circular rectifier chips from a wafer. The blasting creates a beveled pellet that has improved voltage ratings and lower reverse leakage currents than square rectifier chips.
2. Brazing of the chip and molybdenum and copper lead and frame assembly at 600 C. This eliminates any opens, intermittents or voids usually found in soldered assemblies.
3. Cleaning of the brazed assembly and chip to remove impurities. This removes any materials that could cause deteriorated operation.
4. Application of a void-free macro-coating of glass passivation that covers the molybdenum and chip with a hermetic seal. The coating is about 50 to 60 mils thick—about 10 times the typical passivation thickness.
5. Sealing of the glass passivated assembly in a flame-retardant molded epoxy case that meets UL 94VE-O requirements. The epoxy provides additional mechanical strength and makes the diodes easier to handle.

All component parts of the rectifier are matched for thermal coefficients, so that no stresses are present during temperature changes.

As an initial offering, General Instrument will have rectifiers with current ratings of 1 to 3 A and reverse-voltage ratings of 50 to 1600 V. Prices start at 5 cents each in 100,000-piece lots.

CIRCLE NO. 319

Feedback laser emits several wavelengths

A new type of injection laser emits several different, near-infrared wavelengths simultaneously. The laser, developed by Aerospace Corp., El Segundo, CA, is based on the company's previously developed distributed feedback laser (see "Lasers Get Powerfully Efficient and Efficiently Small in R&D Lab," ED No. 19, Sept. 13, 1974, p. 34).

Whereas the original gallium-arsenide laser had a single corrugated metal grating on the outer side of the p part of the p-n diode and the periodicity of the corrugations determined the output wavelength of the laser, the new laser has a set of corrugations with blank areas in between. According to Dr. Harold M. Stoll and Dr. David H. Seib, members of the technical staff at Aerospace: "The blanking is periodic, so that the structure is effectively square-wave modulated. The period of the blanking and the period of the corrugations determine the additional simultaneous frequencies that are generated."

To date, as many as three lasing wavelengths have been observed to oscillate collinearly and simultaneously in the 0.83-to-086-μ region. The laser works at a temperature of 77 K.

"Potential operational advantages," Dr. Stoll says, "include a reduction in total laser power requirements, since, in principle, several wavelengths can be obtained for essentially the threshold power cost of only one."

Rockwell and National sign processor pact

In an effort to capture a larger share of the $80-million microprocessor market and at the same time allay some customer fears about sole-source products, Rockwell International and National Semiconductor have entered into a joint second-source agreement for microprocessor products.

According to Charles V. Kovac, vice president and general manager of Rockwell's Microelectronic Device Div., the new agreement establishes Rockwell and National as direct competitors and provides each company with the broadest microprocessor line in the industry.

Termed a "supported alternate source" agreement, the new pact differs from other second-source agreements that have become standard in the semiconductor industry in that it calls for a two-way exchange of technical information and expertise. It covers all current microprocessor products of each company, provides options on second-sourcing modifications and establishes the machinery for the periodic review of new microprocessor developments.

Most second-source agreements the industry has seen to date require one company to purchase the rights and technology from the company that developed the product to be second-sourced. And that's where it ends.

In the Rockwell-National pact, not only is each party contributing to the exchange, but each also guarantees that the other will be able to make the products. Personnel from each company will teach the other how to produce its product. In addition the agreement covers applications support, which includes extensive software libraries.

Rockwell's Kovac points out that the agreement is not exclusive and either company can enter into similar agreements with other companies. And he hints that more two-way pacts are in the offing for Rockwell, though he won't reveal details now.

Computers to shop by beginning to turn up

Computers not only are ringing up sales in the marketplace in the form of point-of-sale terminals; they are beginning to be used as shopper's aids to generate sales. The Electronic Wine Captain may be the first of many such aids. It is meant to be placed in a store and used by shoppers to plan menus and select the right wines.

Developed by Sheila Hoffman Associates, New York, the device uses the Model 810 intelligent terminal from Sanders Data Systems, Nashua, NH. The terminal contains 100 k of 8-bit data memory and 8 k of 16-bit program memory. Most of the data are stored on a disc memory system produced by Caelus Div. of EM&M, San Jose, CA.

According to Douglas Kolb, a Los Angeles consultant, programming is done with the new Sanders IMP language. Kolb agrees that the 810 terminal is overkill. Future versions of the device will probably use a microprocessor-based CRT terminal with floppy disc storage, he says.

Hoffman Associates looks at the system as the precurser of computers in the kitchen that will serve as shopping aids and menu-planning devices.

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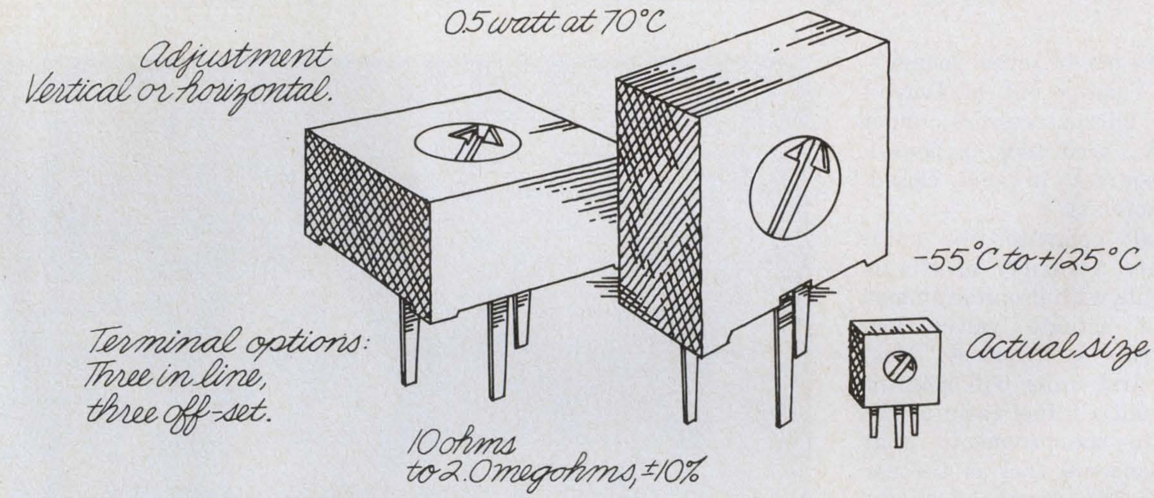

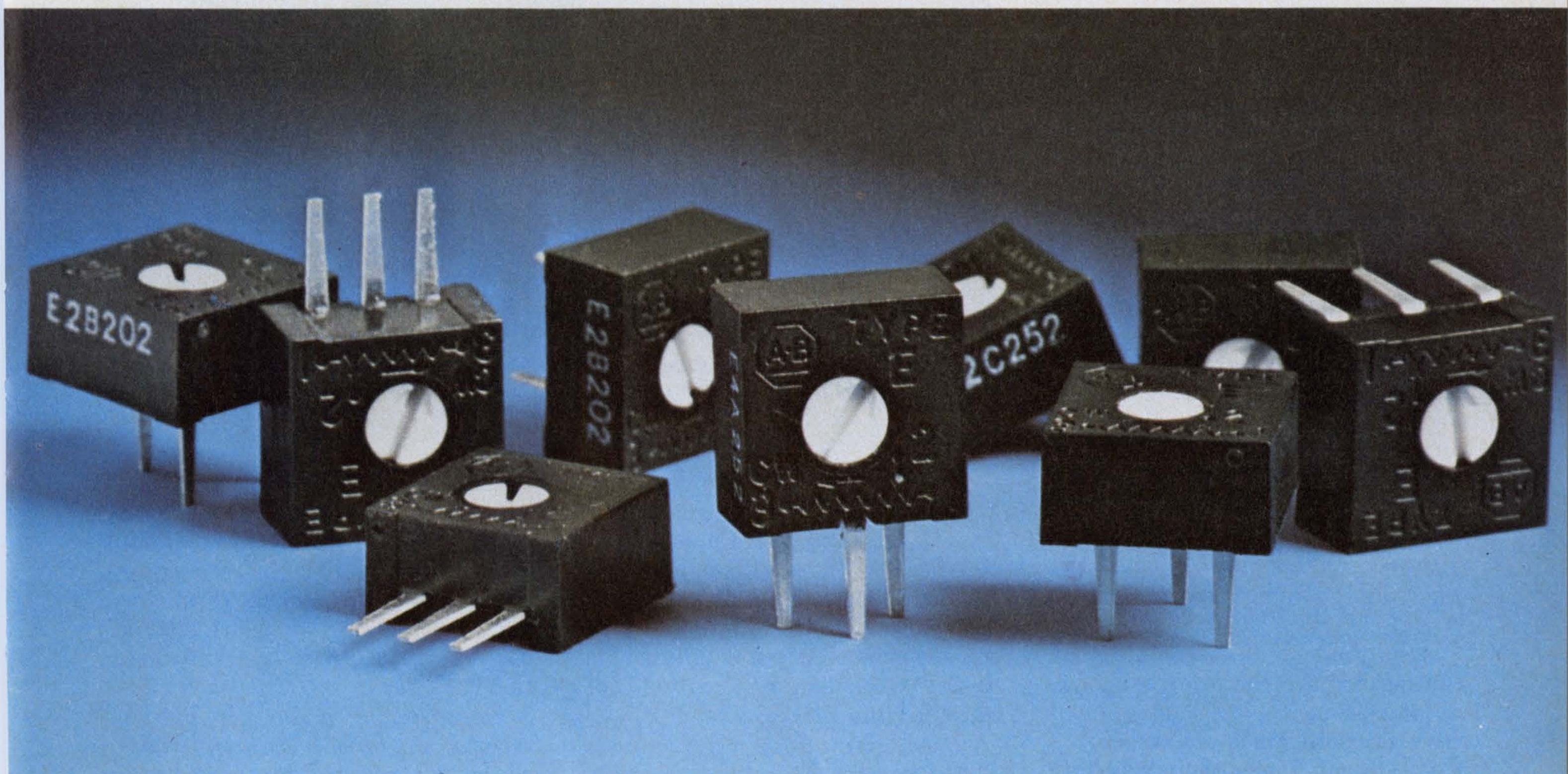

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Under-the-hood microprocessors could turn up in 1979 U.S. cars

By 1979—maybe even sooner—most cars coming out of Detroit will have microprocessors under their hoods, according to knowledgeable sources in this closed-mouth community.

The small computer-like chips will compare a variety of engine measurements with preprogrammed norms and actuate valves and other controls in response. Most likely, the first units will monitor the spark and air fuel ratio in the carburetor—measurements that will help conserve fuel as the car accelerates, slows down or climbs a hill.

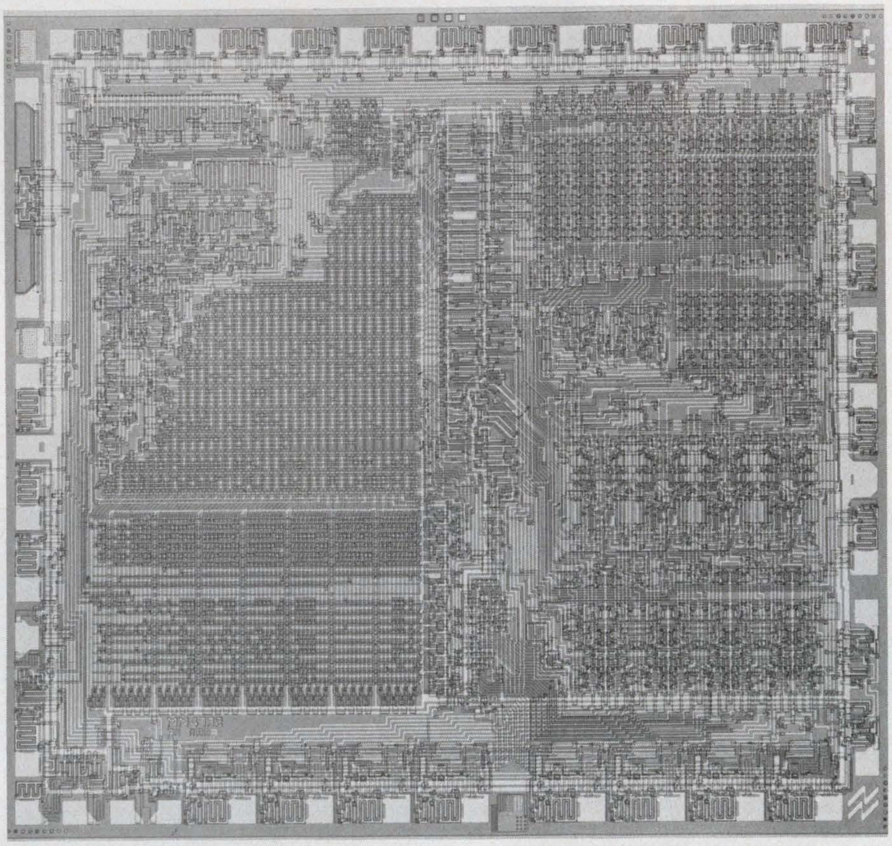
The microprocessor also may monitor the engine's speed and temperature. When conditions pass prescribed limits, the computer chip will actuate a digital display or else cause the engine to make the proper adjustments.

A computer chip can also be used to monitor atmospheric temperature and pressure, to diagnose problems and impending problems and to decide which measurements, if any, should be shown to the driver. These and many more tasks await the microprocessor under an automobile's hood.

Next, the microprocessor will move into the passenger compartment to handle passenger-related equipment—the air conditioning, the radio volume or the electric clock.

Also under discussion among car makers are the relative merits of thick-film devices and printed circuits. Both kinds of components have already found their way into cars and will be used in more applications as electronic subsystems find greater acceptance.

John F. Mason
Associate Editor



National Semiconductor expects its low-cost, general-purpose Scamp microprocessor to fill a number of automotive needs.

There's room for both kinds of components, according to Adrian Pocock, an automotive applications engineer with National Semiconductor. The choice will depend on the characteristics of each when the components are subjected to the environmental conditions of each portion of the car.

Prototype cars being tested

Right now, the three major car manufacturers all have prototype cars with microprocessors installed, but they're not talking—particularly to one another—about their next moves.

The major push at this time, according to Pocock, is to get good sensors and actuators first. "The car makers aren't so concerned about equipment to perform the signal processing but in getting devices to acquire the information," he says.

Being sought by Detroit, Pocock reports, are good, low-cost transducers to measure pressure, temperature and speed. The car makers want magnetic pickups—"any sensor needed in a vehicle to make it run properly."

Detroit's schedule could run something like this, Pocock says:

- 1976—A small advance in the

quantity of electronics in a vehicle.

- 1977—A considerable upsurge in electronics in the vehicle, including stand-alone controls—black boxes to control the exhaust and to save fuel. More analog devices will be used in these subsystems than digital.
- 1978—More complex stand-alone controls that will start "talking" to one another. New systems will be digital rather than analog. And some microprocessors might be introduced.
- 1979—Microprocessors under the hood. At the same time microprocessor-based electronics will be introduced into the passenger compartment—"maybe a digital clock, a digital radio, or solid-state displays rather than electromechanical."

Multiprocessor network envisioned

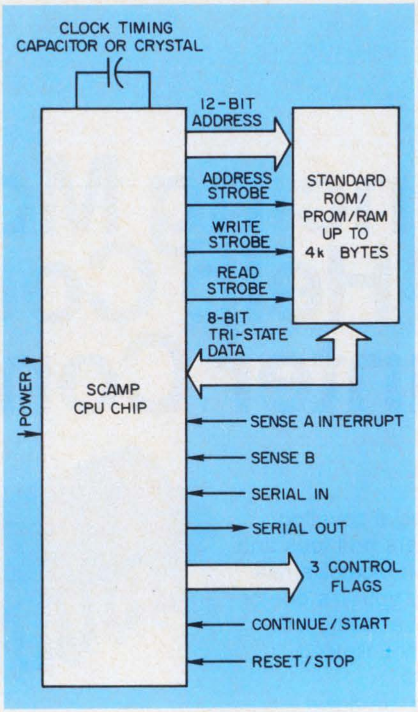
Several microprocessors could be installed by 1980 or 1982. Two or more microprocessor units could be tied together to form a multiprocessor network, which could distribute the work. If the microprocessor in the engine failed, for example, the one in the passenger compartment would take over.

National Semiconductor now has available a "simple, cost-effective applications microprocessor" called Scamp. The design of the computer chip is based on an eight-bit arithmetic logic unit served by an eight-bit accumulator and extension register.

Data and instructions in external, standard, IC memory devices are accessed over an eight-bit Tri-State data bus. Addresses are generated through manipulations on four 16-bit pointer registers. A 12-bit address (allowing 4096 bytes of memory) is available directly from the 12-bit Tri-State address bus—the full 16-bit address requires use of an external 4-bit latch. A status register provides static flag outputs and sense inputs as well as arithmetic carry and overflow information and an interrupt enable flag.

Power requirements are served by a single ±12-V supply. The processor can interface directly to standard TTL or CMOS parts.

The processor timing is generated on the chip, thus saving the cost of providing an external timing element with the attendant problems of transmitting high-speed timing pulses.



A simple microcomputer can be built with one Scamp microprocessor and up to 4-k bytes of standard memory.

A feature of major interest in Scamp, which greatly facilities the structuring of direct-memory-access systems, is that the data-transfer control signals are completely separate from the bus access control. The bus access system is designed to allow direct implementation of a multiprocessor system that can share common memory and peripheral resources. For very simple systems, the Bus Request need not be used. The IC is then permanently enabled.

1979—a year to watch

Many 1979 cars will be equipped with approximately $100 in electronic equipment, not counting the electronics for entertainment, predicts Norman R. Weldon, executive vice president of CTS Corp., Elkhart, IN. About half this amount will be spent for discrete components, including semiconductors. Some $35 worth of the electronics will go for ICs and $15 for hybrids. The semiconductors will be used mainly for a clock-driven module to feed signals to the microprocessor.

At present the electronic components being studied for cars are not designed specifically for this environment, Weldon points out. They're being adapted. But when the microprocessor becomes standard automobile equipment, he predicts, the electronics industry will be motivated to design new devices. "Until we do this," Weldon continues, "the opportunity for us in Detroit won't move too fast."

A point many electronics companies still haven't fully realized, Weldon says, is that reliability for cars actually means survivability. "A component has to operate for only 2000 hours, but it must do this in heat and cold, undergoing tremendous vibration and coated with dirt."

Designing for this environment "is one of the greatest challenges the industry has faced to date," Richard Kramer told the recent Automotive Electronics Conference and Exposition in Detroit. Kramer is a reliability assurance manager for National Semiconductor.

The electronics industry's accomplishments in the harsh environment of space would appear to be helpful in designing for Detroit, but cars make special demands, Kramer points out. Semiconductor packages used in space are too expensive for cars, and they are not suitable for high-volume circuit-board assembly lines. And the screening procedures used by the device manufacturer to find reliability risks include "overkill" tests, which can add 1000% or more to the cost of the finished device.

But there are ways to get around these problems, Kramer contends. Extremely rugged and reliable packages are now available that are cheap enough to interest Detroit. Dual-in-line packages, for example, in either molded epoxy or solder-glass sealed ceramic are relatively inexpensive and have the potential for high reliability in the automotive environment. The actual in-use reliability will, of course, depend on the manufacturer's ability to control his assembly processes and to perform effective screening tests to remove infant failures.

But good design, even with extensive testing, won't necessarily assure success, Kramer warns, adding: "It takes an integrated and disciplined program that includes

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*100 piece quantity

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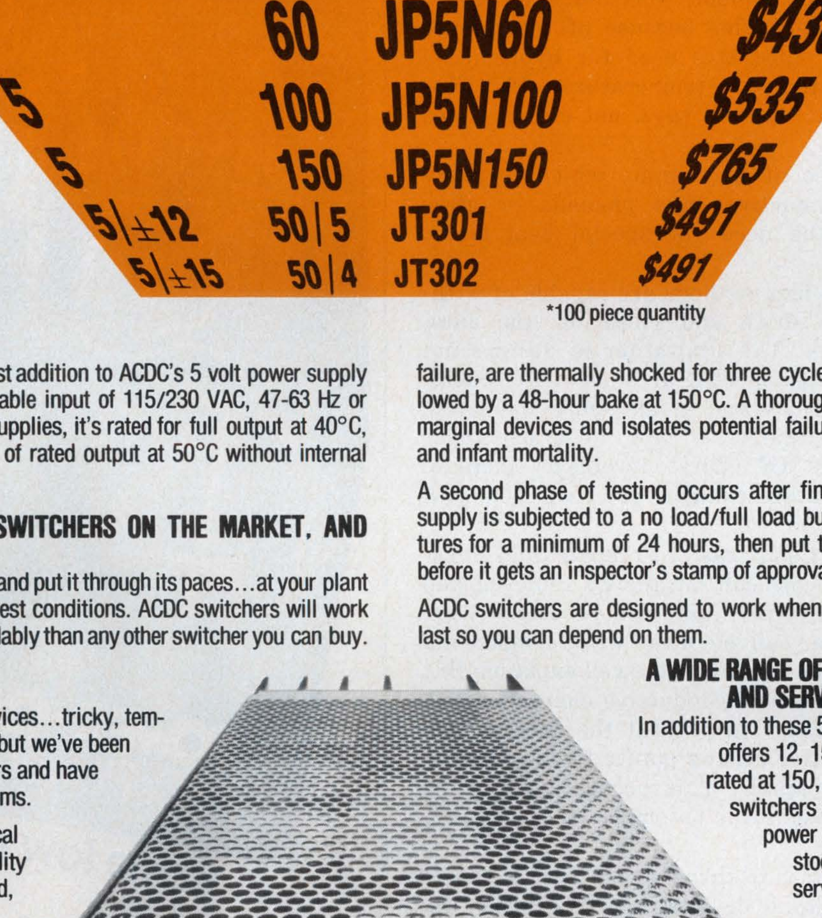

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in-line process controls and screens, 200% electrical testing, cost-effective stress-screening for freaks, product-reliability audits and effective failure analysis."

Thick film or PC boards?

"Designers may feel more comfortable with PC boards than with thick-film hybrids because they're more familiar," says Hugh W. Maxwell, an automotive engineer in the Micro-electronic Device Div. of Rockwell International. "But both have their application."

He says it depends on where the circuit is used and how it is affected by the environment.

While paper-based phenolic board may be adequate in the passenger compartment, Maxwell says, glass-epoxy is better in the engine because of the intense heat there. Ceramic substrates used for hybrids can easily handle any automotive temperatures. The limitation is components, Maxwell says, not circuit-board materials.

In hybrids the use of a ceramic, which is many times more heat-conductive than phenolic or glass epoxy, can reduce the need for special heat sinks, Maxwell says.

Both PC and thick-film methods are capable of withstanding automotive shock and vibration, the automotive engineer says. The limitation is design, not materials. A large unsupported area on a PC board, for example, can resonate and break component leads. A ceramic substrate that's too thin can crack under shock and vibration. Of course, problems increase when sudden temperature changes are combined with mechanical stress.

As for servicing, PCs are easier to repair than thick-film devices. Components can usually be removed and replaced easily, or a solder joint can be touched up. The same, of course, can be done with components soldered into thick-film circuits, Maxwell explains. But because of the good thermal conductive characteristics of ceramic, it's necessary to preheat the substrate to a few degrees below the melting point of solder before proceeding with the repair. This preheating may be impossible if the substrate is assembled to something else.

But it may be cheaper to throw away than to repair the high-volume electronic devices used in automobiles.

And if miniaturization is important, thick film wins hands down, Maxwell notes.

Humidity poses a problem. In hybrids, active devices are mounted uncased onto the substrate. To prevent damage from humidity, a suitable protective coating must be provided, or the substrate must be hermetically sealed.

General Motors' Delco Electronics believes the thick-film hybrid circuit is "ideal for automotive applications," according to Gary M. Wagner, manager of manufacturing development engineering. Delco used the first thick-film hybrid circuit under the hood in 1968 in a voltage regulator, and in 1973 the company used the circuit in an ignition system.

The hybrid was ideal, Wagner says. It provided the advantages of a normal solid-state ignition system, and Delco was able "to functionally adjust the device after assembly to peak it to optimum performance."■■

Optical scanning improved with unusual mirror technique

A resonant optical scanner for laser TV systems, large-scale optical displays and point-of-sale systems is said to give five times greater angular mirror rotation at a given scanning frequency and mirror size than an equivalent tuning-fork device. In addition, insensitivity to radial motion (mirror wobble) is improved by a factor of 10 over the tuning fork at the same frequency and amplitude.

A key element of the scanner, invented by Jean Montagu, president of General Scanning, Watertown, MA, is a torsion bar with a small mirror mounted on the free end and the opposite end fixed in the device. To rotate the scanning mirror, the bar is twisted at its center by a special magnetic driving structure of four elements, one every 90°.

The advantage of this design is twofold, Montagu says. First, the torsion bar requires no bearings. Second, the radial forces of the drive, which tend to pull the bar and the mirror out of vertical alignment, are only one half those of a drive with two elements 180° apart.

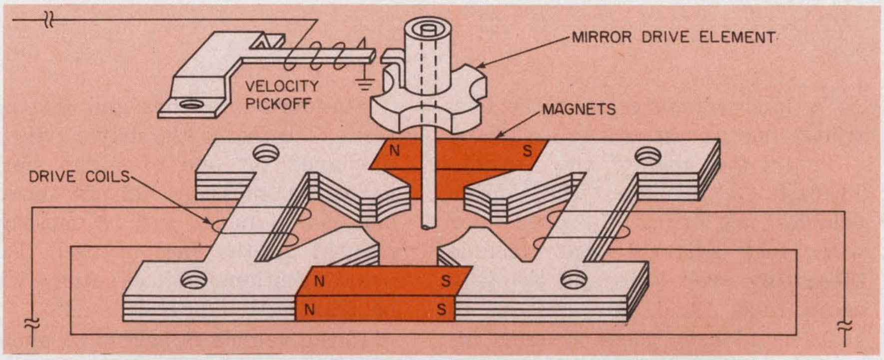
For amplitude control and for synchronizing the mirror rotation with scan-system signals, the Montagu unit—called an Isogonic scanner—has an inductive velocity pickoff. It is ordinarily difficult, if not impossible, to place this type of pickoff close to a large magnetic driving field, Montagu points out. The noise generated in the pickoff frequently is larger than the signal.

However, in the Montagu design the pickoff and drive coils are placed in orthogonal planes with respect to each other. Consequently there is negligible undesirable cross-coupling between them.

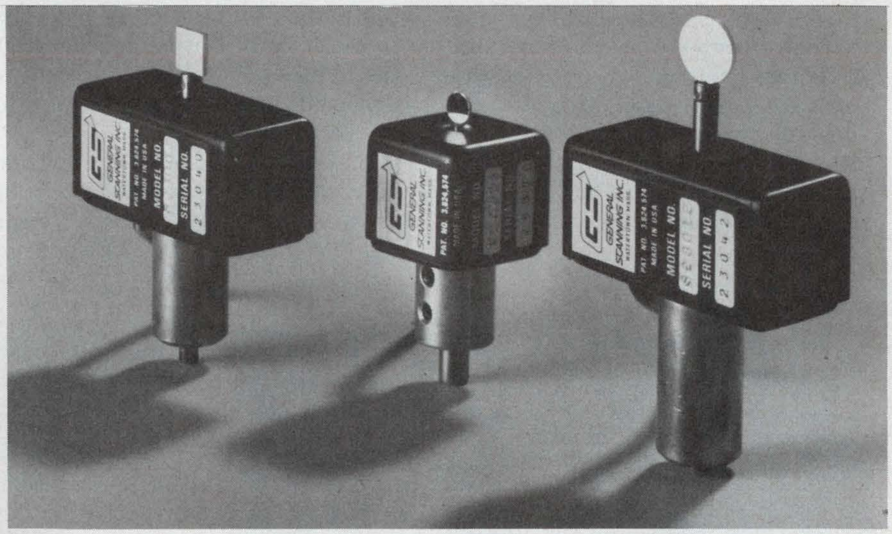
Another unusual feature of the pickoff design is that while these inductive devices usually require their own magnetic field for operation, in the Montagu scanner the leakage field of the magnetic drive circuit—normally undesirable—energizes the pickoff.

Use of the torsion bar contributes to faster response and to high-temperature stability. The tempco is 0.01% of the driving frequency per degree C.

The highest scan frequency successfully demonstrated to date has been 45 kHz. The amplitude of mirror rotation varies with operating frequency. Typically, Montagu says, a 10-kHz resonant system will swing the mirror 10°, peak to peak using a 5-mm diameter mirror. For a 1/4-in.-sq. mirror the upper frequency is 4 kHz. For a 1-kHz device, mirror rotation increases to 30°, and for a 25-kHz unit, it is 6°. ■■



Typical Isogonic scanners are (left) a 4-kHz unit with a 10° peak-peak scan of a 7-mm square mirror; (center) a 25-kHz unit with a 4° peak-peak motion of a 3-mm mirror and (right) a 1200-Hz unit with a 30° peak-peak scan of a 10-mm mirror. The light beam scan is twice that of the mirror motion.



Velocity pickoff uses leakage flux for operation and is designed to eliminate extraneous pickup from drive coils of the Isogonic scanner.

Jim McDermott
Eastern Editor

Microcomputers to be permanent riders on Toronto's transit system

"A microcomputer in every bus, trolley bus and streetcar by 1985."

That's the goal of the Toronto Transit Commission (TTC). Ten vehicles are being equipped now with test systems that include these tiny processors and two-way radio links. And the aim in 10 years is to have these systems installed in 5000 vehicles. The result will be a fully integrated communications and information network for Toronto's entire public transit system.

A control center—there may be one main center or several regional centers—will query each of the small computer chips every 10 seconds for the bus's location. It will also ask the microcomputer for other information it might have stored, such as the number of passengers.

Standard questions and instructions directed to the driver will be displayed on one of eight small dedicated message tablets, about one-inch square, with a message printed on the face of each. Unusual questions or instructions will be transmitted by voice radio.

If the vehicle is behind or ahead of schedule a button lights up advising the driver to speed up or slow down. It can tell him to pass up the next stop, or the bus directly ahead, or to take an alternate route due to traffic. It can also speak directly to the passengers in the vehicle by public address system, with or without telling the driver first.

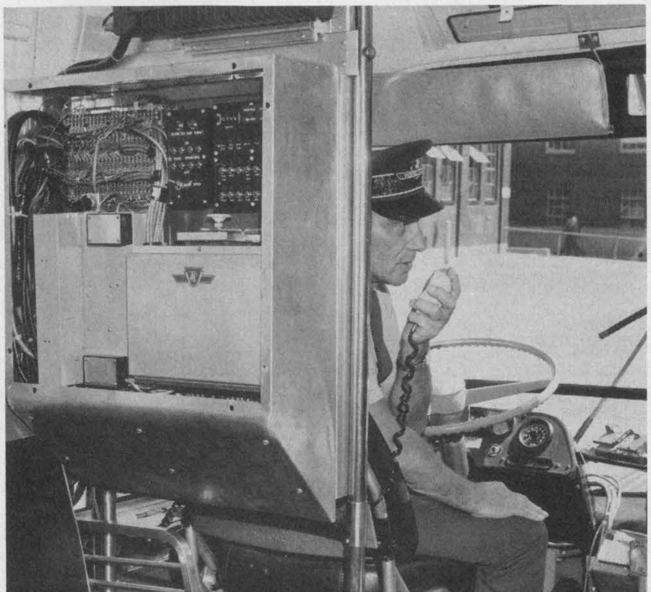
The driver has 16 fixed messages he can send to central control by pressing one of 16 buttons. He can call for the police by pressing one of them with his foot or his knee. Other buttons report traffic jams, or request medical help or permission to talk.

Central control signals back when it's ready to assign the driver a voice channel. At the same time it signals the vehicle's microcomputer to switch the radio from a data link to a voice channel.

The driver has two loudspeaker systems—one to his passengers and one outside the vehicle to talk to people waiting at a stop.

The microprocessor was designed in-house, according to Transit Commission engineer Milan Pristupa. "We couldn't get industry to respond fast enough for our time frame," he says. The design was based on Intel's 8080 microprocessor and its peripheral chips. "We

(continued on page 38)



Control center in Toronto's projected communications and information system will query each of the city's transit system vehicles 10 times a second for its location and other pertinent data. Information is collected automatically on each vehicle and stored in a microprocessor, whose design was based on the Intel 8080.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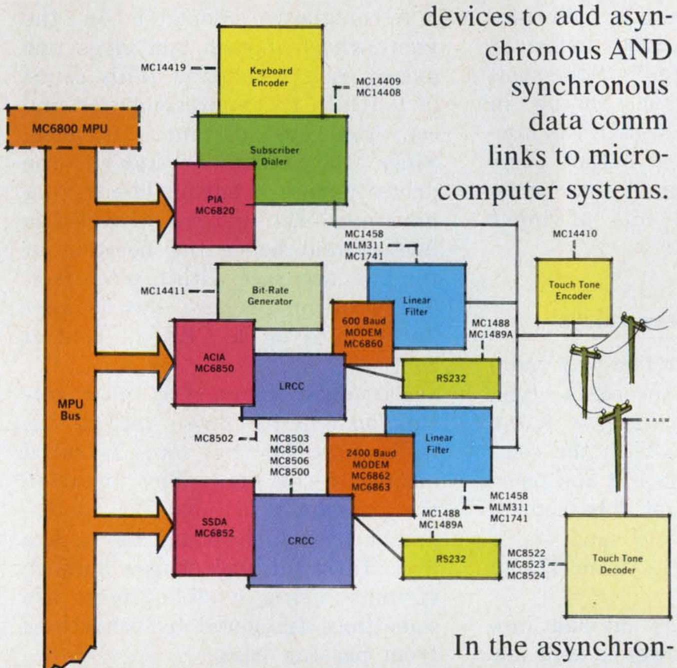

In the asynchronous communications link, the MC6850 ACIA converts parallel data to asynchronous serial format, and vice versa. The MEGALOGIC* LRCC/Data Register, the MC6860 MODEM and a McMOS Bit-Rate Generator fill it out, with EIA standard RS232 Linear circuits handling interface between separated system elements.

In the synchronous system, parallel-to-serial data conversion, and the reverse, is executed by the soon to be announced MC6852 SSDA, with MEGALOGIC CRCC units and the impending two-chip MODEM (MC6862/MC6863) assisting.

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MOTOROLA M6800

Benchmark family for microcomputer systems.

INFORMATION RETRIEVAL NUMBER 27

(continued from page 34)

felt the 8080 offered the most of any available device plus the fact that it has high-level language support."

Called Trump, for transit universal microprocessor, the device has been designed with 4096 bytes of PROM—16 chips with 256 bytes each (Intel's 8702). This portion of the memory holds the vehicle's programs that manipulate all the standard data it receives. Besides this, Trump has 1000 bytes of RAM, which stores on-the-spot, real-time information coming in and going out. The system has nine input ports and nine output ports —each of which is 8 bits wide, thus providing 72 bits of input and 72 of output.

Low-power radio uses relays

A Motorola Micor two-way radio was chosen for the data link, Pristupa says, "because we found it easy to interface with the computer." The Micor is FM and operates in the uhf band. The control center transmits 410 and 411.5 MHz and the vehicle, from 415 to 416 MHz.

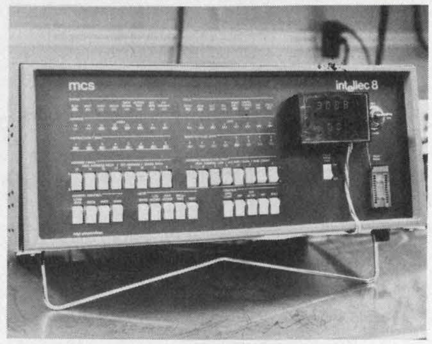
The bandwidth is divided into 60 channels. The power is kept low —10 W—to prevent interference, thus enabling the same frequency to be used in several sections of the city. "We like to keep a distance of about 20 miles," Pristupa says.

Ten relay stations throughout the city pick up signals in the vicinity of each and transmit them back to central control by microwave or telephone wire.

When a vehicle's signal begins to get weak, the computer automatically tells a radio's synthesizer to switch to a frequency being used by a closer relay station. Each vehicle is equipped to operate on any of the 60 channels.

Each channel will handle approximately 100 buses. Each bus has a code number and on the basis of it, Trump accepts or rejects the call.

Being tested now, Pristupa says, is voice transmission running full duplex, with all switching being handled by the computer.



Intellec 8 central control asks for position data every 10 seconds.

A magnetic odometer on the front wheel of each bus gives two pulses each revolution. This count is fed into the microcomputer and converted to distance traveled. Since the route is known—the driver pushes a button identifying his route—the distance traveled is known, and hence the position of the bus, accurate within ±5.6 feet. The position of each bus is kept up to date on a CRT in central control.

Passenger count, for those getting on and for those getting off, is maintained by two infrared beams at the door. The direction the passenger is headed is determined by which beam he breaks first. Infrared was chosen because systems using visible light are sometimes triggered by reflections from passing cars.

Automatic driver identification

A driver identifies himself to central control when he boards his bus to start his run by inserting a special badge into a slot. The badge is built with edge connectors which make electrical contact in the slot. A diode in the badge carries a code which the computer in central control reads.

The system's power supply is designed to operate with all the different voltage levels required, regardless of the vehicle's own power supply, which may vary from 10 V to 36 V. The voltage levels needed by the communications and information system's chips range from +12 V to −12 V.

Central control operates with its Motorola Micor two-way radio, an Intel Intellec 8 microcomputer and and eight-color CRT display built by Xerox. ■■

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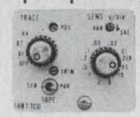

maximum). Similarly, long-term slow-speed tape recordings can be played back at high speed and in just a few seconds yield a complete time history of the data on a short record.

For complete specifications, write or call: Lloyd Moyer, Honeywell Test Instruments Division, P.O. Box 5227, Denver, CO 80217. (303) 771-4700.

