NOVEMBER 5, 1979 A CAHNERS PUBLICATION

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

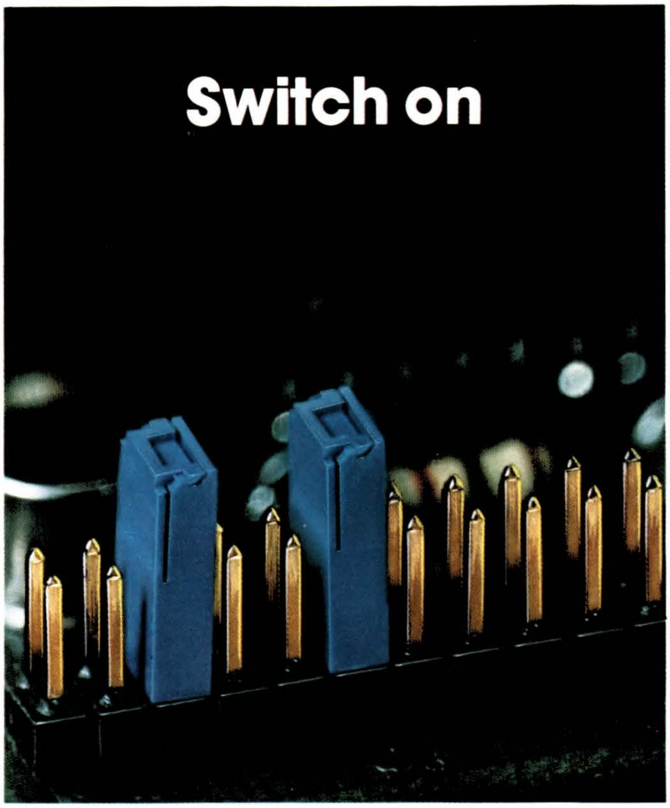
Switched-capacitor filters simplify analog designs

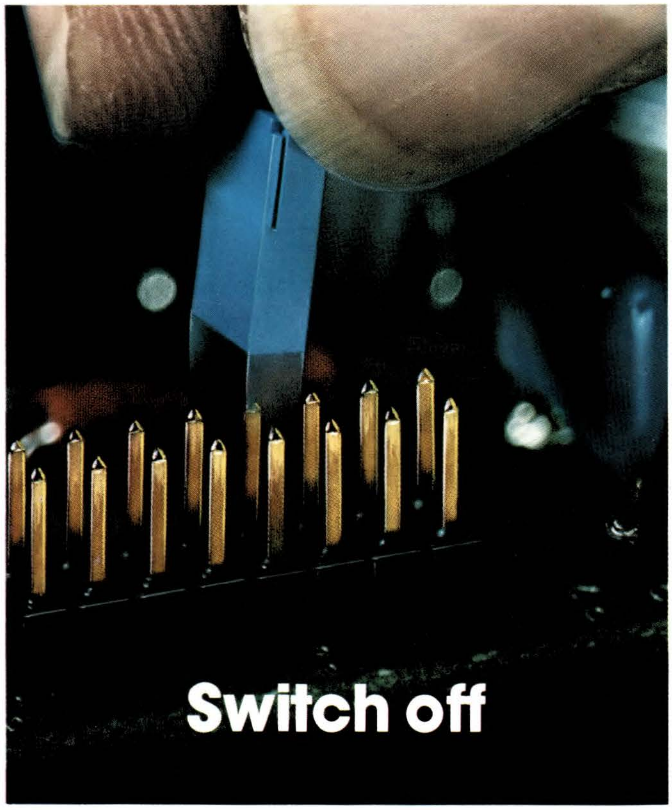
Don't court disaster in DTMF signaling systems

Effective management optimizes R&D productivity

Orchestrate versatile test & measurement systems with IEEE-488-compatible instruments

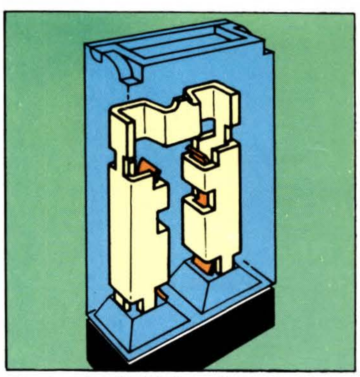
DIP switches can deprogram. Berg's Mini-Jump™ can't. Our design guarantees it.





Far more reliability. Far less field service. Accidents, vibration — anytime you'd expect a DIP switch to fail, you can count on Mini-Jump* to stay programmed. Careless fingers can't deprogram it because there's no switch to hit. Only a deliberate action can change the circuit.

The interior spring of the "Mini-Jump" maintains a high normal contact force for reliability during vibration — even severe vibration. And, because you install the "Mini-Jump" after soldering, you avoid contamination which can lead to corrosion.



Inside the "Mini-Jump", dual metal PV† contacts provide excellent electrical and mechanical performance.

Permits higher density packaging. The "Mini-Jump" is available in single position, stackable on 0.100", 0.125", 0.150" and 0.200" centers. Also in two positions on 0.100" centers and three and five positions on 0.150" centers.

Write for literature. The Du Pont Company, Berg Electronics Division, New Cumberland, PA 17070. Telephone (717) 938-6711.

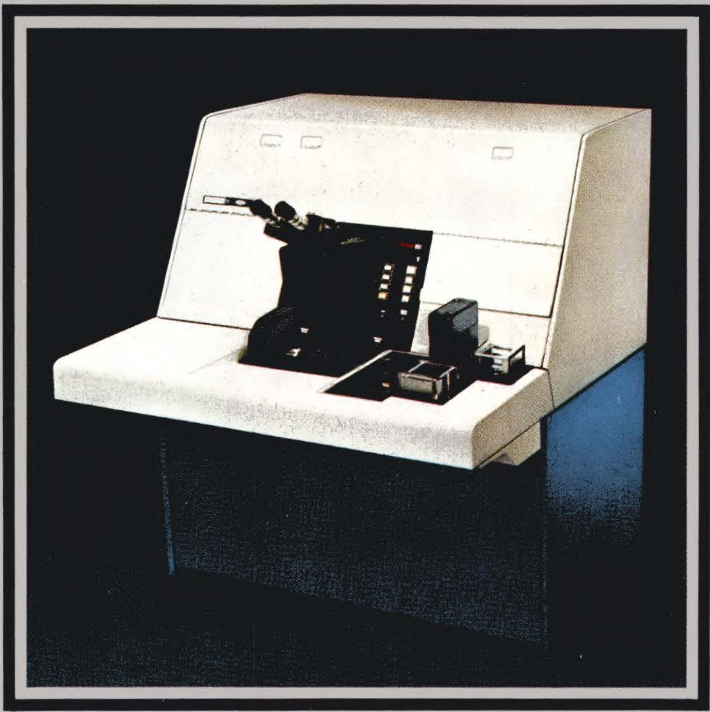
*Du Pont trademark for its .025" disconnect jumper.
†Du Pont trademark for its .025" dual metal female disconnect.

Berg Electronics

DU PONT
REG U S PAT & TM OFF

For more information, Circle No 1

Introducing the Micralign® 200 Series. Higher throughput than step-and-repeat at a much lower price.



Perkin-Elmer designed the new Micralign Model 200 to be the most cost-effective projection mask aligner available. In performance, it achieves 2-micron geometries or better in production, distortion/magnification tolerance of 0.25 micron, and 4 percent uniformity of illumination. Options available include automatic wafer loading and automatic alignment. Soon to be available: deep UV optical coatings for still smaller geometries.

Compared to the leading step-and-repeat aligner, the Micralign Model 200 delivers outstanding performance for not much more than half the cost. It takes about a quarter of the floor space. It provides consistently higher throughput regardless of die size.

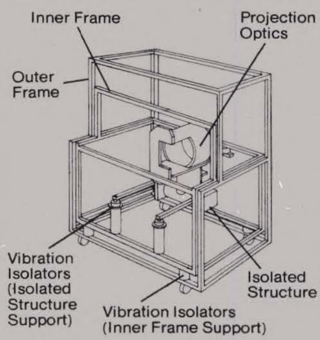
The Model 200's remarkable performance is the result of a number of major innovations.

Improved optical design and fabrication

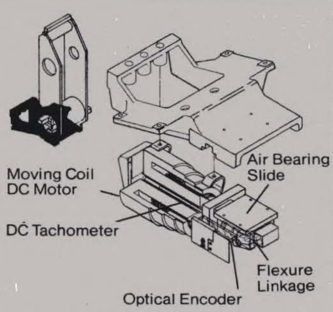
We improved the optical design to provide increased resolution and depth of focus. Optical manufacturing tolerances are five times tighter to ensure precise overlay from aligner to aligner.

Near-zero vibration

We minimized vibration. We constructed the Model 200 with two frames—one inside the other. The inner frame, which carries the projection optics and carriage drive, is completely isolated from the outer frame.

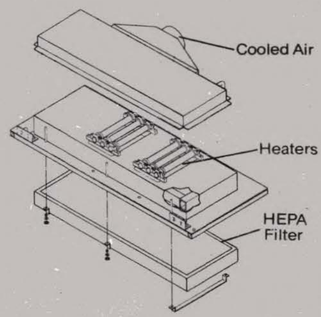


We incorporated a superb linear motor carriage drive with air bearing slide. This drive does more than eliminate vibration. With the air bearing feature there's no contact and no wear. And no limit to carriage drive durability.



Built-in environmental control

We provided the Model 200 with a built-in environmental chamber. External air, supplied by you or from our optional air conditioning system, is blown through a HEPA filter and heating elements built into the Model 200 top cover. A positive-pressure, class 100 environment is carefully controlled to better than 1°F.



We included a separate thermal control for the mask, to compensate for mask run-out.

No mask contamination

We designed a sealed mask carrier for the Model 200. You put the mask in the special carrier right in the mask department. Seal it. When you load the sealed carrier in the Model 200, the cover plates are automatically removed. After use, the cover plates are automatically replaced.

Proven production capabilities

Perkin-Elmer, the leader in projection mask alignment systems, offers six years of proven production capability, with an excellent training and service record.

Get all the facts

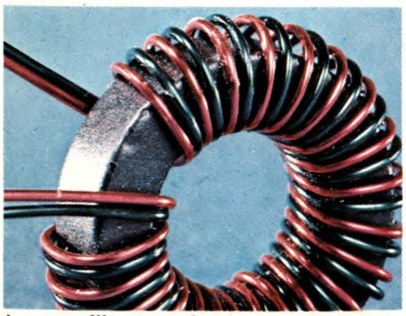
These are just a few of the features that make the Micralign Model 200 Series a completely new concept in projection mask aligners. Get more details on how these and other improvements in design can translate into improvements in your production. For literature, write Perkin-Elmer Corporation, Microlithography Division, 50 Danbury Road, Wilton, CT 06897. Or phone (203) 762-6057.

PERKIN-ELMER

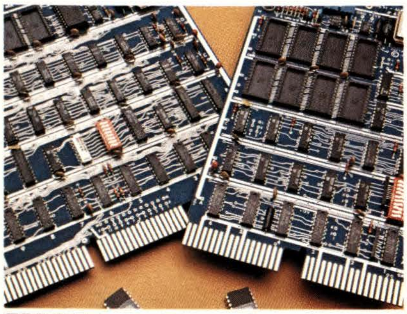
For more information, Circle No 3

EDN

NOVEMBER 5, 1979 ● VOLUME 24, NUMBER 20 ● EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



Low-profile transformers *satisfy pc-board-mounting needs (pg 43).*



EPROM-programmer boards *serve LSI-11s and PDP-11s (pg 81).*

On the cover: *The IEEE-488 bus allows you to configure instrument systems that make beautiful music. For more information, turn to pg 90. (Photo courtesy John Fluke Mfg Co Inc)*

DESIGN FEATURES

TECHNOLOGY NEWS

NEW PRODUCTS

DEPARTMENTS

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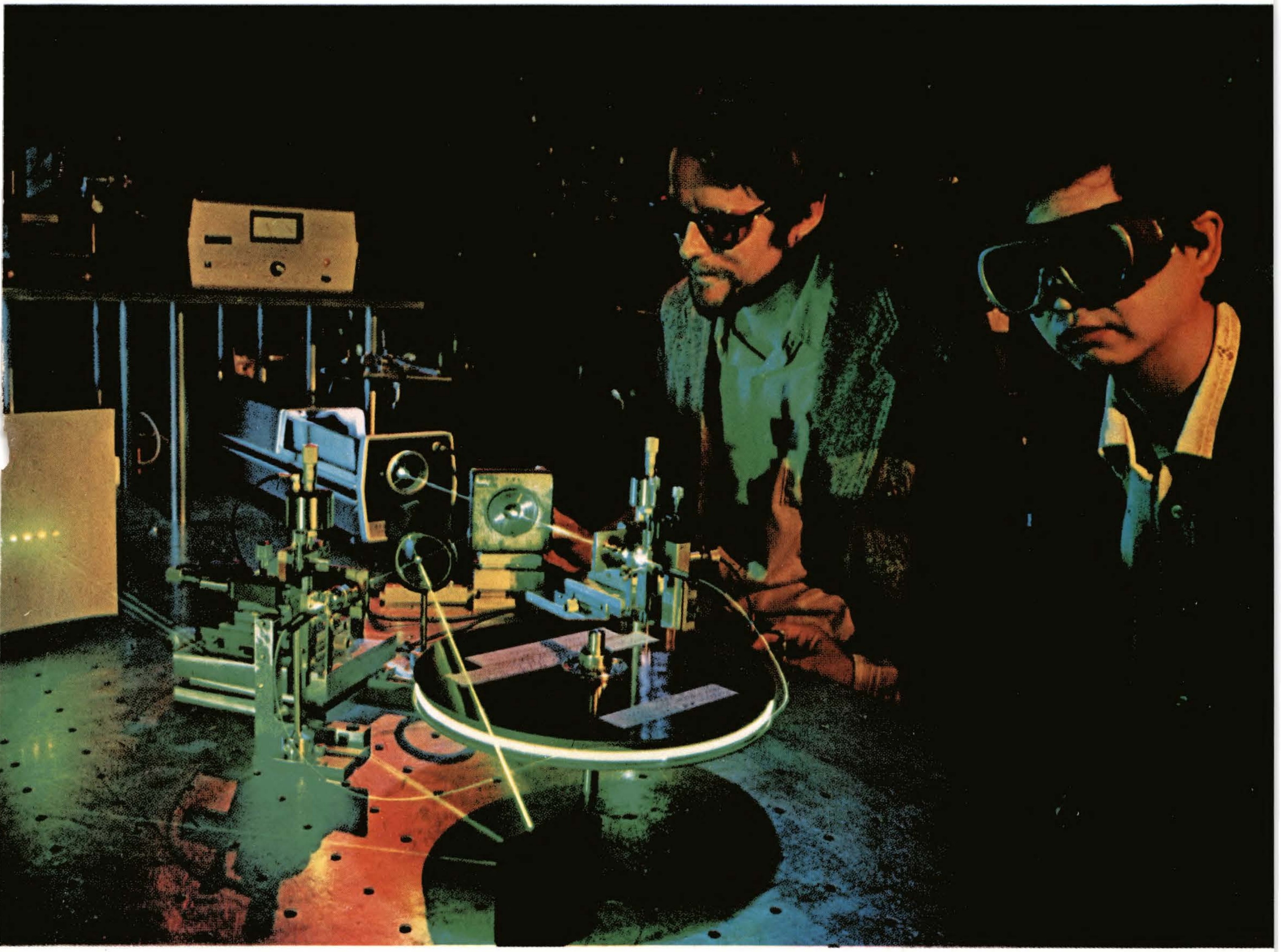
The longest in our long line of laser firsts...



Bell Laboratories
Murray Hill, New Jersey 07974

Bell Labs scientists Roger Stolen and Chinlon Lin work with a fiber Raman laser, one of a new class of light sources that use optical fibers—up to a kilometer long—to produce tunable laser light. At left, the laser's output—which contains multiple Raman-shifted wavelengths—is taken off a beam splitter and dispersed by an external grating to show the broad range of wavelengths that can be tuned.

Bell Labs has developed some of the world's most transparent glass fibers to *carry* light for communications. We've also devised a way to make these highly transparent glass fibers *generate* light. In fact, they are the basis for a new class of tunable light sources called fiber Raman lasers. They're among the latest, and by far the longest, of many lasers invented at Bell Labs, beginning in 1957 with the conception of the laser itself.

Since the new fiber lasers work best at wavelengths at which they are most transparent, we can make them very long. The longest active lasing medium ever built, in fact, was a fiber Raman laser over a kilometer in length. Studying the ways light and glass interact over such distances is part of our research in lightwave communications.

In these new light sources, a glass fiber with high transparency and an extremely thin light-guiding region, or core, is excited by a pump laser. The pump light, interacting with the glass, amplifies light at different wavelengths through a phenomenon known as stimulated Raman scattering. This light is fed back into the fiber by a reflecting mirror. If gain exceeds loss, the repetitively amplified light builds up and "lasing" occurs.

Fiber Raman lasers have conversion efficiencies of about 50%, operate in pulsed and continuous wave modes, and are easily tunable over a broad wavelength range in the visible and near infrared regions of the spectrum.

We've used these lasers to measure the properties of fibers and devices for optical communications; and studies of the lasers themselves have revealed a wealth of information on frequency conversion, optical gain, and other phenomena. Such knowledge could lead to a new class of optoelectronic devices made from fibers, and better fibers for communications.

Looking back

These long lasers come from a long line of Bell Labs firsts:

1957: The basic principles of the laser, conceived by Charles Townes, a Bell Labs consultant, and Bell Labs scientist Arthur Schawlow. (They later received the basic laser patent.)

1960: A laser capable of emitting a continuous beam of coherent light—using helium-neon gas; followed in 1962 by the basic visible light helium-neon laser. (More than 200,000 such lasers are now in use worldwide.) Also, a proposal for a semiconductor laser involving injection across a p-n junction to generate coherent light emitted parallel to the junction.

1961: The continuous wave solid-state laser (neodymium-doped calcium tungstate).

1964: The carbon dioxide laser (highest continuous wave power output system known to date); the neodymium-doped yttrium aluminum garnet laser; the continuously operating argon ion laser; the tunable optical parametric oscillator; and the synchronous mode-locking technique, a basic means for generating short and ultrashort pulses.

1967: The continuous wave helium-cadmium laser (utilizing the Penning ionization effect for high efficiency); such lasers are now used in high-speed graphics, biological and medical applications.

1969: The magnetically tunable spin-flip Raman infrared laser, used in high-resolution spectroscopy, and in pollution detection in both the atmosphere and the stratosphere.

1970: Semiconductor heterostructure lasers capable of continuous operation at room temperature.

1971: The distributed feedback laser, a mirror-free laser structure compatible with integrated optics.

1973: The tunable, continuous wave color-center laser.

1974: Optical pulses less than a trillionth of a second long.

1977: Long-life semiconductor lasers for communications. (Such lasers have performed reliably in the Bell System's lightwave communications installation in Chicago.)

Looking ahead

Today, besides our work with tunable fiber Raman lasers, we're using other lasers to unlock new regions of the spectrum in the near infrared (including tunable light sources for communications), the infrared, and the ultraviolet.

We're also looking to extend the tuning range of the free electron laser into the far infrared region—where no convenient sources of tunable radiation exist.

We're working on integrated optics—combinations of lightwave functions on a single chip.

Lasers are helping us understand ultrafast chemical and biological phenomena, such as the initial events in the process of human vision. By shedding new light on chemical reactions, atmospheric impurities, and microscopic defects in solids, lasers are helping us explore materials and processes useful for tomorrow's communications.

Also under investigation is the use of intense laser irradiation in the fabrication of semiconductor devices. The laser light can be used to heat selective areas of the semiconductor and anneal out defects or produce epitaxial crystalline growth. Laser annealing coupled with ion implantation may provide a unique tool for semiconductor processing.

We've played an important part in the discovery and development of the laser—an invention making dramatic improvements in the way our nation lives, works and communicates.

Technical for impatient

a. Torque test, axle bolt. Type 667 Coaterless film.
b. CRT graphic display. Type 084 film.
c. Interferometric evaluation of flat mirror with laser light. Type 57 High Speed 4 x 5 film.
d. Converter circuit inspection 700x, scanning electron microscope. Type 52 Fine Grain 4 x 5 film
e. Memory circuit, 100x. Type 665 Positive / Negative film.

photography people.

If you need photographs of our work, why sit around vaiting for them? With Polaroid instant photographic equipment you get immediate results.

Our wide range of equipnent lets you record everyhing from microbes to metal stress tests. With Polaroid self-developing films you can have professional quality esults in color in 1 minute, or n black and white (with or vithout a usable negative) in seconds. And our equipment s simple to use. So you can ake the photographs you need without needing to know a lot about photography.

The MP-4 Multipurpose camera (1) is a versatile, selfcontained photo studio anyone can operate. It uses 14 different Polaroid instant films o keep you out of the darkoom. And it copies, delivers close-ups, reductions, macrophotographs and photonicrographs, to bring your inswers to light.

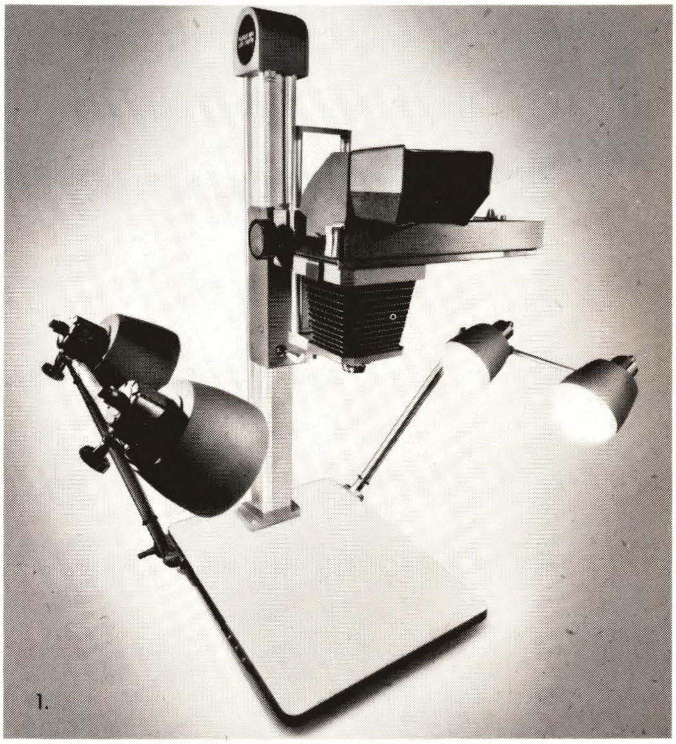
Our CU-5 Close-up camera 2) is a lightweight, hand-held system you can take almost anywhere and get instant photos from ¼ to 3 times life size. Exposure is easy to set, lighting is built in and framing is automatic. So all you have to think about is the picture. You can even use the CU-5 to capture a transient image on a cathode ray tube.

Many cameras and instruments can be adapted quickly and easily for instant photography with Polaroid film holders (3). They come in 3 models to handle 3 different sizes of Polaroid Land film (3¼ x 4¼, 4 x 5, and 8 x 10 in.), so you can get instant results in almost any format.

Many other manufacturers of cameras and instruments also supply Polaroid Land camera backs that adapt their equipment to instant photography. These backs use 9 different convenient Polaroid pack films, so you can see your project in a new light.

To find out how you can get instant results, mail the coupon below. Or if you're a *very* impatient person, call us toll-free from the continental U.S. at 800-225-1618 (from Massachusetts, call collect 617-547-5177).

And stop tapping your foot while you wait for your photos to come back from the lab.



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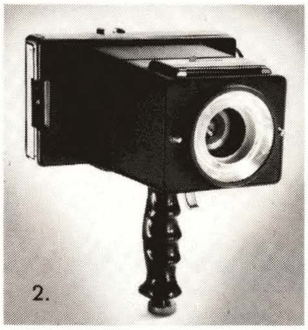

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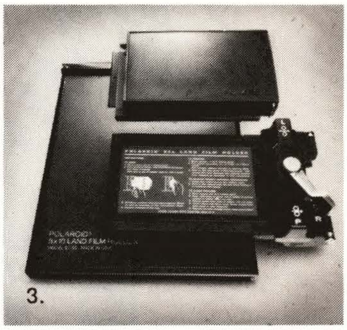


3.