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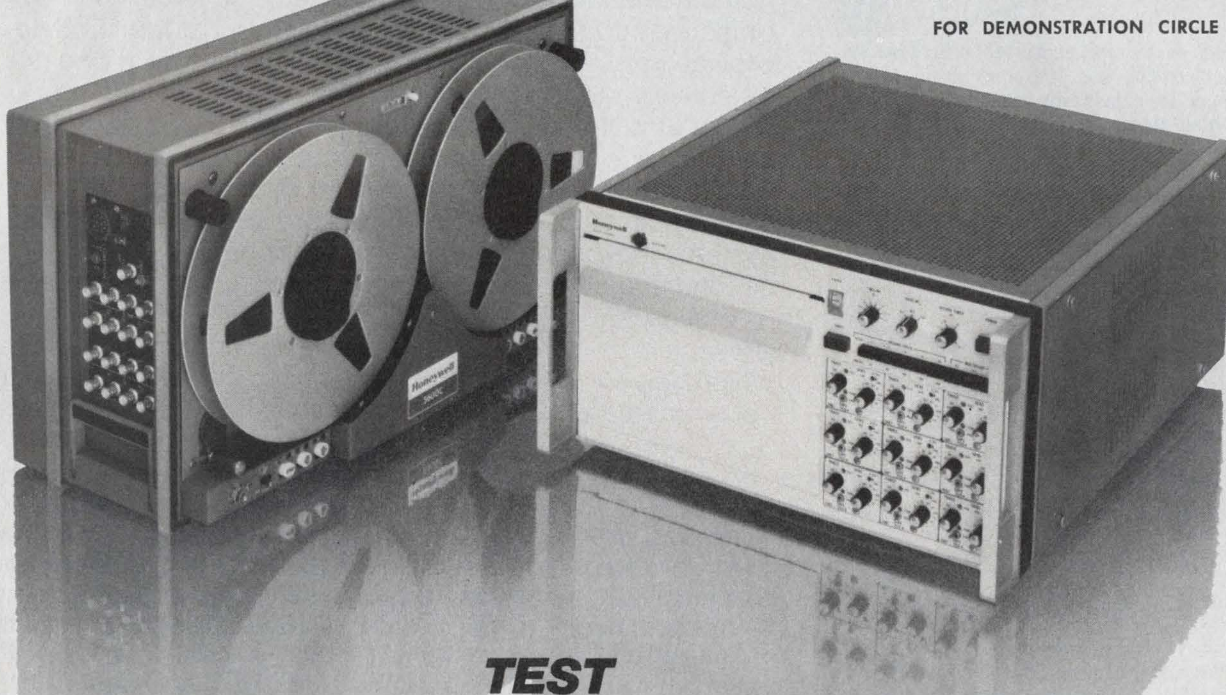

TEST INSTRUMENTS DIVISION

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INFORMATION RETRIEVAL NUMBER 252

COURSE 102: MICROPROCESSORS/MICROCOMPUTERS This basic course provides a comprehensive technical introduction and survey of more than 400 pages. Includes full background information on both microcomputers and microprocessors; suitable and unsuitable applications; alternatives and tradeoffs; applications examples; typical system configurations; a review of fundamental computer concepts; basic elements of a microprocessor system (CPU, RAM, ROM, PROM, I/O structures and techniques, hardware and software); system development, including analysis of requirements, selection, the design cycle, software and hardware, and system integration and debug techniques; a technical survey of available microprocessors; how to get started; and how to estimate costs.

COURSE 168: MOTOROLA'S 6800 VS. INTEL'S 8080 A new, up-to-the-minute course presenting step-by-step comparisons and valid conclusions on two of the most talked-about microprocessor families. Includes a complete analysis of every factor influencing 6800 and 8080 performance, development and production with facts, figures, schematics, benchmark programs and comprehensive documentation. Features an overview, comparison with other 4-bit, 8-bit and 16-bit contenders, and factors influencing selection and costs, architecture; speed benchmarks; memory (including cost); I/O (including circuitry, a comparison of LSI I/O chips, interrupt systems, DMA, and comparative schematics for common interfaces); support circuitry (including what you need and what it costs — including "hidden" costs); the availability and descriptions of microcomputer card sets; a comparison of the EXORciser and the MDS; availability and considerations of development software; a comprehensive cost analysis; customer support; second sources, reliability of components and software, environmental ruggedness and testing; what lies ahead; and a summary of conclusions. AVAILABLE AFTER 9/8/75.

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INFORMATION RETRIEVAL NUMBER 33

Washington Report

Big vs small carriers: A battle looms

The next "great naval battle" is shaping up, this time over the size of future aircraft carriers. Carrier admirals plan to replace existing carriers with large-deck, nuclear-powered Nimitz-class vessels that displace 90,000 tons. Cost-conscious opponents, led by Defense Secretary James R. Schlesinger, favor less expensive and smaller carriers. Some defense experts contend that the smaller vessels would cost 35% less than a $1.2-billion Nimitz-class vessel, but would be only 70 to 80% as effective.

Hints of the brewing conflict came recently in the form of leaks of planning documents sent by the Defense Dept. to the Navy. Confirmation came from Navy Secretary J. William Middendorf 2d in a speech to the American Legion Convention in Minneapolis on Aug. 15.

Noting the cost squeeze, the Navy's civilian chief told of an ongoing study of a new class of aircraft carriers, saying: "This ship would be smaller than our Nimitz-class carriers and displace about two-thirds the tonnage of the 90,000-ton Nimitz. What we would lose in single-ship capability we would gain in having numbers available to meet the vast majority of anticipated commitments."

World standards data offered to manufacturers

American manufacturers can now get from the National Technical Information Service up-to-date information on technical requirements that affect the acceptability of their products in countries throughout the world. The national service recently concluded an agreement with the British Standards Institution for its service called Technical Help to Exporters. This is considered to be the world's largest and most authoritative collection of international standards. The Commerce Dept. is offering the data to manufacturers for a fee. Included in the offering is international regulatory information on product safety standards, performance criteria and coding and certification systems.

Chinese electronics: 'Like trying to read tea leaves'

There are mixed assessments of the degree of success of the recent visit to Red China by a 10-man delegation from the Electronic Industries Association. Those anticipating a flood of purchases were disappointed, but old China watchers say things went along as expected—and as the Chinese preordained.

John Sodolski, the EIA vice president who heads the communications division and who put the program together, says it is too early to know the extent of the Chinese electronics market. To attempt to predict it at this time, he asserts, is like "trying to read tea leaves."

Sodolski left Peking with the impression that the Chinese hadn't yet made up their minds on what they want to do about telecommunications and that they were trying to develop a plan for inclusion in their next five-year plan, starting next year.

The delegation was impressed with the quality and state of the art of Chinese electronic research. From what was seen, it appears that the Chinese are 10 years behind in technology and 20 years behind in production techniques.

Spurt expected in Citizen Band market

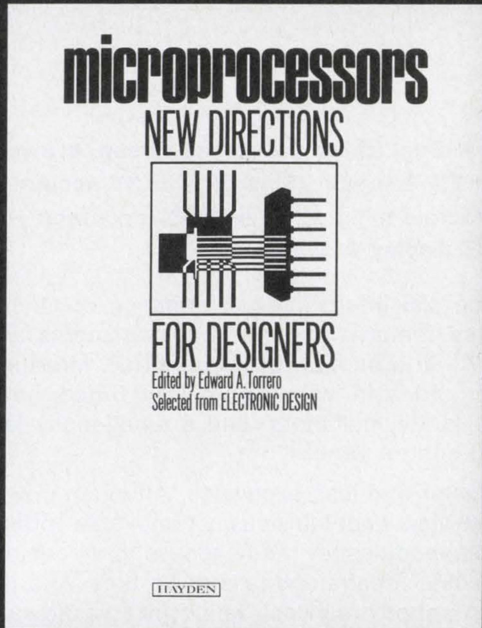
Citizen Band radio operators and manufacturers have won a big concession from the Federal Communications Commission, and if other proposals win approval, there's the distinct possibility of a billion-dollar annual market within a year or two for this section of the electronics industry.

Recently the FCC removed a ban against the use of CB equipment as a hobby. The change simply recognizes that many owners of the gear, including truck drivers, farmers and businessmen use the sets to chat for pleasure. The FCC couldn't control this, and in the future it will concentrate on halting the use of overpowered transmitters, obscene talk and malicious interference.

More and more sets are now expected to appear in autos. A further stimulus will come if the FCC expands the available channels from 23 to 40, as proposed.

As yet, no authoritative figures are available on the total market. About 60 to 70% of the sets now offered are Japanese imports, although U.S. sales are said to have picked up in the last year and are now estimated at from $350-million to $700-million. Next year the total could hit $1-billion. Last year the FCC issued 425,000 permits and this year it could easily grant one million.

Capital Capsules: **The Army Materiel Command is decentralizing its headquarters** to concentrate on resource management, policy and performance evaluation. The focus will be on acquisition and readiness. The Army, which calls the new staff setup a "hard-hitting, corporate type headquarters," expects to cut its present force of 2100 by 700. . . . The Federal Aviation Administration says it **has completed a 10-year program to automate and computerize all 20 air route traffic-control centers.** The final block was activation of a radar data-processing unit at Miami. . . . The Air Force is taking the first deliveries of Pave Spike target-acquisition systems for use on F-4D/E aircraft. **The Westinghouse-built system gives the aircraft the capability of delivering laser-guided bombs** or of acting as a laser target designator. . . . ERDA has awarded a contract to General Electric **to test electric utility transformers to determine causes of insulation breakdown.** One phase will involve an attempt to verify the gas bubble theory of insulation breakdown. . . . The Air Force Systems Command **has put basic research programs under a single manager** in the Office of Scientific Research, separating them from development. In the future they won't compete for funding. . . . **A new avionics system is being developed for the Air Force's F-4 aircraft** that is to provide more accurate navigation, improved bombing accuracy and an automatic aerial reconnaissance capability. Lear-Siegler, Grand Rapids, MI, has a $9.7-million development contract with $42-million in contract options for production of up to 262 operational units.



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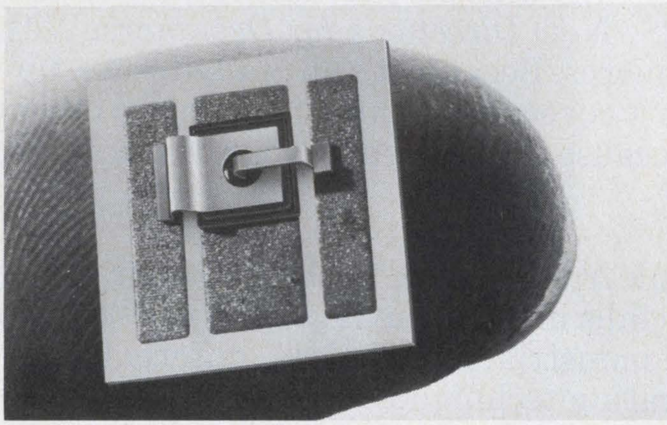

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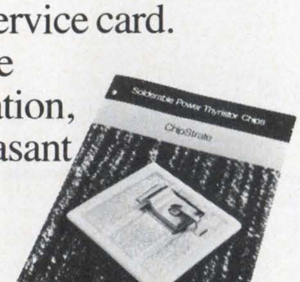

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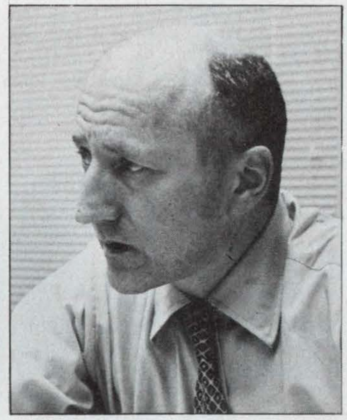
UNITRODE

INFORMATION RETRIEVAL NUMBER 38

Editorial

Look, men. Females



For several weeks we had been on maneuvers in the wilds of Alabama, not far from our base, Ft. McClellan. Lacking many of the benefits of civilization—even Ft. McClellan civilization—we were not entirely joyous as we crawled on our bellies to the crest of another damn hill. Suddenly, our spirits soared when Charlie, crawling over the crest, shouted: "Look, men. Females!"

I confess. Females occupied some of our thoughts in those miserable weeks. So you can imagine our chagrin when, reaching our hilltop, we saw in the valley, a herd of cows. As I recall, we may have made some uncharitable comments to Charlie. But I'm sure this bore no relationship to the snake he found in his bed sheets some weeks later—a female snake, I understand.

Of course, when Charlie shouted, "Females," we all felt he had a warped and malicious sense of humor. But as I think of it now, I believe Charlie was an unsung genius. He was a man able to see things in a different light. Where all of us bitched about miserable forced marches when we should have been enjoying the beauties of Birmingham, or even Anniston, Charlie thought of the fresh air, sunshine and exercise we were getting absolutely free. All of us had unkind words for one of our less popular meals, chipped beef on toast. But Charlie would describe it as a French menu might gush over an elegant dish with a sublime sauce.

And that's a key to genius. If Charlie went into engineering after our sojourn in the infantry, I'm sure he became a magnificent engineer. I'm sure he would always look for different ways to do things. You'd never find him on the beaten, rutted track. He was a genius. Of course, we treated him like a nut. We were all certain that if Charlie shook his head, it would rattle.

But isn't that the way we treat all our colleagues who see and do things differently?

George Rostky

GEORGE ROSTKY
Editor-in-Chief

Your house or ours.

Why it is better to buy DC-to-DC power supplies.

Sure, you can probably build that power supply yourself. First you get out the old breadboard and start designing. When you think you have it, you start testing and compiling reliability data. Then you assemble a load of components. Maybe you have some, maybe you wait for purchasing to buy them. Finally, you set up inventory, inspection, quality control and manufacturing procedures.

All time consuming, and surprisingly expensive. Probably more expensive than you anticipated. Especially when you consider valuable engineering time which could have been put to more creative use.

There's another way. You call up Tecnetics and tell us what you need. And you've got it. Ready to go. You see, we've already done all the designing, engineering, testing, and purchasing. We've been doing it since 1959.

So by now, most of the power supplies you need are in our catalog. Regulated and unregulated, commercial and mil type, hybrid and modular, even our new DC high efficiency types. But if it's something unique, we have the expertise to make it for you. To your specifications. Quickly, with fully documented reliability, and at a price that's more than competitive with in-house production.

Because that's all we do. You see, they don't call us "The Power Conversion Specialists" for nothing. Reputations like ours don't come easy.

So send for our 26-page power supply catalog. It has all the specs, plus prices. And we'll send along an analysis of the economics inherent in the make or buy decision.

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INFORMATION RETRIEVAL NUMBER 40

FOCUS on Switching power supplies

Lord Kelvin once remarked that we know little of a subject unless we can measure it and express it by a number. This hits home when the subject happens to be the switching-regulated power supply.

To pick such a supply from a data sheet alone is to court disaster. True, the switcher has come far in performance and reliability. But designs are still evolving in this relatively young area, and vendors aren't always candid about the shortcomings of their products.

Take efficiency. It's the No. 1 asset of switchers, yet is it guaranteed to be as high as the impressive—and heavily promoted—figure? In most cases, it isn't. Efficiencies of 80%, and even higher, may dazzle you with visions of ice-cool operation or the relief of squeezing a 250-W unit into a leftover volume that is too small for any linear supply. But don't relax. Take another look at the spec.

Look for wording that says "up to," "above," "better than," "average greater than," and the like. All these can warn you that a switcher's nonsinusoidal input current makes efficiency tough to measure exactly. And since efficiency isn't fixed—it can vary with the operating point—such wording is designed to highlight the best rather than the worst-case condition.

Funny, it only works on Wednesdays

The word "typical" should trigger another warning. This can mean that a supply pulled off the assembly line at 3 pm on a rainy Wednesday morning happened to meet the listed number. Or typical can refer to one model of a series (you can almost bet it's not the one in which you're interested).

Stanley Runyon
Associate Editor

Outputs to 1500 W at less than a dollar per watt mark the 800 Series from LH Research. High efficiency plus a fan keep weight down to 15 lb.

What you'd like to know is the minimum efficiency you'll get and the range of efficiencies under the expected variations of load and line. Be aware that a switcher's input current decreases with increasing input voltage, so the low-line spec is of prime interest.

Remember, too, that it's harder to get high efficiency at the lower output voltages—in the 5 or 12-V levels that most applications call for. Though there are 5-V units for which 80% efficiency is claimed, one well-known switcher vendor warns that it's unlikely that a "fully isolated 5-V supply" can be much better than about 70% efficient. (Note the qualifier, "fully isolated.")

Another manufacturer—one who offers only custom switchers—goes even further and flatly states that at low output voltages the efficiency advantage of the switcher is lost. Equivalent efficiency at lower cost, this vendor continues, is offered by a ferroresonant preregulator combined with a linear, series-regulated supply. And there are added benefits of such an arrangement: greater noise attenuation and protection from power-line disturbances, both of which boost system reliability.

Don't get hung up on high efficiency for its own sake. If you're willing to give up a few percentage points you can still get the small size you need—and save money. In any case, it is usually not "high" efficiency in itself that's important, but rather, how much heat the supply must dissipate and how you can get rid of it.

You may think that a neatly compact, super-efficient, switching supply doesn't need cooling. And the spec sheet may reassuringly reinforce that impression, with its lack of information on cooling. But you may be wrong—dead wrong.

Newest offerings from ACDC Electronics include a triple-output unit, 5 V and ±12 or ±15 V (silver case), and a 5-V, 120-A supply (gold case) that accepts dc inputs.

More than any other type, switching-regulated supplies need burn in and life testing to weed out infantile failures and to check new designs (courtesy of Sorensen).

Even a unit that converts 80% of its input power to usable output dissipates 60 W in delivering, say, 240 W. Though the wasted power may be three times less than that in a linear unit, that 60 W still must somhow be eliminated. If it isn't, the supply's temperature will push up and up until the capacitors sizzle. If a portion of the heat is removed, nothing may melt—at least not immediately—but the supply probably will run hotter than it should. Since temperature effects in switchers are more critical than in linear units, performance will be poor. Or reliability suffers and the supply dies young.

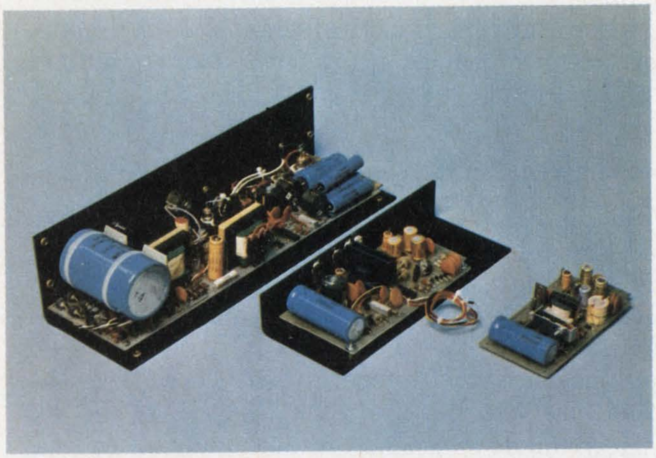
Keeping cool isn't easy

So you can't tuck the supply into an enclosure and conveniently forget about cooling it—even if the spec sheet does. You've got to keep the temperature within safe limits for continuous operation. But just how do you do it? And where do you measure the temperature? Those are the problems.

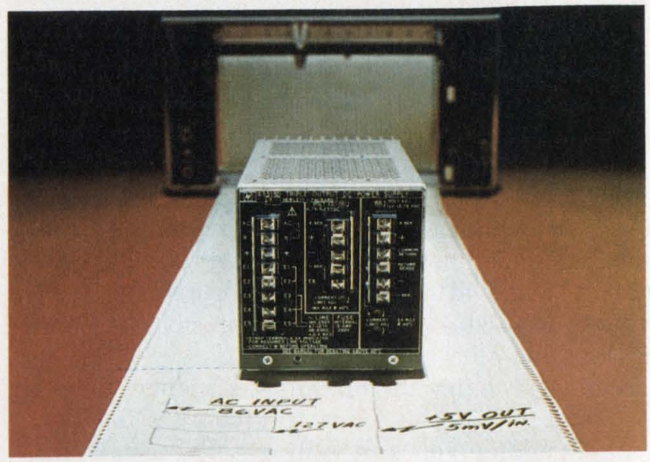
How you do it depends on the supply, of course. Two units, otherwise identically rated, may differ by as much as 50% in temperature rating. One unit may be designed with heat sinks for convection cooling, the other with internal fans for forced air. Still other supplies need forced air but you provide the fan. This may be satisfactory—as long as you know about it.

With convection cooling, heat sinks must be mounted in the proper orientation and with adequate clearance for circulation above, below and alongside the sink. Units with fans can be mounted along any axis, with clearance for intake or exhaust.

Ask some questions: Is forced air required? If so, at what maximum back pressure for safe operation? If self-cooled, what is the maximum back pressure the unit can exhaust into? How does back pressure affect the supply's derating, if any?



Open-frame switchers from Boschert Associates include 10, 60 and 300-W models. Up to four outputs per supply are offered, customized to the application.



Open up Hewlett-Packard's 63315D, a 110-W, triple-output unit, and you'll find just one wire. The unit exemplifies the latest trend: plug-together modularity.

If you do supply air, make sure it isn't preheated by an upstream source (such as another power supply). Keep the air moving—don't let it stagnate or recirculate around several sources of heat.

Forced air versus convection is an old controversy that's been debated ad infinitum. As in any dispute, the pros and cons must be weighed to see which way the scale tips. Fans, of course, can reduce package size or allow more power in the same size. But they do tend to burn out or fail mechanically. With switchers there's an added consideration: Fans use power. So you might ask the vendor: Does the efficiency spec include the fan's consumption?

Many supplies are derated so that less output current is available as temperature rises. Watch for this. The spec sheet may not say that you can't get the maximum current at the maximum operating temperature. To derate, and to keep semiconductors and other components at safe temperatures, just which temperature do you measure? The ambient? The case or heat sink? Exactly where is the ambient? Perhaps at the fan intake or exhaust? Or it is some point above the unit?

Which temperature: oral or . . .?

The vendor may mean any of these when he talks about temperature. But he may not clearly say which. He may not even turn on his supply when he measures "ambient." Thus the self-heating of the supply isn't counted.

Because the ambient is rather vague, and because the possibilities for mounting (or mismounting), rate of air flow, self-heating and other heat-source contributions are endless, perhaps the heat-sink temperature is the best approach. Another way out: Look for units with thermal shutdown. With this protection, the supply shuts itself off if the internal temperature rises too far or too fast. Thermal shutdown, of course, isn't a substitute for proper cooling. But if something goes wrong, at least the transistors won't burn out.

Other things you should know but the spec sheet may not tell you: What is the storage and operating temperature range of the supply? (At a storage of −55 C, watch out for damage to plastic-cased transistors or ICs.) What is the supply's tempco? (Plus-and-minus before the figure neatly chops it in half.)

Games with numbers can be played in other areas too. For example, the figures for regulation, overshoot and response time can vary significantly, depending on how much load or line change is specified. The smaller the load or line variation, the better the specs look.

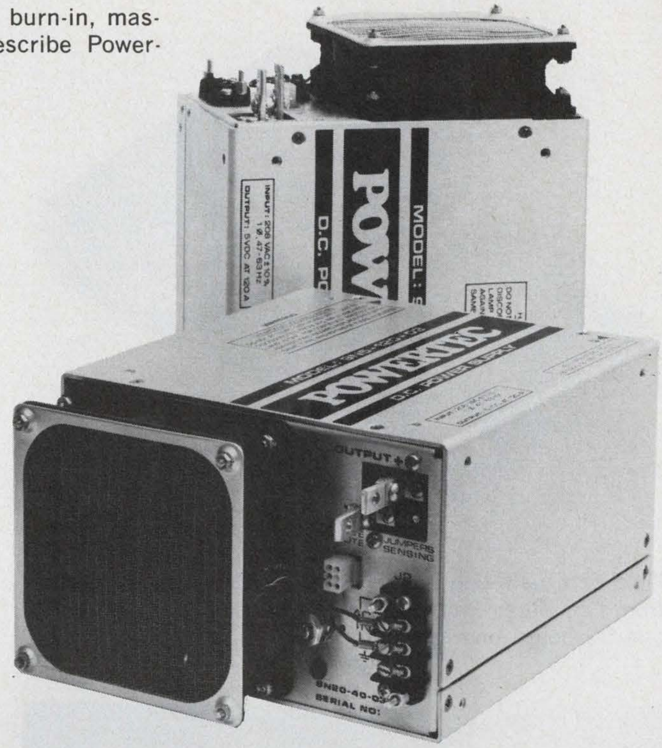
Be especially wary in evaluating dynamic and transient performance. This is one area that some manufacturers tend to downplay for good reason—the switcher's dynamic characteristics are inferior to those of the linear supply by one to two orders of magnitude.

If your load never changes, then you won't care how a switcher can react. But if you're powering, say, a memory or modulated power amplifier—or any stepped or pulsed load—then you certainly should know that a switching regulator can have serious drawbacks. In fact, the switcher may not do the job in these applications. But don't rely on the spec sheet to tell you.

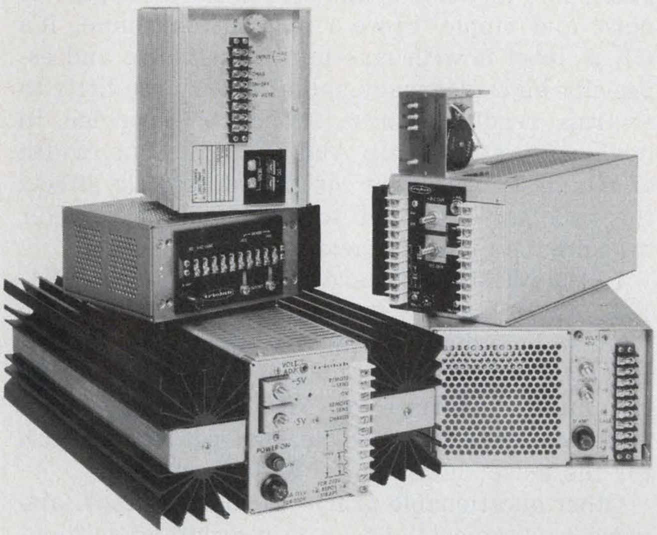
First, the information just isn't there on many spec sheets. Second, when transient response is mentioned, frequently only half the story is told. What you need to learn is not just the response time, but under what load change (magnitude and frequency or risetime) and for what maximum voltage excursion. And check these too: Between which two points is the response time defined, and at what line voltage?

A "short" response time sounds terrific—until you find out the vendor's load hardly budged

Modular construction by function, 24-hour burn-in, master/slave operation and other features describe Powertec's SS Series—12 lb of efficient power.



Units that deliver 50 to 1000 W are marketed by Trio Laboratories. The company's 5-V, 200-A supply stands out with 82% efficiency—high for a 5-V unit.



when he measured the time. Or until you measure it yourself and grimace at the 0.5-V leap in the 5-V output during that "short time." If your circuitry is immune to such excursions, fine. If the excursion never leaves the stated or desired regulation band, that may be OK, too. Yet keep in mind that the peak deviation is usually more important than the response time.

Those peaks can reach lofty—and dangerous—levels if your load transients unluckily occur at the resonant frequency of the switcher's output filter. As one vendor's director of engineering candidly admits: Some supplies will even blow up. When you evaluate dynamic performance, remember that practically all power-supply specs are given at the supply terminals. What your load sees is another story.

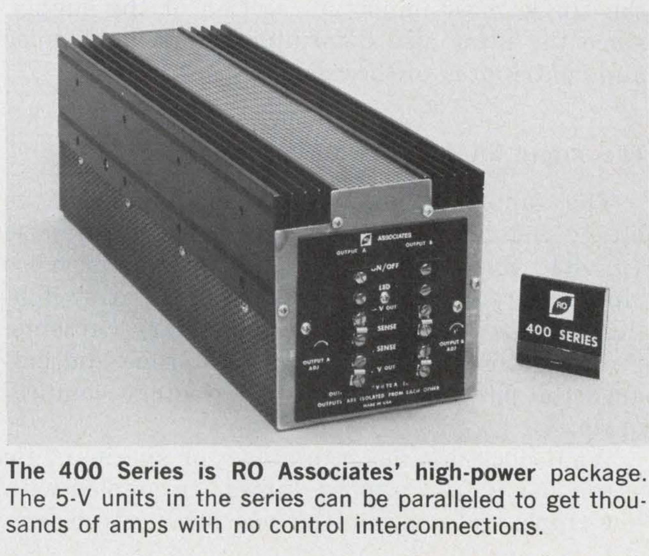
Between the power supply and its load in most cases sits a distribution bus. With low or static currents, you may not care that the bus has inductance or resistance. But with 50 or 100 A flowing, or with the load varying by 50 A, the bus impedance makes a difference. With a 5-V source, for instance, the dynamic specs can crumble at the load—by a factor of five over the specs at the supply's terminals.

Remember that static regulation—no matter how good—is meaningless with a time-varying load. Look instead for low dynamic output impedance in the frequency range of interest, and don't overlook the distribution impedance. With sufficiently low output Z, you may not have to hang large capacitors on the bus to get the needed performance.

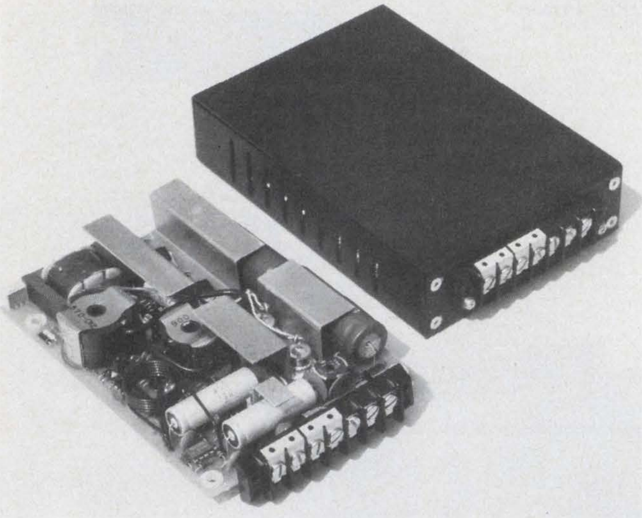
Bear in mind that just five feet of heavy-gauge leads can represent about 4 μH of inductance. Though this sounds small, a 50-A load change in 10 μs produces a 20-V drop across the leads. This disturbance can play havoc at both ends of the line—and lead to instability.

Don't expect to improve dynamic regulation with remote sensing, either. This is strictly a static technique, one which you'll probably need to deliver high currents to a remote load. Just 5 mΩ bus resistance in a 5-V, 200-A system is enough to drop 1 V along the way. With a TTL load that's three quarters of a volt too much.

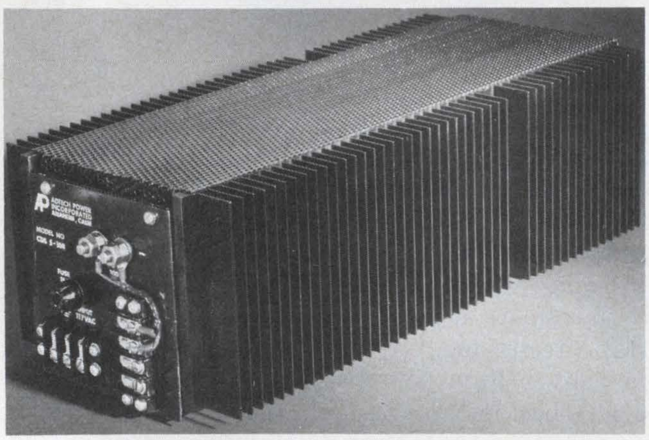
And to top it off, 200 W will be lost in the 5-mΩ distribution system. This means you've got to write off 20% of the power you bought an efficient supply to get. The moral: Watch the bus and all external connections as well as the supply



The 400 Series is RO Associates' high-power package. The 5-V units in the series can be paralleled to get thousands of amps with no control interconnections.



First of a new line is this 50-W switcher, Model HE237 from Computer Products. The entire unit is built on just one PC board and delivers 10 A at 5 V.



In an unusual approach to switching-regulator design, Adtech Power drops power transistors in favor of SCRs. Advantages include fewer components, better regulation.

itself. Other options: Check into distributed power, point-of-load regulators and the like.

A switcher's transient response is largely controlled by the supply's output LC filter—perhaps the single most important section of the supply, since the filter also determines ripple and noise and contributes to the efficiency spec.

The output filter: key to performance

The supply designer would like to keep the filter inductance down to boost response (di/dt). But a low inductance results in more ripple current into the capacitor, greater switching losses and increased peak primary currents. So the designer must walk a tight rope and balance the parameters for a satisfactory compromise.

What does this mean to a user or specifier? Be suspicious if fast response times are coupled with low ripple and noise on the spec sheet. Most commercial, off-the-shelf switchers can't recover in less than 500 μs for a 50% load change, and you can't expect better than about 50-mV pk-pk combined ripple and noise in a 20-Hz-to-10-MHz bandwidth.

Watch for imaginative spec writing that disguises the switcher's limitations with respect to noise and ripple. Since ripple is sinusoidal, it's OK to label it with rms units. But noise and especially high-frequency spikes contribute little to an rms reading. These should be specified in terms of peak-to-peak. And since the bandwidth of the noise-measuring equipment directly affects the results, you've got to know this parameter to make the numbers meaningful.

In the NEMA standard for the industry, PY1-1972, ripple and noise are lumped together into PARD—periodic and random deviations. PARD, says the standard, should be measured within the range of 20 Hz to 10 MHz. But some manufacturers state that the measurement bandwidth for the noise should be 20 MHz or greater.

Other questionable practices: listing ripple and noise as "typical," or as a percentage without saying of what. Check for these.

With the switcher, of course, fast spikes can be especially prevalent—and an especial nuisance. And ripple comes out at two frequencies: 120 Hz and 40 kHz (in 20-kHz units). Though the two frequencies are usually combined into one spec, sometimes you may want to know the individual figures.

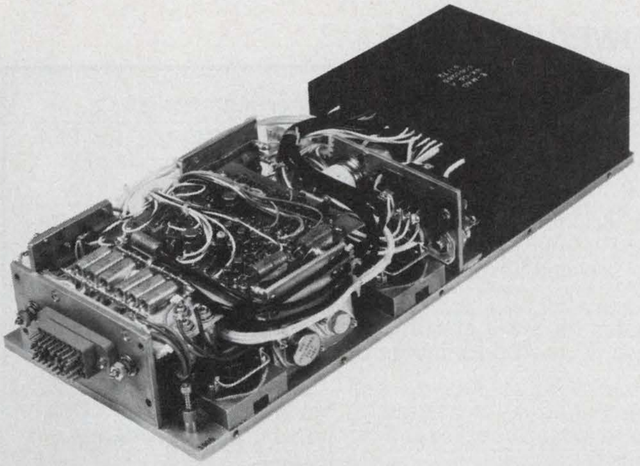
Switching spikes can not only damage sensitive circuits but can produce ringing in long output leads and contribute to EMI. Unfortunately, a single measurement of output noise doesn't give the whole picture. Reflected ripple and "common-mode" noise are needed too.

Little ripples become big waves

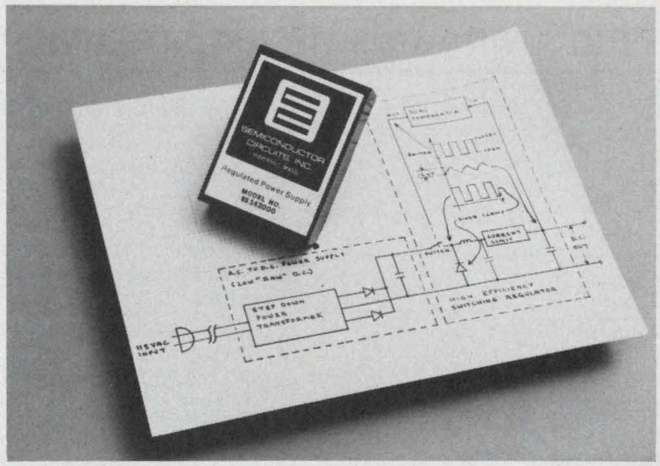
Reflected ripple—also called conducted or back-noise current—can contaminate the ac input line. But because it's hard to measure you won't find a reflected ripple spec on most data sheets. Even if you do, chances are you won't be able to duplicate the results in your own lab. What really counts is how much noise you'll get in your own application, whether the noise can affect other loads on the ac line, and whether the ac line can be adequately decoupled, if necessary.

Also seldom specified is common-mode ripple and noise—unwanted spikes or other hash that appear at the supply's common output terminal (measured with respect to the input common terminal or the case). This noise penetrates the load through a ground loop and can, for example, saturate a differential op amp or other low-level analog circuit.

Both reflected ripple and common-mode noise



Both commercial and military units are built by Electro-Module, a company which specializes in marine, airborne and exotic switchers, such as the one shown.



Encapsulated modular switchers for PC-board mounting are offered by Semiconductor Circuits in its ES/EA Series. Size is just 2.5 × 3.5 inches.

can be dealt with—at a price. An input filter adds to a switcher's cost, of course. And the filter cuts into efficiency—one spec the vendor likes to keep high. So some vendors leave the filter out or offer it as an option. One vendor points out that if conducted noise at the input is to conform to the requirements of, say, MIL-STD-461, the required filter could be as large as a 50-W supply in some cases. This, however, is an extreme case.

You can certainly add your own filter to decouple the line. But since the dynamic input impedance of a switching-regulated supply can be negative (current increases as voltage decreases), don't be surprised if oscillations are touched off when you add the filter. Perhaps this may never happen. But, with the right combination of filter and switcher input impedances, it's a possibility you shouldn't overlook.

To combat common-mode noise, you can throw a capacitor across the supply's common terminals or from output common to ground. This is a simple, inexpensive solution—one which the vendor may have already implemented. But like many too easy solutions, there may be a penalty —in this case, degraded input/output isolation or inadvertent ground loops.

Careful inspection of a switcher's circuit design and layout can help you sidestep this potential headache. You can be almost certain the data sheet won't help. In fact, most sheets don't mention isolation at all.

Isolated isolation specs

Because of the filter networks, which tie the input and output lines to the chassis, switching regulators generally don't provide the high isolation found in linear supplies. So some manufacturers keep the isolation spec off the data sheet, hoping that nobody will ask about it.

But you'll find out about the limitation soon enough—when fast line faults, transients or other power-line garbage punch through the supply and zap your sensitive load. You can always drop the input filter—or look for a unit with high isolation (which could mean the vendor did the dropping)—but with no input filter the supply turns turtle and spits hash back into the line. Somewhere between these extremes lies a reasonable compromise or a clever design that boosts isolation.

Even when isolation is given, it isn't always simple to compare competing units because no standard for isolation exists. Consequently, you'll find "isolation" listed variously as an input/output capacitance, capacitance to chassis, resistive/capacitive coupling, or in terms of various breakdown voltages. Perhaps the best way out here is to measure isolation yourself.

While you're in a measuring mood, you might want to determine the possible effects of EMI in your own setup and how much filtering is really needed. This is probably the safest and most accurate approach. Remember that EMI can be radiated, as well as conducted, out of the supply. Shielding can contain radiation, of course, but at the expense of size and cost.

Again, there's no US standard for EMI, except for military specs, which may be too stringent for many commercial applications. Therefore, you may want to look into VDE 0875/7.71—the widely accepted German standard, which gives definitions, levels and test procedures (available from McDonald Associates, 933 Sixth St., Santa Monica, CA 90403). Some test set-ups are also given in the NEMA standard.

Before you sit down to make any measurements, however, be certain that the supply isn't a time bomb waiting to throw on the switch. With inadequately protected switchers, it's a real possibility.

Because of the very nature of its design, a switcher has more ways to blow itself up than its linear counterpart. If it doesn't destroy itself,

Who's who in switching-regulated power supplies

Company	Capabilities, special features, outstanding models & other information
Abbott Transistor Laboratories	Model VN: Hermetically sealed units, 25, 50 or 100 W, meet MIL-STD-461 for EMI and MIL-STD-810 for environmental requirements. Guaranteed transient protection.
ACDC Electronics	Outstanding models in JP series include the 150 & 750-W units. Featured are modular PC board construction & field changeable heat sinks. Triple-output unit delivers 300 W. Company "wrings out" semiconductors per MIL-STD-833 & burns in after assembly.
Acme Electric	MS Series includes 5-V family, rated for 5.5 V at 50 or 100 A with convection cooling at 40 C. Units accept 110/220-V, 50 to 400-Hz inputs or dc input. Extensive fuse & other protection included.
Adtech Power	Unusual design uses SCRs instead of power transistors in Models CDS5-60 & CDS5-100 (the Controswitchers). Advantages include: fewer components, boosted regulation ($\pm 0.01\%$) & smaller, lighter units.
Advanced High Voltage	Specialist in high-voltage units. Series ARRXXO delivers 150 W. Six models range from 3 kV at 50 mA to 30 kV at 5 mA, and weigh about 9 lb. Voltage & current meters are included.
Arnold Magnetics	Submodular "thin mods" system lets you design your own power conversion package. Choose from a selection of input modules and regulator output modules. To 1000 W.
Boschert Associates	New line includes 3 models, 10, 60 & 300 W, competing on cost, among other things. The 300-W unit delivers quad outputs & sells for $400 (1-25).
Bikor Corp.	ATS Series delivers 10, 20 or 30 A at 5 V. Submodular construction, convection or conduction cooled.
Computer Products	Model HE237 delivers 5 V, 10 A, is built on single PC board. Overvoltage, current limiting & short-circuit (continuous) protected.
Control Data	Introducing new line early 1976. Modular design plugs 300 or 600-W submodules into "bulk" module. Featured are: Full power to 60 C, high isolation (input can swing to 2100 V pk), filters & safety std conformance.
Datel Systems	Miniature units housed in a 2 × 2 × 0.4-in. case & weighing 2.5 oz. Outputs are 5 V at 350 mA or ± 15 V at 60 mA. Regulation is 0.05%, tempco is $\pm 0.005\%/°C$, high I/O isolation.
Electro-Module, Inc.	"Off-the-shelf" FEC Series offers 24 models to 300 W in various voltages to 30 V. Three-year warranty. Model DLR 5100 (5 V, 100 A) is 80% efficient, weighs 13 lb.
Electronic Measurements	Units geared toward xenon, mercury & other arc lamps. Ratings from 35 to 1000 W, 115/230-V inputs. Special attention to turn-on surges & power interruptions.
Hewlett-Packard	Extensive family covers 5 to 28 V, 110 to 600 W. Outstanding Models 62605M (5 V, 100 A) & 63315D (5 & ± 15 V, 110 W) conform to U.S. & international safety stds. Plug-apart modularity. Life tests show 3 failures in 124,000 hours for the "M."

it may try to kill the ac power source, the line switch or the load. Or, as if to prove that turnabout is fair play, the ac line or load can do the same to the supply. So protection is a must. The problem is to find out how much, where it's needed and under what conditions.

Internal fuses, links or circuits are used to protect the switcher against its own complexity or from the effects of component failure. In general, the switching and bias circuits are most problem prone, as are such crucial components as the rectifiers and electrolytic capacitors.

Remember that the performance of power transistors especially, and other components that work at relatively high voltages and high frequencies (> 20 kHz), isn't well documented. Transistors still burn out mysteriously—even when protected against second breakdown or other potential failures. Switching power transistors are usually specified with resistive loads and at room temperature. But does the transistor see 25 C in a supply? Probably not. Is the load resistive? Chances are, its inductive.

Just how many internal fuses or protective circuits are needed is anybody's guess. One viewpoint holds that too many indicates design weakness. Perhaps this is true. But how many is "too many"? And if there's even a remote possibility of failure—even with good designs—you've got to weigh the cost of extra protection against that of potential catastrophe.

Some internal protection can't be avoided. For instance, in pulse-width modulated regulators—a design that most switchers use—supply designers must keep the two switching transistors from being on simultaneously. That is, one transistor must be completely off before the other turns on, or—poof. Of if the on transistor comes out of saturation too soon or a transformer saturates, get out the fire extinguisher. The designer, you see, has his hands full.

Other protection—from the line or load—may

Company	Capabilities, special features, outstanding models & other information
LH Research	Comprehensive line includes models to 1500 W (800 Series). Characterized by high efficiency & modular, unpluggable construction. Brand new line, the MM features units with up to 6 outputs at up to 62 W/lb.
Power Dynamics Div. of ASI	Four series to 1000 W offer up to triple outputs. Fan cooling keeps heat rise down. Soft-start, modular packaging. Units mount in 1/2 rack or 19-in. panels.
Powertec	Latest from this well-known Co. is the SS series featuring: modular, functional construction that eliminates internal harnessing; fan cooling; 24-hour, cyclic, high-temperature burn-in; 30-ms carryover, slow turn-on; and master/slave operation: Up to 4 units share load equally.
Power/Mate Corp.	PSW Series operates to 50 C with convection cooling. Outputs range from 5 to 28 V, 200 to 300 W. Overvoltage, overcurrent, overtemperature & reverse voltage protection are standard.
RO Associates	Over 25,000 units delivered in 6 years makes RO an "old-line" company in a relatively young field. Three major series provide 50 to 360 W in various packages. Two stages of switching in 400 Series for isolation & regulation. 5-year warranty. Single & multiple outputs.
Semiconductor Circuits, Inc.	Encapsulated miniatures, ES/EA Series, in 3.5 × 2.5-in. package. Eight models deliver 4 to 15 W with > 60-dB line transient immunity. Case temperature kept to 15 C rise max.
Sola Electric	Specializes in custom designs, which make up about 12% of the company's production.
Sorensen	40 units in STM Series offer 4 power levels to 700 W in wide range of voltages. Line filters meet MIL-STD-461A for conducted noise. Input is ac or dc (150 V). Overvoltage & current limiting are adjustable.
Tecnetics	Up to 100 W with 400-Hz input is delivered by the 4000 Series. Voltages range from 5 to 48 V and efficiencies from 70 to 86%. Low output impedance, high I/O isolation, Filtered.
Trio Laboratories	Power to 1000 W in 3 series. 5-V, 200-A unit is 82% efficient. 300, 500 & 600-W units are UL recognized, accept 115 or 220 V. Fan cools 600-W unit. Inrush current limiting & margin capability are standard. Single, dual & triple output models.
Trygon Electronics	SHA Series offers 1.83 W/in^3, 0.006-Ω output impedance at 10 kHz & 12 mV pk pk ripple. Fast response: 300 μs to return to regulation band after load transient. 10% load pulse causes max departure from regulation band of 25 mV.
Velonex	Precision high-voltage bench supplies. Models 180 & 190 give adjustable output to 30 kV, digital voltage selection. Output stays within 1 V for "instantaneous" full-load application.
Wilmore Electronics	Triple-output Model 1256 delivers 5 V at 10 A & ±12 V at ±1 A. Unit weighs 2.2 lb, operates open frame with customer's heat sink to 40 C at full load. Custom OEM units, too.

also be essential. Most switchers rectify and filter the ac line before regulation takes place. This means some fairly beefy capacitors are sitting there waiting for the line switch to click on. When it does, a hefty current suddenly surges in to charge the capacitors—and burn out your line switch. If the ac line goes out and then reappears, surges can still occur. Even when you're up and running, you're not OK yet. A line transient can come along and—pow. In each case, how high is the surge? How long does it last? Is there any inrush or transient protection? If so what kind? Better ask.

More deadly inclinations

Find out also how long it takes for the dc to come up after the ac turns on. Look into other possible turn-on quirks. Throw a variable transformer on the input and drop the voltage significantly below your "normal" low line. If the supply isn't protected for low input voltages, stand back.

Vary the load and see what happens. Does the output oscillate or show instability at a certain load or rate of change? Can the supply handle any load from a short to an open? Some supplies must be loaded before you dare energize them. Be especially careful with multiple-output units.

Overload protection of switchers is more difficult than linear units. Thus the unit may be protected for shorts only. One vendor offers this advice: Repeatedly short the output while you simultaneously turn the ac on and off at maximum line voltage. If the design isn't up to par, bye-bye switching transistors.

One characteristic many manufacturers are quick to enumerate is a spec variously termed carryover, hold-up, dropout, fallout or storage time. This spec tells you how long a supply's output remains within the unit's regulation band after a loss in input power. Typically, switchers can store energy for 20 to 30 ms—about ten times better than linear supplies.

What vendors aren't quick to point out is that carryover isn't necessarily a constant. When the line voltage drops, so can the storage time. Unless the spec is otherwise qualified, you can be almost certain that it is given for nominal, or even high, line and not for the worst case.

Other ways of safeguarding the load or supply include overvoltage, reverse voltage and thermal, or over-temperature, protection. Any of these may be necessary, depending on the application. Note that, unlike linear units, a failure in the switching section of a pulse-width-modulated converter usually results in zero or low output voltage. Thus a crowbar to guard the load may not be needed. (But other failure modes can cause overvoltage—as many as 13 modes are possible, claims one supply vendor.) What you may need, however, is something to guard your safety —and your sanity. Which brings us to the nebulous areas of reliability, serviceability and product safety.

Can switchers be trusted?

Because of the many potential failure modes, and because of the increased parts count, the switcher understandably has made many would-be users nervous. And there's no doubt that early units—and some present-day designs—were prone to failure. Vendors rightly point out, however, that much progress has been made and that the switcher's reduced heat tends to boost reliability.

Whatever the arguments and counter arguments, users must still determine a unit's reliability for themselves. To do this, forget about calculated MTBFs—they're useless. Ignore sales pitches for special features or hot-shot designs. Instead, look into the vendor's reputation. Check for a demonstrated field record. Question satisfied —and not-so-satisfied—customers, if you can get a list.

Visit the vendor and see how he builds. Of particular importance: Does he life test? How? Get the results.

Practically every major supplier of switchers states that it's a costly mistake not to evaluate a unit in your own set-up. And this must be done over a fairly long period of time to detect weaknesses that may not show up initially. Effects of reverse leakage current, for example, may be cumulative and not appear for six months to a year.

Those manufacturers who have lived with switchers for many years have learned this the hard way. They've learned to life test at elevated temperatures and to debug their units over a long period of refinement. Our advice: Do the same if you want to be sure.

Safety and serviceability are other areas in which vendors are working to erase the bad marks of early units. Remember: That innocent-looking black box stores enough high-voltage energy to blow a hole in a PC board, start a fire —or send the careless owner to that great design lab in the sky.

More and more, UL approval is becoming a must. If you don't require it, chances are your customer will or the city or state to which you're shipping. But watch out. The word "UL" doesn't guarantee a safe product.

A statement such as "UL recognized (UL-478)" means that the supply has been examined by an independent agency and found to conform with specific safety requirements. One that says, "designed to conform to UL478" is a potential booby trap. Read the UL statement carefully. Keep in mind, too, that only the line cord or other components may have qualified.

Some vendors recommend that you don't try to repair a switching supply yourself. If you do, hook-up an isolation transformer whenever you remove the cover. Look for current-probe loops and test points that ease testing and reduce the hazard. Storage capacitors and switching transistors should be shielded or insulated.

Other safety specs you can look into, besides UL478 for data products, are UL114 for office equipment, IEC 348, also for office equipment, IEC-435 for data products and the German (VDE) specs.

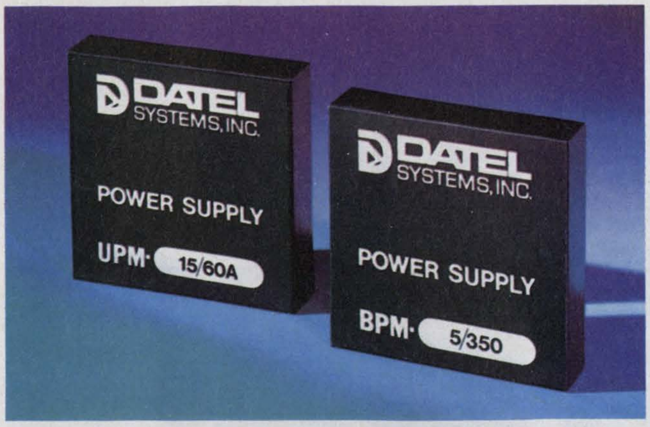
Lift the lid and peak in

If you do remove the cover, watch for tip-offs to possible trouble: Are the storage caps operated beyond the ripple rating? How about the rectifiers—are peak and reverse currents within ratings? Do components heat up until they crackle? (Careful what you touch.) What do the switching waveforms look like? Is there any ringing? Are the transistors fully saturated?

What does the wiring look like—neat or a hodgepodge? Newer supplies—with modular construction—may have little or no internal wiring. Check component quality, especially the switching transistors, rectifiers and capacitors.

The latest designs may take advantage of the recent advances made in these components: power transistors with higher operating voltages and frequencies, high-temperature Schottky rectifiers and four-terminal capacitors, with especially low impedance. But don't forget that many of these are relatively new components, with no established, long-term failure rate.

And don't make these mistakes when you evaluate a switcher: Don't buy on dollars per watt or watts per cubic inch alone. Don't specify a



Miniature modules, from Datel Systems, are housed in a 2 × 2 × 0.4-in. case and weigh just 2.5 oz. Despite the small size, specs rival those of larger units.

switching unit as you would a linear supply—you can't replace one for the other, spec for spec.

Be extra wary with multiple-output switchers or with units tied together for more power. In dual or triple-output (5 V and ±12 or 15 V) units, does each auxiliary output have its own regulator (usually a linear regulator) or are all regulated off the main output (5 V)? Does the regulation spec cover the auxiliary levels? How about the other specs?

Do the auxiliary outputs function without some loading of the main output, or is a 5 or 10% loading essential? Are load transients reflected from the main into the auxiliary outputs? Does the extra parts count cut into the reliability?

Though each output is rated for a maximum current, this doesn't mean you'll necessarily get all maximums simultaneously. The supply will probably carry a maximum wattage rating so that you'll have to juggle the currents to stay within that power rating.

If you need lots of power (> 1000 W), you'll have to bring units together to multiply the current. When you do this, you can easily multiply your problems too. With straight parallel connections, watch for additive ripple and noise, interactions between units and problems in load sharing—one unit can loaf while the other carries almost the full load or goes into limiting. Look into master/slave capability for equal load sharing.

With all its potential for disaster, should you avoid the switcher? Not at all. You can walk around the hazards—if you first chart the mine field.

Remember that the switcher is at the acme in efficiency—which means it saves energy and slashes your electric bill. For the highest in power density, again, the switcher is tops. And it stays on the top for cool operation. So learn the good and the bad. Then step into the marketplace. ■■

Need more information?

The products cited in this report don't represent the manufacturers' full lines. For additional details, circle the appropriate information retrieval numbers. For data sheets and more vendors, consult ELECTRONIC DESIGN's GOLD BOOK.

Abbott Transistor Laboratories, Inc., 5200 W. Jefferson Blvd., Los Angeles, CA 90016. (213) 936-8185. (R. Baldarrama). **Circle No. 401**

ACDC Electronics Inc., 401 Jones Rd., Oceanside, CA 92054. (714) 757-1880. (W. Hirschberg). **Circle No. 402**

Acme Electric Corporation, Cuba, NY 14727. (716) 968-2400. (R. J. Milne). **Circle No. 403**

Adtech Power Inc., 1621 S. Sinclair St., Anaheim, CA 92806. (714) 997-0034. (J. McNulty). **Circle No. 404**

Advanced High Voltage Co., Inc., 14532 Arminta St., Van Nuys, CA 91402. (213) 997-7222. (M. Alexander). **Circle No. 405**

Arnold Magnetics, 11520 W. Jefferson, Culver City, CA 90230. (213) 870-7014. (F. M. Arnold). **Circle No. 406**

Autronics Corp., 180 N. Vinedo Ave., Pasadena, CA 91107. (213) 681-3545. **Circle No. 430**

Bikor Corp., 1228 253 St., Harbor City, CA 90710. (213) 325-2820. (R. Pizer). **Circle No. 407**

Boschert Associates, 3010 Lawrence Expwy., Santa Clara, CA 95051. (408) 732-2440. (D. Snyder). **Circle No. 408**

Computer Products, Inc., Box 23849, Fort Lauderdale, FL 33307. (305) 974-5500. (W. Ford). **Circle No. 409**

Control Data, Magnetic Components Div., 7801 Computer Ave., Minneapolis, MN 55435. (612) 830-5800. (L. Muehleisen). **Circle No. 410**

Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. (617) 828-8000. (E. Zuch). **Circle No. 411**

Dressen-Barnes Electronics Corp., 2695 E. Foothill Blvd., Pasadena, CA 91107. (213) 795-7731. **Circle No. 431**

Dynage Inc., 1331 Blue Hills Ave., Bloomfield, CT 06002. (203) 243-0315 (J. A. Pflngsten). **Circle No. 432**

Electro-Module Inc., 2855 Metropolitan Pl., Pomona, CA 91767. (714) 593-3565. (G. Churchouse). **Circle No. 412**

Electronic Measurements Inc., 405 Essex Rd., Neptune, NJ 07753. (201) 922-9300. (R. J. Hill). **Circle No. 413**

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. **Circle No. 414**

LH Research Inc., 2052 S. Grand Ave., Santa Ana, CA 92705. (714) 546-5279. (J. Cooper). **Circle No. 415**

Nippon Electronics Memory Industry Co., Ltd., Park Ave., 1-20-1 Sendagaya, Shibuya-Ku, Tokyo 151, Japan. **Circle No. 416**

NJE Corp., P.O. Box 50, Dayton, NJ 08810. (201) 329-4611. **Circle No. 433**

North Electric Co., Electronics Div., P.O. Box 688, Galion, OH 44833. (419) 468 8100. (J. D. Neff). **Circle No. 417**

Parko Electric Co., 16722 Milliken Ave., Irvine, CA 92705. (714) 549-8301. **Circle No. 434**

Pioneer Magnetics Inc., 1745 Berkley St., Santa Monica, CA 90404. (213) 829-3305. **Circle No. 435**

Power Dynamics Div. ASI Inc., Box 965, Acton, MA 01720. (617) 263-9100. (W. Boyden). **Circle No. 418**

Power/Mate Corp., 514 S. River St., Hackensack, NJ 07601. (201) 343-6294. (M. Charter). **Circle No. 419**

Powertec Incorporated, 9168 Desoto Ave., Chatsworth, CA 91311. (213) 882-0004. (J. Poturny). **Circle No. 420**

RO Associates Inc., 3705 Haven Ave., Menlo Park, CA 94025. (415) 322-5321. (F. Kamp). **Circle No. 421**

Semiconductor Circuits Inc., 306 River St., Haverhill, MA 01830. (617) 373-9104. (J. Parent). **Circle No. 422**

Sola Electric Div., 1717 Busse Rd., Elk Grove Village, IL 60007. (312) 439-2800. (R. Tucker). **Circle No. 423**

Sorensen Co., 676 Island Pond Rd., Manchester, NJ 02103. (603) 668-4500. (K. W. Lent). **Circle No. 424**

Tecnetics Inc., 1626 Range St., Boulder, CO 80302. (803) 442-3837. (V. L. Garrison). **Circle No. 425**

Topaz Electronics, 3855 Ruffin Rd., San Diego, CA 92123. (714) 279-0831. **Circle No. 436**

Trio Laboratories, Inc., 80 Dupont St., Plainview, NY 11803. (516) 681-0400. (J. Crawford). **Circle No. 426**

Trygon Electronics, Sub. of Systron-Donner Corp., 1200 Shames Dr., Westbury, NY 11590. (516) 997-6200. (E. Weiss). **Circle No. 427**

Velonex Div. Varian 560 Robert Ave., Santa Clara, CA 95050. (408) 244-7370. (E. Rudee). **Circle No. 428**

Wilmore Electronics Company, Inc., P.O. Box 2973, West Durham Station, Durham, NC 27705. (919) 489-3318. (J. L. Harris). **Circle No. 429**

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Data Precision's Model 3500 5½ digit multimeter gives you more at reduced costs.

1. BCD Output and Digital Control
Parallel BCD output and digital control signal capability at *no extra cost.*

2. Ratio Measurements
DC/DC and AC/DC ratio measurement capability at *no extra cost.*

3. High Normal Mode and Common Mode Rejection
Model 3500 performance is significantly more effective in rejecting normal mode and common mode signals up to 80dB NMRR and up to 160dB CMRR.

4. Hi-Frequency Measurements
The Model 3500 AC voltage measuring capability is specified up to 100KHz.

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Provides a measurement capability of AC voltages on 5 range scales, including the low scale with 1μV resolution and a high scale to 700 volts RMS.

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Model 3500 incorporates Tri-Phasic tm autozeroing performance eliminating the need for zero adjustment between measurements on any range and any function.

7. Price
High quality performance and accuracy for $995 complete.

The Model 3500 has a 6 months basic DC accuracy of ±0.007% of reading ±1 LSD, full autoranging from 1 microvolt to 1000V (DC or AC peak) and 1 milliohm through 12 Megohms resistance, 20% overranging and an easy-to-read ½ inch planar display.

The Model 3500 also features our Tri-Phasic tm conversion cycle, Ratiohmic tm resistance mode, and Isopolar tm referencing, circuit techniques that increase performance and decrease price.

To arrange an immediate demonstration or for technical data and a comparative analysis of the Model 3500 contact: Data Precision, Audubon Road, Wakefield, MA. 01880 (617) 246-1600.

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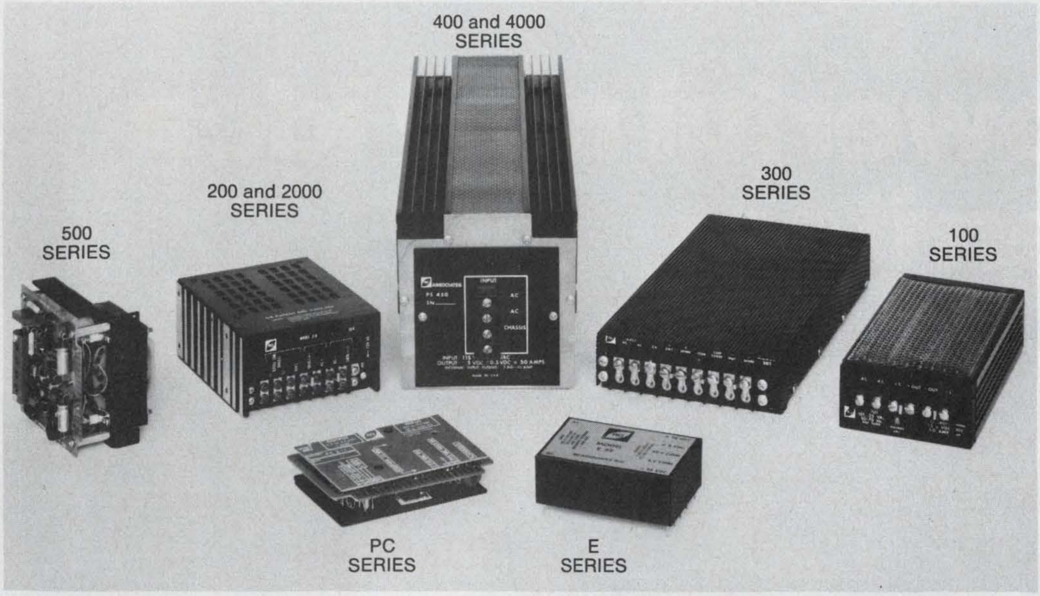

20kHz 'switchers'

5 year warranty

reliable

with a five year warranty
now from the leader in 20kHz switching power supplies

This increase in warranty coverage is offered because of the success we have enjoyed in producing in excess of 25,000 SWITCHERS at a very low failure rate. It is proof of the confidence we have in our proven designs and production techniques. Extensive in-process quality control and 100% burn-in practically eliminates infant mortality, thus guaranteeing you long trouble-free operation.

Please consult the manufacturers' directory section for a listing of our sales representatives offices.

Call or write for our complete catalog which includes the informative article, "The Principles and Facts About Switching Power Supplies."

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It's the new Power E core . . . the first ferrite core specifically designed for switched mode power supplies.

Because of its unique shape, it has the power to . . . reduce size, weight, and cost . . . reduce component count for greater assembly ease and higher reliability . . . increase overall equipment efficiency.

Virtually a pot core with the two sides removed—or an E core with a round center leg—the new Series EC core provides an external magnetic field that is a compromise between these other two core types. Because it has a circular cross section for the center leg, turn length of windings is minimized, reducing copper losses. The more compact winding reduces leakage inductance. And the open side design provides for maximum ease of winding and termination.

Accessories available, too. A complete line of standard bobbins has been designed and tooled to accept the new core. And specially designed mounting hardware helps make for easiest possible assembly.

If you're not yet using ferrites for power converters, you're not yet on to a good thing. And if you haven't investigated this newest and most powerful idea in ferrites yet, perhaps you'd better.

For further information, or quantities from stock, write or phone Ferroxcube or any of the offices listed below.

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19172

INFORMATION RETRIEVAL NUMBER 43

International Rectifier.

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

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

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

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

New International Rectifier Fast Switching Power Transistors

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

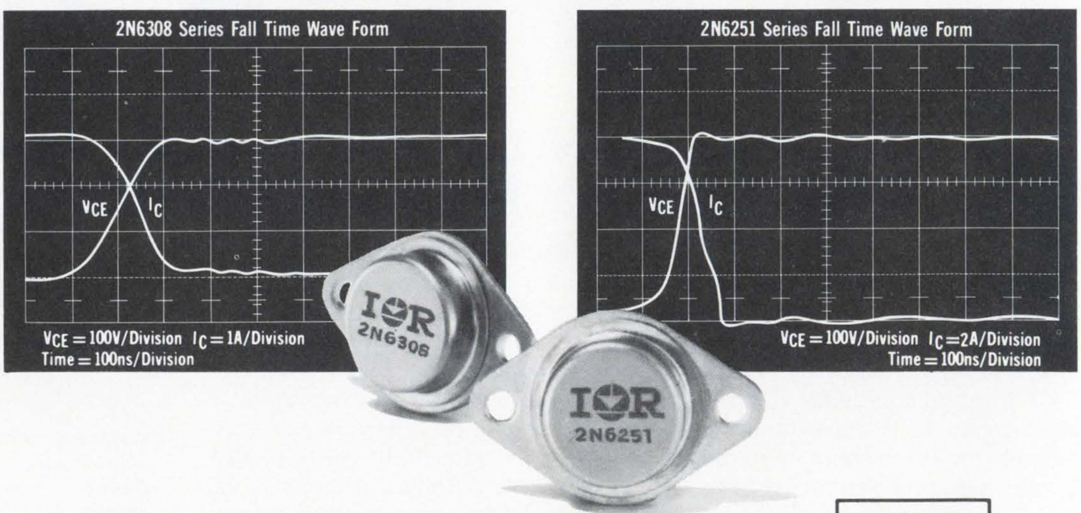
High Second Breakdown — High Reliability . . . high second breakdown helps provide a broad safe-operating area for an extra margin of safety.

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

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

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

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



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LH

SWITCHERS

The *world's largest* manufacturer of high power switching regulated power supplies—whose only product line is high power switchers—announces

The NEW "MIGHTY MITES"

(MM) Series *

The most dramatic and revolutionary breakthrough ever made in the power supply industry.

- **Most comprehensive line of switchers ever developed** — one, two, three, four, five and six outputs.
- **Most watts/in.³** — up to 2.26 watts/in.³ — more than 2 times denser than competitive switchers; 5 to 6 times denser than conventional linears.
- **Most efficient** — up to 80% efficient.
- **Most economical** — less than 60¢/watt in quantity.

*Patent Pending

- **Most reliable** — only LH Research guarantees all models for two years.
- **Most modular** — any pc board may be removed and re-installed in less than two minutes.
- **Smallest size** — 5V - 75 amp model is only 5" x 4" x 12"; 5V - 150 amp 5" x 5" x 12.75".
- **Lightest weight** — up to 62 watts/lb.
- **All models designed to meet UL 478.**

LH SWITCHERS

LH "MIGHTY MITES"

16 models with the most advanced specs in the industry.

Efficiency
Up to 80%.

Input
115VAC ±10% 47-63 Hz.
or 230VAC ±10% 47-63 Hz.
115/230VAC ±10% 47-63 Hz optional.

Output
(see listings under individual models)
Any output between 2 volts and 70 volts available. Contact factory.

Line Regulation
0.4% on primary output over entire input range.
0.2% on 2nd, 3rd and 4th.

Load Regulation
0.4% from no load to full load.

Note: Multiple output supplies require a minimum of 10% load on main output to maintain voltage on minor outputs.

Interaction
0.1% maximum.

Ripple and Noise
1% P-P or 50 MV.

Over-voltage Protection
Standard on primary output, factory set at 125% ±5%. OVP available for other outputs as an option.

Overshoot and Undershoot
2% maximum deviation for a 25% load change at 5A/μs.

Response Time
200 μs to 1% after a 25% load change at 5A/μs.

Drop Out Time
Supply will remain in regulation for 15 ms after removal of nominal AC power.

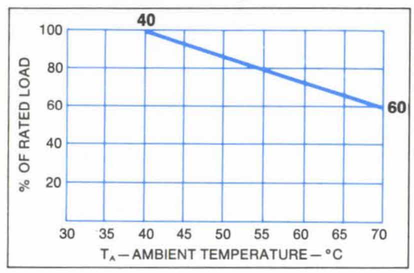
Current Limit
All outputs have "fold-back" current limiting. Constant current limiting available as an option.

Temperature Coefficient
±.02%/°C.

Storage Temperature
−55°C to 85°C.

Operating Temperature
0°C to 70°C (see derating curve).

Power Derating Curve



Minimum Load
Zero for single output models; 10% on primary output for multiple output models.

Output Polarity
Single output models:
Either output terminal may be grounded or left floating up to 100V off chassis ground.

Multiple output models:
Outputs of these supplies are floating and independent and may be referenced as desired up to 100V off chassis ground.

Input Connections
AC input is provided through a heavy duty non-breakable terminal block.

Output Connections
Primary outputs that have ratings up to 375 watts use nickel plated 1/4 x 20 studs. Primary outputs that have ratings up to 750 watts have nickel plated 5/16 x 18 studs. Other outputs on multiple supplies are provided through a heavy duty non-breakable terminal block.

Output Adjustment
All outputs have voltage adjustment potentiometers accessible from the front panel. Current limit and OVP adjustments are internal and factory set.

Standard Features

- *Remote sense on primary outputs.* Compensation for up to 250 MV load cable loss can be accommodated. Remote sense is also provided on 2nd and 3rd outputs of 2 and 3 output supplies.
- *Internal thermal switch.* Will turn off the power supply in case of overheating.
- *Input RFI line filter.* Independent LC section on each side of the AC line.
- *Reverse voltage protection.* All outputs have reverse voltage protection up to 100% of rated current on primary outputs. 3 amps average on all other outputs.
- *Limited inrush current.* AC input inrush current is limited to 2½ times normal running current when averaged over one cycle.
- *Automatic internal sensing.* Internal sensing is automatic through resistors if the sense lines are opened.

Optional Features

- *Power fail detection.* Upon AC removal, power fail signal will drop to a logic zero at least 10 ms before loss of DC output. This signal is referenced to the (−) output stud.
- *Remote on-off.* The power supply output(s) can be activated by customer supplied switch or transistor circuit. (Consult factory for further details.)
- *Master/slave parallel.* Up to 10 single output units can be paralleled. Advantages are: current sharing between units to within 10%. Voltage adjustment made at master unit. All supplies switch at the same frequency.
- *Straight paralleling.* (no master) Single output supplies are available with constant current overload to allow reliable turn on when units are to be used in straight parallel.
- *Special AC inputs.* Units can be built with wider AC input ranges to give added protection against brown out.
- *DC inputs.* Most MM Series units can be configured for 28, 48, and 120 VDC.

Look how the "Mighty Mites" compare against competitive switchers.*

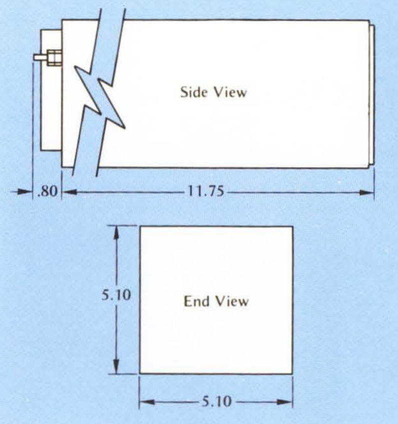
	ACDC	ACME	H-P	PIONEER	POWERTECH	SORENSON	TRIO	LH
Power/Watts	500	500	500	500	600	500	500	**750**
Cost	$595	$605	$650	$595	$625	$650	$650	**$590**
Size (in.^{3})	523	397	507	480	400	525	461	**331**
Cost/Watt**	$1.19	$1.21	$1.30	$1.19	$1.04	$1.30	$1.30	**$.78**
Watt/in.^{3}	.96	1.25	.98	1.04	1.5	.95	1.08	**2.26**

*Specifications and prices based on published information. **Based on single unit price.

MM-300 One output, 750 watts

5V, 150 amps	18V, 41 amps
12V, 62 amps	24V, 31 amps
15V, 50 amps	

Price $590.00, 1 to 9 supplies



MM-420 Two outputs, 750 watts

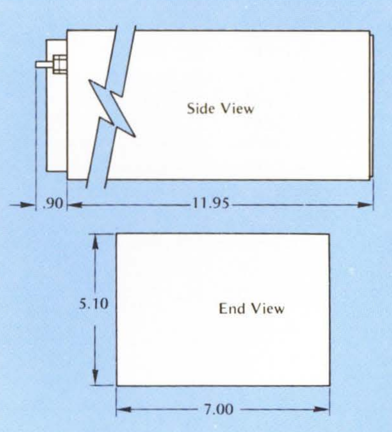
Primary voltage:
5V, 150 amps

2nd voltage: (these voltages also available at twice the current ratings shown).

2V, 12 amps	15V, 10 amps
5V, 12 amps	18V, 8 amps
12V, 10 amps	24V, 5 amps

Total wattage of all outputs not to exceed 750 watts

Price $650.00, 1 to 9 supplies



MM-430 Three outputs, 750 watts

Primary voltage:
5V, 150 amps

2nd and 3rd voltages:

± 5V, 12 amps	±18V, 8 amps
±12V, 10 amps	±24V, 5 amps
±15V, 10 amps	

Total wattage of all outputs not to exceed 750 watts

Price $695.00, 1 to 9 supplies

MM-440 Four outputs, 750 watts

Primary voltage:
5V, 150 amps

2nd voltage:

2V, 12 amps	15V, 10 amps
5V, 12 amps	18V, 8 amps
12V, 10 amps	24V, 5 amps

3rd and 4th voltages:

5V, 5 amps	18V, 4 amps
12V, 5 amps	24V, 3 amps
15V, 5 amps	

Total wattage of all outputs not to exceed 750 watts

Price $745.00, 1 to 9 supplies

MM-450 Five outputs, 750 watts

Primary voltage:
5V, 150 amps

2nd, 3rd, 4th and 5th voltages, any combination of the following:

5V, 5 amps	18V, 4 amps
12V, 5 amps	24V, 3 amps
15V, 5 amps	

Total wattage of all outputs not to exceed 750 watts

Price $775.00, 1 to 9 supplies

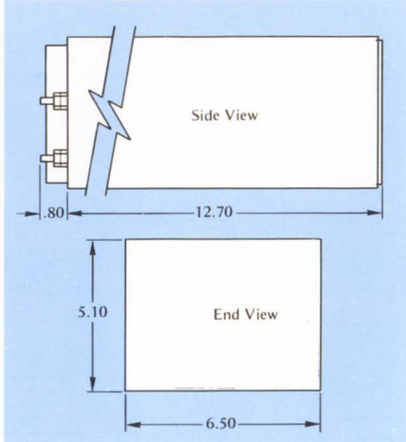
Prices and specifications are subject to change without notice.