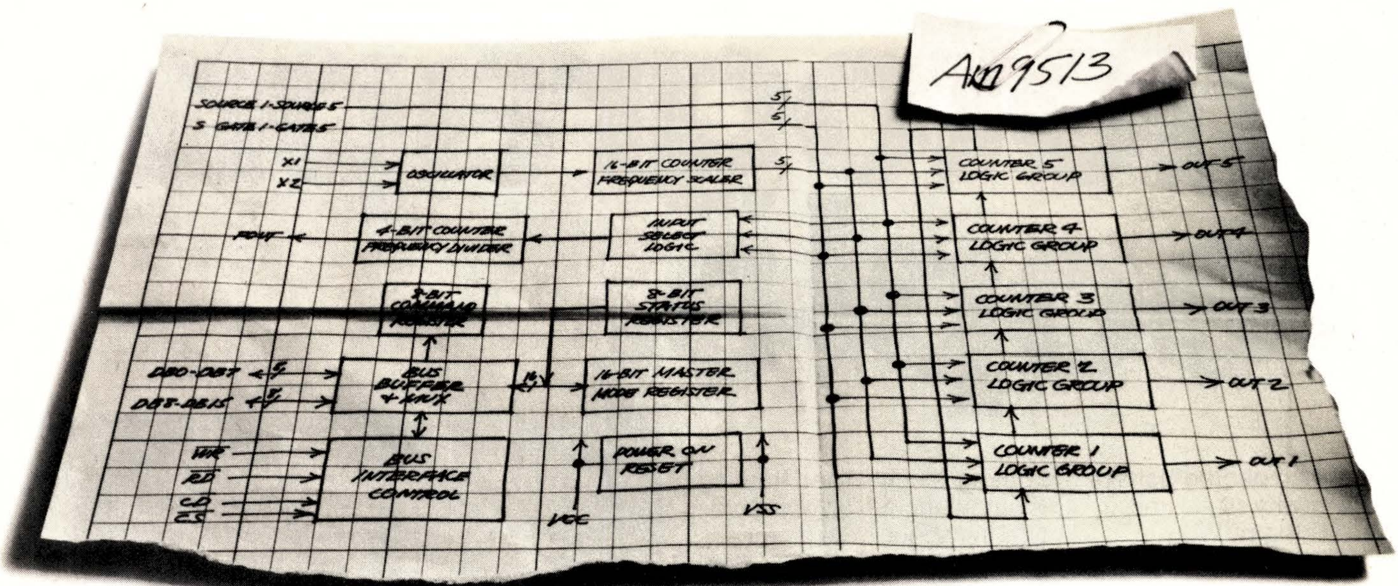
Polaroid
Instant Laboratory Pictures

EDN-11/5

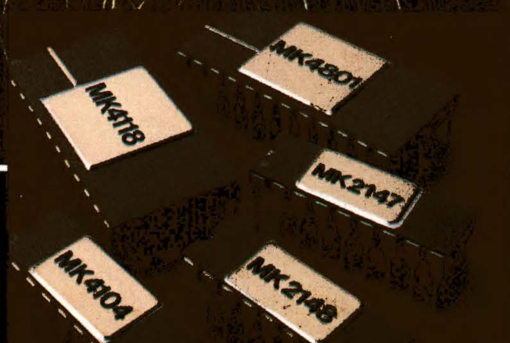
Polaroid Corporation
Industrial Marketing, Dept. A435
575 Technology Square
Cambridge, Mass. 02139

I'm impatient. Please send me more information on how I can use Polaroid instant photography in my work.

Name ____________________
Title ____________________
Company ____________________
Address ____________________
City ________ State ________ Zip ________
Current camera or instrument ____________________
Application or need ____________________



And now, The Time Machine.™



We learned about memory leadership by becoming the world's largest supplier of dynamic RAMs. Now, we're becoming a leader in static RAMs.

Our commitment to statics began in the early 70's when we pioneered the use of the depletion load resistor. Next, we developed our superior Poly R™ process, which resulted in the best speed/power product available. Now we've taken our Poly R™ process to volume production with the MK4104 4K and MK4118 8K static RAMs. With the MK4104 we used our Edge-Activated™ technique to combine state-of-the-art circuit design and processing in the same device.

Our MK4118 is designed with the user in mind, providing optimum density and performance in a pin-out that's compatible with ROMs and EPROMs. It's the first of many RAMs in Mostek's family of Byte-Wyde™ memories, developed for easy interface to all microprocessors.

Product	Org.	Speed
MK4104-3	4K X 1	200ns
MK4118-2	1K X 8	150ns
MK4801	1K X 8	<100ns
*MK2147	4K X 1	<100ns
*MK2148	1K X 4	<100ns

Our next introduction will be a 2K x 8-bit static RAM for even more flexibility of system design.

In addition to 16K RAMs, we will introduce a pair of 4K RAMs. The MK2147 and MK2148 will provide sub-100ns performance. And, like the high-speed 1K X 8-bit MK4801, these new products will use our advanced Scaled Poly 5™ process. So you can look forward to higher system density, lower power and reduced system cost.

You've always depended on Mostek for dynamic RAMs. For a lot of good reasons. Now you can depend on Mostek for static RAMs for the same reasons.

To find out more, write Mostek at 1215 West Crosby Road, Carrollton, Texas 75006. Or call 214/323-6000. In Europe, contact Mostek Brussels, phone: 660.69.24.

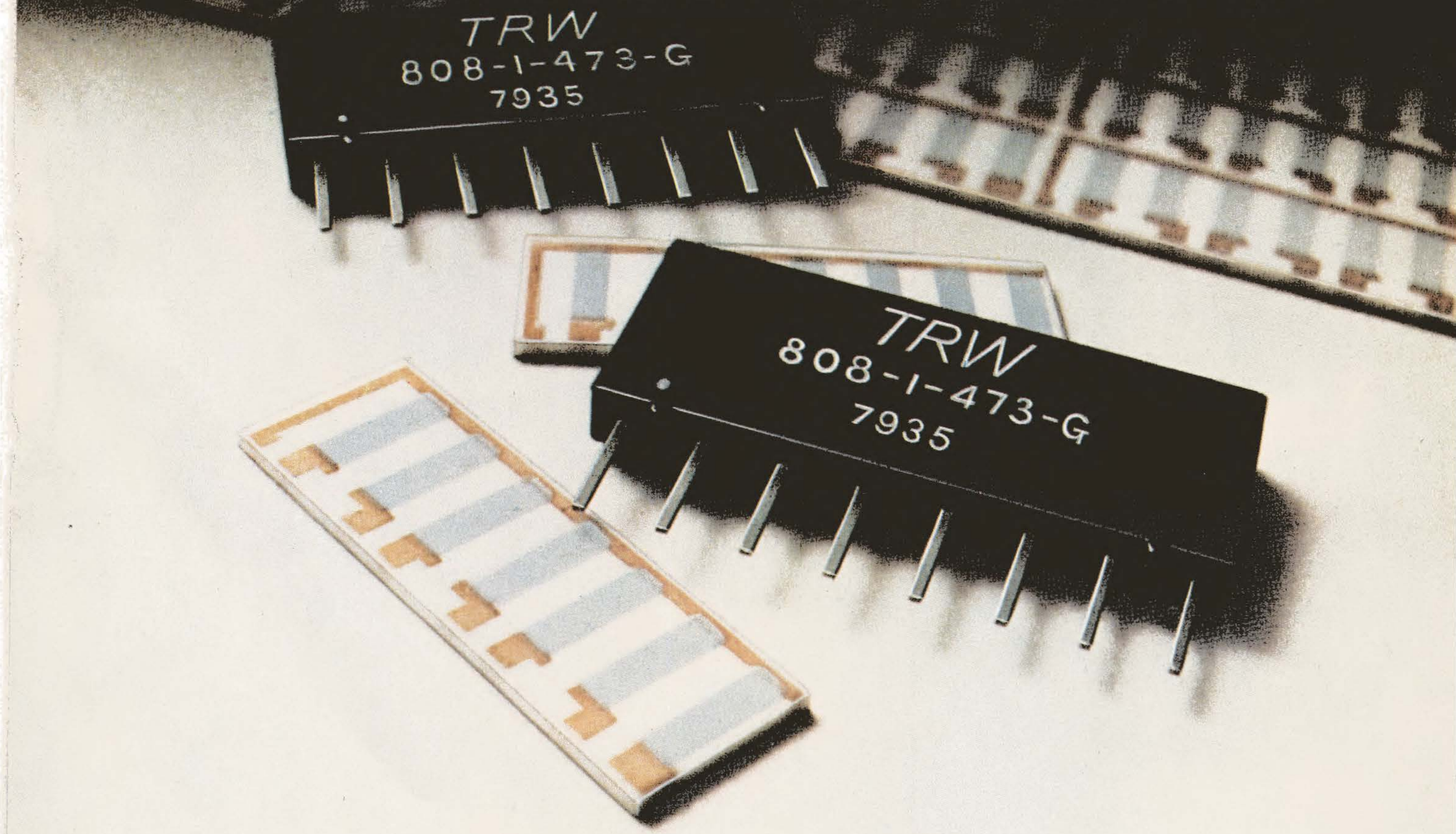
MOSTEK®

For more information, Circle No 7

*Available first quarter 1980

What's TRW up to now?

The performance is noble. The metals aren't.



New! TRW Series 800 Single-in-line Thick Film Networks.

TRW's cermet thick film networks perform like they were made with precious metals. Except that our system is totally non-noble, *eliminating* gold, silver and platinum group metals entirely.

Take our patented TanTin™ resistive material. It's a tin oxide system fired in inert N_2 at 1000°C. Our own thick film copper conductors are also fired at very high temperatures, producing an exceptionally rugged, stable resistor network. And an IR100 award winner.*

Our *new series 800* SIP's come in a transfer molded package in 6, 8, and 10 pin configurations, dimensionally clean and saving PCB real estate.

For example, 808-1 7 resistor SIP uses < 46 mm². That's less than one discrete ½W resistor laying flat on the board.

Now, you can get noble performance, without noble metals. Look:

Resistance Range = 33Ω–1 Meg, ± 2, 5% tolerance laser trimmed.

Schematics include N-1 common, N/2 isolated resistors.

Power Ratings are 1.5–2.7W/package, 0.3–0.5W/resistor.

TCR Tracking is ≤ .005%/°C. ± .02%/°C absolute TCR.

TCR Slope provides excellent hot to cold side differential.

See EEM '79-'80 Master Catalog pp 3644-45

Also ask for our low profile SIP and DIP configurations.

For more information contact your local TRW/ECG sales office or TRW/IRC Resistors, an Electronic Components Division of TRW Inc., Greenway Road, Boone, N.C. 28607. Dept. N, (704) 264-8861.

*(TM) TanTin (a TRW trademark), received *Industrial Research/Development Magazine* award as one of the top 100 industrial product developments of 1978.

TRW IRC RESISTORS
A DIVISION OF TRW INC.

For more information, Circle No 8

Signals & Noise

Get more out of OTAs

Dear Editor:

The linear-IC feature appearing on pgs 70-76 of your August 20 issue is of great value in promoting the sadly under-utilized operational transconductance amplifier (OTA).

The electronic-music industry, largely based on voltage-controlled devices, has been using OTAs for years. In fact, two companies involved with electronic music have recently released OTA-type products with outstanding specifications and useful special features as well. These manufacturers, not included in your listing, are Solid State Music, 2102A Walsh Ave, Santa Clara, CA 95050, and Curtis Electromusic Specialties, 2900 Maurica Ave, Santa Clara, CA 95051.

Sincerely,
Bernie Hutchins
Editor
Electronotes
Ithaca, NY

The state of the art in 16-bit μPs

Dear Editor:

Congratulations on the truly first-rate review of the 16-bit-μP world appearing in EDN, August 5, pgs 70-85.

I would like to suggest some key considerations in evaluating these products.

1. The 16-bit micros fall into two distinct classes—minicomputer emulations designed to capture the vast existing software base, and new architectures emanating from the semiconductor industry.

2. In an attempt to compensate for their current lack of software, the new architectures provide upward compatibility at the source-code level, but only at that level, for their developers' 8-bit products.

3. It is likely to be quite some time before manufacturers offer a high level of support, in the form of peripheral circuits and software, for the new 16-bit products.