MM-520 "Dual" — Two 375 - watt outputs, 750 watts total

No. 1 and No. 2 primary voltages, any combination of the following:

2V, 75 amps	15V, 25 amps
5V, 75 amps	18V, 21 amps
12V, 31 amps	24V, 15 amps

Price $750.00, 1 to 9 supplies



MM-630 Three outputs, 750 watts: 2 high power and 1 low power

No. 1 and No. 2 primary voltages, any combination of the following:

2V, 75 amps	12V, 31 amps
5V, 75 amps	15V, 25 amps

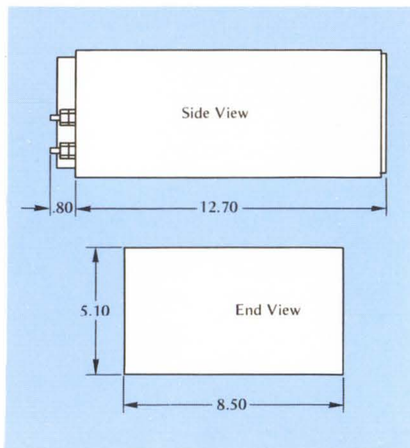
3rd voltage*: (these voltages also available at twice the current ratings shown)

2V, 12 amps	15V, 10 amps
5V, 12 amps	18V, 8 amps
12V, 10 amps	24V, 5 amps

Total wattage of all outputs not to exceed 750 watts

*Third voltage plus the No. 1 primary cannot exceed 375 watts.

Price $810.00, 1 to 9 supplies



MM-640 Four outputs: 2 high power and 2 low power, 750 watts total

No. 1 and No. 2 primary voltages, any combination of the following:

2V, 75 amps	12V, 31 amps
5V, 75 amps	15V, 25 amps

3rd and 4th voltages*, any combination of the following:

2V, 12 amps	15V, 10 amps
5V, 12 amps	18V, 8 amps
12V, 10 amps	24V, 5 amps

Total wattage of all outputs not to exceed 750 watts

*Combination of third voltage and the No. 1 primary cannot exceed 375 watts.

*Combination of fourth voltage and the No. 2 primary cannot exceed 375 watts.

Price $855.00, 1 to 9 supplies

MM-650 Five outputs: 2 high power and 3 low power, 750 watts total

No. 1 and No. 2 primary voltages, any combination of the following:

2V, 75 amps	12V, 31 amps
5V, 75 amps	15V, 25 amps

3rd voltage*:

2V, 12 amps	15V, 10 amps
5V, 12 amps	18V, 8 amps
12V, 10 amps	24V, 5 amps

4th and 5th voltages*, any combination of the following:

5V, 5 amps	18V, 4 amps
12V, 5 amps	24V, 3 amps
15V, 5 amps	

Total wattage of all outputs not to exceed 750 watts

*Combination of third voltage and the No. 1 primary cannot exceed 375 watts.

*Combination of fourth and fifth voltages and the No. 2 primary cannot exceed 375 watts.

Price $905.00, 1 to 9 supplies

MM-660 Six outputs: 2 high power and 4 low power, 750 watts total

No. 1 and No. 2 primary voltages, any combination of the following:

2V, 75 amps	12V, 31 amps
5V, 75 amps	15V, 25 amps

3rd, 4th, 5th and 6th voltages*, any combination of the following:

5V, 5 amps	18V, 1 amp
12V, 5 amps	24V, 1 amp
15V, 5 amps	

Total wattage of all outputs not to exceed 750 watts

*Combination of third and fourth voltages and the No. 1 primary cannot exceed 375 watts.

*Combination of fifth and sixth voltages and the No. 2 primary cannot exceed 375 watts.

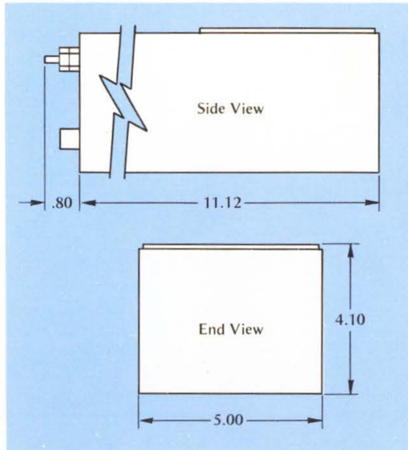
Price $935.00, 1 to 9 supplies

Prices and specifications are subject to change without notice.

MM-100 One output, 375 watts

5V, 75 amps	18V, 21 amps
12V, 31 amps	24V, 15 amps
15V, 25 amps	

Price $445.00, 1 to 9 supplies



MM-220 Two outputs, 375 watts

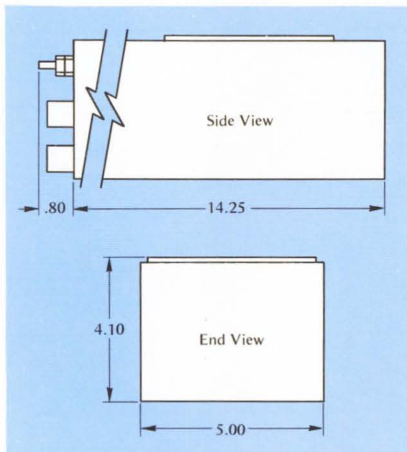
Primary voltage:
5V, 75 amps

2nd voltage:

2V, 12 amps	15V, 10 amps
5V, 12 amps	18V, 8 amps
12V, 10 amps	24V, 5 amps

Total wattage of all outputs not to exceed 375 watts

Price $495.00, 1 to 9 supplies



MM-230 Three outputs, 375 watts

Primary voltage:
5V, 75 amps

2nd and 3rd voltages:
±12V, 8 amps
±15V, 8 amps
±18V, 6 amps

Total wattage of all outputs not to exceed 375 watts

Price $530.00, 1 to 9 supplies

MM-240 Four outputs, 375 watts

Primary voltage:
5V, 75 amps

2nd voltage:

2V, 12 amps	15V, 10 amps
5V, 12 amps	18V, 8 amps
12V, 10 amps	24V, 5 amps

3rd and 4th voltages, any combination of the following:

5V, 5 amps	18V, 2 amps
12V, 3 amps	24V, 2 amps
15V, 3 amps	

Total wattage of all outputs not to exceed 375 watts

Price $565.00, 1 to 9 supplies

MM-250 Five outputs, 375 watts

Primary voltage:
5V, 75 amps

2nd, 3rd, 4th and 5th voltages, any combination of the following:

2V, 5 amps	15V, 3 amps
5V, 5 amps	18V, 3 amps
12V, 3 amps	24V, 2 amps

Total wattage of all outputs not to exceed 375 watts

Price $595.00, 1 to 9 supplies

Prices and specifications are subject to change without notice.

MM-730 "Flat Pak" — Three outputs, 375 watts

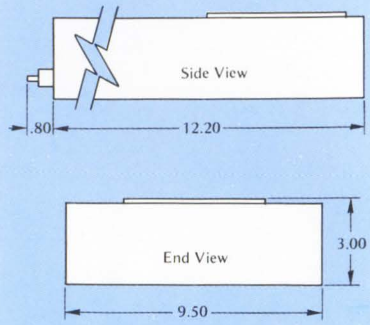
Primary voltage:
5V, 75 amps

2nd and 3rd voltages:

± 2V, 12 amps	±15V, 10 amps
± 5V, 12 amps	±18V, 8 amps
±12V, 10 amps	±24V, 5 amps

Total wattage of all outputs not to exceed 375 watts

Price $530.00, 1 to 9 supplies



How to order MM Series Switchers

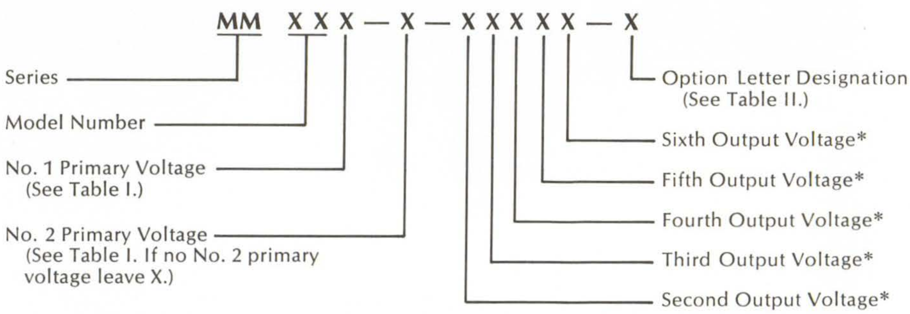


TABLE I.
OUTPUT VOLTAGE CODE

0=2 VOLTS	3=15 VOLTS
1=5 VOLTS	4=18 VOLTS
2=12 VOLTS	5=24 VOLTS

TABLE II.
OPTION ORDER CODE

O=REMOTE ON-OFF
P=POWER-FAIL DETECTION
C=CONSTANT CURRENT LIMITING

*For *each* output which needs over-voltage protection (where it is not standard) add the letter Y immediately following the output voltage code, i.e. 1Y, 3Y, etc.

Typical example: MM 661 — 1 — 1Y2Y3Y5-P

The above Model Number describes a MM 660 Series Switcher with
a 5-Volt No. 1 primary output voltage,
a 5-Volt No. 2 primary output voltage,
a 5-Volt second output voltage with over-voltage protection,
a 12-Volt third output voltage with over-voltage protection,
a 15-Volt fourth output voltage with over-voltage protection,
a 24-Volt fifth output voltage *without* over-voltage protection,
and the power-fail detection option.

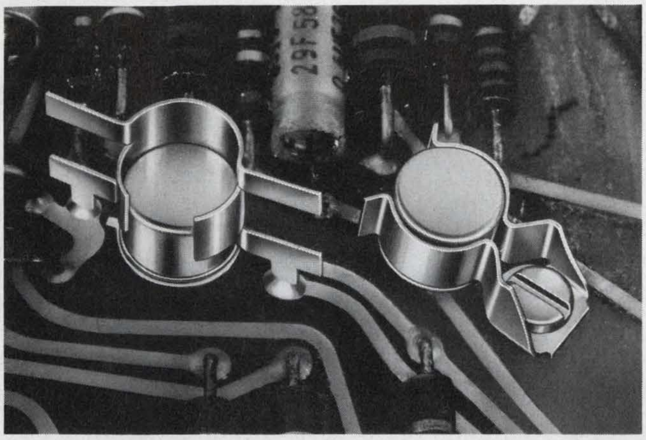
LH RESEARCH

L H Research, Inc., 2052 S. Grand Ave., Santa Ana, Calif. 92705 • (714) 546-5279

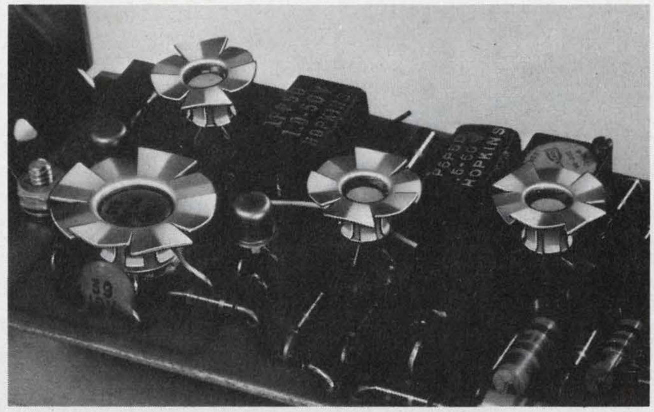
These semiconductor cooling ideas can slash unit cost of high-production circuits

No. 25 of a Series

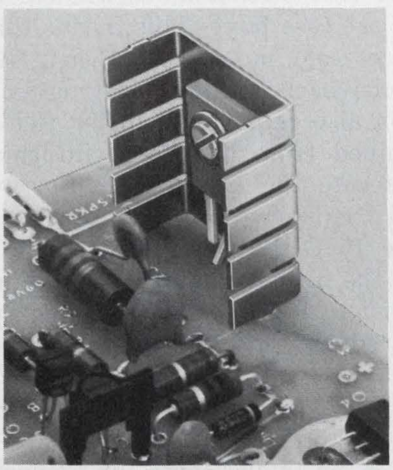
Our low-cost dissipators and dissipator/retainers will let you use the lower-cost semiconductors while you get the reliability of high-priced devices and save money at the same time. Or you can use these thermal management components to reduce the number of semiconductors required to perform your circuit's function. These heat dissipator benefits add up to the kind of savings that makes your industrial or consumer product competitive. Here are some examples of how designers of high-production equipment used IERC dissipator/retainers costing only pennies each to cut unit cost and get the competitive edge.



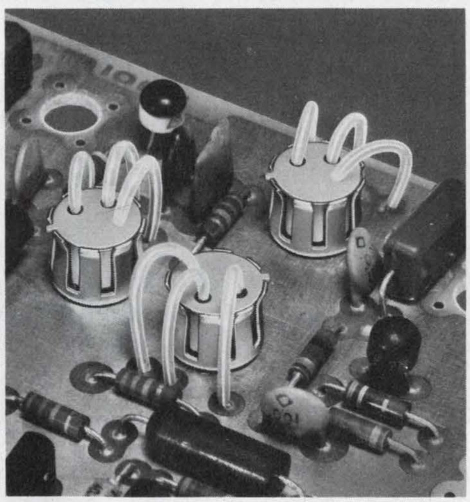
High-priced reliability for this high-speed switching circuit was achieved for pennies by using IERC heat dissipators/retainers. Low-cost ceramic and plastic semiconductors plus dissipators (priced from 2.5¢ to 3.9¢ each in 100K quantities) gave same reliability as next higher grade semiconductors that cost twice as much.



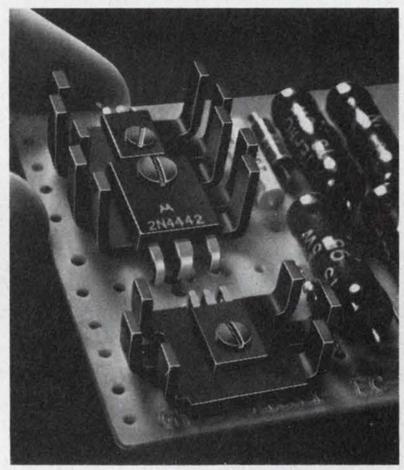
Big savings and neat, uncrowded board resulted when designer of this regulator got rid of three TO-18 devices by using press-on Fan Top dissipators that permitted 2N706 transistors to operate at twice the power rating with the same 75°C case rise. Available for a variety of transistor cases, Fan Tops cost under 4¢ each in 100K quantities.



Stand-up heat dissipator takes little investment in board real estate or money but it let designer of this power supply double power of 2N4442 power pack plastic transistor with same substrate temperature rise above ambient as the bare device. Nickel plated dissipator solders to board along with other components.



Shaky washing machine environment dictated strong TO-5 device retention while designer got enough cooling from Thermal Links to go to a cheaper transistor for this solid-state controller. Soldered, riveted, or eyeletted to board, Thermal Links lowered case rise 25°C with same power. Cost for OEM quantity was under 6¢ each.



Double the power for a nickel netted a big cost savings for this amplifier circuit. IERC PA and PB Staggered Finger dissipators maintain safe case temperatures for Power Pack, Power Tab and other flat-case plastics while permitting up to twice the dissipation. They cost about 4¢ to 6¢ in OEM quantities.

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

IERC

Heat Sinks/Dissipators

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

INFORMATION RETRIEVAL NUMBER 44

Technology

Design your own microcomputer by using bipolar/LSI processor slices. An example shows how to build a 16-bit processor and develop its instruction set.

Bipolar/LSI microprocessor slices offer several advantages over their MOS cousins. The bipolar speeds of "bit slice" processors, or microcontrollers, assure a precise emulation of conventional systems, which employ standard-bipolar circuits. By using microprogramming techniques, designers can replace scores of SSI and MSI packages at reduced power. And in applications such as minicomputers, processor slices provide the hardware flexibility to reduce equipment size without changes in existing software.

In essence, the bit-slice approach lets you design your own microprocessor and develop a variety of specialized instruction sets. For example, a 16-bit processor (Fig. 1) can be built with 24 ICs that typically use 9.4 W. It has an instruction set that can handle programs written for popular minicomputers—and speeds to match. The microcycle time is 300 ns, and instruction execution times are 0.9 to 1.2 μs.

Processor uses four microcontrollers

The processor employs four 4-bit microcontroller chips (Fig. 2). Each chip consists of a 16-register file that may be read simultaneously by two address multiplexers, A and B. Data contained in the selected registers pass through the respective latches. The B-address input are also used to select the register to be loaded with new data. When the register is loaded, the A and B latches hold output data, thereby providing edge-triggered, master/slave operation.

The chip also contains an ALU (arithmetic logic unit) similar to the popular 74181 and variant multiplexers to provide data routing and shifting of results prior to their storage. An internal Q register, with its own shift multiplexers, can be used for temporary storage of results and for double-precision shift operations.

The microcontrollers provide 16 GPRs (general-purpose registers) and an ALU. If we assign one of the registers as the program counter, this still leaves 15 GPRs. Other circuits needed to complete the CPU are an instruction register, a memory-address register and instruction-execution control logic.

To design the instruction-execution logic, we must define the instruction format and the execution sequence for each instruction. The instruction format determines how the instruction will be decoded. The execution sequence defines the steps required to execute the instruction.

The instruction execution for each depends on the instruction word size, the number of GPRs (15 in our example) and the total number of instructions. We have a memory word size of 16 bits and a total of 18 instructions to implement a general purpose set (see box). This means that our operation code field must be at least five bits in size to specify each of the 18 instructions.

Each instruction also requires modifier fields. These are determined from additional information needed to execute the instruction. For instance, in a Load Register instruction we must specify one of the 15 GPRs to be loaded and a 16-bit address for the memory data. After listing all required modifier data, similar instruction formats are then reduced to a minimum number.

Specifying the instruction format

For our computer, all instructions can be specified by a single instruction format (Fig. 3). This format consists of an 8-bit operation-code field and two 4-bit fields that define up to two GPRs.

A second modifier word, following the instruction, defines memory addresses and immediate data for GPR Load and Store, Load PC (program counter) and Test instructions.

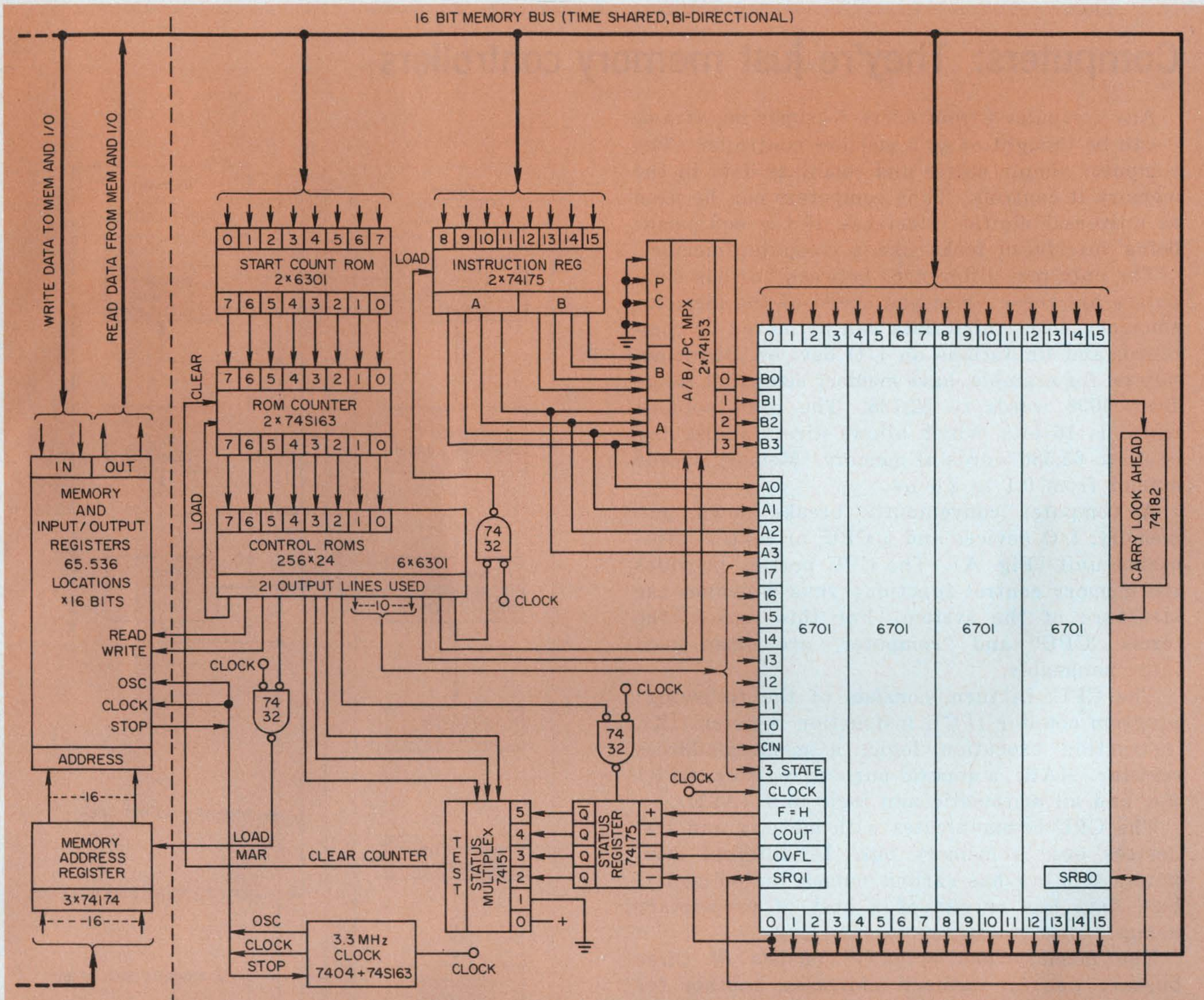
The instruction-execution control logic generates a sequence of operations to perform the following tasks:

1. Get the next instruction from memory and load it into the instruction register. (Memory location is defined by the contents of PC).

2. Decode the instruction to select the execution sequence.

3. Step through the sequence (this can involve

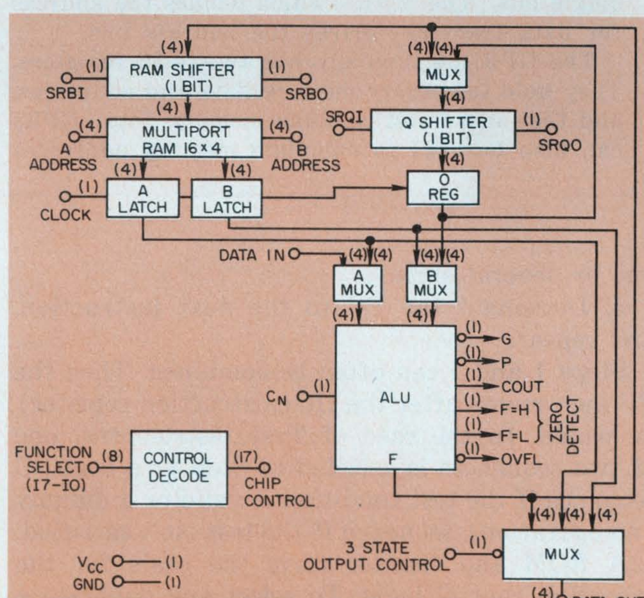
David C. Wyland, Manager, Microprocessor Design, Monolithic Memories, 1165 E. Arques Ave., Sunnyvale, CA 94086.



Performance Summary

WORD SIZE	16 BITS
ADDRESSING CAPABILITY	65,536 WORDS
MIROCYCLE TIME	300 NANOSECONDS
ADDRESSABLE I/O REGISTERS	65,536 SHARED WITH MEMORY
INSTRUCTION EXECUTION TIMES:	
Add 2 Registers	0.90 Microseconds
Load/Store Direct	1.50 Microseconds
Load/Store through REG	1.20 Microseconds
Test	1.20 Microseconds
PARTS COUNT (Excluding memory and MAR	24 CHIPS
POWER REQUIRED	9.4 WATTS TYPICAL (1.88 amps @ 5.0 volts)

1. **A 16-bit bipolar microcomputer** employs four 4-bit microcontroller chips. The complete microcomputer uses 24 ICs that dissipate less than 10 W. Typically instructions can be executed in 1.2 μs or less.



2. **The 4-bit microcontroller** contains an arithmetic logic unit and 16 general-purpose registers that can be read from either of two multiplexers. The chip employs an external control ROM.

Computers: They're just memory controllers

Any computer—from micro to super mainframe—can be thought of as a memory controller. The computer simply moves and combines data in the memory it controls. Thus computers can be used as universal digital interfaces, if the equipment being interfaced looks like a computer memory.

The only real differences between various computers are these: size and speed of the memory, efficiency with which data can be moved or combined, and limitations on I/O devices. Minicomputers, for example, have memory sizes that range from 4096 words to 32,768. The most popular width is 16 bits, which allows direct addressing of up to 65,536 words of memory. Memory speeds extend from 0.1 to 2.0 μs.

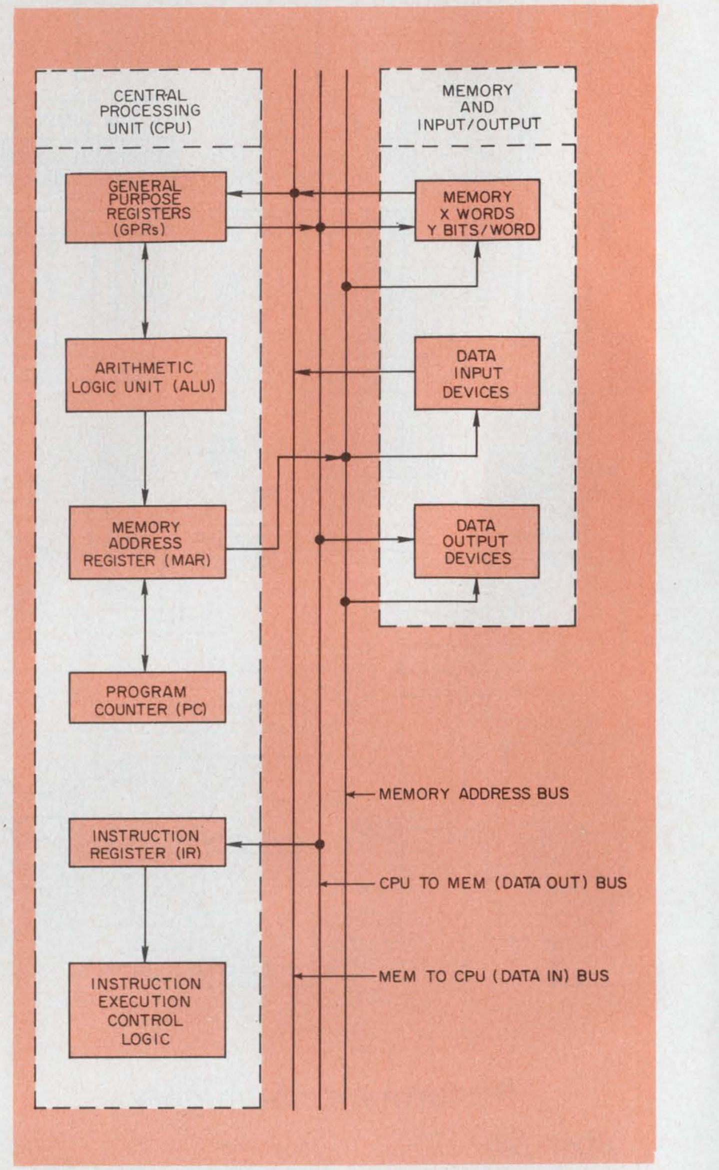
A computer conveniently breaks down into memory, I/O devices and a CPU, or central processing unit (Fig. A). The CPU portion provides the memory control function; thus it defines the structure of the system. For this reason, the terms "CPU" and "computer" are often used interchangeably.

The CPU, in turn, consists of the following: program counter (PC), instruction register (IR), instruction execution logic, a memory-address register (MAR), a general-purpose register (GPR) file, and an arithmetic and logic unit (ALU).

The CPU communicates with memory and I/O devices over a memory bus. In different computers this bus has various names, including I/O bus, data bus or one of a host of proprietary names.

The memory bus actually consists of three busses: one for memory addresses, another for data to the CPU and the third for CPU data to the memory. Typically these three time-share a single bus. The MAR—which defines the address for data transfer—drives the address bus.

The GPR file typically has two-to-16 registers. They hold temporary memory data and addresses, and they move and combine memory data. GPRs can also be used to calculate memory addresses



A. **Internally a computer interfaces** its central-processing unit with memory and I/O devices.

one or several steps).

4. Increment the PC to the next instruction, and repeat.

Steps 1 and 4 can often be combined. Then the PC increments after the IR (instruction register) is loaded. In the case of Test instructions, one of two sequences is selected in Step 3: a load-PC sequence if the test condition is valid or a dummy (no operation) sequence if the test isn't satisfied.

A ROM and counter form the basis for the execution control logic. To select and generate a timing sequence, we set the counter to the start value and increment it for each step. The ROM decodes each counter value to activate appropriate ROM-output lines. This technique is called microprogram control, since the contents of the ROM control the sequence of operations.

Forming the microprogram control

The microprogram control in Fig. 1 contains the following major blocks: an 8-bit ROM counter, a 256 $\times$ 24-bit control ROM, the IR, a 256 $\times$ 8-bit start-count ROM and a multiplexer to select the A or B fields of the IR or the PC (register 15). Also included are a 4-bit status register, a counter-controlling multiplexer and a clock oscillator.

The 8-bit ROM counter, a 74S163 type, increments, loads or clears on the trailing (negative-

1. LOAD REGISTER

   A. From address specified by instruction
   B. From calculated address specified by register

2. STORE REGISTER

   A. To specified address
   B. To calculated address

3. COMBINE REGISTERS

A	COPY:	$A \rightarrow B$
B.	ADD:	$B + A \rightarrow B$
C.	SUBTRACT:	$B - A \rightarrow B$
D.	AND:	$B \wedge A \rightarrow B$
E.	OR:	$\underline{B} \vee A \rightarrow B$
F.	INVERT:	$\overline{A} \rightarrow B$

4. MODIFY REGISTER: SHIFT

A.	SHIFT LEFT:	$B \times 2 \rightarrow B$
B.	SHIFT RIGHT:	$B \div 2 \rightarrow B$

5. LOAD PROGRAM COUNTER (JUMP)

   A. With address specified by instruction
   B. With calculated address specified by register

6. LOAD PROGRAM COUNTER AND SAVE OLD VALUE (JUMP TO SUBROUTINE)

7. TEST- RESULT OF PREVIOUS COMBINE OPERATION AND LOAD PC IF:

   A. Result was zero
   B. Result was negative
   C. A carry was generated

8. ILLEGAL INSTRUCTION

B. **A general instruction set** offers many of the features of popular minicomputers.

for move and combine operations.

Computers manipulate memory data according to a list of instruction words stored in the same memory. The PC defines the location of the next instruction to be executed. The IR holds the instruction word for the current instruction being executed. The instruction-execution logic causes each instruction to be retrieved—or fetched—from memory, decoded and then executed. The instruction logic performs these functions in the following three ways:

1. The contents of the PC are sent to the MAR to define the location of the next instruction.

2. The contents of the memory at the address are loaded into the IR.

3. The execution of the instruction in the IR may then involve many steps and many transfers between memory and the GPR file.

A general-purpose instruction set (Fig. B) covers a variety of current minicomputers. Note the following four features:

1. In the modify-register instruction (4), the bit shifted out is saved, and a zero or a specified bit shifts into the location vacated.

2. The load program counter and save old instruction (6) provides the ability to set the PC to a new value, execute a list of instructions and then return to the original list and continue. Thus programs can be partitioned into subroutines.

3. No instructions have been included for hardware input and output. Individual registers for hardware I/O are assumed to have memory addresses, so that I/O operations do not appear different from other transfers/between GPRs and memory. This technique is used in the Digital Equipment Corp. PDP-11 minicomputer, among other computing systems.

4. An illegal instruction is included. This covers the case of hardware or software errors that result in the accidental interpretation of data as an instruction.

to-positive) edge of the clock pulse. The counter increments unless the load or clear lines are activated. The control ROM decodes the counter and sets up data transfer paths and clock gates. All registers are loaded on the trailing edge of the clock pulse.

All logic levels, except inputs and outputs from the ROM counter, are negative active: logic ONE = 0.0 V, logic ZERO = +5.0 V. This provides these three features:

1. Noise immunity for inactive high lines in TTL greatly exceeds that for inactive low.

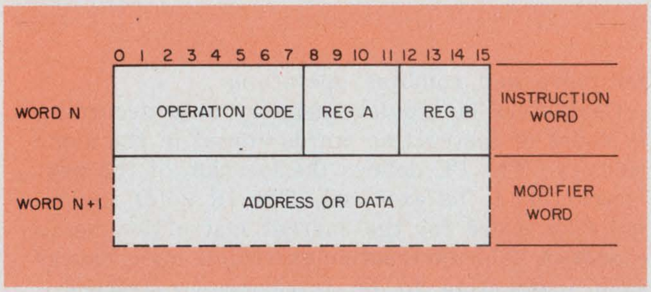
2. When not in use or disconnected, the data bus lines float to an all-zero state, and the control lines float to the inactive state.

3. Open collector drivers can be used on the data bus, as long as pull-up resistors are employed.

Fetch and execute operations

Instruction fetch and execute proceeds according to the flow chart of Fig. 4. The instruction is decoded to select one of 256 possible execution sequences. This is done by decoding the first eight bits of the instruction to generate an 8-bit starting address. After the last execution step, the ROM counter clears to zero and a fetch of the next instruction begins.

For example, consider the fetch and execute



3. **A single-instruction format** can be used with the 16-bit microprocessor. The instruction word contains three fields: one that defines the operation code and two that define general-purpose registers.

procedure for a Register-to-Register Add instruction, which requires three steps. The ROM counter begins with a count of 0, State 0:

State 0. The contents of PC transfer to the MAR (memory-address register). The contents of PC also increment at the end of the state. This occurs when the control ROM decodes the values of zero in the ROM counter and sets up the following four conditions:

1. The B-input multiplexer is forced to an all-low output, thereby selecting register 15.

2. The microcontroller is set to perform the function, B → output, (B + 1) → B. This gates out the old PC value and simultaneously increments PC at the end of the cycle.

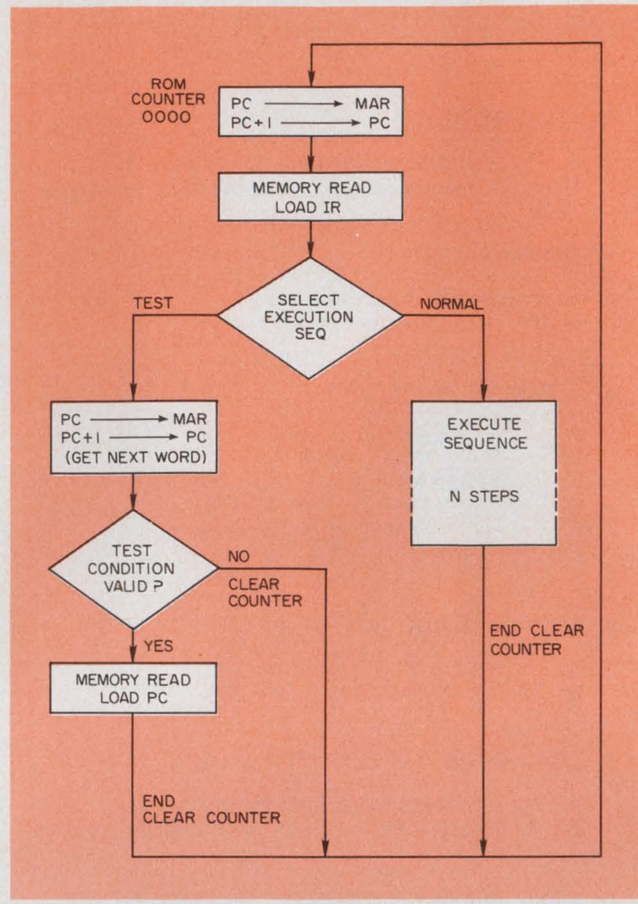
3. The microcontroller's three-state drivers are gated onto the bus and the MAR load clock is enabled.

4. The ROM counter steps from 0 to 1 at the end of the state.

State 1. The next instruction enters the IR. The contents of memory at the location defined by MAR enter the bus, and the IR load clock is enabled. Instruction decode is then performed by the 256 × 8-bit start-count ROM. One of 256 possible instructions are decoded directly from bits 0 to 7 of the data bus. However, only 18 of the 256 possible instructions will be decoded; the remainder decode as illegal instructions.

Since we have decoded a Register-to-Register Add instruction, the start count becomes 15. Thus we go immediately from State 1 to State 15.

State 15. The control ROMs decode the count of 15 in the ROM counter and set up the microcontroller to perform an (A+B) → B ADD function. Also, the control ROMs set up the status multiplexer for an unconditional clear function: The multiplexer will select a logic ONE condition and enable the clear-gate line to the 74S163, the 8-bit ROM counter. Since the 74S163 is a synchronous clear counter, the ROM counter is cleared to zero by the clock pulse at the end of State 15. Thus the machine returns to State 0 and begins the execution of another fetch sequence.



4. **The instruction execution flow chart** begins with two steps—for instruction fetch and decode—that are common to all instructions.

All instructions are executed in this manner. However, each instruction has its own starting count and may be one or several steps in length before its returns to State 0.

Note that State 0 performs two functions: It sends the contents of PC to memory as an address, and it increments the contents of PC after instruction fetch. State 1 loads and decodes IR, while State 15 executes the instruction.

Defining the instruction set

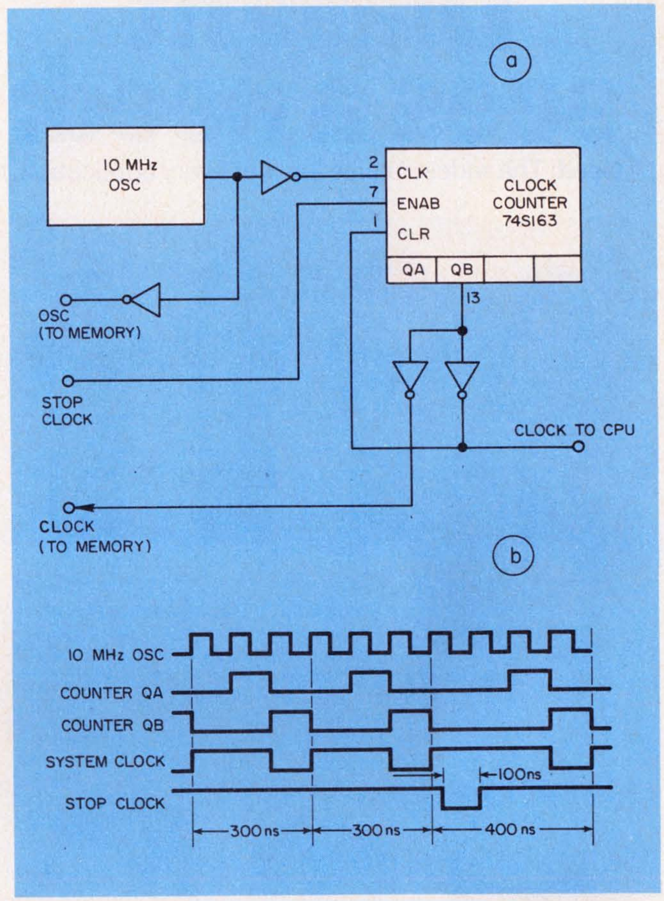
The processor instruction set is intended to be a general-purpose one (Fig. 5). Register-load-from-memory and store-to-memory instructions use the B field to define the register. The A field defines the register to be used as the source of the memory address in calculated-address instructions.

A second word of memory following the instruction defines the address for Load and Store instructions; the address is defined as part of the instruction. The second word is fetched from memory in a manner similar to the initial fetch of the instruction. And the program counter increments to point to the following word. An ad-

OP CODE	A	B	WORD 1
ADDRESS/DATA			WORD 2 (Optional)

OP CODE	INSTRUCTION
0	Illegal: Load PC with 0000
1	Load Register B, address follows instruction
2	Load Register B, address in Register A
3	Load Register B, data follows instruction
4	Store Register B, address follow instruction
5	Store Register B, address in Register A
6	Copy A to B: A → B
7	ADD: B + A → B
8	SUBTRACT: B − A → B
9	AND: B ∧ A → B
10	OR: B ∨ A → B
11	INVERT: $\overline{A}$ → B
12	Rotate left A and B, A = most significant
13	Rotate right A and B, A = most significant
14	Load PC with Word 2, Save old PC in B
15	Test Zero: Load PC with Word 2 if zero FF ON
16	Test Sign: Load PC with Word 2 if sign FF ON
17	Test Carry: Load PC with Word 2 of carry FF ON
18	Test Overflow: Load PC with Word 2 if overflow FF ON
19	Not used (ILLEGAL)
↓	↓ ↓ ↓
255	Not used (ILLEGAL)

5. **A simplified version** of the microprocessor's instruction set uses the format of Fig. 3. The word following instructions defines addresses or data.



6. **The microprocessor's clocking requirements** can be met by an oscillator-counter circuit (a) and its associated timing diagram (b).

ditional mode permits the direct loading of the second word into a register rather than the word's use as a memory address.

Shift instructions use the internal Q register. The A and B fields define two registers that are shifted as a single 32-bit word. The instruction is executed when the register specified by the B field is loaded into Q. Simultaneously the register defined by the A field is shifted with Q, and then the contents of Q tranfer back to B. The B and Q shifters yield the 32-bit result, with the least-significant bit of the B shifter becoming the most-significant bit of Q. Zeros are shifted into the least-significant bit of Q or most significant bit of B for, respectively, Shift Left and Shift Right instructions.

The program counter can be loaded directly by any of the load or register-modify instructions. The Load Program Counter and Save Old Value instruction uses the B field to specify the register that will receive the old PC value. The new PC value is loaded from the word immediately.

The Test and Conditional Load Program Counter instructions use the status multiplexer. The execution sequence for these instructions appears as a load program-counter sequence, with the new PC contents following the instruction word in memory. However, the status multiplexer terminates the sequence early if the tested status condition isn't met. The termination occurs just before the PC would be loaded with the new value.

Illegal instructions select ROM address 255. This location contains a restart sequence that clears the PC to 0000 and then restarts the program at zero. It's common to reserve all zeroes and all ones as illegal operation codes for these three reasons:

1. If the PC points to an address outside of existing memory, an all-zero instruction results.

2. Most data consist of small positive or negative numbers. Their first eight bits are, respectively all zeroes or all ones.

3. The illegal-instruction restart feature can be used as a manual restart by momentarily disabling the start-count ROM so an all-high output results.

The clock circuitry and timing diagram for each microcycle appear in Fig. 6. A stop-clock line can be used to halt the clock during the first part of any microcycle. This line can be used by a slow memory to force the processor to wait until it has completed its read or write cycle. It can also be

ROM ADDRS	OPERATION	COMMENTS
0	PC → MAR, PC + 1 → PC	Instruction Fetch
1	MEM → IR Decode and Load Start Count	
2	PC → MAR, PC + 1 → PC	OP = 1, Load B @ ADDRS
3	MEM → MAR	
4	MEM → B, END	
5	A REG → MAR	OP = 2, Load B @ A
6	MEM → B, END	
7	PC → MAR, PC + 1 → PC	OP = 3, Load B Data
8	MEM B, END	
9	PC → MAR, PC + 1 → PC	OP = 4, Store B @ ADDRS
10	MEM → MAR	
11	B → MEM, END	
12	A → MAR	OP = 5, Store B @ A
13	B → MEM, END	
14	A → B, END	OP = 6, Copy
15	B + A → B, END	OP = 7, Add
16	B − A → B, END	OP= 8, Subtract
17	B ∧ A → B, END	OP = 9, AND
18	B ∨ A → B, END	OP = 10, OR
19	$\overline{B}$ → B, END	OP = 11, Invert
20	B → Q	OP = 12, Rotate Left A & B
21	Shift Left A & Q	
22	Q → B, END	
23	B → Q	OP = 13, Rotate Right A & B
24	Shift Right A & Q	
25	Q → B, END	
26	PC → MAR, PC + 1 → PC	OP = 14, Load PC, Save Old
27	PC + 1 → B	
28	MEM → PC, END	
29	PC → MAR, PC + 1 → PC END if Zero FF OFF	OP = 15, Test Zero
30	MEM → PC, END	
31	PC → MAR, PC + 1 → PC END if Sign FF OFF	OP = 16, Test Sign
32	MEM → PC, END	
33	PC → MAR, PC + 1 → PC END if Carry FF OFF	OP = 17, Test Carry
34	MEM → PC, END	
35	PC → MAR, PC + 1 → PC END if OVFL FF OFF	OP = 18, Test OVFL
36	MEM → PC, END	
37	Not used	
254	Not used	
255	0 → PC, END	OP = X, Illegal OP (Restart @ 0)

7. **The processor's complete microprogram** employs only 37 out of 256 possible steps.

used with external logic to obtain single-step operations.

Specifying processor capabilities

Speed of execution depends on the settling times of the ROM counter, control ROMs and the micrcontroller. A 300-ns clocking interval—practical for our computer—results in a 900-ns register-to-register add time when we assume a 150-ns access memory.

The full microprogram appears in Fig. 7. Note that only 37 out of 256 possible steps implement 19 out of 256 possible instructions. Furthermore the instruction set can be expanded to include more powerful instructions. For example, two additional instructions might be the following:

1. Indexed Register Load and Store. This combines the contents of a specified register with contents of the word following, thereby defining the memory address for the data transfer.

2. Byte Swap. This shifts a register eight spaces to simplify the handling of 8-bit characters. ▪▪

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*Add dash number for desired input: 115VAC, -01; 208VAC, -03; 220VAC, -04

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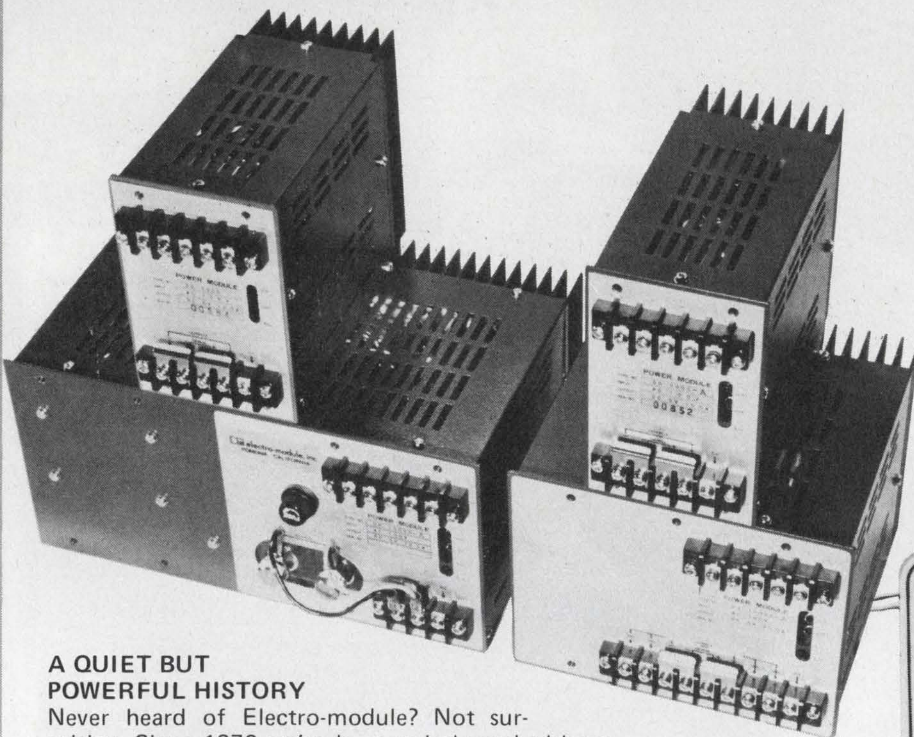

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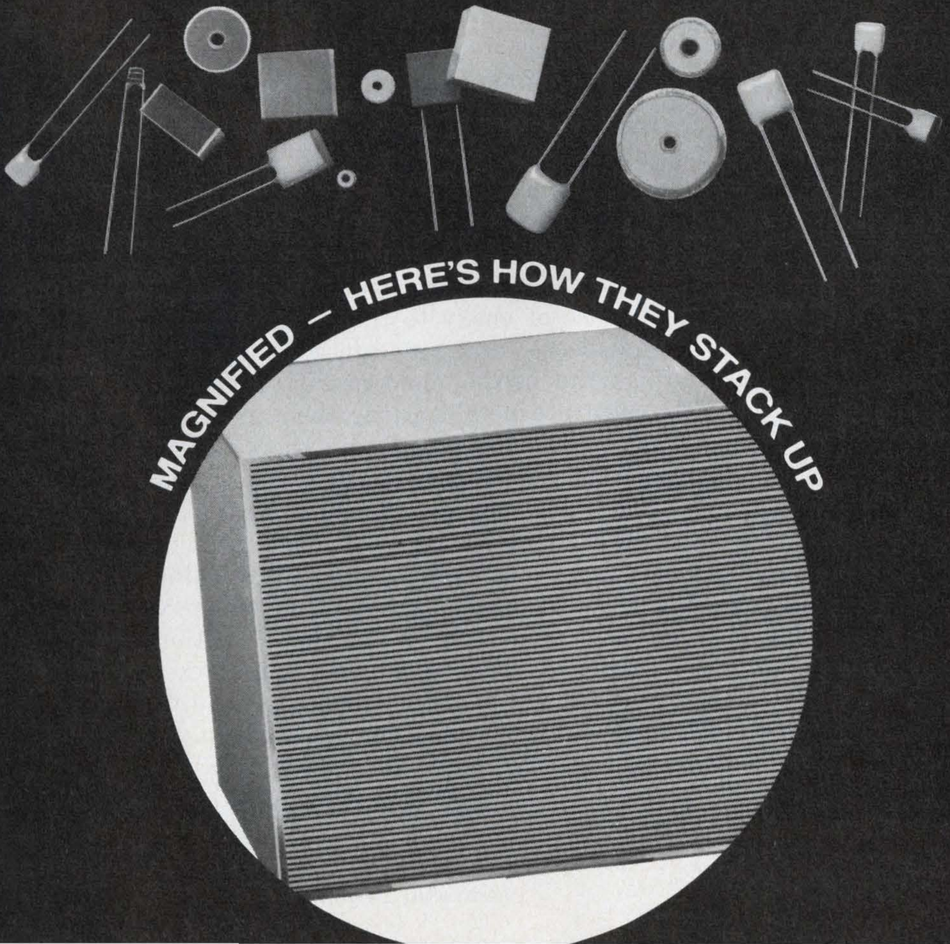

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Bond chips with conductive epoxies.

Their low curing temperatures avoid damage to delicate parts, while the assembly process is inexpensive and easily automated.

Epoxies have found wide acceptance for the attachment of active semiconductors, chip capacitors and resistors and other small parts to hybrid microcircuits. Their use gives the designer a high degree of freedom when building complex units, and they allow employment of easily automated processes that provide good yields.

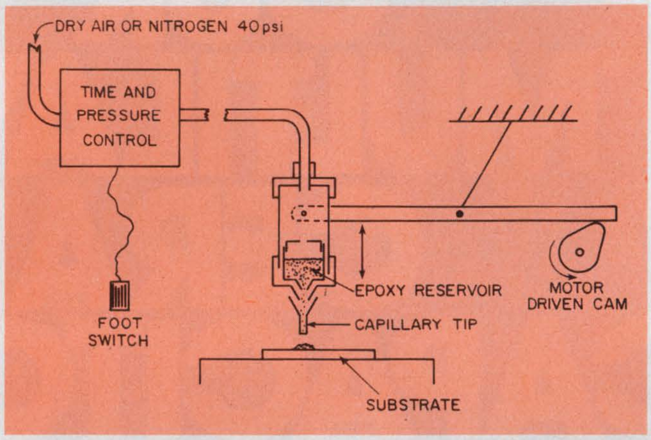
Of the three attachment methods currently in use—gold-silicon eutectic bonding, soft solder and conductive epoxy—epoxy is the fastest growing technique. Epoxy techniques include the following advantages:

- Conductor-pattern requirements are not demanding, and a wide range of conductor materials can be used. Epoxies allow the use of low-cost palladium-silver or platinum-silver conductor patterns.
- Epoxies can be applied by accurate pneumatic dispensing or screen printing—both low-cost, easily automated processes.
- Low-temperature curing—as low as 150 C—removes a possible source of damage to delicate components, especially active devices. High yields of over 99% are readily attained.
- Any wire-bonding method may be used with epoxy-attached devices. The epoxy can withstand thermocompression temperatures of even 320 C for short periods.

Historically, eutectic bonding was the method first used. But this process places many restrictions on the freedom of component layout. Expensive pure-gold, or gold-bearing conductors such as platinum-gold, must be used as the eutectic material. The bonding process takes place at a higher temperature than epoxy curing—about 380 C. And a nitrogen atmosphere must be used to reduce chip degradation. Finally, the expected yield is only about 95%.

Though soft-solder methods give the advantage of a high chip yield, problems result from the need to use flux to make a good joint. And the choice of a wire-bonding method is limited to a cold-substrate method. Thermocompression wire bonding cannot be used.

David R. Hetherington, Chief Development Engineer, Newmarket Transistors, Ltd., Exning Rd., Newmarket, Suffolk, England.

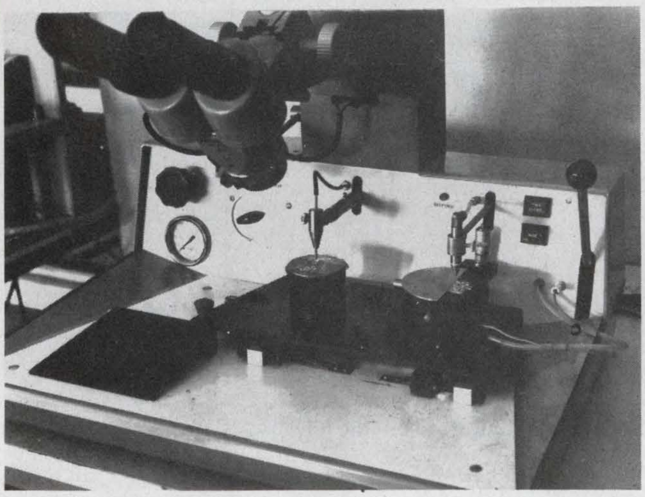


1. **A hypodermic needle** with timed and controlled air pressure can dispense calibrated amounts of conductive epoxy to mount chip components on substrates. Epoxy spot diameter can go as low as 0.25 mm.

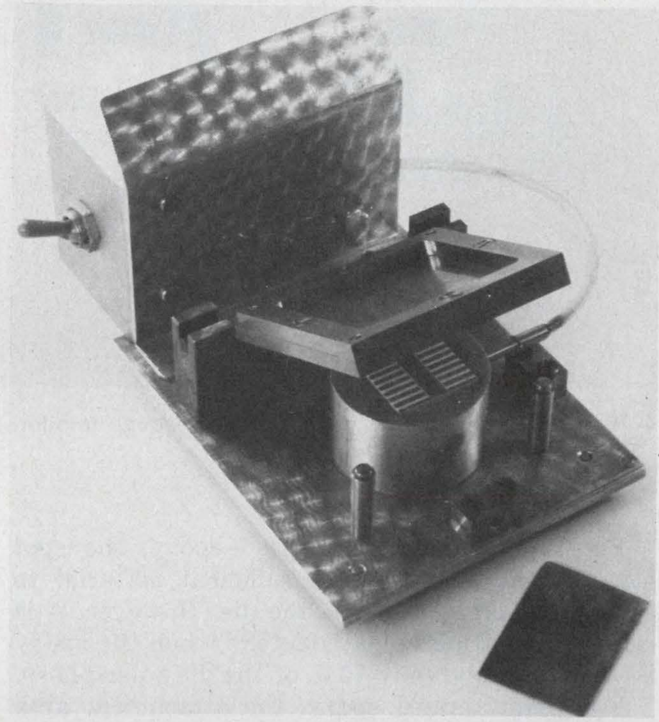
Applying epoxies

Epoxy can be dispensed via a hypodermic needle by compressed air (Fig. 1). Epoxy is stored in a plastic reservoir, which usually holds about 2 ml, and the compressed air can be adjusted over a range of 5 to 20 psi. A timer-controlled solenoid value provides a predetermined shot pulse of epoxy to the needle. At the end of the dispense time, a cam-actuated mechanism brings the needle momentarily in contact with the substrate metallization. An accurate epoxy spot is left on the substrate. Epoxy spots as fine as 0.25-mm diameter can be obtained with a good epoxy and well-designed dispensing system (Fig. 2).

However, epoxy spots, or pads, can be reproduced more consistently by screen printing. Printing allows a controlled quantity of epoxy to be deposited accurately in the same position on the substrate. A great advantage is that the process can be carried on with the setup conditions and screen materials that are already familiar to thick-film engineers. The same conditions that apply for obtaining good results with any thick-film paste also hold for most attachment epoxies.



2. **Epoxy pads for mounting components** can be accurately placed by well-designed machines.



3. **Epoxy mounting pads can be applied by printing.** This hand printer uses an etched-foil screen, but automated printers and wire-mesh screens can be used.

A 250-mesh stainless-steel screen with indirect emulsion can provide a cured print thickness of as little as 15 to 20 microns.

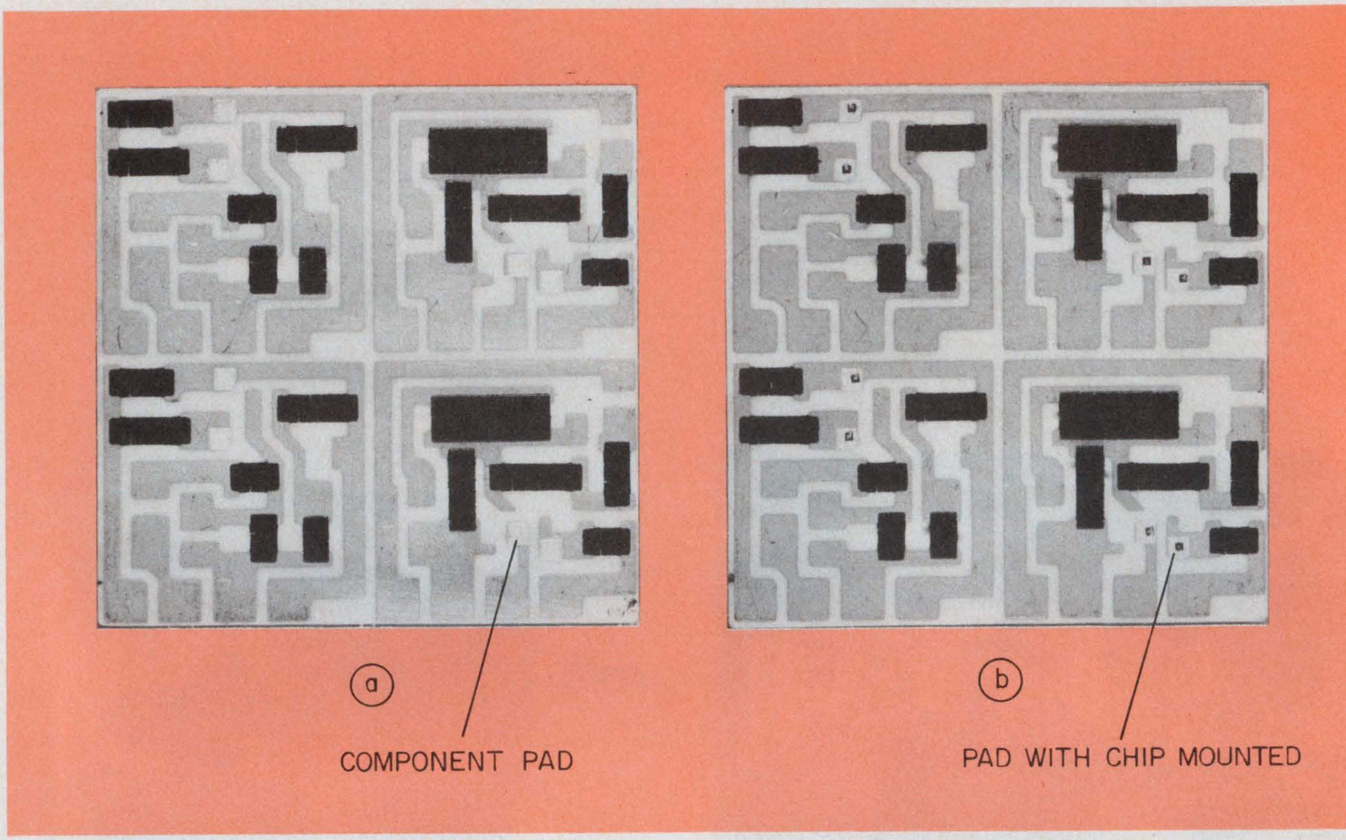
The epoxy can be printed with either automatic or hand printers. In Fig. 3, a simple but effective hand printer uses an etched-foil screen on a 50-mm-square frame. The squeegee used is a rectangle of silicon rubber that is hand held and wiped across the screen.

But not all epoxies are suitable for both application methods. One material, when tested for needle application, tended to separate into its silver filler and carrier components in the needle. With another material—a high viscosity epoxy—the upward motion of the needle left a tail that could produce short circuits. And though many epoxies are sold as "screen printable," some tend to dry on the screen and clog the mesh. Consequently, the choice of epoxy must not only suit the circuit's electrical requirements, but also the way the epoxy is to be applied to the substrate.

Attaching a silicon device

To achieve low electrical and thermal resistance in the attachment of a silicon device, the silicon slice's revere side must be etched or lapped to remove oxide and diffusion material and to reduce the slice to a thickness of 100 to 150 microns. This is done with the slice's active side held with wax against a glass block. After a washing cycle and removal from the etching block, the slice must be metallized immediately to prevent the formation of silicon oxide, which is an insulator. Metals normally used are nickel, titanium-gold or gold-arsenic.

The slice is then diamond-scribed into dice sections. A plastic backing film applied to the slice, when stretched, separates the slice into individual dice, or chips. Chips can now be placed on the hybrid's epoxy spots with a vacuum pickup mechanism. Its stainless-steel pickup needle is first lowered to an epoxied spot, the vacuum removed, and the weight of the needle presses the die into the epoxy. Dice 0.5-mm square require about 20 gm, and 3 mm about 300 gm, to press the epoxy into a thickness falling into the range of 10 to 15 microns.



4. **Printed epoxy pads** (a) must be large enough to allow room for component positioning tolerances (b).

For pneumatically dispensed epoxy, the spot size is ideal when it has sufficient material to spread out on all sides of the die. However, it is generally considered satisfactory when the epoxy is visible around only 75% of the die's periphery.

For print-applied epoxy, the attachment area should be four times that of the die for dice sizes to 0.5 mm square. For larger dice, a border around the die of 0.25 mm is sufficient. In any event, the epoxy area must be large enough to allow for the placement tolerances when automatic die-positioning equipment is used.

Epoxy printing is particularly desirable when automatic placement equipment is used. The screens can be made from the same master that is used for the conductor-pattern thick-film work. Also, the same printer line-up targets are used. Thus good location tolerances for the epoxy can be obtained.

If the substrate is located on the die bonder with the same X-Y coordinates used on the printer, the placement accuracy for a small die can be as close as ±0.1 mm.

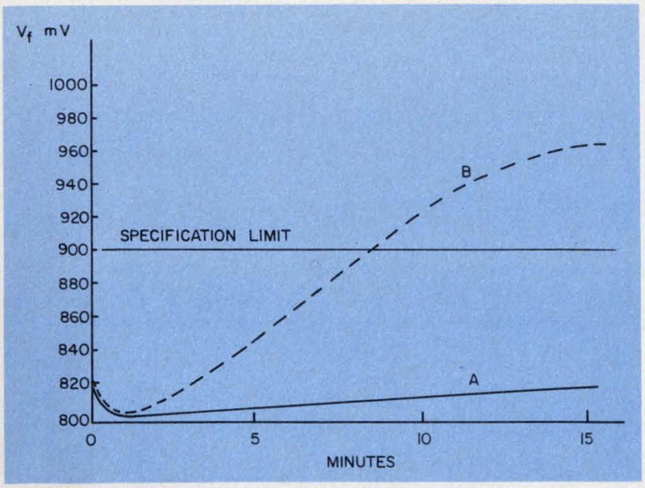
Fig. 4 shows a substrate with printed epoxy pads before and after die placement. Note that the tiny chips are not placed exactly in the center of their pads, but they all fall within the pad's area.

No easy tests can determine the shelf life or manufacturing quality of epoxy at incoming inspection. However, some epoxies tend to develop a yellow tinge towards the end of their shelf life and their viscosities usually increase with age. With experience, an operator soon learns to recognize when all is not well with the epoxy. Old material tends to block needle applicator capillaries and to flow at a reduced rate. Or screens clog during printing and parts of the epoxy pattern are not printed.

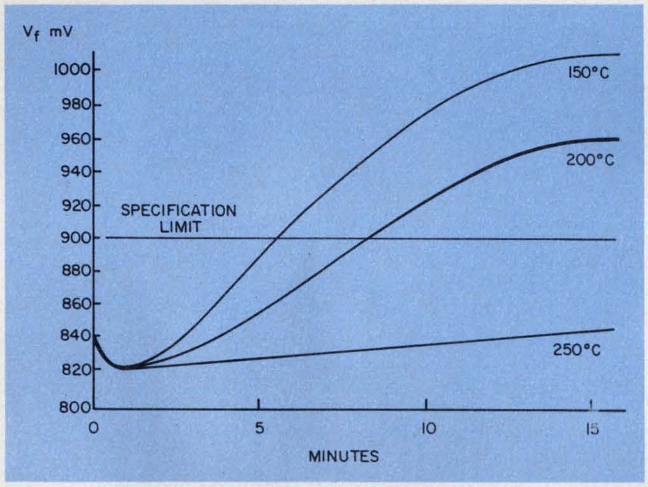
The most reliable test of an epoxy is to use it to mount several samples of an active device, and then to monitor specific characteristics of the device. The characteristic that best shows the quality of an epoxy is the saturated forward-voltage drop from base to collector, V_f, of a transistor. For example, a BC108 silicon transistor at 10 mA has a V_f that ranges between 810 and 900 mV. If the initial value of V_f increases by more than 10% after, say, 168 h at 150 C, then the epoxy bonding is suspect.

Epoxies are usually supplied in 28 or 550-gm containers. But a 28-gm quantity can print 1800 cm^2, which translates into a huge number of mounting pads. For 0.5-mm-square pads this is sufficient to bond 700,000 devices. Thus even a small amount can last a long time.

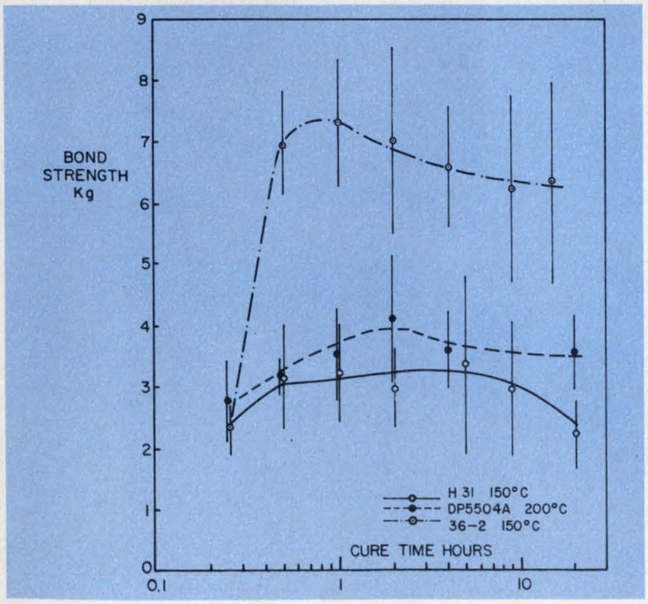
Since the cost of epoxy per die is insignificant but the cost of a wafer is considerable, it can be an expensive mistake to use epoxy near the end of its shelf life. Therefore it may be advisable



5. **Fresh epoxy (curve A) provides better V_f stability** than the three-month-old epoxy (curve B) when the transistor is subjected to 325 C during wire bonding. Curve B fails the spec limit after 7 min.



6. **A cure temperature of 250 C results in best V_f stability,** when the transistor is heated.



7. **Different epoxy materials require different curing times** to attain maximum bonding strength.

to buy epoxy in 1 cc syringes.

Many syringes are made to fit the dispenser heads of pneumatic spotting equipment. Also, the epoxy from a syringe can be easily dispensed onto printing screens. After, say, one day of use, even if the syringe is not empty, it may be wise to throw it away and start with a fresh one the next day.

Epoxy manufacturers advise that the storage life of most epoxies is no more than six months when stored at −15 C and only 90 days when kept in the regular compartment of a standard refrigerator at 4 C. The storage life in a freezer at −6 C is somewhat more than 90 days. Also, the temperature conditions during packing and shipping are important. Now, many British suppliers of USA-made epoxies, ship them at −40 C, with indicators to warn of the temperature conditions during shipment.

The deleterious effects of long storage time and excessive temperature are clearly demonstrated in tests on the V_f of silicon transistors (Fig. 5). When thermocompression gold-wire bonding is used to wire a transistor into a hybrid circuit, the substrate may reach 325 C for several minutes. This heating can affect V_f appreciably. Curve A is for a transistor that was attached with epoxy immediately after the epoxy was received. However, the epoxy was held at −40 C for three weeks during shipment. Curve B is the same type epoxy, but this material was three months old and stored at only −5 C. Note that curve B fails the spec limit after only 7 min on the wire bonder.

To avoid this problem use fresh epoxy. Also keep the time of exposure to high temperatures to a minimum. A cold bonding method is helpful.

The epoxy cure temperature also strongly affects the V_f of a transistor. A cure temperature of 250 C provided greater stability than 150 C, when test samples were exposed to 325 C (Fig 6).

Cure time determines bond strength

In addition to high electrical and thermal conductivity, the epoxy attachment should provide a strong bond. Here cure time is the important factor. Tests of bond strength vs cure time for three different silver-loaded epoxies are shown in Fig. 7. The components tested were 0.6-mm-thick ceramic resistors with a bond area at each end of 1.25 × 0.5 mm. The bonds were tested with a hook arrangement and with the substrates firmly held. For each of the epoxy types, the manufacturer's recommended cure time was 1 h. Note that epoxy type 36-2 has a decreasing bond strength after 1-h cure, but the strength of the other two materials still increase somewhat to about 2-h of cure, and then taper off. ■■

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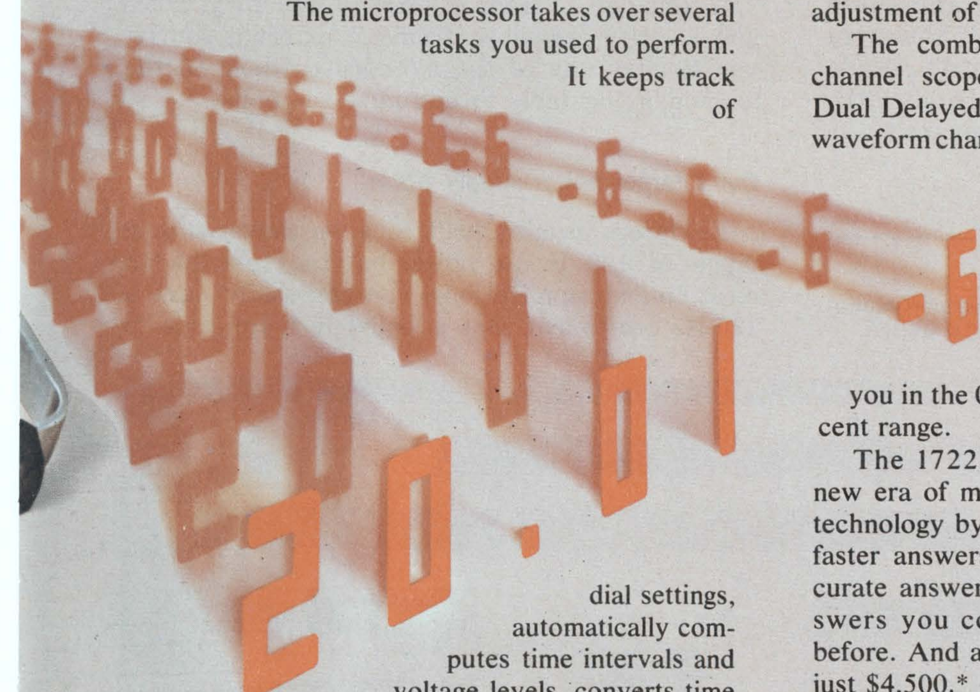

The microprocessor takes over several tasks you used to perform. It keeps track of dial settings, automatically computes time intervals and voltage levels, converts time measurements to frequency, and calculates percent. It even signals if you make an erroneous setting. In addition, the microprocessor drives a 3½-digit LED display to give you a direct digital reading of your measurements...in seconds, hertz, volts, or percent. Working with the 1722A is like having an assistant that takes care of the mental gymnastics.

There's another reason for easier, more accurate measurements—HP's unique Dual Delayed Sweep. It gives you two adjustable intensified markers for displaying the start and stop points of a time interval. The microprocessor then gives you an automatic readout of the time interval between the markers. This speeds digital timing measurements and simplifies the adjustment of circuits to meet a timing spec.

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Keep your op-amp circuits quiet.

By isolating and minimizing the different sources of noise you can take advantage of today's high performance ICs.

To take advantage of today's high-performance op amps, you must first minimize the effects of external circuit noise. The solution is twofold: (1) Identify the noise sources; (2) Eliminate as much of the noise as possible with improved bypassing of the power supply leads, more complete shielding and better understanding of what noise is.

For most applications, noise is any signal that appears in the output of an op amp that can't be predicted by ac or dc input error analysis. The noise can be random or repetitive, narrow or wideband, high or low frequency, current or voltage, and internally or externally generated.

You must determine the bandwidth and location in the frequency spectrum of the noise source. In Fig. 1, examples of some of the more common sources are compared over an 11-decade frequency spectrum. Noise-source bandwidths overlap; thus noise is a composite quantity at any frequency.

Donn Soderquist, Applications Engineer, Precision Monolithics, 1500 Space Park Dr., Santa Clara, CA 95050.

Most externally generated noise is repetitive rather than random and can be examined at a specific frequency. For example, 60-Hz powerline pickup commonly appears at an op amp's output as a sine wave with a 16-ms period.