4. The pseudo-16-bit μPs have been developed to take advantage of the many 8-bit support circuits now available and deserve careful attention.

These factors, which should

have considerable impact on designs employing 16-bit μPs, should be kept in mind during any evaluation.

Yours sincerely,
Andrew Allison
Consultant
Los Altos Hills, CA

The age of conservation

Dear Editor:

Your June 5 editorial entitled "A 'throwaway' microcomputer?" (pg 37), doesn't account for our society's recycling and conservation trends. A throwaway philosophy might be good for Computer Automation, but what is really needed is a tool that would pinpoint failures to a DIP within 5 to 15 min. Then, if reasonable repair efforts in the field proved unsuccessful, you could exchange the board at the factory.

Fortunately, signature-analysis equipment, combined with a diagnostic capability, indicates where to begin troubleshooting.

Electronic equipment seldom shows wear and, if properly designed, exhibits increasing reliability as you replace marginally bad components. Thus, MTBF will continue to increase.

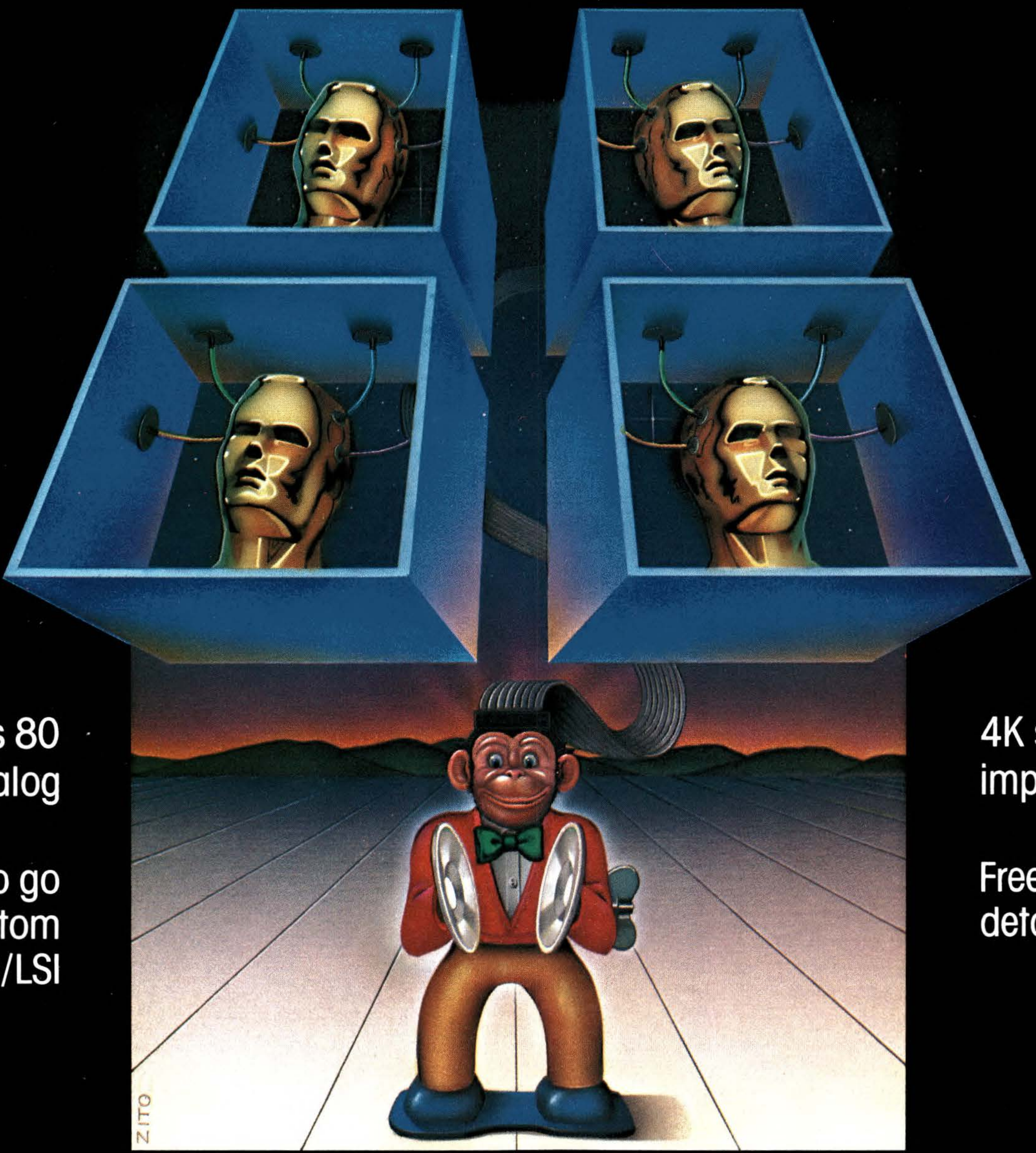
Sincerely,
John P Densler
Auburndale, MA

NO. 1

NATIONAL ANTHEM

Curing microprocessor overkill.

MICROCONTROLLERS THAT DO A LOT WITH A LITTLE.



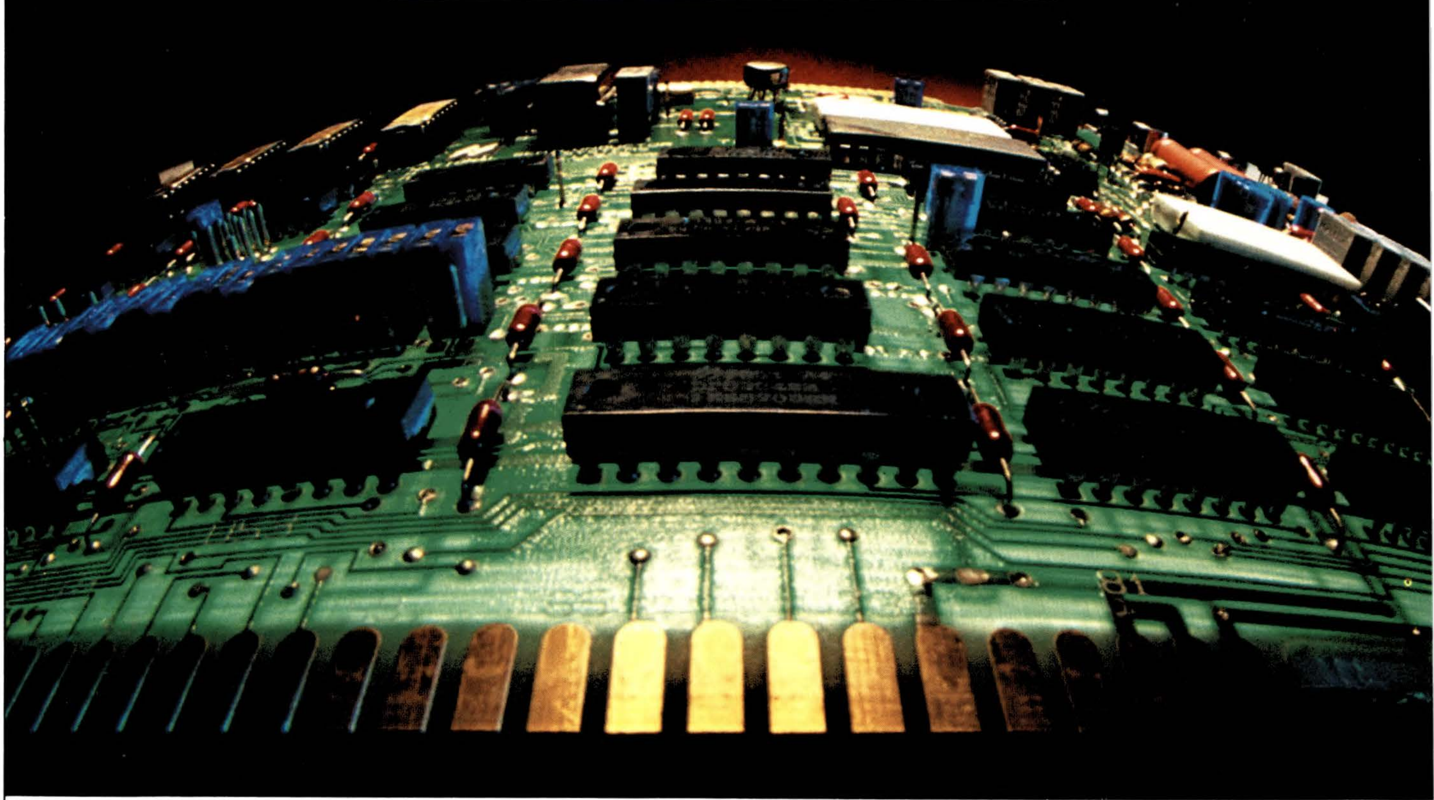
Series 80 goes analog

Where to go for custom MOS/LSI

4K static RAMs improved.

Free literature—details inside

Data Acquisition Digital Discrete Hybrid Linear Memory Components
Microcomputers Microprocessors MOS/LSI Optoelectronics Transducers



The BLC-8737. The analog I/O board they'll think of next.

The real world is analog. And National's new BLC-8737 analog I/O board gives you easy interface with that real world. The BLC-8737 is very easy to use because its built-in intelligence takes care of the analog functions automatically.

Onboard intelligence handles the complete analog conversion and scanning control. So you don't have to spend time writing conversion routines, for example, and run the risk of messing them up. You save considerable time, not to mention aggravation. Perhaps the best part, however, is that it saves you considerable development cost and gets you to market quicker.

It may be simple, but it handles a lot. Thanks to the BLC-8737's simplicity, the programmer need only tell the board what gains he wants for each channel. In fact, the BLC-8737 strongly resembles a simple memory board, with each input channel behaving very much like a memory address.

In addition, the BLC-8737 can handle a lot of data because it gives you 12-bit resolution. And it only requires a single 5 volt power supply.

With this new MULTIBUS-compatible board, National has simplified the design of microcomputer systems even further.

When you get right down to it, the BLC-8737 represents impressive capability for designers of analog system applications such as industrial/process control, energy management, testing and instrumentation, to mention just a few.

The BLC-8737. Just part of a very large family. But the BLC-8737 is only the newest addition to National's broad board line. The fact is, National offers over 75 different products in the family, all of them MULTIBUS compatible.

And National also makes a number of unique boards (such as the BLC-8737) that design engineers find very useful. That's because National is putting more and more intelligence on the board. And taking more and more of the tedious board design work off of you. The BLC-8737 is but one example among many.

National provides a broad spectrum of boards, including CPU's, memories, controllers, analog and digital I/Os, peripheral controllers, rack-mounted systems, a full complement of card cages, power supplies, cables, and other accessories.

A warranty four times as long. National knows how to build products that work. And they also know how to test their products, at the chip and board level.

That translates into better reliability. And explains why they're able to back this claim up with a warranty four times as long as the competition's: a full 12 months.

In addition to their guarantee, National maintains inventory levels that let them quote very competitive delivery schedules.

The bottom line is simple. If you're looking at MULTIBUS-compatible boards, you should be looking at National.

The COP 402 cures microprocessor overkill.

For those millions of repetitive tasks that don't need too much thinking capacity, National Semiconductor has come up with a timely solution.

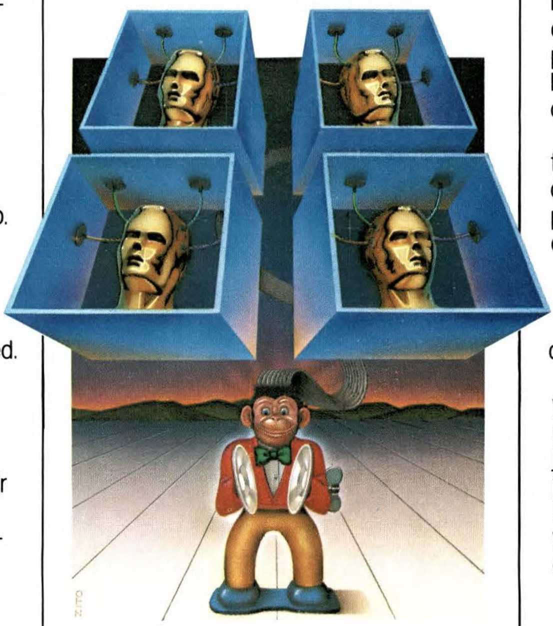
Their COPS™ microcontrollers actually improve upon the performance of the microprocessors most people use in their place. That's because most microprocessors can do a lot very well, but they can't really do very little very well. Many repetitive jobs applications that are being handled with microprocessors are really cases of overkill.

National Semiconductor recognized the situation and took steps to fill an obvious gap.

Being single-minded has its advantages. The fact is that these many jobs being done by multiple discrete circuits and overly complex microprocessors require a lot of headaches before they're accomplished. Shoe-horning a complicated circuit into a situation that is in fact too simple can be more trouble than it's worth.

So, for under $10, National is introducing two additions to the COPS family: their COP402 and COP402M. Both designed to handle simple tasks in an efficient way. Customers not only get devices that control little things, they get devices that control them inexpensively.

Introducing another microcontroller that handles little control processing jobs better than complex microprocessors.



Benefits haven't been forgotten, either. The COPS alternative, though simple in theory and action, actually has quite a lot of thought behind it, as well as on it.

For example, each model features a RAM right on the chip, direct I/O instructions, direct LED drive, easy interface to COPS peripherals (like the COP470), binary and BCD operations, direct KBD scan, and built-in address decoder.

But National didn't stop there. In addition to the above benefits, the entire line can scan switches, maintain real time, display in LED or VF, use external data from a read/write memory, and even function as a computer peripheral. When you consider all the COP402 does, you begin to wonder why you ever thought you needed a complex microprocessor.

The COP 402. Simply competent. If you're currently handling tedious, repetitive, or single-minded tasks with a circuit that's just too over-qualified, you should look into this new National alternative. The bottom line is that the COP402 could be handling your chores for you with a lot less hassle, and a lot less money.

Practicality is the National philosophy.

SEE SPECS ON BACK.

No one puts more manufacturing muscle and engineering talent into custom MOS/LSI.

"Custom MOS/LSI gives you proprietary features that signify a competitive edge – which gets you the market sooner, with a better product, at less cost.

"When it comes to custom MOS/LSI, National Semiconductor offers the lowest cost solution for volume production. We also have dedicated production lines for custom products, so that you always have guaranteed capacity.

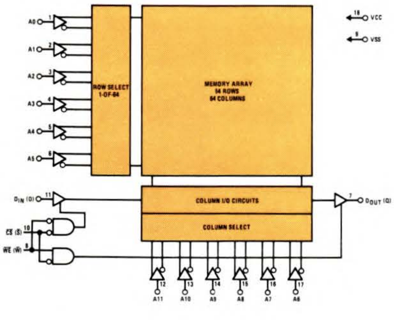
"National's capability in custom MOS/LSI is reflected in three key areas. First, we've got the necessary manufacturing capability. Second, our engineering talent cuts across virtually all electronic design disciplines. And third, we've been in the custom business for years and intend to stay there as long as customers have needs.

"In terms of customer benefits, custom MOS/LSI is the best solution for minimizing system costs. It's the best solution for maximizing system reliability. It makes your product unique.

"And from design through production capability National Semiconductor is your best source for Custom MOS/LSI."

William Sanderson
Group Marketing Manager,
Custom MOS/LSI

Working wonders on the 2147 4K static RAM.



National's new MM2147 static RAM is a 4096-word by 1-bit random access memory that uses National's XMOS™ N-channel silicon-gate technology.

All of the 2147's internal circuits are full static. And they therefore need no clocks or other refreshing for operation. All data is read out non-destructively, and has the same polarity the input data has.

The 2147's separate chip select input automatically switches the part to its low power standby mode when it goes high. And the output is held in a high impedance state during write in order to simplify your common I/O applications.

The 2147 has other impressive features as well. All its inputs and outputs are directly TTL compatible. It has automatic power down, and high speed – down to 55 ns cycle time. It has a TRI-STATE® output for bus interface, separate Data In and Data Out pins, and a standard 18-pin dual in-line package.

In addition to all this, the 2147 is available.

National Semiconductor

COP402/COP402M ROMless N-Channel Microcontrollers

General Description

The COP402 and COP402M ROMless Microcontrollers are members of the Control Oriented Processor (COP) family, fabricated using N-channel silicon gate MOS technology. Each part contains CPU, RAM and I/O, and is identical to a COP420 device, except the ROM has been removed; pins have been added to output the ROM address and to input ROM data. In a system, the COP402 or 402M will perform exactly as the COP420; this important benefit facilitates development and debug of a COP420 program prior to masking the final part. These devices are also appropriate in low volume applications, or when the program may require changing. The COP402M is identical to the COP402, except the MICROBUS™ interface option has been implemented.

The COP402 may also be used to emulate the COP410L, 411L, 420L or 420C by appropriately reducing the clock frequency.

Features

- Low cost
- Exact circuit equivalent of COP420
- Standard 40-pin dual-in-line package
- Interfaces with standard PROM or ROM
- 64×4 RAM, addresses up to 1k×8 ROM
- MICROBUS™ compatible (COP402M)
- Powerful instruction set
- True vectored interrupt, plus restart
- Three-level subroutine stack
- 4.0μs instruction time
- Single supply operation (4.5V to 6.3V)
- Internal time-base counter for real-time processing
- Internal binary counter register with serial I/O capability
- Software/hardware compatible with other members of COP400 family

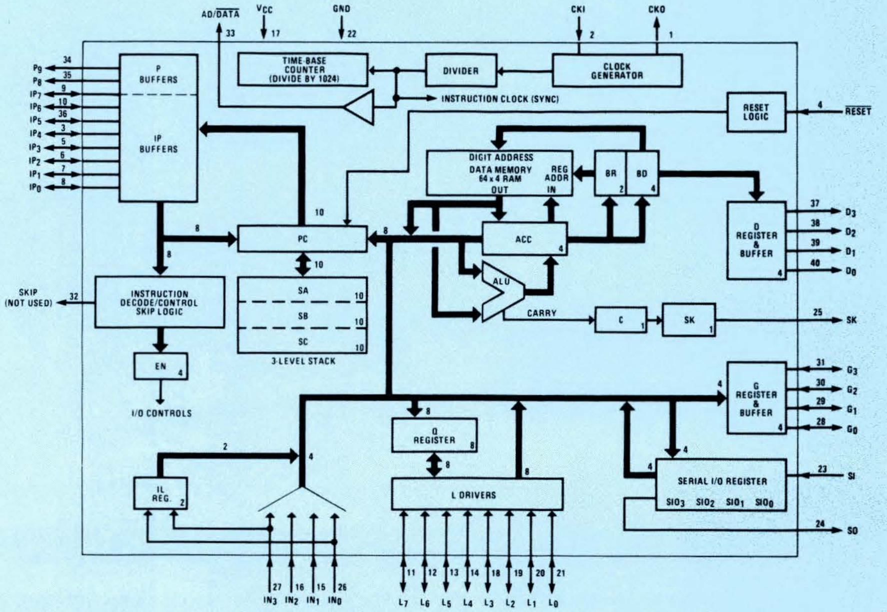
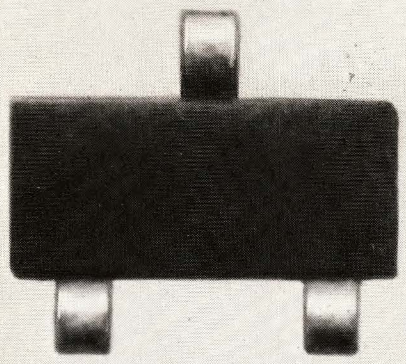
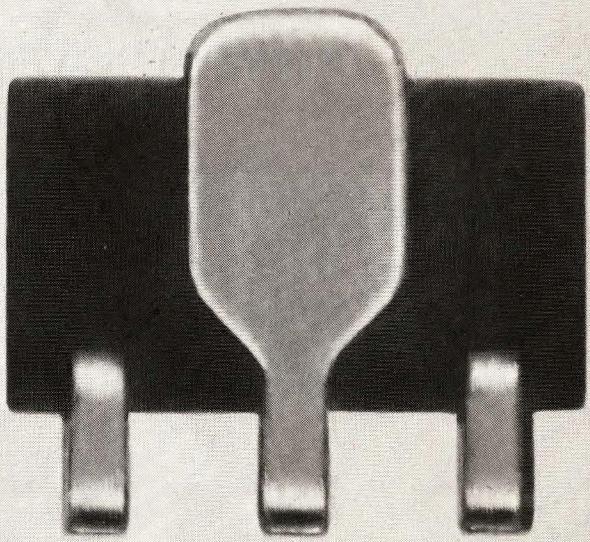


Figure 1. COP402/402M Block Diagram

SIEMENS

The latest designs in discrete semiconductors.





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Hybrid-circuit diodes and transistors. Plastic encapsulation. Varactor diodes, Schottky diodes, zener diodes, switching diodes, general purpose transistors, RF transistors, Darlington transistors and Broadband RF and microwave transistors.
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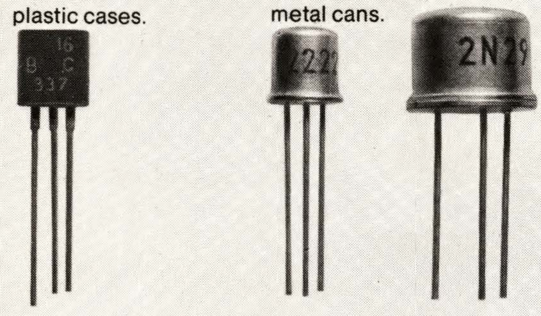

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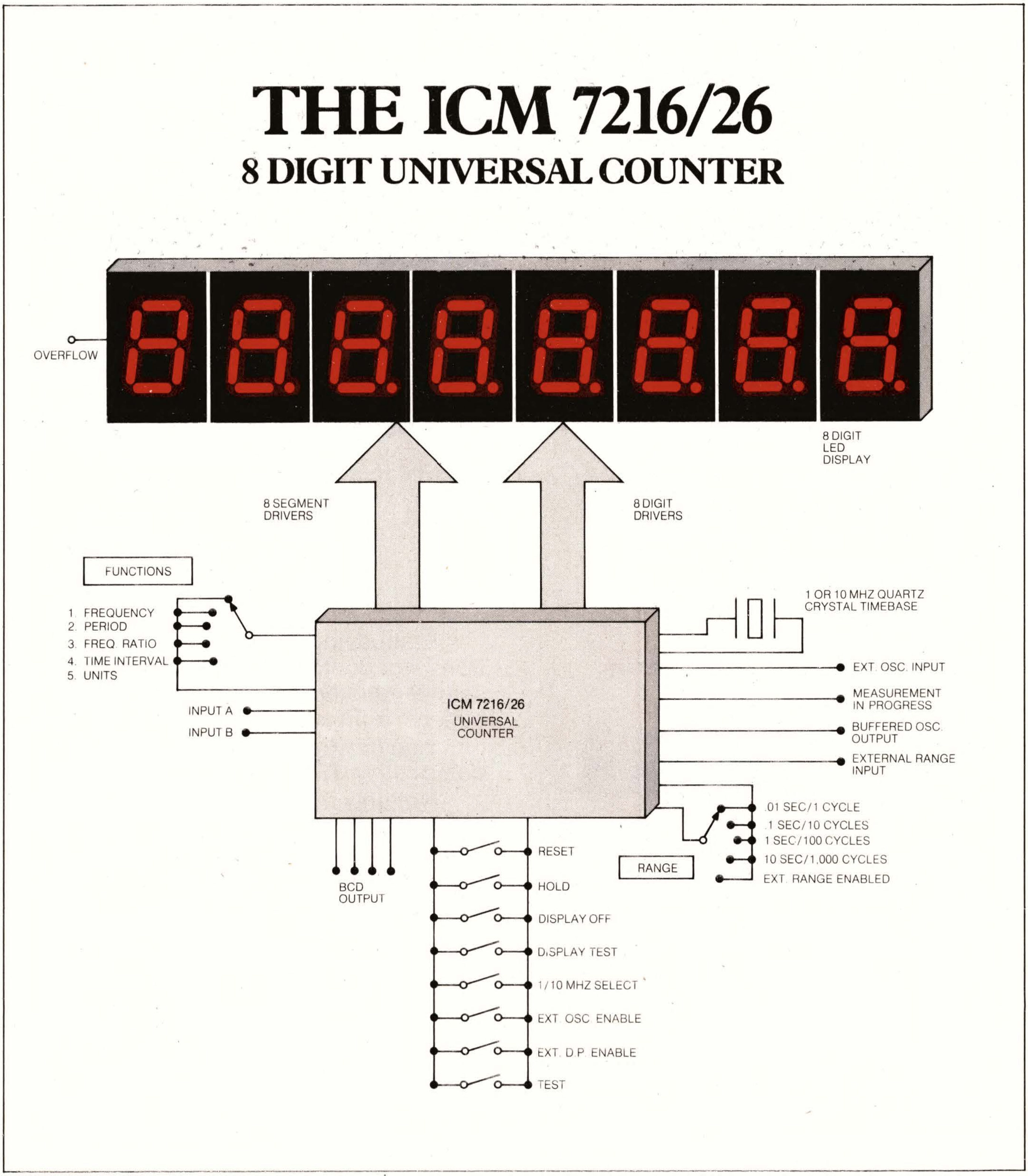

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- Computer compatible BCD outputs

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ICM7216B		28 pin DIP	16.65
ICM7216C	Frequency counter only	28 pin DIP	16.65
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*1000 pc. price (7216BIPI)

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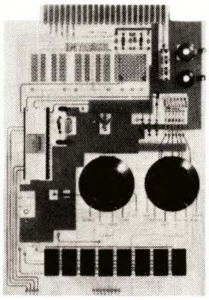

Call or write your nearest Intersil Franchised Distributor for a complete evaluation kit. Including: the ICM7226AIDL; a 10MHz quartz crystal; eight 7 segment .3″ LED's; PC board; resistors; capacitors; diodes; DIP switches and IC socket. Slip it together. Plug it in. And start counting.