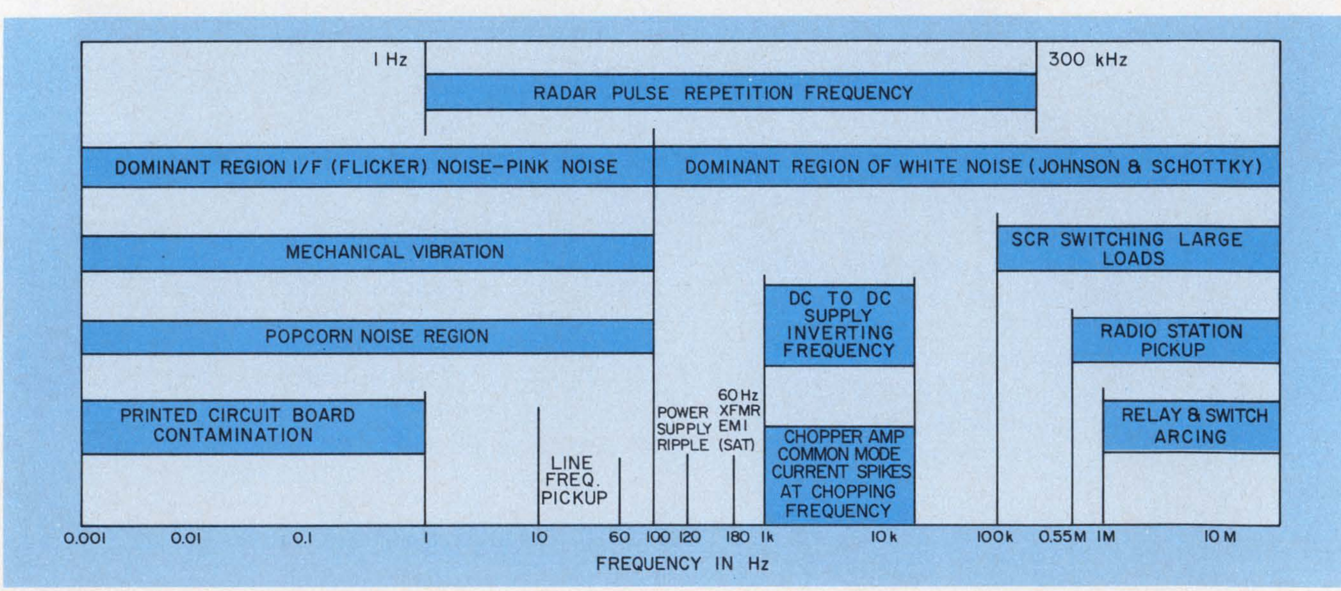
The basic tool for examining external noise is the oscilloscope. To help do the measurements, at least one scope manufacturer produces preamplifiers that have variable bandwidths and frequencies. Another basic tool is the simple lowpass filter (Fig. 2), where the corner frequency can be calculated by

$$f_o = 1/2\pi RC.$$

With this filter, you can change the input bandwidth to the scope from about 10 Hz to 100 kHz (change C from 4.7 μF to 470 pF). Once you identify the noise from an external source, you can try any of the methods outlined in the accompanying table to minimize the noise.

Don't forget power-supply noise

Engineers usually don't consider power-supply ripple at 120 Hz as noise, but they should. In most op-amp applications, you can easily have a 120-Hz component that is equal in magnitude to



1. **This frequency range chart** covers most of the sources of noise that can affect op-amp performance.

all other noise sources combined.

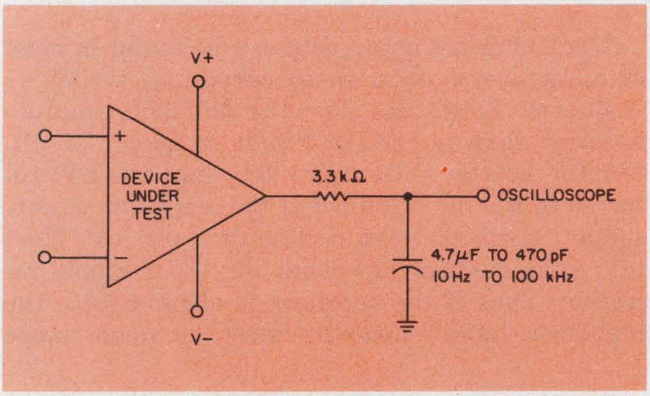
To be negligible, 120-Hz ripple noise should not be greater than 100 nV when referred to the op-amp input. To achieve this low level, you must consider these three factors when selecting an op amp:

1. The op amp's 120-Hz power-supply rejection ratio (PSRR).
2. The regulator's ripple rejection ratio.
3. The regulator's input capacitor value.

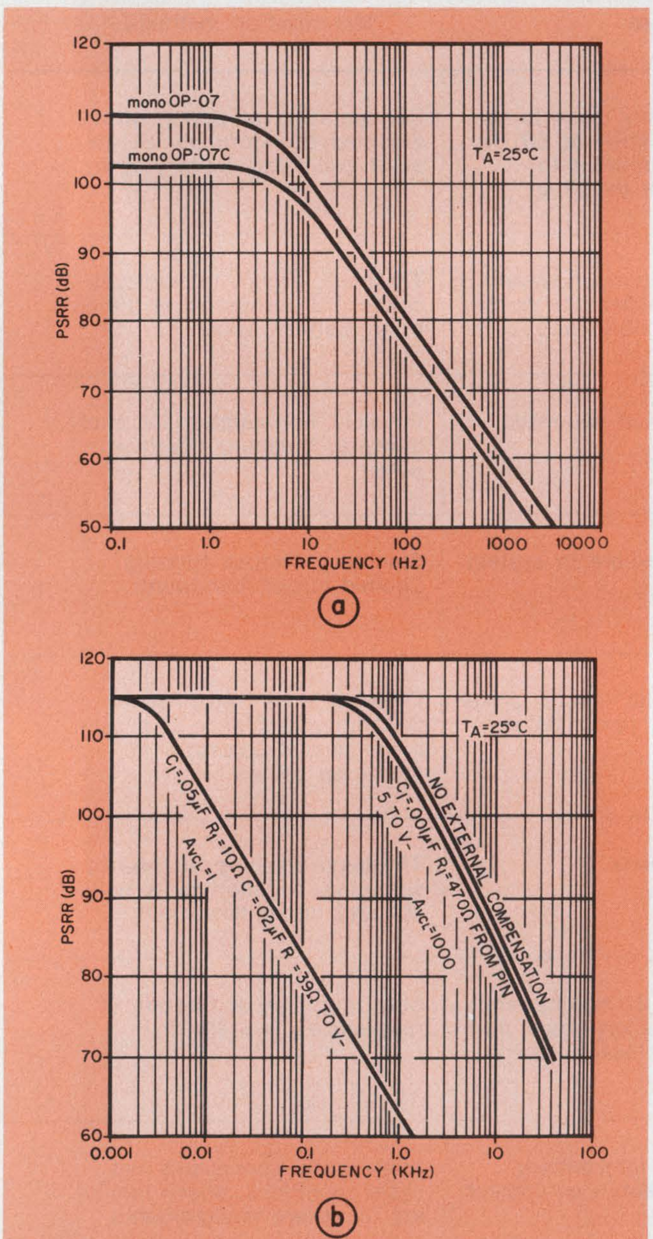
The PSRR for an op amp can be found in most manufacturers' data sheet curves of PSRR vs frequency (Fig. 3a). For the amplifier characteristics shown, 120-Hz PSRR is about 74 dB. For the 120-Hz noise to be less than 100 nV, referred to the input, ripple at the amplifier power-supply terminals must be less than 0.5 mV. Most IC regulators provide about 60 dB of ripple rejection. Thus if the rejection is about 60 dB, the regulator input capacitor must be made large

Noise sources external to the op amp

Source	Nature	Causes	Minimization methods
60-Hz Power	Repetitive interference	Power lines physically close to op-amp inputs. Poor CMRR at 60 Hz. Power transformer primary-to-secondary capacitive coupling.	Reorientation of power wiring. Shielded transformers. Single point grounding. Battery power.
120-Hz Ripple	Repetitive	Full-wave rectifier ripple on op-amp's supply terminals. Inadequate ripple consideration. Poor PSRR at 120 Hz.	Thorough design to minimize ripple. RC decoupling at the op amp. Battery power.
180-Hz	Repetitive EMI	180 Hz radiated from saturated 60-Hz transformers.	Physical reorientation of components. Shielding. Battery power.
Radio stations	Standard broadcast AM through FM	Antenna action anywhere in system.	Shielding. Output filtering. Limited circuit bandwidth.
Relay and switch arcing	High frequency burst at switching rate	Proximity to amplifier inputs, power lines, compensation terminals or nulling terminals.	Filtering of hf components. Shielding. Avoidance of ground loops. Arc suppressors at switching source.
Printed-circuit-board contamination	Random low frequency	Dirty boards or sockets.	Thorough cleaning at time of soldering, followed by a bake-out and humidity sealant.
Radar transmitters	High frequency gated at radar pulse repetition rate	Radar transmitters, from long-range surface search to short-range navigational—especially near airports.	Shielding. Output filtering of frequencies >> PRR.
Mechanical vibration	Random < 100 Hz	Loose connections, intermittent metallic contact in mobile equipment.	Attention to connectors and cable conditions. Shock mounting in severe environments.
Chopper frequency noise	Common-mode input current at chopping frequency	Abnormally high-noise chopper amplifier in system.	Use of balanced source resistors, bipolar input op amps instead of a chopper amplifier or use of a premium low noise chopper amplifier.



2. **A simple low-pass filter** helps to identify the different types of noise at an op-amp's output.



3. **Power-supply noise rejection** decreases as ripple frequency increases for all op amps. Internally compensated op amps have low PSRRs (a) compared with externally compensated op amps (b) when the externally compensated units are connected for high closed-loop gain applications.

enough to limit regulator input ripple to about 0.5 V.

Externally compensated op amps can provide improved 120-Hz PSRR in high closed-loop gain applications (Fig. 3b). When the op amp is compensated for a closed-loop gain of 1000, the 120-Hz PSRR increases to 115 dB. As noise frequencies increase, the PSRR will start to drop because of internal amplifier circuit leakage paths.

The 120-Hz ripple is not the only power-supply noise problem. Series-regulator outputs typically contain at least 150 μV of noise in the 100-Hz-to-10-kHz range. Switching regulator types generate even more.

Unpredictable amounts of induced noise from other sources can also be present on power leads. Since high-frequency PSRR decreases at 20 dB/decade, these higher-frequency supply noise components must not be allowed to reach the op amp's power terminals. RC decoupling can adequately filter most wideband noise (Fig. 4). Some caution, though, must be used with this type of decoupling, since load-current changes may modulate the voltage at the op amp's supply pins.

Any change in power-supply voltage has an effect on the op amp that you can refer to the amplifier's input. For the op amp curves in Fig. 3a, the PSRR at dc is 110 dB (3 μV/V). Power supplies for low-noise op-amp applications should be both low in ripple and well-regulated. And don't mistake inadequate supply regulation for low frequency noise internally generated by the op amp.

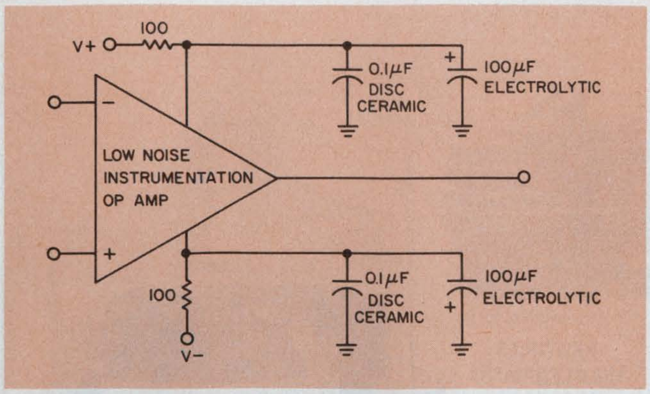
Complete data sheets specify current and voltage noises in a 1-Hz bandwidth and low frequency noise over a range of 0.1 to 10 Hz. Let's look at random noise mechanisms of the basic op amp and some simple methods to calculate the total input-referred noise.

Characteristics of random noise

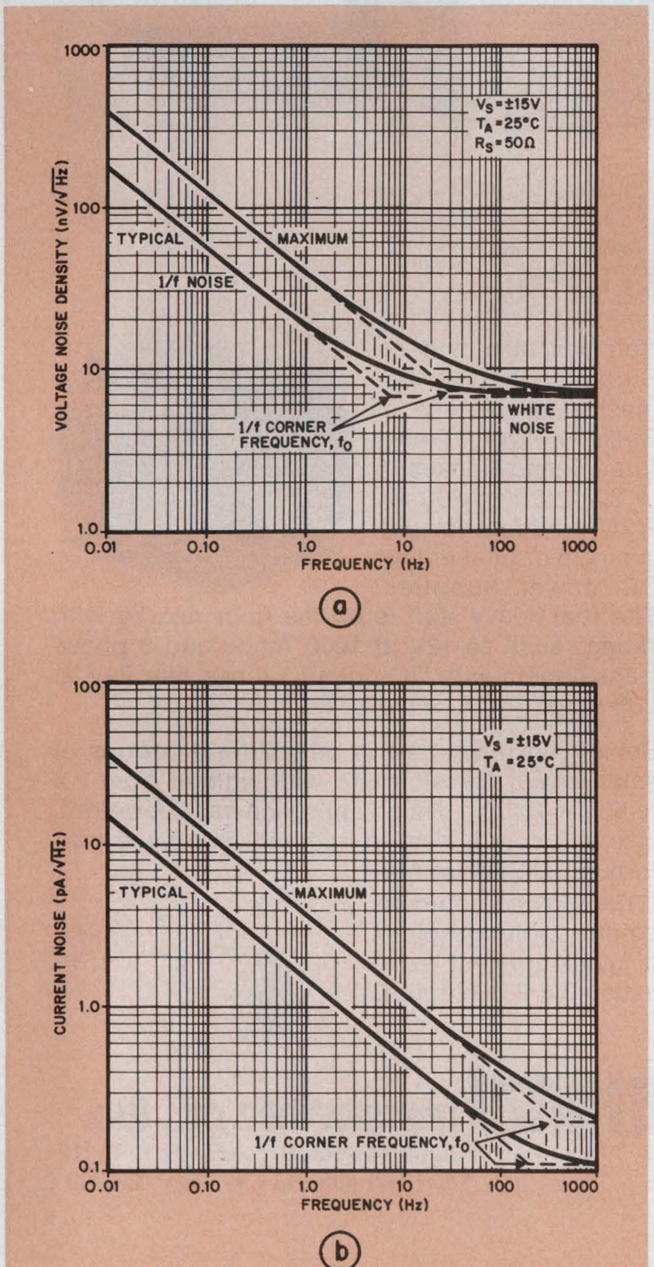
Op-amp noise currents and voltages are random, aperiodic and uncorrelated. They also have a Gaussian amplitude distribution—the highest noise amplitudes have the least likelihood of occurring. Gaussian distributions permit random noises to be expressed as rms quantities, and by multiplying the rms value by 6, you can get the peak-to-peak value that will not be exceeded 99.73% of the time.

The two basic types of noise associated with internal op-amp problems are white noise and flicker (1/f) noise. White noise contains equal amounts of power in each 1 Hz of bandwidth. Flicker noise contains equal amounts of power in each decade of bandwidth (Fig. 5).

Above a certain "corner" frequency, white



4. **Bypass the power-supply terminals** of a low noise op amp if you don't want any noise to enter from the source or from pickup on the power-supply leads.



5. **You can determine the corner frequencies** for flicker noise by using plots of voltage-noise density (a) and current-noise density (b) vs frequency.

noise dominates the noise content. Below the same frequency, 1/f noise dominates. A low corner frequency is the distinguishing factor between general-purpose and low-noise op amps.

The spectral density of noise can be written as

$$e_n^2 = d(E_n)^2/df \text{ and } i_n^2 = d(I_n)^2/df,$$

where

$$E_n = \sqrt{\int_{f_L}^{f_H} e_n^2\, df} \text{ and } I_n = \sqrt{\int_{f_L}^{f_H} i_n^2\, df}.$$

In these equations, e_n and i_n are the spectral noise densities, E_n and I_n are the total rms values of the noise, f_H is the upper frequency limit and f_L the lower frequency limit.

To evaluate the total noise voltage or current, you must know the values of the upper and lower frequency limits and the way the noise behaves as the frequency changes.

When you substitute the equations for E_n and I_n into the spectral density equations, e_n and i_n, the resulting equations express the spectral density of white noise in terms of volts/$\sqrt{\text{Hz}}$ or amperes/$\sqrt{\text{Hz}}$, where $f_H - f_L = 1$ Hz. When $f_H >> 10 f_L$, the white-noise equations reduce to

$$E_n(w) = e_n\sqrt{f_H} \text{ and } I_n(w) = i_n\sqrt{f_H}.$$

Since the flicker noise content in each decade of bandwidth remains constant, you can find the total flicker noise if the noise in one decade is known. The 0.1-to-1-Hz decade noise content (K) is widely used for this purpose, because the white-noise contributions below 10 Hz are usually negligible. Thus

$$E_n(f) = K\sqrt{1/f} \text{ and } I_n(f) = K\sqrt{1/f}.$$

If you substitute these two equations into the equations for E_n and I_n, you get

$$E_n(f) = K\sqrt{\ln(f_H/f_L)} \text{ and } I_n(f) = K\sqrt{\ln(f_H/f_L)}.$$

When you know the corner frequencies of the noise, the simplified expressions for the total voltage and current noise can be combined to give

$$E_N(f_H - f_L) = e_n\sqrt{f_{ce}\ln(f_H/f_L) + f_H - f_L}. \quad (1)$$

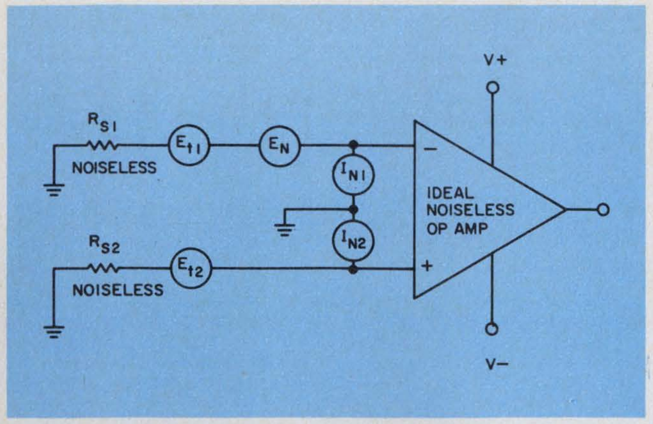
$$I_N(f_H - f_L) = i_n\sqrt{f_{ci}\ln(f_H/f_L) + f_H - f_L}. \quad (2)$$

In these equations e_n is the white-noise voltage in a 1-Hz bandwidth, i_n the noise current in a 1-Hz bandwidth, f_{ce} the voltage-noise corner frequency, f_{ci} the current-noise corner frequency, and E_N and I_N represent total voltage and current noise, respectively.

The two most important design rules for low-noise applications—limit the circuit bandwidth and use op amps with low corner frequencies—stem from Eqs. 1 and 2.

A complete model of an op amp, with all noise sources referred to the input, splits the noise into five equivalent sources: E_N, I_{N1}, I_{N2}, E_{t1} and E_{t2} (Fig. 6). The noise current generators produce noise voltage drops across their respective source resistors, R_{s1} and R_{s2}. And the source resistors generate thermal noise voltages, E_{t1} and E_{t2}, that must be included.

Thus the total rms input-referred noise volt-



6. The "ideal" op amp has all the noise sources removed from inside the amplifier. Then you can evaluate the circuit separately.

age, E_{NT}, over a given bandwidth becomes

$$E_{NT}(f_H - f_L) = \sqrt{E_N^2 + (I_{N1}R_{s1})^2 + (I_{N2}R_{s2})^2 + E_{t1}^2 + E_{t2}^2}.$$

Let's look at the two types of white-noise —thermal and shot—and the two low-frequency noise types—flicker and popcorn.

Examine the noise sources

Thermal, or Johnson, noise is created by the random movement of thermally charged carriers in a resistance. In most op-amp circuits this is the noise produced in the series resistance of each input element. The rms value of the thermal noise can be found from

$$E_t = \sqrt{4kTR(f_H - f_L)},$$

where k is Boltzmann's constant, T is absolute temperature in degrees Kelvin, and R is the resistance in ohms.

At room temperature this equation simplifies to

$$E_t = 1.28 \times 10^{-10}\sqrt{R(f_H - f_L)}.$$

To minimize thermal noise caused by R_{s1} and R_{s2}, keep the source resistances as small as possible and avoid excessive system bandwidths. You can't do much about internally generated thermal noise; since it usually is caused by the base-spreading resistances ($r_{bb'}$) of the input stage transistors.

Shot, or Schottky, noise is related to the amplifier's dc input bias currents:

$$I_{sh} = \sqrt{2qI_{BIAS}(f_H - f_L)},$$

where I_{sh} is the rms value of shot noise in amperes, q is the charge of an electron, and I_{BIAS} is the dc bias current in amperes.

At room temperature the equation simplifies to

$$I_{sh} = 5.64 \times 10^{-10}\sqrt{I_{BIAS}(f_H - f_L)}.$$

Flicker and popcorn noise are internally generated disturbances that you must live with, unless you can design your own op amps. Only the IC manufacturer can minimize the noise caused by either of these sources. ■■

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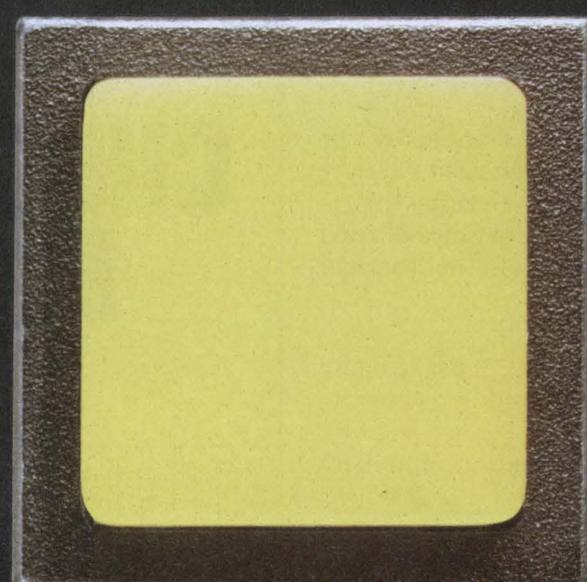

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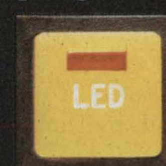

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CIRCLE 291 FOR DATA, 292 FOR SALESMAN CALL

Squelch RFI in switching supplies. Proper heat-sink connections, plus filters and screens, can steer unwanted currents away from input/output terminals.

Switched-mode power supplies need not be a troublesome source of interference. There are a number of steps you can take in practically any switching supply to keep RFI within specified limits.[1]

Direct radiation, for instance, is easily stopped: Just enclose the supply in a perforated metal box and pay careful attention to the layout of internal wiring.

Interference conducted through the input or output terminals, however, is a bit more difficult to suppress. But careful placement and design of line filters, transformer shields, heat sinks and other components can do the job.

Limits for RFI and corresponding measurement methods are set by many national and international standards organizations. One such test circuit measures interference injected into the line current (Fig. 1).

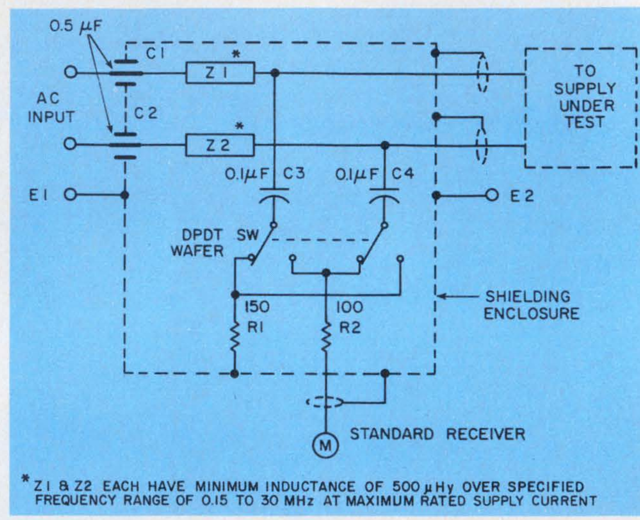
In the figure, impedances Z_1 and Z_2 divert interfering currents through capacitors C_3 and C_4 and shunt the currents into resistors R_1 and R_2. These resistors, combined with the 50-Ω input resistance of the measuring receiver, M, represent the 150-Ω impedance typical of a supply in the frequency range from 0.15 to 30 MHz.

Fig. 2 shows commonly accepted limits of interference across 150 Ω. More stringent standards exist in some countries. But if you ignore the particularly severe requirements of special receiving sites, a power supply is acceptable in all countries if the RFI voltage above 150 kHz at the input terminals is less than +54 dB above 1 μV, or 500 μV.

Watch for heat-sink capacitance

In a typical switched-mode power supply, the output switching transistor, TR_1, is mounted with an insulating washer on a grounded heat sink (Fig. 3). Two separate iron-core chokes, L_2 and L_3, plus capacitor C_1 attenuate line-to-line interference.

John Turnbull, Ferroxcube Corp., Old Kings Highway, Saugerties, NY 12477.



1. **Unwanted currents reflected** into the input terminals can be a problem in switching supplies. The currents can be measured with an interference receiver.

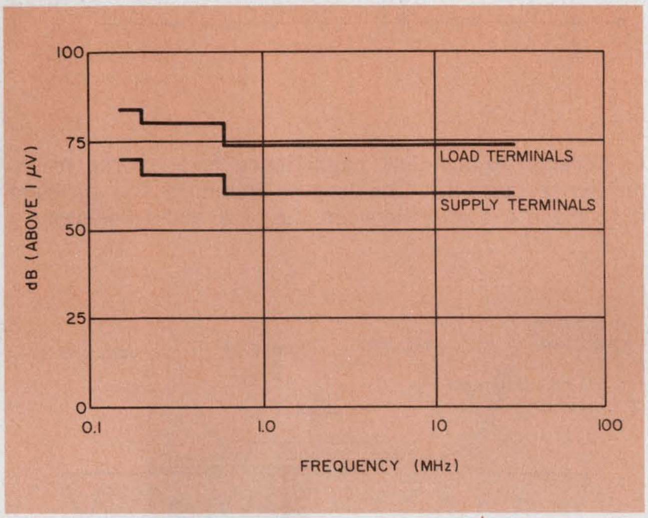
Similarly a bifilar-wound, high-inductance ferrite choke, L_1, plus the 5-nF capacitors, C_2 and C_3, limit line-to-ground RFI currents generated in the collector-to-heat-sink capacitance, C_5. These currents must be prevented from flowing into the 150-Ω input impedance and should be routed along the path indicated by the arrows in Fig. 3. Note that since the 60-Hz currents flowing in the bifilar windings of L_1 cancel out each other, the ferrite core does not saturate.

To remain within specifications, the voltage across the 150-Ω resistors must not exceed 500 μV. Since the switching waveform at the transistor collector has an amplitude of about 500 V, this requires an over-all attenuation of at least 10^6 from the collector to the line.

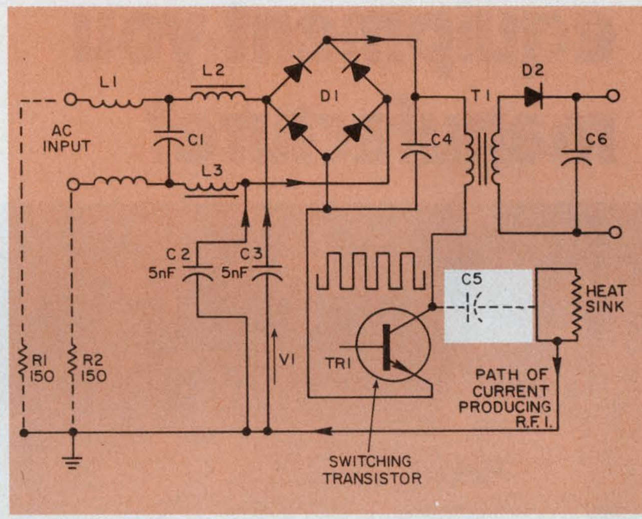
At 150 kHz, a practical line filter can attenuate line-to-ground interference voltage by 40 dB (100 times). Furthermore the first relevant harmonic is usually about 10% of the peak-to-peak collector voltage. This leaves an attenuation of about 10^3 to be achieved. For safety, the values of C_2 and C_3 are limited to 5 nF, for total attenuation capacitance of 10 nF. To obtain the required attenuation of 1000, the total capacitance, C_5, must not exceed about 10 pF from collector to ground.

Most often, the capacitance between a TO-3 encapsulated transistor and its heat sink is 100 pF when a mica insulating washer is used. Therefore expect a power supply so constructed to produce about 10 times more interference than is permitted.

One solution is to connect the heat sink to the transistor emitter or positive supply line instead of to ground. This ensures that the current in the collector-to-heat-sink capacitance remains in the primary circuit and won't flow into the line via the ground connection. Another solution is to enclose the heat sink within a screen that connects to the dc supply line.



2. **Commonly accepted limits of interference** across 150 Ω. Some sites require more stringent limits. Anything better than 50 dB above 1 μV is usually good.



3. **To keep interfering currents away** from a supply's input impedance, provide a shunt path as shown. The level across R_1 or R_2 shouldn't exceed 150 μV.

Screens reduce intercapacitances

Still a third solution, but proprietary to Advance Electronics Ltd., is to construct a screen between the transistor and the heat sink (Figs. 4 and 5). The optimum solution depends on the electrical and mechanical details of the individual power supply.

Providing another path for interference currents is the unwanted capacitance that couples the harmonics of the switching waveform to ground—that is, the interwinding capacitance in the output transformer. The solution here is to place a thin copper screen between the primary and secondary of the output transformer, so that capacitive current from the primary returns harmlessly to the supply line.

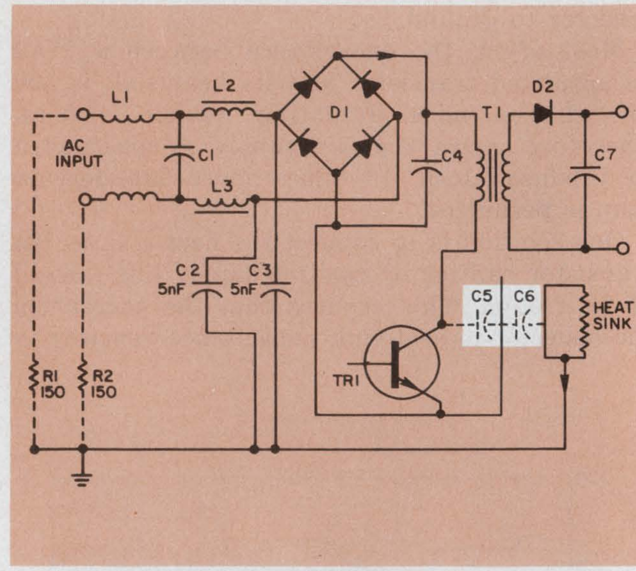
For low-output-voltage supplies, a screen may be adequate. However, in high-output units, the switching waveform on the transformer secondary can produce unwanted interference current through the capacitance between the secondary and the screen. A second screen therefore becomes necessary. Capacitive currents caused by the switching waveform in the primary now return to the primary, and those caused by the switching waveform in the secondary are returned to the secondary.

Capacitance between the output transformer primary and its ferrite core can also produce excessive interference if the core is simply clamped to a grounded mounting bracket. If you connect the core to the positive supply line, however, the primary will be adjacent to the core, and any capacitance between a high-voltage secondary and the core won't be a problem.

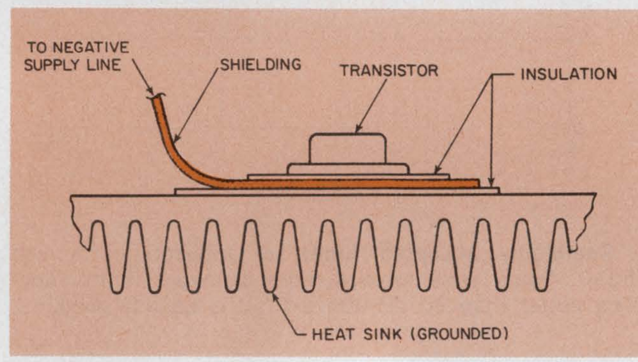
The suppression principles described should be applied to each part of a circuit that carries switching waveforms. These include interwiring capacitance, the capacitance from wiring to ground and interwinding capacitance in any base-drive or feedback transformers. In addition you must minimize unwanted inductive coupling in conductors carrying switching currents.

Frequency effects

Interference voltage at the line terminals of a switched-mode power supply is normally maximum at the lowest frequency of measurement, and it falls rapidly with increasing frequency. This is because the efficiency of the line filter increases with frequency and because the amplitudes of the switching harmonics decrease with frequency. It is often found, however, that at frequencies in the range of 10 to 20 MHz the interference voltage reappears, rising with increasing frequency. The culprit: fast switch-



4. **Collector-to-heat-sink capacitance** is a source of interference currents. One way to minimize the problem is to place a screen between the sink and transistor.



5. **Shielding construction needed** to reduce an output transistor's capacitance to ground. Each supply has its own optimum arrangement.

ing transients produced by diode "snap-off."

Typically the fall time of the reverse current at snap-off is about 10 ns. At very high frequencies this sudden current change can result in ringing, depending on transformer leakage inductance, wiring inductance and stray capacitance. Because the frequency is very high, interference can easily couple into all parts of the power-supply circuit, and it can develop appreciable voltage across connections, grounds and across the metal case enclosing the supply.

Snap-off can also cause malfunctioning of control circuits within the supply, resulting in output-transistor failure or instability in the control loop. The solution is to use soft recovery diodes when possible or to connect small capacitors across the offending diodes. You must also minimize circuit resonances that can sustain ringing after the diode currents drop to zero. ■■

References

1. Jansson, L. E., "Radio Frequency Interference Suppression in Switched-Mode Power Supplies," *Mullard Technical Communications*, Oct., 1973, Vol. 12, No. 120.

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INFORMATION RETRIEVAL NUMBER 55

Trio Power Supplies

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Circuit turns on tape recorder only when sound is detected

The circuit for a long-term audio remote-monitoring system can be built simply for less than $10. It makes use of the built-in microphone and amplifier of any common transistorized cassette tape recorder to do the monitoring until sound is detected. Sound of sufficient amplitude turns on the tape motor, and recording starts.

Low standby power allows long-term battery operation. No recorder modifications are required. Access to the recorder circuitry is via the recorder's external "monitor" and "remote" jacks.

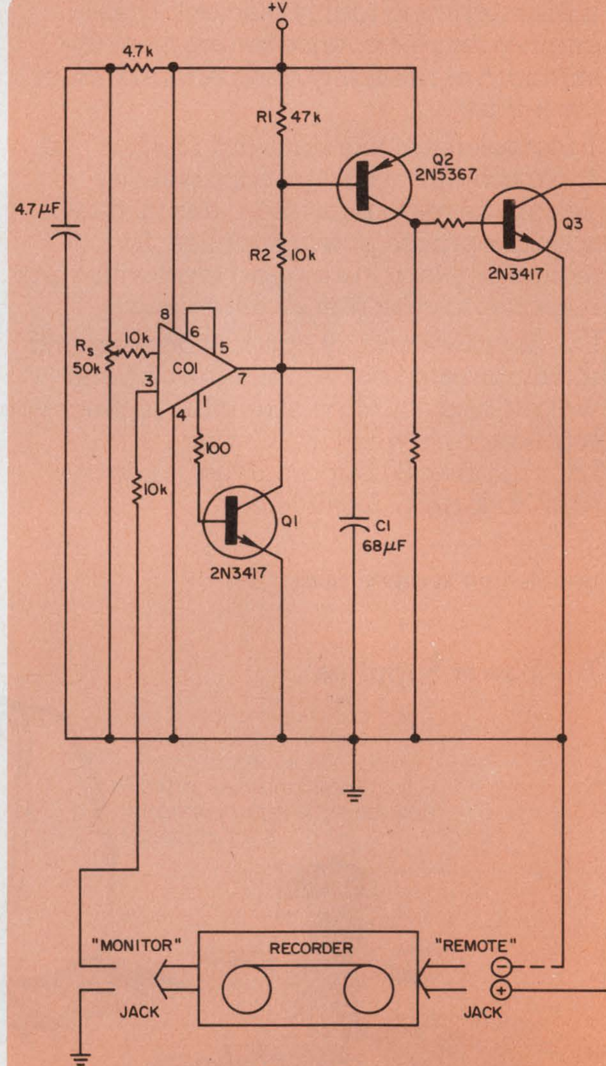
With the tape recorder in the record mode, the recorder's monitor jack is connected to the inverting input of comparator CO_1. The comparator's noninverting input is connected to an adjustable bias potentiometer, R_s, which sets the sound level that will start the recorder. The comparator output circuit has an uncommitted output transistor that is connected in a Darlington configuration with external transistor Q_1.

Network R_1, R_2 and C_1 provides time delays for fast-start and slow-stop of the tape-drive motor under control of Q_1 and the time constant of R_1, R_2 and C_1. Transistor Q_2 inverts and sharpens the signal to turn on transistor Q_3, which then operates the tape-drive motor.

Under silent conditions, the CO_1 output is low and transistor Q_1 is cut off. This allows capacitor C_1 to charge via resistors R_1 and R_2. When the charging current ceases, Q_2 and Q_3 also are cut off. If the sound level exceeds the preset threshold, Q_1 is driven into saturation to discharge C_1 rapidly. Transistors Q_2 and Q_3 turn on, and the recorder motor runs.

The presence of sound keeps C_1 in a discharged condition and the recorder running.

Michael L. Roginsky, Staff Engineer, Engineering Data Systems Dept., Lockheed-Georgia Co., Marietta, GA 30063. CIRCLE NO. 311



Monitor circuit conserves tape by turning on tape-recorder motor only when the sound level exceeds a level preset by R_s.

Pulse amplifier can deliver over 500 V with frequencies to 100 kHz

Few pulse amplifiers can handle a wide voltage range—0 to 700 V—and a wide frequency range—dc to 100 kHz.[1] Here is a circuit that can perform both functions economically and is suitable for driving capacitive loads.

An optical coupler allows isolation of the bias voltages for Q_1 and the high-voltage transistor, Q_3. Thus only TTL level voltage swings can control the base-emitter junctions of both output transistors Q_3 and Q_4. They are the only transistors that swing the entire output-voltage range.

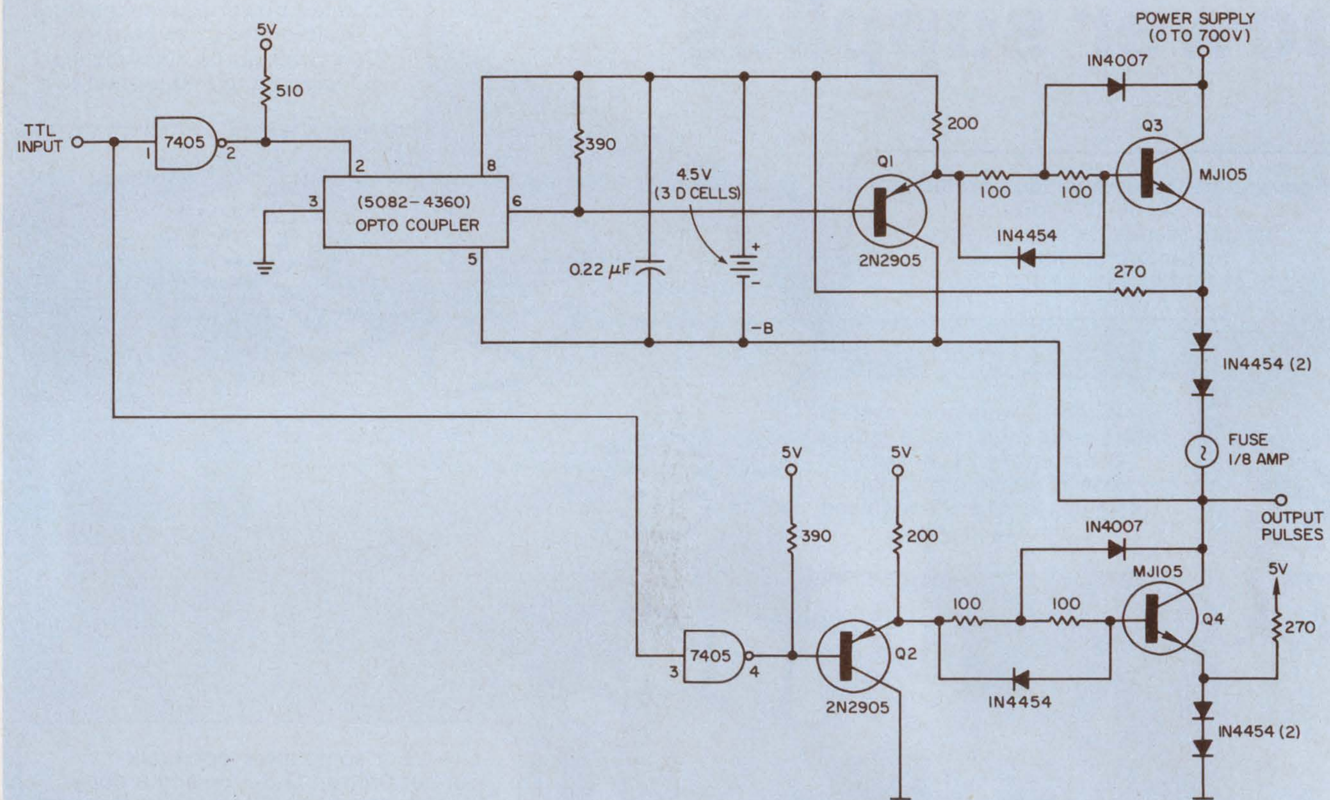
Note that the circuit requires a floating 4.5-V power supply, which is provided by three D cells. Unlike the circuit in the reference, which merely opens and closes a path to a voltage source, this pulse amplifier drives the load between ground and the positive voltage. Thus the load can be capacitive.

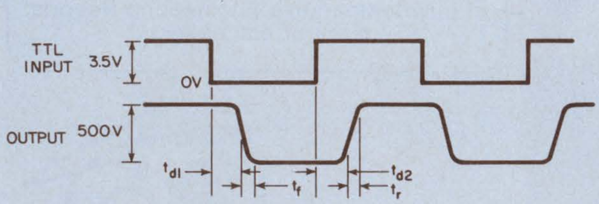
Reference

1. Anderson, Stephan D., "High-speed Switch Handles ±400-V Peak," *Electronic Design*, Jan. 18, 1975, p. 74.

Donald Limuti, Research Engineer, Digital Development Group, Stanford Research Institute, Menlo Park, CA 94025.

CIRCLE NO. 312





INPUT	LOAD	t_{dl}	t_f	t_{dr}	t_r
2 kHz SQ. WAVE	NO LOAD	3.0	2.5	2.2	3.0
2 kHz SQ. WAVE	22 kΩ 1000 pF	2.5	5.0	2.5	2.4
100 kHz SQ. WAVE	150 kΩ 47 pF	2.5	4.0	2.5	4.0

High-voltage pulse amplifier uses an optocoupler to enable TTL levels to control greater than 500 V of output. It does, though, require an isolated 4.5-V power supply.

INFORMATION RETRIEVAL NUMBER 57

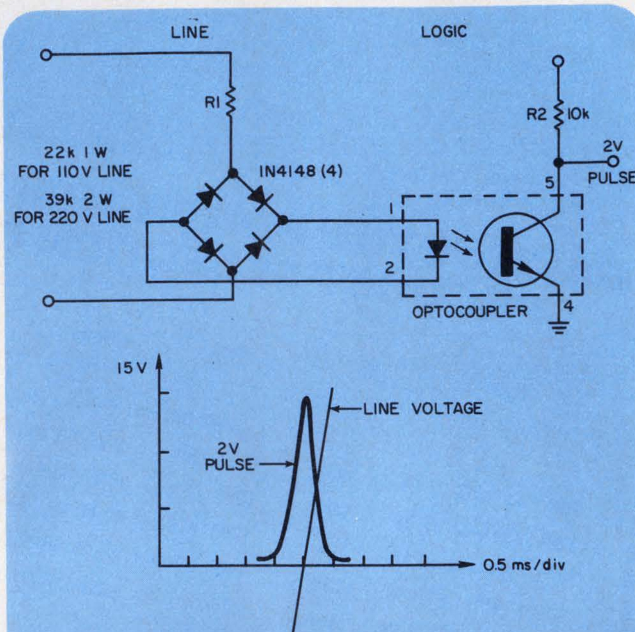
Optocoupler is zero-crossing detector and isolator in triac power control

An optocoupler can provide both isolation and zero-crossing detection, as often required by solid-state relays and other power controls, without use of expensive transformers or complex circuits.

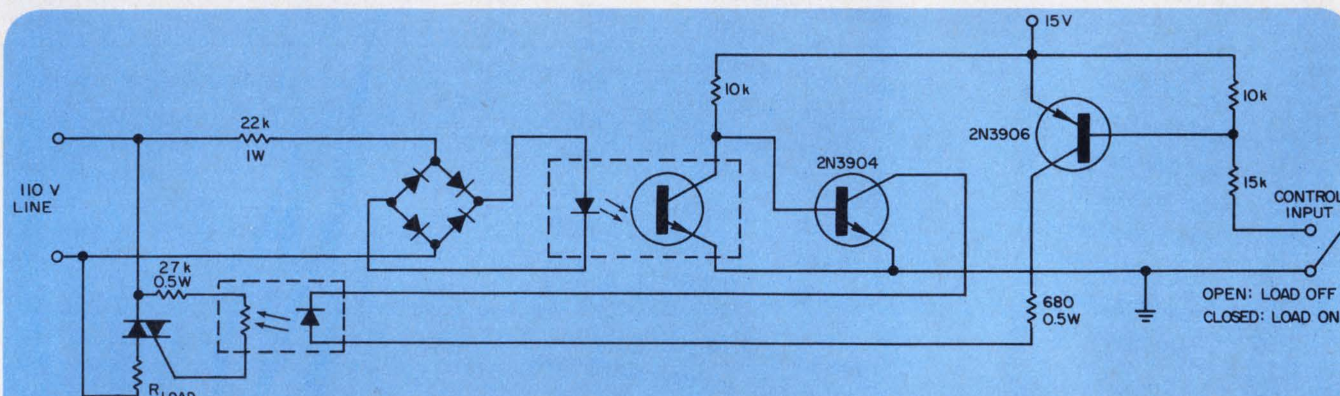
In the zero-crossing detector in Fig. 1, the output transistor of the optocoupler conducts continuously, except for a very brief period near the zero-volt crossing of the line voltage, when the coupler's internal LED turns off for about 1 ms. The width of the output pulse when the LED turns off can be increased by use of a higher value for resistor R_2. And the pulse can be advanced with a capacitor placed in series or parallel with R_1 to phase-shift the current flow through the LED portion of the optocoupler.

Fig. 2 shows how the zero-crossing detector circuit of Fig. 1 can be used to trigger a triac only when ac power is traversing zero. This action reduces transients and RFI noise.

Pekka Ritamaki, Electronics Engineer, Oy Nokia Ab Cable Works, Capacitor Factory, Pl. 60, 33101 Tampere 10, Finland CIRCLE No. 313



1. **An optocoupler is used as a power-line zero-voltage crossing detector** to provide electrically isolated pulses suitable for power controls.



2. **The optocoupler zero-crossing detector triggers a triac** to control an ac load with a minimum of transients and RFI. The detector also provides complete line isolations from the control.

IFD Winner of May 24, 1975

Leonard Kaplan, Member of Technical Staff, RCA Solid State Div., Route 202, Somerville, NJ 08876. His idea "CMOS Audio Amplifier Features ±15-dB Bass/Treble Control Range" has been voted the Most Valuable of Issue Award.

Vote for the best Idea in this issue by circling the number for your selection on the Information Retrieval Card at the back of this issue.

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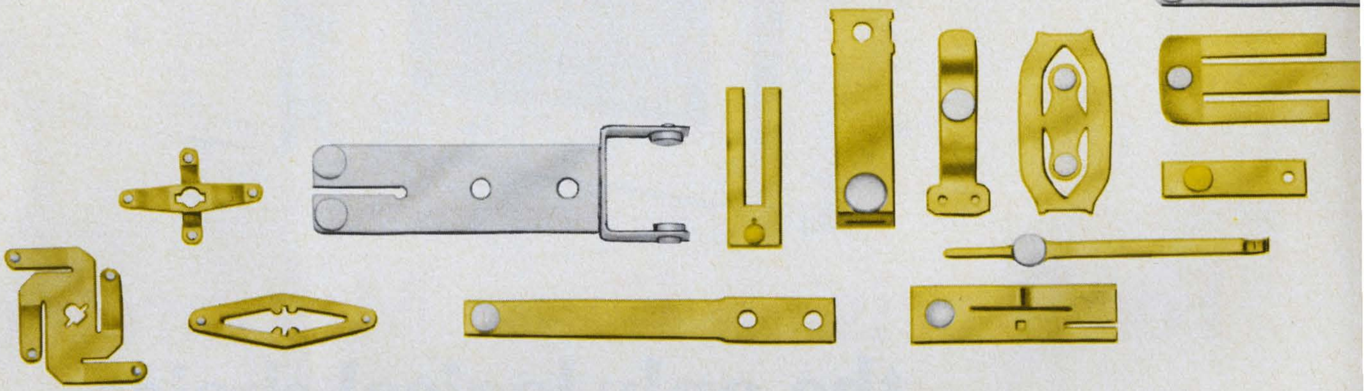
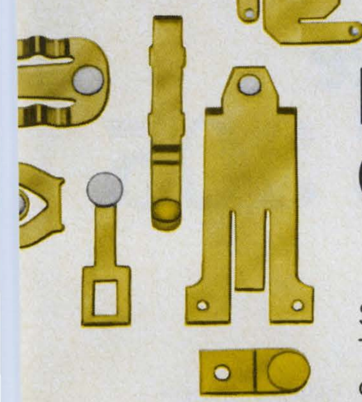
Which of these spring contacts can you get from Instrument Specialties?





None of them! (But we'll make some just for you!)

Sorry, we can't sell you any of the springs shown here. They're all proprietary. Each was designed for a specific application at a particular company. A *very* particular company. Which is why each one came to I/S!

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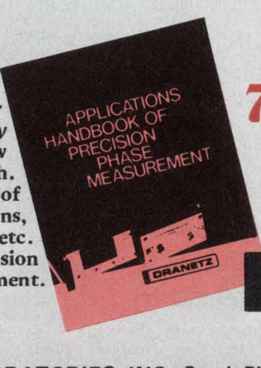
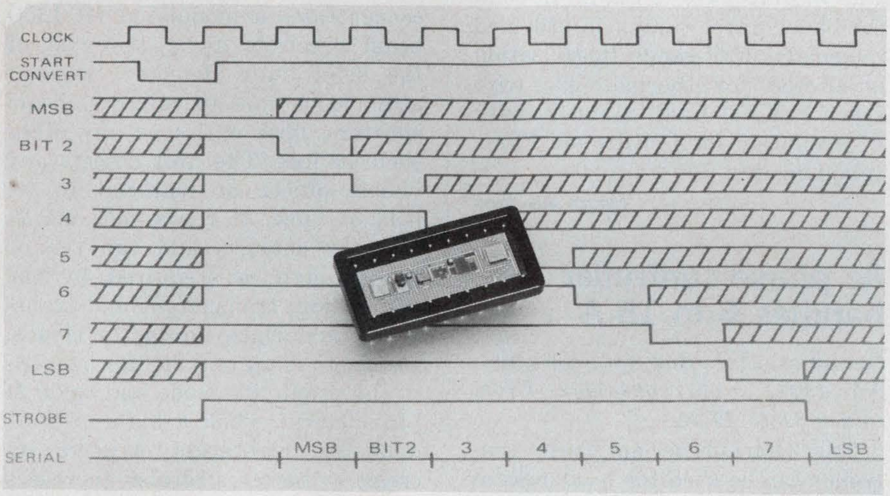


DRANETZ

DRANETZ ENGINEERING LABORATORIES, INC., South Plainfield, N.J. 07080, Tel: (201) 755-7080, TWX: 710-997-9553

18-pin DIP houses speedy 8-bit hybrid a/d converter



Micro Networks, 324 Clark St., Worcester, MA 01606. (617) 852-5400. P&A: See text.

Many companies offer modular eight-bit analog-to-digital converters for under $100. And a few companies even have lower cost IC versions—but many of these are slow and most require external components, such as a voltage reference or comparator.

Micro Networks now offers a third alternative—the MN5120 series of hybrid-microelectronic eight-bit a/d converters. These are successive-approximation units that cost only $59 in unit quantities and are housed in 18-pin hermetic DIPs.

The MN5120 units include their own reference and comparator, but need an external clock signal. They deliver an eight-bit data word in only 6 μs, maximum. Nonlinearities are only ±0.5 LSB over an operating temperature range of 0 to 70 C. The worst-case absolute accuracy is ±1 LSB at 25 C and ±2 LSB over the 0-to-70-C range.

There are four units in the MN-5120 series: the MN5120, 5121, 5122 and 5123. They are identical, except for their analog input ranges, which are: 0 to −10, −5 to +5, −10 to +10 and 0 to +10 V, respectively. Input impedance for all models is 5 kΩ except for the MN5122 for which it rises to 10 kΩ. All versions deliver serial and parallel data outputs in straight binary form.

Power requirements for the MN-5120 series are low. Total power for any of the units is 1 W, maximum; all units need ±15 and +5-V supplies. Power supply tolerance should be tighter than ±3% to ensure full accuracy.

The converter comes completely pre-trimmed and uses nichrome, thin-film resistor networks for high stability.

Competitive single package, successive approximation, converters include the AD7570J CMOS a/d converter from Analog Devices (Norwood, MA) the ADC-EH-8B from Datel (Canton, MA), the 540-8 from Hybrid Systems (Burlington, MA) and the MM5357 from National Semiconductor (Santa Clara, CA).

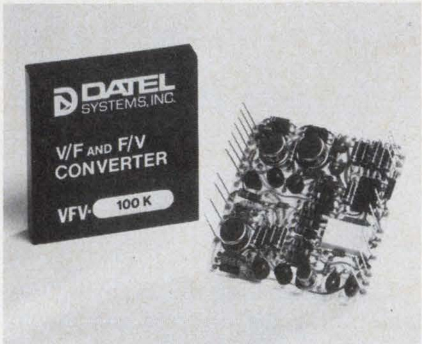
The Datel and the Hybrid Systems units are discrete component modules, measuring 2 × 2 × 0.4 in., while the converter from Analog Devices is a single 28-pin IC and the National unit is housed in an 18-pin DIP. The AD7570J, though, does require an external comparator, clock and voltage reference and the MM5357, just a clock and reference, while the Datel and Hybrid Systems units have a built-in clock source, so all that's needed is the convert command.

The AD7570J and the MM5357 beat the Micro Networks converters for low power consumption—the 7570J requires only 20 mW for operation, not including the current needed for the comparator or reference and costs $52 and the 5357 requires only 170 mW, not including the reference, and costs only $12. Also, the Datel unit is faster than the units from Micro Networks—it converts in 4 μs or less and costs $85. However, it does require almost double the power—1.675 W, maximum. The Hybrid Systems 540-8 converts in 5 μs and requires the same power as the MN5120 units—only 1 W, maximum and costs $85. Conversion time for the Analog Devices and National IC units is slower—under 20 μs for the AD7570J and 40 μs for the MM5357, respectively. Analog Devices, though, does offer a 10-bit converter the AD7570L, which costs $69 in unit quantities.

The Micro Networks converters are available from stock.

For Micro Networks **CIRCLE NO. 301**
Analog Devices **CIRCLE NO. 302**
Datel **CIRCLE NO. 303**
Hybrid Systems **CIRCLE NO. 304**
National Semiconductor **CIRCLE NO. 305**

Universal v/f and f/v converter spans 100 kHz



Datel, 1020 Turnpike St., Canton, MA 02021. (617) 828-8000. $179; stock to 4 wk.

The VFV-100K universal voltage-to-frequency or frequency-to-voltage converter has a large number of operating characteristics determined by pin connection. With a frequency range of 0 to 100 kHz, the unit has a resolution of one part in 100,000. The input and output also have a minimum over-range of 10%. Some of the pin-programmable characteristics include: 0 to +10 or 0 to −10 V inputs, 0 to +1 or 0 to −1 mA inputs, positive or negative going output pulses, 5 to 15 V amplitudes and operation as either a v/f or f/v converter. The output pulses have a constant width of 7 μs and the output is short circuit proof. Other features include a 0.05% maximum nonlinearity, 100 ppm/°C maximum temperature coefficient, and a 10 kΩ input impedance. The VFV-100K is packaged in a 2 × 2 × 0.375 in. case.

CIRCLE NO. 306

Thermocouple linearizer provides 1° resolution

San Diego Instrument Lab, 8098 Engineer Rd., San Diego, CA 92111. (714) 292-0646. $287 (1 to 9); stock.

The Model 201 digital thermocouple linearizer receives parallel binary or BCD data from digitized thermocouple data and linearizes the data in conformance with NBS thermocouple tables. Each linearizer consists of an input/output module and a processor module, and measures 3.5 × 4.5 × 0.6 in. Inputs and outputs are TTL/DTL compatible; control timing is provided internally. Full-range linearization is offered for thermocouple wire types J, K, T, E, R, S and B, with 1° resolution for Celsius and Fahrenheit models.

CIRCLE NO. 307

Ac phase controller handles 6 to 15 A

Omnetics, P.O. Box 113, Syracuse, NY 13211. (315) 699-5262. From under $1 to $7.22.

The Omnephase ac phase controller can be used for incandescent lamp dimming, heating element temperature control and speed control of universal and induction motors. Six models of the integrated functional control are offered in two package configurations. Current/voltage combinations that range from 6 to 15 A at 230 V ac are available. Forward voltage drop is 1.8 V at maximum on-state current. Conduction angles range typically from 30 to 155° at 15% hysteresis. Operating temperature range spans −40 to +100 C.

CIRCLE NO. 308

Noncontacting sensor uses modulated IR beam

Scientific Technology, 1201 San Antonio Rd., Mountain View, CA 94043. (415) 965-0910. $139.50; 4 to 6 wk.

The 2050-series Optaxial control concentrates a modulated IR LED beam precisely along the axis of the solid state detector, without attenuation due to mirrors, beam splitters, fiber optics or any other such devices. The unit detects any visible object or material in its field of view. It reads code marks or color changes and can see or see through, as required by the application, transparent and translucent materials, liquids or clouds. Its range is up to 6 ft (1.8 meters) in the proximity mode and to 50 ft (15 meters) when a 3 in. (8 cm) diameter retrotarget is used. Increasing target size also increases retroreflective range. The rugged, sealed sensor head of the 2050-series measures 1.4 × 1.75 × 3.25 in. (3.6 × 3.8 × 8.3 cm) and may be remotely mounted up to 100 ft (30 meters) from the control electronics. The control is available for any 2.5-W input from 12 V dc to 240 V ac and the control output may be selected to meet any requirement. Standard plug-in control option modules include time delays, one shots, latches and predetermined counters.

CIRCLE NO. 309

Instrumentation amp accurate to 0.002%

Analog Devices, P.O. Box 280, Route 1 Industrial Park, Norwood, MA 02062. (617) 329-4700. Unit prices: $69 (J); $85 (K); $98 (L); stock.

The Model 606 instrument amplifier has an almost constant bandwidth over a gain range of 1 to 10,000 V/V. It is also claimed by the manufacturer to be the most accurate unit available, with an accuracy of 0.002%. Precision performance is further assured by a 0.5 μV/°C maximum input offset drift combined with a 90 dB minimum CMRR and 1 μV pk-pk maximum input noise. Total drift from all sources is guaranteed to be less than 0.5 μV/C referred to the input when measured at a gain of 1000. The Model 606 has a 10 MHz gain bandwidth product and 50 μs settling to 0.01%, making it fast enough for most high speed applications. A 12 kHz full power response independent of gain, and a gain stability of 15 ppm/°C and 6 ppm/month are further assurances of long time reliability. The amp consumes only 75 mW, operates over a ±9 to ±18 V dc power supply range and is housed in a 2 × 2 × 0.4 in. module.

CIRCLE NO. 320

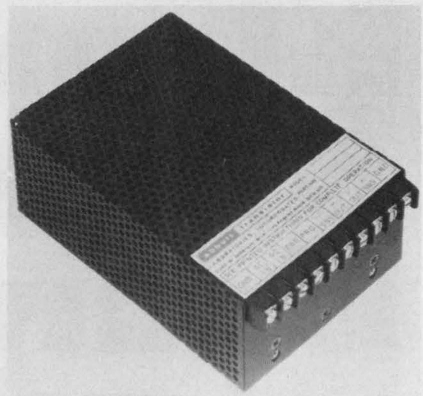
D/s converters provide 14-bit resolution

Transmagnetics, 210 Adams Blvd., Farmingdale, NY 11735. (516) 293-3100. $495 (1 to 4); stock to 6 wk.

The Model 1673, 14-bit digital-to-synchro converter is accurate to within 4 minutes of angle. The unit continuously converts a 14-bit parallel-binary coded angle input into a three-wire synchro or four-wire resolver output. Digital inputs are TTL/DTL compatible. Synchro output and reference are transformer isolated. Standard output voltages are 11.8 or 90 V rms line-to-line, 50 to 400 Hz. Full power output can be supplied up to +85 C. The 1673 has continuous short-circuit and overcurrent protection and can be supplied for 0 to +70 C or −55 to +85 C operation. The module measures 3.125 × 2.625 × 0.82 in. and requires ±15-V-dc and +5-V-dc supplies.

CIRCLE NO. 321

60-W switcher offers dual outputs



Abbott Transistor, 5200 W. Jefferson Blvd., Los Angeles, CA 90016. (213) 936-8185. $349.

Model ZZ expands the spectrum of the company's Model Z by offering a dual-output, switching-regulated ac-to-dc power supply. This unit converts low-frequency (47 to 440 Hz) ac lines (100 to 132 V rms) to 60 W of regulated power in a package measuring 4 × 7-1/2 × 2-1/2 in. and weighing 3 lb. Model ZZ15T2.0 offers an adjustable output voltage from 14.5 to 15.5 V and delivers 2.0 A per channel. Regulation is within 0.15% for input voltage changes of 100 to 132 V rms and load changes of no load to full load, while the ripple is less than 5 mV rms or 100 mV pk-pk.

CIRCLE NO. 322

Forty models comprise open-frame series

Deltron Inc., Wissahickon Ave., North Wales, PA 19454. (215) 699-9261. $32 to $113.

Forty models make up the "Q" Series open-frame, power-supply line. Featured are reverse and forward-voltage protection, loss of sense protection, socketed semiconductors, an IC regulation system, infinite resolution adjustments and a barrier-block interface. In addition, the "Q" Series has remote sensing and programming capabilities along with automatic series and parallel operation. Line regulation is 0.02%, load regulation is 0.05%, ripple and noise are 0.01%.

CIRCLE NO. 323

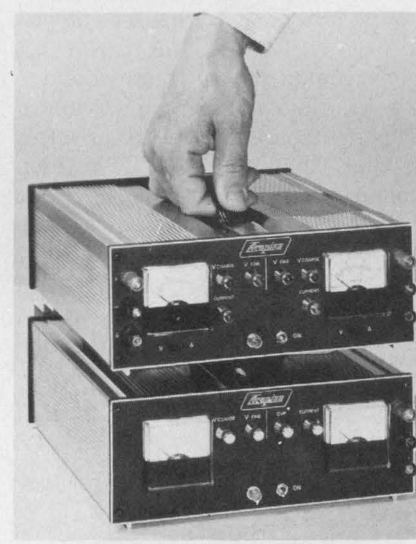
Switchers work at up to 82% efficiency

Trygon Electronics, 1200 Shames Dr., Westbury, NY 11590. (516) 997-6200. From $650.

A new series of modular units with 20-kHz switching regulators, the SHA series is available in nominal voltages of 1.25, 3, 5, 12, 15, 24, 28, and 48 V dc with currents ranging from 15 to 120 A. Other features include no turn-on/turn-off transients, soft-start, low-inrush turn-on current, 0.1% load and source effect, less than 20 mV rms pard (ripple and noise) and stability of 0.1%. Overvoltage protection is standard on all units below 5 V dc and optional on all others.

CIRCLE NO. 324

Benchtop units meter both volts & amps



Acopian Corp., Easton, PA 18042. (215) 258-5441. $99 to 190; stock.

K series, a new family of benchtop-mount laboratory power supplies, includes models with voltage ranges from 0-7 to 0-50 V, and with output current ratings to 5 A. Unlike most other power supplies in their price range, even the $99 models have two meters, so that voltage and current may be monitored simultaneously. The units can be stacked to conserve bench space. Solid top and side surfaces ensure that a stray bit of wire or solder can't fall in and cause a short circuit. The casework is constructed of gold-finished extruded aluminum. A recessed carrying handle is provided.

CIRCLE NO. 325

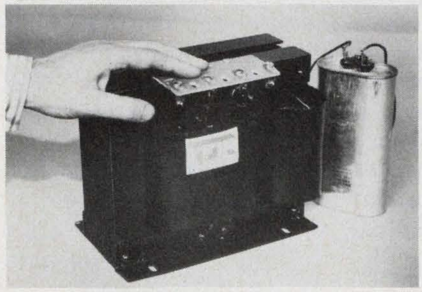
Current source offers digital readout

Probex Corp., 999 Commercial St., Palo Alto, CA 94303. (415) 321-1800. $665; stock.

Model 200A is a combination digital readout/power supply for resistivity measurements of semiconductor material. The unit can be used with all currently available permanent and nonpermanent four-point probes. Featured is a programmable constant-current generator offering pushbutton selection of five current modes: 0.01, 0.1, 1.0, 10.0 and 100.00 mA. Voltage compliance is 100 V min in all ranges except 100 mA, where it is 90-V max. Three dc-voltage ranges from 200 mV to 20-V fs are also included and are selected by pushbutton switches.

CIRCLE NO. 326

Ac source smooths input-line variations

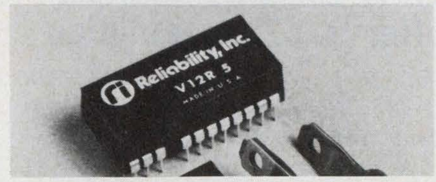


Frequency Technology, Inc., TDC Div., Box 365 Whitcomb Ave., Littleton, MA 01460. (617) 456-3374. Start at $309 (2 kVA).

Series OC1 stable ac sources are offered for a wide range of nominal ac input and output voltage levels. For example, actual specifications of ±15% line regulation for ±3% output variation means that the OC1 source will handle an actual 102-to-138-V input voltage variation, yet deliver a 116.4-to-123.6-V stabilized output. If input voltage remains constant, but the load changes from half to full, output may vary by as much as 5%.

CIRCLE NO. 327

DIP-like sources deliver regulated power



Reliability, Inc., 5325 Glenmount, Houston, TX 77036. (713) 666-3261. $3325.

A new series of regulated "V-PAC" dc/dc power sources operates with 5-V input and provides users with regulated positive or negative 3, 5, 9, 12, or 15-V output, depending upon device type. They provide isolation, built-in short-circuit and thermal overload protection as well. Prefixed V5R, the sources offer output voltage tolerance of ±5%; output ripple of 100 mV pk-pk max, line regulation of ±0.2%; and load regulation of 150 mV, no load to full load. V-PAC sources occupy less than 0.3 cubic inches. Their pins are on standard 0.1-in. centers and fit 24-pin DIP sockets. Or they may be soldered to PC cards.

CIRCLE NO. 328

POWER SOURCES

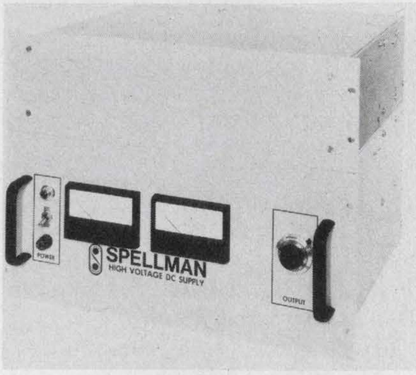
15-W class 81 sources offer ±0.2% regulation

Sola Electric, 1717 Busse Rd., Elk Grove Village, IL 60007. (312) 439-2800. $29 to $89.50; stock.

A new series of 15-W Class 81 IC-regulated dc power supplies is designed as a low-cost alternative for bench and rack installations. Features include low noise and ripple of 0.1% pk-pk and combined line/load regulation of ±0.2%. Automatic short-circuit protection is built in, with automatic return upon removal of the short. Manual adjustments are provided for both current limiting and output voltage. Operating temperatures range from 0 to 50 C without derating, and extend from −20 to 70 C with minor derating. Tempco is 0.03%/°C.

CIRCLE NO. 330

High-voltage sources deliver to 250 W



Spellman High-Voltage Electronics, 1930 Adec Ave., Bronx, NY 10469. (212) 671-0300. Start at $445; 6 wks.

The company's RHR line of rack-mounted, high-voltage power supplies—previously limited in output power to 120 W—is now available with output powers up to 250 W. These higher power models can be selected with maximum output voltage ratings of 5, 10, 15, 20, 30, 40, 50, 60, 80 and 100 kV. The line features 0.01% regulation for both line and load and 0.02% rms ripple. Output polarity can be selected to be either positive, negative, or reversible with respect to ground. All RHR units are overload, short-circuit and arc protected.

CIRCLE NO. 329

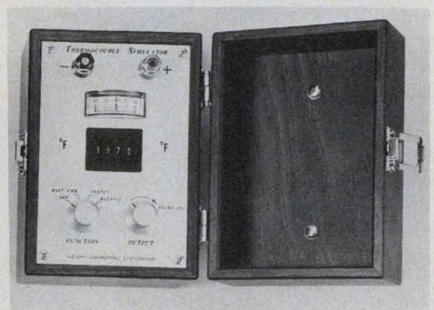
Sources let you vary outputs from 0 to 30 V

Power/Mate Corp., 514 S. River St., Hackensack, NJ 07601. (201) 343-6294. Start at $110; stock.

SUPER/UNI series replaces the company's older UNI series of power supplies. The series consist of nine models, each of which may be operated at any voltage from zero to 30 V at currents to 36 A. Thus the nine units literally replace thousands of more-expensive narrow-range slot supplies. The units mount on any of three sides and meet MIL spec environmental requirements. They are also UL recognized, short-circuit proof and contain built-in solid state overload protection. Line and load regulation are better than ±0.05%, with ripple less than 250 μV.

CIRCLE NO. 393

Thermocouple simulator permits accurate setting



Victory Engineering Corp., Victory Rd., Springfield, NJ 07081. (201) 379-5900. $299; 4 to 6 wk.

The Model 20 thermocouple simulator not only checks the output from thermocouples or similar sources but also generates its own precision voltage to simulate these sources. The portable instrument is powered by rechargeable batteries or can be plugged into a 115-V-ac line. The digital dial maximizes resolution and minimizes reading error. Built-in automatic cold junction compensation eliminates panel complexity and constant manual temperature correction. Dimensions without cover are 5 in. high, 7.5 in. long and 5.5 in. wide. The unit is available in either °C or °F for all standard thermocouples.

CIRCLE NO. 331

Minis join instruments on standard bus

Hewlett-Packard, 1501 Page Mill Rd., Palo Atlo, CA 94304. (415) 493-1501. $1535; 6-8 wks.

With a plug-in card, Model 59310A, any of the company's 2100 or 21MX minicomputers may be hardware-interfaced to instruments that are programmable via the HP Interface Bus. The HP-IB is HP's implementation of IEEE Standard 488-1975, "Digital Interface for Programmable Instrumentation." All minicomputers of the HP 2100 series, and the new semiconductor-memory 21MX series, have a number of powered input-output channels, each able to accept a plug-in PC interface board. A variety of these is offered, so the HP minis interface readily to many different peripheral devices.

CIRCLE NO. 332

INSTRUMENTATION

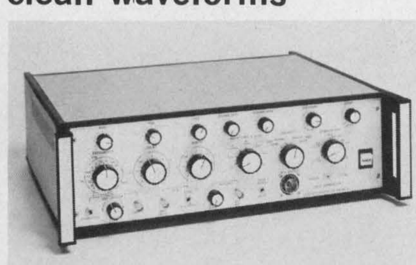
4-1/2-digit DPM claims mini title

Datel Systems, 1020 Turnpike St., Canton, MA 02021. (617) 828-8000. $219; stock-4 wks.

Said to be the world's smallest 4-1/2-digit, 5-V-powered DPM, the DM-4000 is shorter and nearly 1-in. narrower than most comparable units. Outstanding features include a 0.43-in.-high red LED display, ratiometric operation and optional full-parallel BCD output. Full-scale input is ±1.9999 V and 120-dB CMR rejection is achieved over the ±300-V common-mode range with opto-isolation. Other specs include automatic zero correction and 60-dB NMR. Input impedance exceeds 100 MΩ and input bias current is 100 pA. Accuracy of the DM-4000 is ±0.01% of reading ±1 digit.

CIRCLE NO. 333

Pulse gen emphasizes clean waveforms



E-H Research Laboratories, 515 11th St., Box 1289, Oakland, CA 94604. (415) 834-3030. $2195.

Clean waveforms are the most important feature of the Model 137A pulse generator, with distortion of less than 5% peak-to-peak. Other key specs include a rep rate of 10 Hz to 125 MHz, rise and fall time variable from less than 2 ns to more than 160 μs, amplitude of ±5 V into 50 Ω, ±10 V into an open circuit.

CIRCLE NO. 334

Tester self-programs, tests boards in 6 s

Faultfinders, Inc., 15 Avis Dr., Latham, NY 12110. (518) 783-7786. Under $20,000.

SHORTFINDER FF202 is a self-programming system that tests loaded PC boards, isolates shorts and opens, and prints out data for circuit repair. Programs are derived from a known good board and may be stored in a mag tape cassette. Microprocessor-controlled, the FF202 can generate a test program for a typical board in 6 m and test it in 6 s. The unit can also check the integrity of bare PC boards, testing for shorts, continuity, opens and leakage between circuit paths.

CIRCLE NO. 335

Sweeper covers 0.1 to 120 MHz in one band

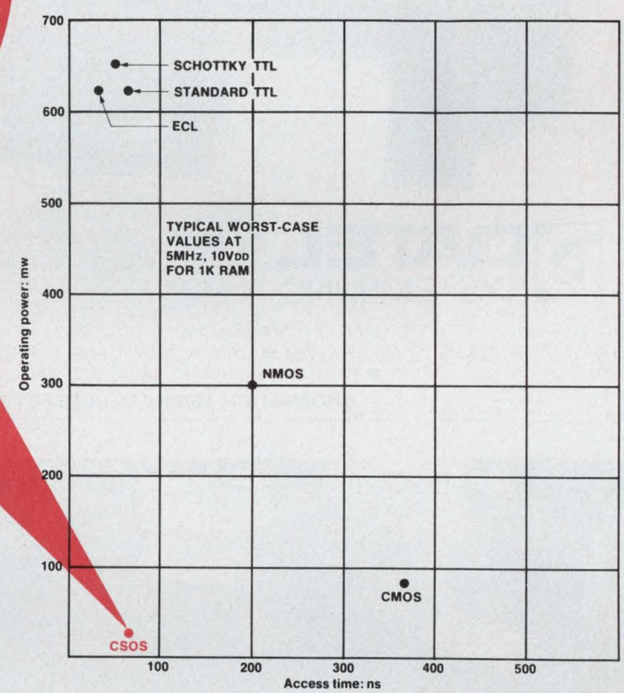
Telonic Altair, 2825 Laguna Canyon Rd., Laguna Beach, CA 92652. (714) 494-9401. From $1075; 6 wks.

Model 1202A sweep generator covers a full 100-kHz to 120-MHz range in a single band. Attenuation at 50-Ω impedance is 100 dB in 1-dB steps and 80 dB at 75 Ω. The unit combines a complete sweep oscillator system with accurate output attenuators, and up to seven crystal-controlled frequency markers, single or harmonic, in a compact housing. The instrument measures only 7 × 9 × 13 in. Flatness is ±0.25 dB.

CIRCLE NO. 336

The designer's dream memory.

SOS RAMs are here.



From Solid State Scientific.

Speeds as fast as Schottky TTL. Access time is less than 100 nsec. Typical values from our production measure 50-80 nsec.