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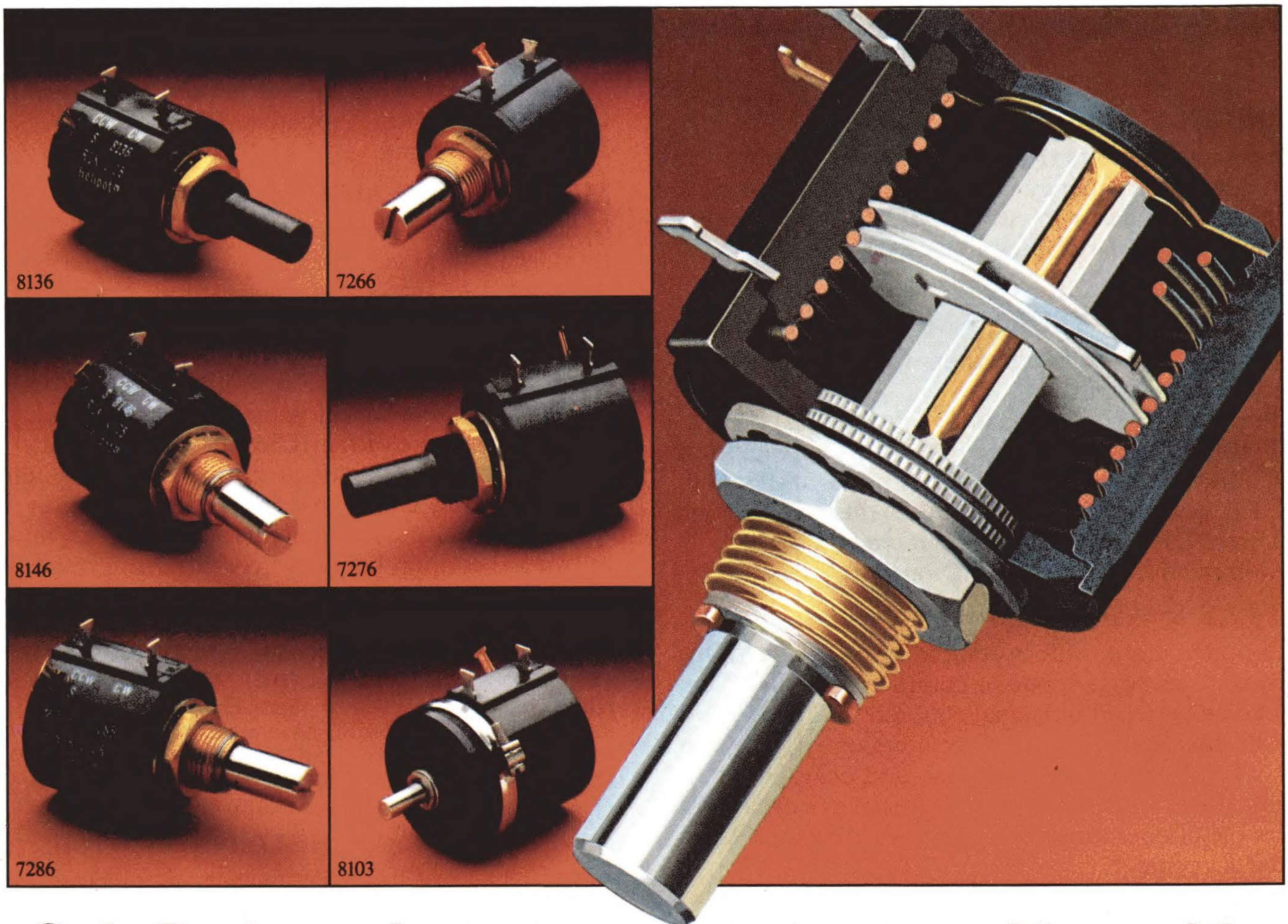
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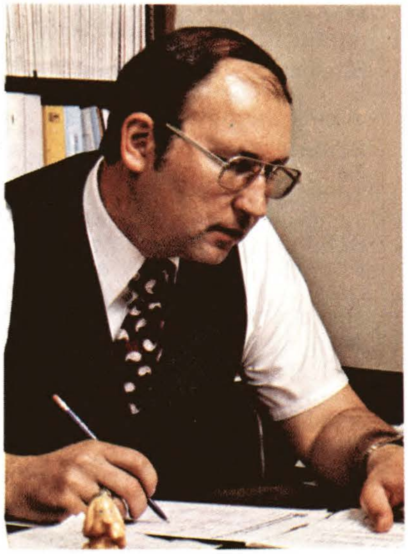
Editorial



Business is good—don't knock it

Business activity in electronics continues its healthy, dynamic pace, despite the general economy's current recession, high gold prices and high rate of inflation. Can the industry sustain this trend? It should.

Certainly Wescon/79 was a strong indication of how well the industry's been doing; the record attendance and number of exhibitors in evidence there mirrored what happened at Electro/79 and NCC. Pessimists' predictions that companies would keep their engineers at home, fearing that they might be picked off by the competition, just didn't come true—not noticeably, anyway.

What pessimistic talk we heard at the show, other than mention of some materials and parts shortages, was that business is so good that it's scary. The biggest problem electronics could face, therefore, is that decision makers might ignore the positive economic forecast for it and talk themselves into a recession.

But why and how, many ask, can the electronics industry perform so well in a recessionary cycle? It's true that real GNP is down and that consumer spending has decreased. However, when you consider that only 10% of the electronics industry's output is sold in the consumer segment, the reason for the current strong business outlook becomes clearer. That other 90% goes to military, industrial and commercial markets—all growing at very healthy rates. (Perhaps the loss of consumer-electronics sales to Japan isn't so critical after all.)

The electronics business can exhibit its high growth rates so long as it continues to offer the best cost- and energy-efficient products to those markets. To ensure high levels of growth in the future, however, R&D on new and better products and processes, as well as capital investment in new and better production equipment, must continue. In short, the electronics industry can't afford to merely rely on its past achievements to carry it through the next decade.

Roy W. Forsberg

Roy Forsberg
Editorial Director

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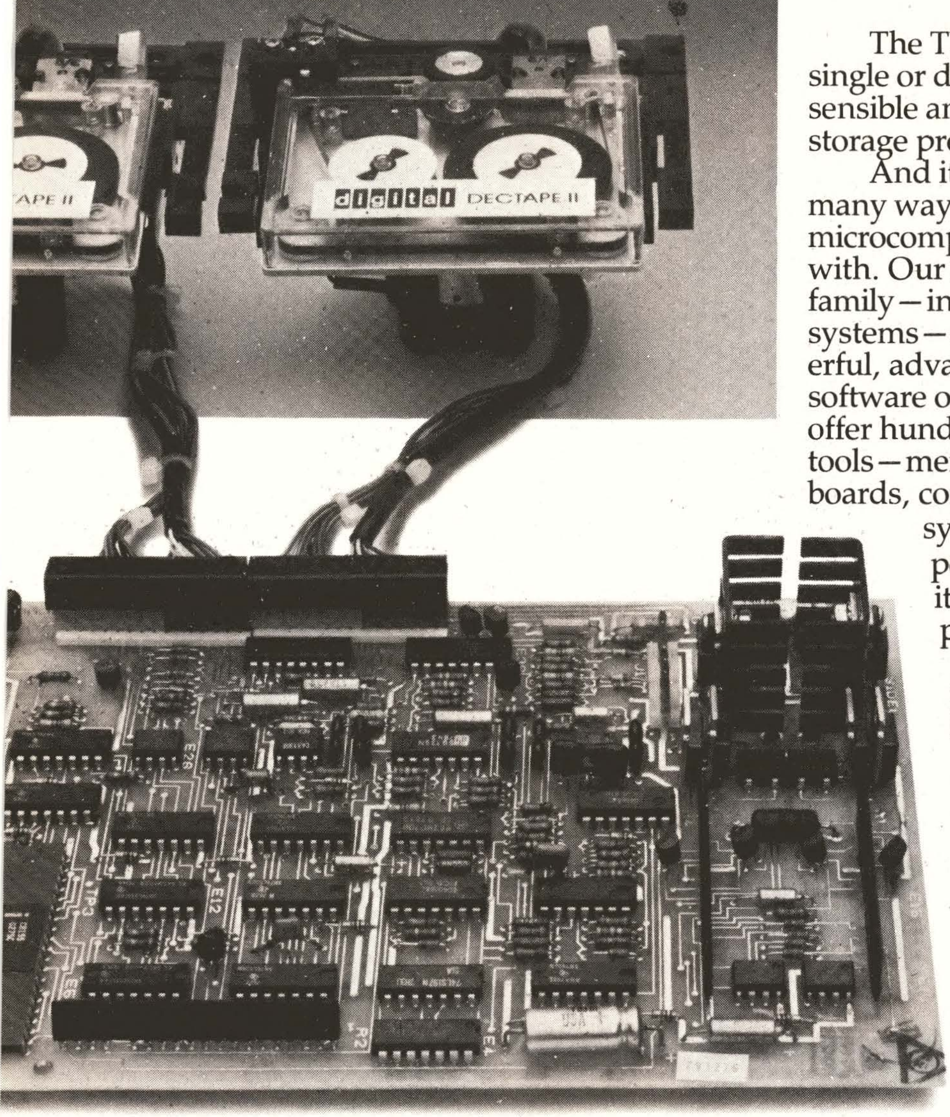
Introducing mass storage for micros.

It costs like a tape, but thinks like a disk.



The TU58 cartridge tape, single or dual drive. It's the first sensible answer to micro mass storage problems.

And it's just one of the many ways Digital makes microcomputers easier to work with. Our 16-bit microcomputer family—in boards, boxes and systems—offers the most powerful, advanced and proven software on the market. We also offer hundreds of hardware tools—memory and interface boards, complete development systems, terminals and peripherals. And we back it all with over 11,000 support people worldwide.

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Digital's 512Kb TU58 cartridge tape subsystem. At $562 in 100's, it's priced like a tape device. But with random-access block addressing, and EIA serial interfacing, it's like no other tape drive on the market.

That's because the TU58's controller board has a built-in MPU that makes it think like a disk. It reads, writes and searches for data in blocks, instead of running serially through the whole tape like conventional systems. And the TU58's small size—the board measures just 5.2" x 10.4" (13.2 cm x 26.5 cm)—makes it easy to design into your product.

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It took the minicomputer company to make micros this easy.

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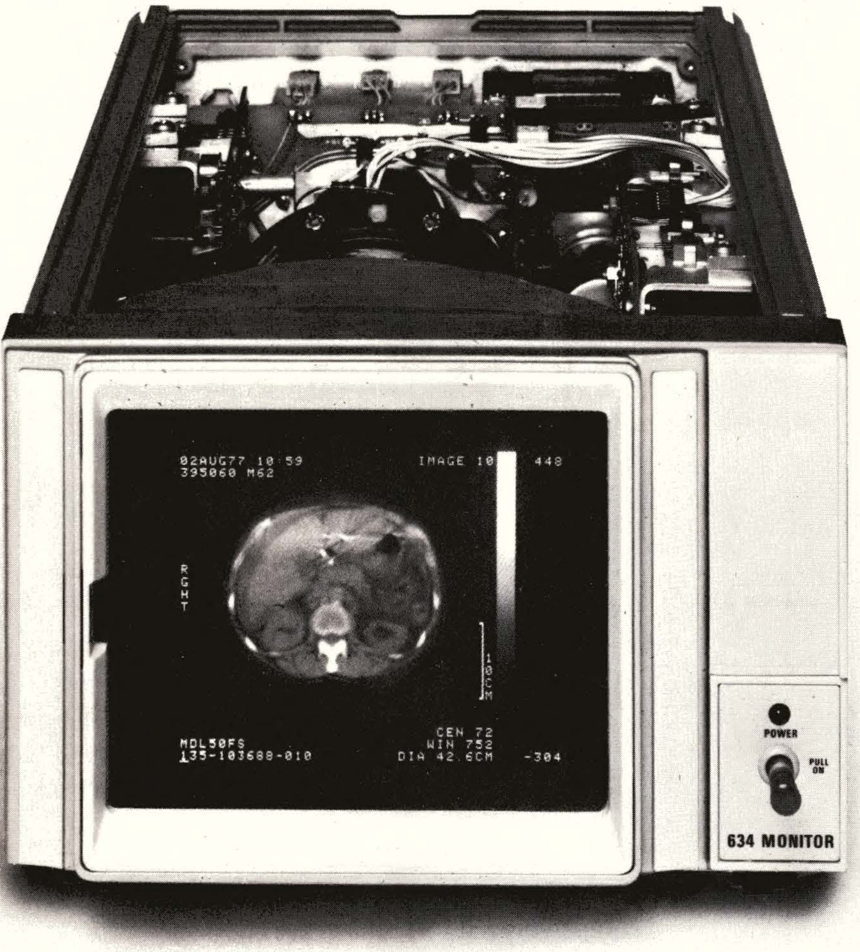
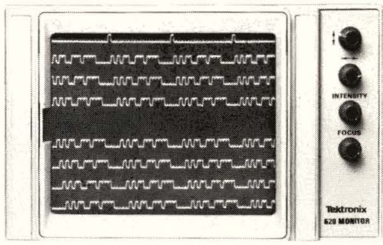
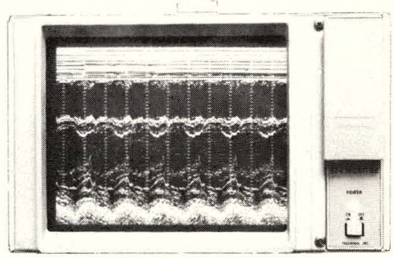
No matter Tektronix





620. For logic analyzer, A-scan ultrasound, optical electronics, and mechanical measurement applications.



624. For electronic test and measurement applications and for A, B, M-mode and real time ultrasound use.

634. For ultrasound, computerized tomography, video multi-imaging, ECM and other high-performance raster-scan applications.

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Leadtime Index

PASSIVE COMPONENTS

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
CAPACITORS			
Ceramic, disc	7	16	=
Ceramic, monolithic	8	16	=
Electrolytic, aluminum	7	21	=
Electrolytic, tantalum	12	32	up
Film	7	12	=
Mica	12	26	up
Paper	11	16	=
Trimming	8	14	up
CRYSTALS, FILTERS AND NETWORKS			
Filter, active	12	19	=
Filter, EMI	14	18	=
Filter, lumped-constant	12	18	=
Filter, quartz (monolithic)	12	18	=
Freq. determining crystal	6	16	up
ENCLOSURES			
Custom	12	14	=
Modified standard	10	12	=
Standard	4	10	=
FANS AND BLOWERS	9	18	up
FRACTIONAL HP MOTORS	8	10	▼
INDUCTIVE COMPONENTS			
Coil	6	10	=
Solenoid	6	8	=
Transformer, power	9	18	=
Transformer, other	11	20	up
INTERCONNECTION COMPONENTS			
Back panel	3	4	▼
Flat cable	4	11	▼
Multipin circular high-density	23	40	=
Multipin circular standard	15	25	=
Packaging panel	2	4	▼
PC, one-piece	3	5	▼
PC, two-piece	10	17	▼
Rack and panel	17	23	=
RF coaxial	14	20	=
Socket	2	4	▼
PRINTED CIRCUITS			
Double-sided	13	16	=
Flexible	10	20	up
Multilayer	13	19	=

PRODUCT	LEADTIME IN WEEKS Min	Max	Trend
Single-sided	8	12	▼
RELAYS AND TIMERS			
Crystal can	6	26	up
General purpose	7	9	=
Miniature (TO-5, square)	22	32	up
Reed, dry	8	10	=
Reed, mercury-wetted	11	16	=
Solid state	1	3	=
Telephone	6	11	=
Time delay and timer	12	14	=
RESISTORS, FIXED			
Carbon film	2	12	=
Composition	2	16	=
Metal film	13	20	=
Network	15	24	up
Wirewound	10	17	=
RESISTORS, VARIABLE			
Pot, nonprecision WW	15	18	=
Pot, precision WW	7	13	=
Pot, nonprecision comp.	16	24	=
Pot, precision comp.	7	19	=
Trimmer, WW	9	13	=
Trimmer, comp.	7	15	=
SWITCHES AND KEYBOARDS			
Circuit breaker	12	20	up
Dual in-line	8	14	=
Keyboard and keyswitch	6	10	=
Lighted pushbutton	6	8	=
Pushbutton	6	8	▼
Rotary	6	13	up
Snap action	5	9	=
Thumbwheel	5	8	=
Toggle	6	9	=
TRANSDUCERS			
Pressure	4	13	▼
Temperature	6	10	=
WIRE AND CABLE			
Coaxial cable	6	8	=
Flat and ribbon cable	2	9	=
Hookup wire	5	9	=
Multiconductor cable	8	12	=

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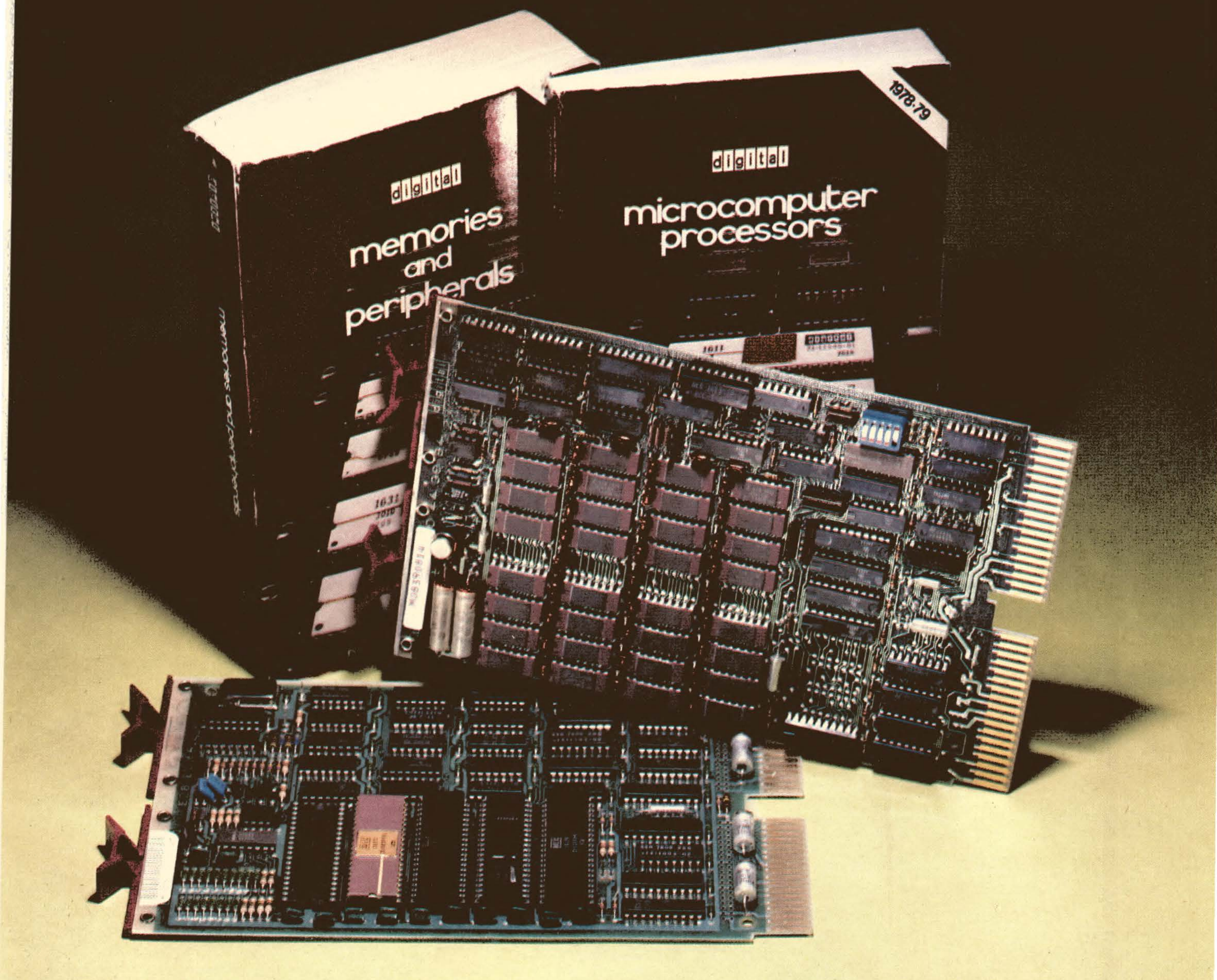
GET A FREE HEADSTART FROM DIGITAL.



That's right. Digital Equipment Corporation, in conjunction with Hamilton/Avnet, wants to give you two handbooks. Why? Because we think this is a great way to introduce you to Digital, and their incredible LSI-11 and LSI-11/2. You see, the LSI-11 (and its smaller version - the LSI-11/2) really is a design miracle, and provides the perfect place to start when you're ready for computer power. Its 16-bit design results in easier programming and higher throughput, and its addressing flexibility allows it to handle data in the most efficient manner. And the LSI-11 and LSI-11/2 offer many attractive features. Like the DMA I/O bus. Power fail/auto restart. Automatic on-board debugging. And an extended arithmetic option. But none of this actually gets you started on a microcomputer design. That's where the handbooks come in. So, if you're interested in getting started on a 16-bit microcomputer design, give us a call at (800) 421-4645*. And then, whether you know microcomputers, or are just starting out, remember this: they're available immediately, off-the-shelf from your nearest Hamilton/Avnet location. So give us a call, and get started!