Low drain. Typical operating power is 5 mw. No more need to trade-off power for speed. Battery back-up needs only two volts to store data.

Fully static. No need for refresh circuitry.

Attractive prices. Our manufacturing process, developed specifically for CSOS, has high yield and fewer steps than bulk silicon processing, so we can offer lower prices.

First of our CSOS RAM line, now in volume production, is a 256 bit device that is pin compatible with comparable bipolar and n-channel MOS RAMs.

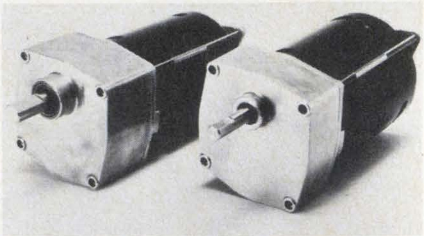
Soon to come are 1024 bit RAMs, both 1024 x 1 and 256 x 4. Ask us for prices and specs. You'll be pleasantly surprised.

And look for future CSOS developments from Solid State Scientific: more RAMs, quad switches, and the most advanced microprocessors.

SOLID STATE SCIENTIFIC INC.
Montgomeryville, Pa. 18936/(215) 855-8400/TWX 510-661-7267

INFORMATION RETRIEVAL NUMBER 72

Gear motor features oil or grease-filled case



Molon Motor & Coil Corp., 3737 Industrial Ave., Rolling Meadows, IL 60008. (312) 259-8700.

A heavy-duty 1/10 or 1/15-hp reversible-gear motor, Model EM5, is 3-3/8-in. square by 6-in. long with a parallel-shaft design to make it interchangeable with existing Molon lines. The gear case is available in two versions—oil filled or grease filled. The oil-lubricated version, recommended for high-torque loads, uses heavy-duty needle-roller output bearings, wide-faced hardened-steel gears and has a 1/2-in. shaft diameter. Output speeds from 8 to 300 rpm and torques through 75 lb-in. are available. The grease-filled version is recommended for light output loads. The case is grease lubricated and the unit has porous-bronze bearings and a 3/8-in. diameter output shaft. Output speeds are from 70 to 300 rpm.

CIRCLE NO. 337

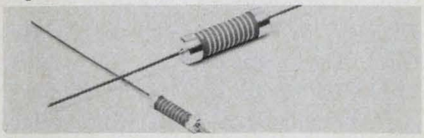
WW resistor/fuse safe with 1000 times overload

TRW Inc., 401 N. Broad St., Philadelphia, PA 19108. (215) 922-8900. $0.15: 5% tolerance, $0.115: 10% (100 up); stock.

Wirewound resistor, the BW-20F, has predictable overload fusing characteristics and remains flame-proof under fault conditions up to 1000-times rated power. Maximum rated voltage is 1000 V. The new resistor has a 1-W rating in a 1/2-W size and is available in 0.1-Ω to 1-kΩ resistance values with tolerances of ±5% and ±10%. It offers the circuit designer savings by elimination of the need to use both resistors and fuses, and in some cases also thermistors or diodes.

CIRCLE NO. 338

Semiprecision resistors operate at 200 C

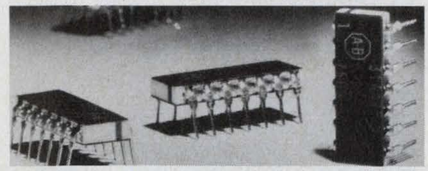


American Components, Inc., RPC Div., Eighth Avenue at Harry St., Conshohocken, PA 19428. (215) 825-6200. $0.28 to $1.50; stock to 8 wks.

A family of semiprecision resistors for high-temperature operation is noninsulated and can operate in standard and inert atmospheres, and also in oil and vacuum applications. Construction is completely inorganic, and there is no outgassing. The resistors, ACI Type HVW, have ratings of 0.5 through 2.6 W at 200 C. Deratings are to 350 C. The voltage range is 3.5 to 15.0 kV, depending on resistor type. Standard tolerance is 5%, and tighter tolerances are available. Resistance range coverage is from 1 kΩ to 1000 MΩ. Resistor lengths vary from 0.6 to 2.075 in. and diameters from 0.14 to 0.275 in.

CIRCLE NO. 339

DIP resistor networks in ceramic package



Allen-Bradley, 1201 S. Second St., Milwaukee, WI 53204. (414) 671-2000. Stock to 6 wks.

A new ceramic package for thick-film DIP resistor networks provides higher power ratings and larger resistance values than previously available. In addition, external solder joints permit easy visual inspection. These I-DIP networks can be factory-adjusted to a predetermined tolerance or designed for functional calibration by the user. The new package also provides a color-coded identification stripe—blue for 14-pin, green for 16—for quick package orientation. A-B distributors offer 347 standard networks, which include six new circuit configurations, an expanded resistance range and pull-up/pull-down termination networks from 22 Ω to 100 kΩ.

CIRCLE NO. 340

V3 case houses Hall-effect switch

Micro Switch, 11 W. Spring St., Freeport, IL 61032. (815) 232-1122. $1.50 (OEM qty).

Micro Switch's new Hall-effect XL line of solid-state miniature switches is compatible with the firm's traditional V3 switch configuration. A 0.050-in. IC is actuated by a plunger-driven magnet. There are no contacts and the output is bounce free. The circuit allows the use of an unregulated 6-to-16-V-dc power supply. Temperature range for the new line is from −40 to 100 C. The XL is available with either current-sinking or current-sourcing outputs, and it can be used directly with most electronic circuits, according to Micro Switch.

CIRCLE NO. 341

INFORMATION RETRIEVAL NUMBER 75

INFORMATION RETRIEVAL NUMBER 76

DATA PROCESSING

Floppy-disc storage imitates paper tape

Tri-Data Corp., 800 Maude Ave., Mountain View, CA 94043. (415) 969-3700. See text, stock.

The FlexiFile 10 is a floppy-disc system that mimics paper tape. Plug-compatible with most current readers and punches, the FlexiFile 10 reduces the time required to load long programs and offers random access to any track on the disc. The unit has both read and write capability, thus enabling replacement of both paper-tape reader and punch with a common system. Selection of read or write operation is from the front panel. The flexible disc used is a Memorex FD V or equivalent with a capacity of 192 bytes/sector, 3072 bytes/track (16 sectors) and 98,304 bytes disc (32 tracks). The transfer rate is 1 to 40 kbytes/s asynchronous at 100 rpm.

CIRCLE NO. 342

Processor faster than microprocessor

Display & Decision Systems, Ltd., 80 Galaxy Blvd, Unit 11, Rexdale, Toronto, Canada M9W 4Y8. (416) 678-7525. $880 (unit qty).

The Extra-80 is a new processor compatible with Intel's 8080 but it has a higher speed and more instructions. The approximate speed of an 8 × 8-bit multiply is 3 μs. This is approximately 40-times faster than the 8080. The new processor uses LSI Schottky bipolar 3000 logic and is available on an 8 × 9-in. board with an 86-pin connector. Additional features include a 5-V supply, three-state outputs, a 10-TTL load capability and TTL-compatible inputs. User specified op codes available at a nominal fee.

CIRCLE NO. 343

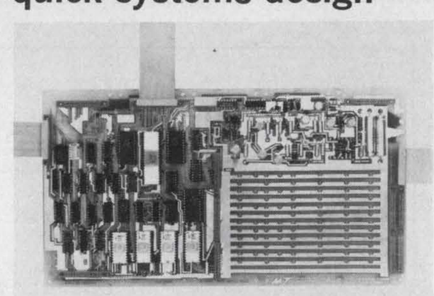
Semi ROM is nonvolatile and easily altered

Plessey Microsystems, 1674 McGaw Ave., Santa Ana, CA 92705. (714) 540-9945. See text; 30 days.

More efficient than ultraviolet-erasable PROMs, the PM-1000 is designed for applications that require frequent or periodic program changes. The PM-1000 uses MNOS storage devices and achieves a write time of 11 ms, read time of 3.5 μs and access time of 2.0 μs. Capacity is expandable in increments of 256 × 4 to 1024 × 16. Memory data are erasable in 100 ms and can be rewritten without removal of the memory card from the user's system. The PM-1000 provides unpowered data retention for up to 10 years. Sold in two basic configurations, the prototype version is equipped with programming aids, and the bare version is for volume applications. A 1 k × 16 unit sells for $1000 in quantity.

CIRCLE NO. 344

CPU wired on board for quick systems design

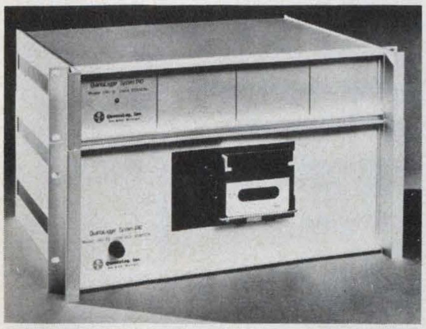


Mycro-Tek, Suite 214, 6631 E. Kellogg, Wichita, KS 67207. (316) 686-3311. See text.

A general-purpose microcomputer on a single board costs less than $600 in quantity. The board has a large wrapped-wire section to allow tailoring to a wide range of microcomputer applications. Called the MT 8080 PB, the single board is built around an Intel 8080 CPU and includes clock generator, power inverter, bus interface, timing logic and provisions for 1k × 8 PROM memory. The over-all size of the board is 7-1/2 × 13-1/2 in., and it is Augat frame-compatible. An on-card power inverter allows the system to be operated from a single 5-V power source to reduce system costs further.

CIRCLE NO. 345

Master/slave acquisition system is local & remote



Quantalog, 42 Enterprise Dr., Ann Arbor, MI 48106. (313) 769-4936. From $5000; 15 to 60 days.

Model 1740/C is a data-acquisition instrument capable of local or remote acquisition, processing and storage. A control station manages 16 channels plus any number of slaves; total capacity is 256 channels. The control uses programmable MOS memory and cassette recorder storage. It contains an a/d converter and 16-channel multiplexer. Slaves report to the master via 8-bit ASCII data by direct wire link, radio or phone line.

CIRCLE NO. 346

CMOS memory includes standby battery supply

Monolithic Systems Corp., 14 Inverness Drive East, Englewood, CO 80110. $1160 (unit quantity); 4 wks.

Monostore IX/Planar is a CMOS nonvolatile memory system with a battery backup. The system is designed around a 1024 × 1 CMOS static RAM. A single board provides up to 4-k × 8-bit word capacity, and several boards can be combined for 64-k, 8-bit words on the same bus. Access and cycle time are 450 ns, and input and output levels are TTL-compatible. Each memory board includes timing, control, module decode and address register, input and output data register, backup battery and memory array. A single +5-V-dc supply powers the board. Standby power of +3.25 V dc at 120 μA is supplied by the battery. The backup battery has a 450 mAh capacity and is rechargeable at a rate of 45 mA/hr. Board dimensions are 7.475 × 10.78 in. and total weight is 0.75 lb.

CIRCLE NO. 347

Smart calculator has low price tag

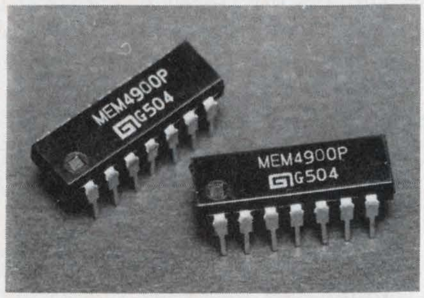
Tektronix, P.O. Box 500, Beaverton, OR 97005. (503) 644-0161. $2495; stock.

The E31 calculator retains many of its predecessor's features but costs $355 less. Like the basic 31, it has 512 program steps and 74 data registers. The memory of the E31 can be expanded to 8192 program steps and 256 data registers (Option 10), or to 2048 program steps and 1000 data registers (Option 8), or a combination of both. A magnetic tape cartridge is provided for programs or data, adding even more memory without detracting from the machine's internal memory. The calculator has user-definable overlays and 24 user-defined keys for special programs.

CIRCLE NO. 348

INTEGRATED CIRCUITS

CMOS driver/converter handles 4 channels



General Instrument Corp., 600 W. John St., Hicksville, NY 11802. (516) 733-3036. $1.90 (1000).

The MEM 4900 CMOS four-channel driver and bidirectional voltage level-converter features TTL compatibility and provides logic operations via a "chip enable" control. Output-signal swings up to 15-V pk can be generated by input amplitudes of 0 to 3 V. Other features include quiescent power of typically 2.5 µW, output capacitance of 8 pF, propagation delay of 180 ns and response to 5 MHz.

CIRCLE NO. 349

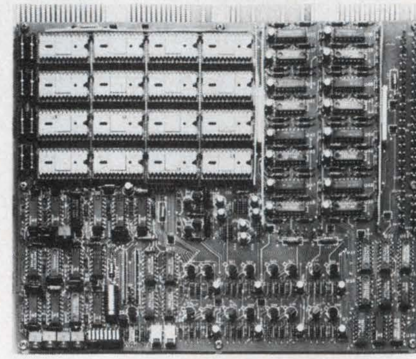
Program this logic array in the field

Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $25.00 (100-999).

A field-programmable logic array, the IM5200, has 14 inputs and eight outputs. The electrically programmable array has a total of 48 product terms, provides a complexity of more than 480 four-input logic gates and uses the company's avalanche-induced migration process. The IC comes in a 24-pin Cerdip and is pin compatible with the 7576 mask-programmable logic array. The new FPLA uses a single 5-V supply. Typical propagation delay is 65 ns.

CIRCLE NO. 350

MNOS ROMs boost board densities

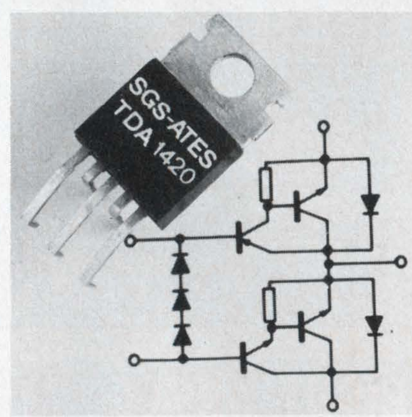


Plessey Microsystems Inc., 1674 McGaw Ave., Santa Ana, CA 92705. (714) 540-9945.

A nonvolatile, electrically alterable ROM, the PM-1000, permits storage capacities in increments of 256 × 4-bits up to 1024 × 16 bits on a single 8 × 10-in. card. Using MNOS technology, the PM-1000 has a write time of 11 ms, a read time of 3.5 µs and an access time of 2.0 µs. Memory data are erasable in 100 ms and can be rewritten without removing the memory card from the system. The PM-1000 provides unpowered data retention for up to 10 years.

CIRCLE NO. 351

Darlington IC delivers 3 A



SGS-ATES Semiconductor Corp., 435 Newtonville Ave., Newtonville, MA 02160. (617) 969-1610. $1.60 to $2.00 (100 up).

A quasi-complementary Darlington pair, the TDA1420, comes with associated biasing system in a Pentawatt—five lead TO-220—package. Each Darlington can deliver a current in excess of 3 A and can withstand a supply voltage of 44 V. Also available is a 36-V version, the TDA1410.

CIRCLE NO. 352

0.1-to-1-GHz linear amp delivers 6-W

Microwave Power Devices Inc., Adams Court, Plainview, NY 11803. (516) 433-1400.

The Model LWA110-6, a class-A power amplifier, operates over the frequency range of 100 to 1000 MHz with a 900-MHz bandwidth, and it provides a power output of 6 W at 1-dB compression and saturated power output of 10 W. Other features include a gain of 46 dB, harmonics of −20 dB minimum, intercept point of +48 dBm and gain flatness of ±1 dB. The unit has a 9-dB noise figure, and it operates from a 24-V supply, drawing 4.5 A.

CIRCLE NO. 353

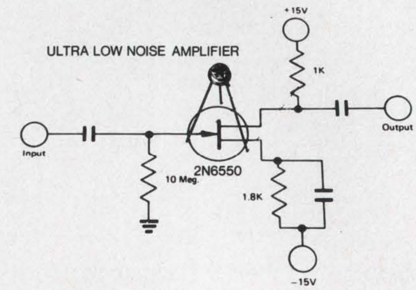
Rf front end aims for compact radars

Engelmann Microwave Co., Skyline Dr., Montville, NJ 07045. (201) 334-5700.

The Model AY-93 rf front end for collision-avoidance applications contains three microstrip boards on Duroid and a cavity-type oscillator. The unit's specifications include an input frequency of 1607 MHz and output frequency of 60 MHz. Gain is 7 dB minimum and noise figure, with one antenna port terminated, is 12.5 dB maximum. LO frequency is 1547 MHz ±2 MHz and image reradiation is −35 dBm. The unit lists a transmitter power of 1 kW pk.

CIRCLE NO. 354

Low noise FET designed for transducers



Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. (617) 491-1670. $10 (100-up); stock.

The 2N6550 is an ultra-low-noise n-channel JFET. It is designed for use at the front end of low frequency amplifiers and in transducer applications. The device has a noise figure of only 2 $nV/\sqrt{Hz}$ at 1 kHz, and has an I_{DSS} that can span 10 to 250 mA.

CIRCLE NO. 394

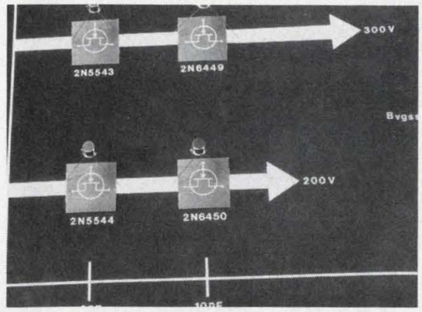
Schottky diodes cover 100 MHz through X-band

Microwave Associates, South Ave., Burlington, MA 01803. (617) 272-3000. From $9.23 (100-up); 4 to 6 wk.

Two series of broadband Schottky diodes in stripline packages are designed for use in MIC, stripline and microstrip—for frequencies from 100 MHz through X-band. These diodes, which are also available as matched pairs, have good conversion efficiency. The MA-40060 series is for up-converter applications; the MR-40080 series, for modulator use. The miniature stripline package (MA Style 137) is plastic coated to protect the diode from shock and abrasion. Its gold plated copper leads provide transmission to the diode, which is in series with the line. The leads can also be soldered per MIL-STD-202, method 208, with a maximum solder temperature of 230 C for 5 s. The package has a capacitance of 0.05 pF. All models are rated for 100 mW rf cw power, and 4 W rf peak pulse power at 25 C.

CIRCLE NO. 395

N-channel FETs handle up to 300 V loads

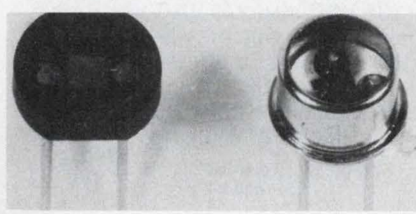


Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. (617) 491-1670. From $2.40 (100-up); stock.

Four high voltage n-channel FETs are available in TO-39 packages. Two of the new devices, the 2N6449 with a gate breakdown voltage rating (BV_{GSS}) of 300 V min. and the 2N6450 with a BV_{GSS} rating of 200 V min., are capable of dissipating 5 W. The other two units, the 2N5543 at 300 V min. and the 2N5544 at 200 V min., are similarly rated except for extremely low reverse transfer capacitance, 2 pF, when measured at 1 MHz.

CIRCLE NO. 357

Low leakage photodiodes have currents of 20 pA



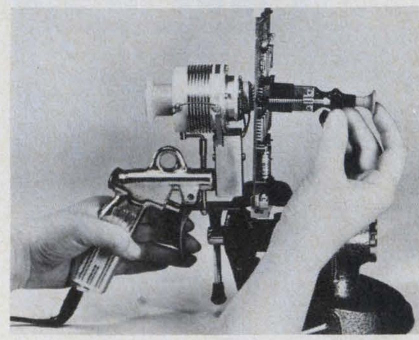
Vactec, 2423 Northline Industrial Blvd., Maryland Heights, MO 63043. (314) 872-8300. From $1.50 (1000-up).

The VTB series of ultra-low leakage photodiodes is intended for use in the short circuit photovoltaic mode. Applications include calorimetric analytical instruments as well as photographic and illumination measuring instruments. Characteristics include reverse leakage current of less than 20 pA at −0.1 V, for a 100 mil square chip, and less than 10 pA for a 60 mil square chip. The diodes have a spectral response at 400 nanometers of typically 35% and are available with or without an integral infrared cutoff filter.

CIRCLE NO. 358

PACKAGING & MATERIALS

IC desoldering tool cleans PC-board holes



Micro Electronic Systems, 8 Kevin Dr., Danbury, CT 06810. (203) 746-2525. $295; stock.

The Remove-A-DIP IC desoldering station combines the heating element, the removal tool and the cleaning of the PCB holes into a single action system. The tool is light and includes a handheld vacuum system. The vacuum chamber is evacuated prior to desoldering and at the end of the desoldering period is released by the trigger on the pistol grip, sucking the solder out of the PC-board holes. A DIP removal operation is less than one minute and the DIP is usable for further test or reuse.

CIRCLE NO. 359

Fused power-connector has see-through cover

Corcom, 2635 N. Kildare Ave., Chicago, IL 60639. (312) 384-7400. From $5.95 (list); stock.

The Models 6J1 and 6J4 voltage selecting fuse connectors are designed for the manufacturer who markets his product worldwide. The unit eliminates the need for internal wiring changes and special power supplies. The connector can handle currents of up to 6 A and uses type 3AG fuses. Only one rectangular panel cut-out is required and spring actuated mounting tabs eliminate the need for mounting hardware regardless of panel thickness. The fuse and voltage selector card are enclosed behind a see-through cover, which cannot be removed until the power cord is removed from the equipment. This provides complete safety when changing fuses or selecting new operating voltages. The connector is also available with an RFI power line filter.

CIRCLE NO. 360

Application Notes

Phase sequence indicator

Component selection, construction and operation of an inexpensive, portable phase sequence indicator are discussed in Tech Tips 5-4. Westinghouse Electric, Semiconductor Div., Youngwood, PA

CIRCLE NO. 361

SCR handbook

A 528-page handbook incorporates state-of-the-art applications information for silicon controlled rectifiers. The handbook is illustrated with circuit schematics, performance curves and photos. Appendices include a glossary of symbols and terms and a review of device specifications. Price is $3. International Rectifier, 233 Kansas St., El Segundo, CA 90245

INQUIRE DIRECT

Antenna measurements

"Basic Antenna Measurements," a 12-page booklet, discusses antenna pattern, directivity, gain and polarization measurements. Coordinate systems and the important factors in setting up an antenna range are included. Scientific-Atlanta, Atlanta, GA

CIRCLE NO. 362

Thermoplastics

A "Rigid Foam Designers Handbook" outlines the advantages of rigid foam, gives comparative properties and details specifications. FCM Div., Gulf & Western Manufacturing, Grand Rapids, MI

CIRCLE NO. 363

FM data gathering

Problems encountered when recording large quantities of FM multiplex data on multitrack instrumentation recorders are discussed in a booklet. Head configuration drawings and block diagrams illustrate the problems and their possible solutions. EMR-Telemetry, Sarasota, FL

CIRCLE NO. 364

X-ray diffraction system

A new and simple method for quantitative analysis of lead sulfate accumulations in automobile catalytic converters is described in an application note. Ortec, Oak Ridge, TN

CIRCLE NO. 365

Flexible discs

Hard-sector formatting for flexible disc drives is described in a 12-page bulletin. Formulas are given and discussed for timing factors, computing sector and speed tolerances and computing the size of the data field. Pertec, Chatsworth, CA

CIRCLE NO. 366

Waveguide breakdown

"The Effects of System Waveguide Breakdown on Crossed-Field Devices," a 20-page booklet, discusses the pulse length, pressure, altitude, VSWR, duty factors and other characteristics on the reliability and life potential of the devices. Varian, Beverly Div., Beverly, MA

CIRCLE NO. 367

INFORMATION RETRIEVAL NUMBER 87

INFORMATION RETRIEVAL NUMBER 88

New Literature

Power supplies

Modular, encapsulated power supplies are described in a 12-page catalog. Included with each catalog is an introductory offer. A coupon is provided that enables the customer to buy any two power supplies and get a third one free. Calex Manufacturing Co., Pleasant Hill, CA

CIRCLE NO. 368

Illuminated lamps

Specifications and ordering information on lighted pushbutton switches, indicators, lamps, sockets and rear-projection indicators are listed in a 20-page catalog. Compu-Lite, Irvine, CA

CIRCLE NO. 369

Programmable controllers

Programmable controllers are featured in a 12-page catalog. Photos, tables and specs are included. CIT-ALCATEL, 92120 Montrouge, France

CIRCLE NO. 370

Noise, vibration analyzers

Portable analyzers suited to analysis of sound and vibration data under field conditions are highlighted in an eight-page brochure. B & K Instruments, Cleveland, OH

CIRCLE NO. 371

Gaussmeters

Three data sheets give practical information on the use of gaussmeters. F.W. Bell, Columbus, OH

CIRCLE NO. 372

RFI/EMI filters

More than 100 RFI/EMI filters are featured in a brochure. RtroN, Skokie, IL

CIRCLE NO. 373

Production furnaces

The design, engineering and construction of production furnaces and equipment are illustrated in a 12-page brochure. Watkins-Johnson, Scotts Valley, CA

CIRCLE NO. 374

Sweep generators

Five low-cost, solid-state sweep/signal generators capable of covering frequency ranges to 1500 MHz are described in a 12-page brochure. Telonic Altair, Laguna Beach, CA

CIRCLE NO. 375

10-A gp relays

Fully illustrated, a two-page bulletin provides outline and mounting dimensions and specifications and coil data for 10-A general-purpose relays. North American Philips Controls, Cheshire, CT

CIRCLE NO. 376

Electronic enclosures

Modular electronic enclosures are featured in an eight-page catalog. Ingersoll Products, Chicago, IL

CIRCLE NO. 377

Conformal coatings

Photos, tables and graphs illustrate a 16-page conformal coating catalog. Union Carbide, New York, NY

CIRCLE NO. 378

Software

Features and capabilities of the Real-Time Executive operating software, RTE-III, are described in a 20-page booklet. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 379

Multipoint recorder

A 16-page bulletin, "Multipoint Recorder with Thermal Matrix Printing," details print pattern programming, print/skip channel format, alarms and how the recorder's servo mechanism provides even printing and fast response. Esterline Angus, Indianapolis, IN

CIRCLE NO. 380

Data comm monthly

What mother never told you about Bell's Digital Dataphone Service (DDS) is the subject of a new monthly publication for people involved with on-line data-communication networks. Intertel, Burlington, MA

CIRCLE NO. 381

Standard systems

A 20-page catalog describes standard models based on the System 390 automatic test systems. Diagrams and photographs illustrate various sections. Instrumentation Engineering, Franklin Lakes, NJ

CIRCLE NO. 382

Vendors Report

Annual and interim reports can provide much more than financial-position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

The Bendix Corp. Automotive electronics and aerospace.

CIRCLE NO. 383

Data General. Computers.

CIRCLE NO. 384

Celesco. Aerospace and underwater research, defense systems, industrial process control, environmental quality control and automated arc welding.

CIRCLE NO. 385

Fluke. Test and measurement instruments.

CIRCLE NO. 386

Pertec. Computer peripheral equipment.

CIRCLE NO. 387

Gulf & Western. Natural resources, automotive replacement parts, manufacturing and consumer products.

CIRCLE NO. 388

Penril. Data communications and test equipment.

CIRCLE NO. 389

Comtech. Satellite communication earth stations and subsystems and communications products and systems.

CIRCLE NO. 390

Analog Devices. ICs, interface products and DPMs. An 18-page report, "Structural Changes and New Opportunities in the Electronics Industry," is also available.

CIRCLE NO. 391

recruitment and classified ads

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Advertiser's Index

**Advertisers in non-U.S. edition.*

quick ads

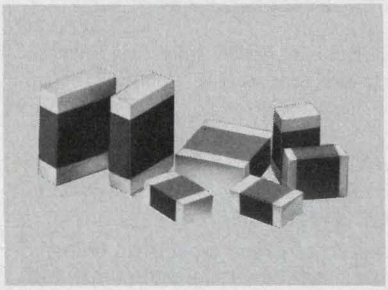
New and current products for the electronic designer presented by their manufacturers.

New crimp type miniature coaxial connectors. Straight cable plugs and jacks, can be crimped with standard tool. Connectors compatible with SMA types cost considerably less. Available in gold or copper plated brass bodies, teflon insulators, beryllium center contacts. E. F. Johnson, Co., Waseca, Mn., 56093, Dept. EP-9 (612) 835-5222

COAXIAL CONNECTORS **601**

Solid State Digital Power Line Monitor is ideally suited for use with power generation equipment, computer systems, control panel installation labs where power sources must be monitored for assuring test equipment accuracies. Four models available. From $129 ea. Electro Industries, P.O. Box 3542, No. New Hyde Park N.Y. 11040. (516) 621-6652

POWER LINE MONITOR **604**

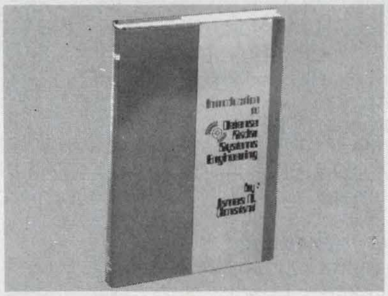


HIGH Q MULTILAYER CAPACITORS feature very high quality factors at microwave frequencies. Offered in three standard sizes: .050 x .040, .080 x .050, .125 x .095. Capacitance values from 0.1 pf to 1000 pf with close tolerance and voltages to 1000 VDCW. Johanson/Monolithic Dielectrics Div., Box 6456, Burbank, Ca. 91510, (213) 848-4465.

MULTILAYER CHIP CAPACITORS **607**

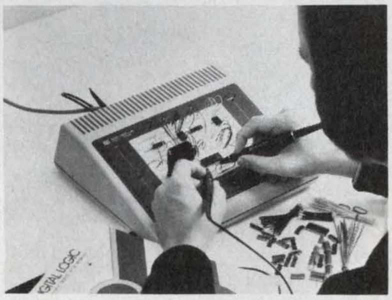
Free catalog of 34,500 power supplies from the worlds largest manufacturer of quality Power Supplies. New '74 catalog covers over 34,500 D.C. Power Supplies for every application. All units are UL approved, and meet most military and commercial specs for industrial and computer uses. Power Mate Corp. (201) 343-6294.

POWER SUPPLY **602**



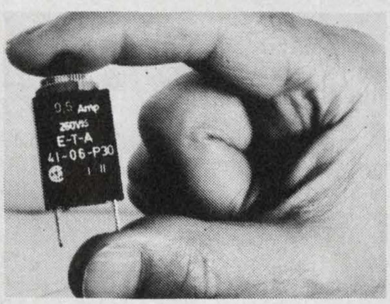
Introduction To Defense Radar Systems Engineering. Excellent introduction and practical reference to radar systems design and applications. #9194, 260 pp., $22.95. Circle the Info Retrieval No. to order 15-day exam copy. When billed, remit or return book with no obligation. Hayden Book Co. 50 Essex St. Rochelle Park, N.J. 07662

RADAR SYSTEMS **605**



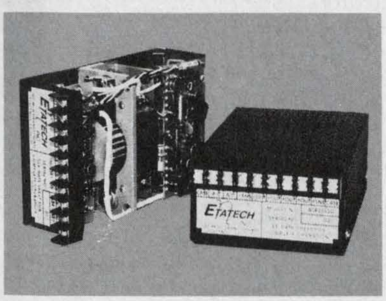
COMPLETE, INDUSTRIAL-QUALITY IC course-Model 5035T comes with text & workbooks, parts, fully-decoded LED numeric displays, and interconnecting wires. Handy proven HP Probe, Pulser, and Clip included. HEWLETT-PACKARD 1501 PAGE MILL RD. PALO ALTO, CAL. 94304

IC COURSE **608**



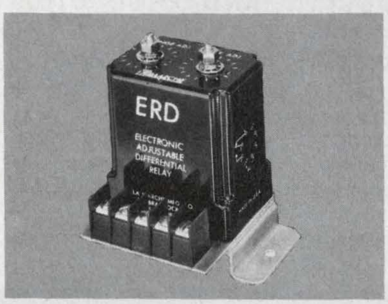
Overcurrent Protector, manual reset eliminates fuse replacement. Convenient panel mounting. 15 fractional ratings from 0.1 to 3 amp. Other models up to 400 amp. Trip-free and fool-proof, UL and CSA approved. High quality, low cost $1.29 ea. in 1000 lots. E-T-A Products Co. of America, 7400 N. Croname Rd., Chicago, Ill. 60648. Tel: (312) 647-8303. Telex: 253780.

CIRCUIT BREAKER **603**



ETATECH'S 100 WATT STITCHERS BREAK POWER DENSITY BARRIER: 2w/cu. in and 40w/lb. in an off-line, fully regulated module. The highly efficient (75% min. @ 5v) units are easy to cool (33w maz. loss). Excellent reliability of 71K Hrs. MTBF. Outputs 5 to 60VDC. ETATECH, INC. 187M W. Orangethorpe, Placentia, CA 92670 (714) 996-0981.

WATT SWITCHES **606**



New Model ERD & ERT (time delay) solid state dc relays for use with supervisory control equipment to initiate control. Nominal voltage: 6-250 vdc. Maximum reset time: 50 msec. Repeat accuracy: 0.1%. Also ac models. LaMarche Mfg. Co., 106 Bradrock Drive, Des Plaines, IL 60018 (312/299-1188).

ERD/ERT DC RELAYS **609**

Product Index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

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When you need a power supply to meet a specific need, don't start from scratch. We'll modify one of our custom jobs to work like it was made just for you.

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Our champions include the Model 502 switching design, 5VDC, 150 amp mini-computer supply that can function in master or slave mode in parallel operation. The Model 774 linear design bank terminal supply with a high power to cost ratio enabling throw-away replacement. The long lasting mini-CRT display supply. And the programmable voltage, multi-application guided missile system supply that delivers better than 2 watts per cubic inch at 75 percent-plus efficiency. Plus many more — there's one that fits your needs.

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You'll get the checkered flag every time.

NCR

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INFORMATION RETRIEVAL NUMBER 243

What's new in solid state...

RCA "Gold CHIP" LICs. Hermeticity in plastic at plastic prices.

Plastic LICs may have caused you some worries about field failures, actual or potential. But you didn't want to pay the price of ceramic or frit seal. Or, maybe the expensive hermetic packages you did use were damaged during insertion.

Now, the solution. RCA "Gold CHIP" linear integrated circuits. With gold metalization plus Chip Hermeticity In Plastic (CHIP). For reliability *plus* the economy and ruggedness of plastic.

Gold CHIP LICs have noncorroding gold metalization and leads. No aluminum with its potential problems. We make the chip itself hermetic. And put it in our advanced plastic package with proven outstanding reliability. Result: truly cost-effective hermetic LICs at the price of standard plastic LICs.

How reliable are they? We experienced *zero* failures in the following tests (data available): Temperature/Humidity/Bias, Operating Life, Thermal Fatigue, Pressure Cooker, Thermal Shock, Temperature Cycle.

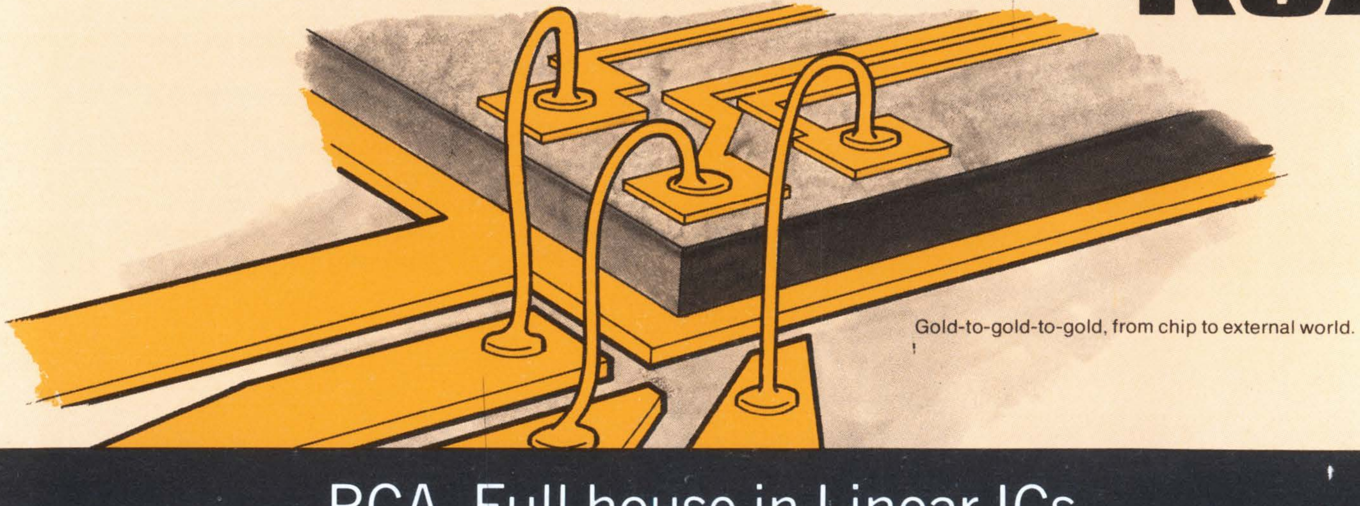
Free Gold CHIP Sample

Evaluate them yourself! We'll send you one of the 6 off-the-shelf "G" standards listed here, free: CA741CG op amp; CA747G dual op amp; CA324G quad op amp; CA339G quad voltage comparator; CA3724G high voltage transistor array; CA3725G high voltage transistor array. Just specify which one, on a self-addressed label.

To find out more, contact your local RCA Solid State distributor. Or RCA.

Write: RCA Solid State. Box 3200, Somerville, New Jersey 08876; Ste. Anne de Bellevue 810, Canada; Sunbury-on-Thames, U.K.; Fuji Bldg., Tokyo, Japan.

RCA



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