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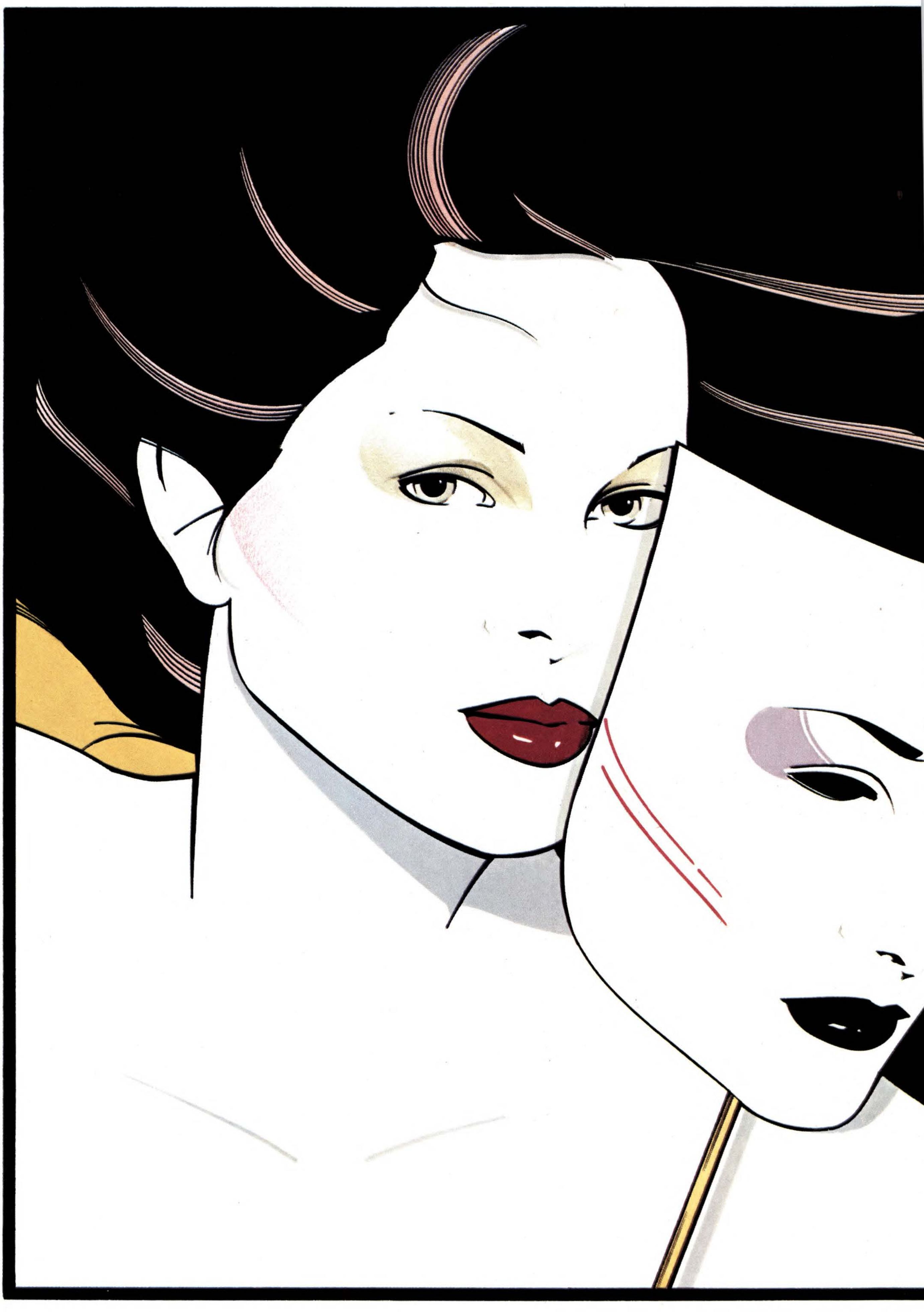

8088: Twin Reality

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The 8088 is both. Therein lies its ultimate beauty.

When we introduced the 8086 family more than 18 months ago we called it a new beginning, a microcomputer system architecture so advanced it would deliver a dramatic increase in system sophistication, performance and expandability. Now the 8088 delivers the same performance increase for 8-bit designs.

8088: Designed with reality in mind.

We built the 8088 to perform in the type of systems you're designing today and well into the future, too.

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Its byte-wide orientation and extensive string-handling instructions give it unprecedented capabilities—block moves, string comparisons, data scans and translations—that make the 8088 the ideal CPU for your business-oriented applications as well.

The 8088 addresses up to a megabyte of memory, in 64K byte segments. Segmentation and efficient register utilization enabled us to build in the capability for such minicomputer-like features as instruction pre-fetch, re-entrant code, position independent code and dynamic relocation. And 64K I/O space and indirect I/O simplify programming even further.

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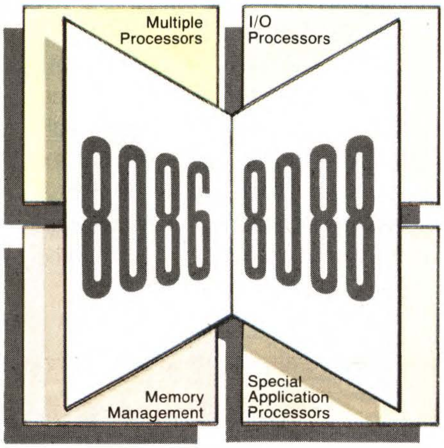
Any way you look at it, the 8088 is a tantalizing prospect. If you are upgrading your 8080, 8085 or Z80 design, the basic 5MHz 8088 delivers two to five times



the performance, yet preserves your entire hardware investment. And with the CONV-86 code converter and PL-M/86 compiler, your software can be easily upgraded, too.

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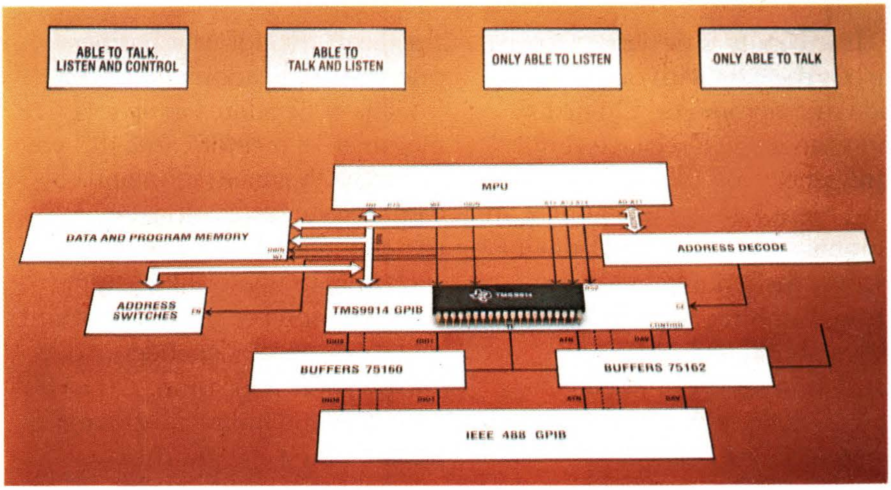
Circle no 29 for information

Low-cost, high-capability LSI chips ease interface-bus implementation

William Twaddell, Western Editor

Dramatic increases in the number of products incorporating the IEEE-488 General-Purpose Interface Bus (GPIB) have spurred semiconductor houses to develop several LSI circuits that implement this communications protocol. Acting as the parallel-bus counterparts to serial-communication devices (such as UARTs and USARTs), these GPIB ICs come in a wide range of configurations and capabilities, at bargain prices compared with previously available alternatives. (See the Special Report on pg 90 for information on IEEE-488-compatible instruments.)



Combining GPIB talker/listener/controller functions *on one chip, Texas Instruments' TMS9914 meets all IEEE Standard 488-1978 specifications. The device combines a highly flexible interrupt structure with an extensive auxiliary-command set to simplify design tasks.*

Older implementations of the GPIB required 40 to 60 MSI and SSI parts on dedicated boards and cost more than $1000. The new chips, in contrast, cost from $20 to $45, bringing down the total interface price to less than $100.

The prices and special features offered by different GPIB ICs reflect the order in which the devices were introduced. The older chips operate at moderate speeds and have only a talker/listener capability (see **box**), while more recent devices add controller functions but require a separate package for them.

The latest bus-IC introduction, however, performs all ten of the functions defined by the 488 standard—including controller tasks—on a single chip. It thus requires the addition of only two bus transceivers to form an interface between a μP and the GPIB.

Talker/listeners start it off

The first bus chips on the market were the CMOS HEF4738 from Philips (marketed in the US by Signetics) and Motorola's NMOS MC68488. Although both parts perform most basic GPIB functions, the Philips part requires multiplexers, level shifters, decoders and bus drivers to utilize all its capabilities,

Text continues on pg 39

GENERAL-PURPOSE-INTERFACE-BUS IC CHARACTERISTICS

MANUFACTURER	PART NUMBER	SUPPLY VOLTAGE (V)	CLOCK RATE (MHz)	POWER DISSIPATION (mW)	DATA TRANSFER RATE (BYTES/SEC)	SECOND SOURCE	FUNCTION
FAIRCHILD	96LS488	5	10	*1250	1M	NONE ANNOUNCED	TALKER/ LISTENER
INTEL	8291	5	8	500	448k	NONE ANNOUNCED	TALKER/ LISTENER/
	8292	5	6	625		NEC	CONTROLLER
MOTOROLA	MC68488	5	1 TO 1.5	600	125k	FAIRCHILD AMI	TALKER/ LISTENER
PHILIPS/ SIGNETICS	HEF4738V	4.5 TO 12.5	2	**1	200k	NONE ANNOUNCED	TALKER/ LISTENER
TEXAS INSTRUMENTS	TMS9914	5	5	750	250k	NONE ANNOUNCED	TALKER/ LISTENER/ CONTROLLER

*WITH ANY THREE BUS OUTPUTS IN A LOW STATE. (TYPICAL VALUE, 900 mW)

**WHEN IN A QUIESCENT STATE AT 10V

The development and nature of the GPIB

In the beginning was Hewlett-Packard. And there also was a team of HP engineers interested in creating a standard instrument-connection bus. From their efforts came the digital-communication concept known as the HP-IB.

At about the same time, discussions on the feasibility, scope and objectives for a standard interface were occurring in Europe as well, and—at the instigation of the German National Committee—the International Electrochemical Commission (IEC) authorized a development project and formed a working group. Concurrently, an IEC Advisory Committee and an IEEE subcommittee were formed to consider the needs of US manufacturers and users.

Both of these study groups chose the interface concepts originated at Hewlett-Packard as a model for further development. Several years later, after the concepts were refined and elaborated at the international and local levels, the IEEE Standards Board approved what is now known as IEEE Standard 488.

Physically, the bus consists of a 24-wire shielded passive cable: Eight wires carry data, eight carry control signals and eight are reserved for signal and system grounds. Cables connect in a star or daisy-chain configuration and can handle a maximum of 15 instruments interfaced to the bus without bus extenders. (Maximum cable length equals either 2m times the number of instruments or 20m, whichever is smaller.) Of the eight GPIB control lines, three implement an interlocked handshake sequence when passing bit-parallel, byte-serial data: DAV, data valid; NRFD, not ready for data; and NDAC, not data accepted **(figure).**

The other five control lines implement the following interface-management commands:

- **Attention** (ATN)—Used by a controller to indicate whether information on the data lines is device data or an interface-control message
- **Interface Clear** (IFC)—Used by a controller to reset the complete interface system to its quiescent state
- **Service Request** (SRQ)—Utilized by a device to indicate to a controller that the device requires attention and an interruption of the current event sequence
- **Remote Enable** (REN)—Utilized by a controller to select between two sources of device-programming data
- **End or Identify** (EOI)—Can be used by a talker to indicate the end of a multiple-byte transfer sequence or by a controller in conjunction with the ATN signal to execute a parallel-polling sequence.

GPIB functional specifications comprise a set of state diagrams that describe uniline and multiline commands, local and remote messages, and addressing and data handshakes:

- **Source Handshake** (SH)—Provides a device with the capability to guarantee the correct transfer of multiline messages (works in conjunction with Acceptor Handshake)
- **Acceptor Handshake** (AH)—Lets a device guarantee correct reception of remote multiline messages
- **Talker** or **Extended Talker** (T or TE)—Allows an instrument to send data to another instrument over the bus
- **Listener** or **Extended Listener** (L or LE)—Permits an instrument to receive data from another instrument over the bus
- **Service Request** (SR)—Lets a device request service actions from the controller
- **Remote/Local** (RL) and local lockout—Allows device control to switch between its local (front-panel) and remote instructions (programming codes received while addressed as a listener); local lockout blocks the front panel's ability to place instruments in local mode
- **Parallel Poll** (PP)—Allows a device to return one status bit to a controller in response to being polled without being addressed as a talker (each instrument is assigned one of the eight data lines)
- **Device Clear** (DC)—Provides a means of initializing an instrument to a predefined state
- **Device Trigger** (DT)—Allows a controller to command a device to start its basic operation
- **Controller** (C)—Lets a device send device addresses, universal commands and addressed commands to other units over the interface.

The state diagrams represented by these definitions specify GPIB interfaces that are independent of the means employed to implement them, so the 488 standard suits discrete logic as well as μP-based hardware and software approaches.

Unfortunately, though, while these state diagrams simplify GPIB definitions, the standard's text doesn't make easy reading, and despite strenuous efforts to prevent misinterpretation, a few clauses have been misunderstood.

Several of these misunderstandings are cited by HP's Don Loughry, an original HP-IB designer and a strong 488 proponent; one of them concerns a problem involving the EOI line. This control signal has been used for purposes other than those intended

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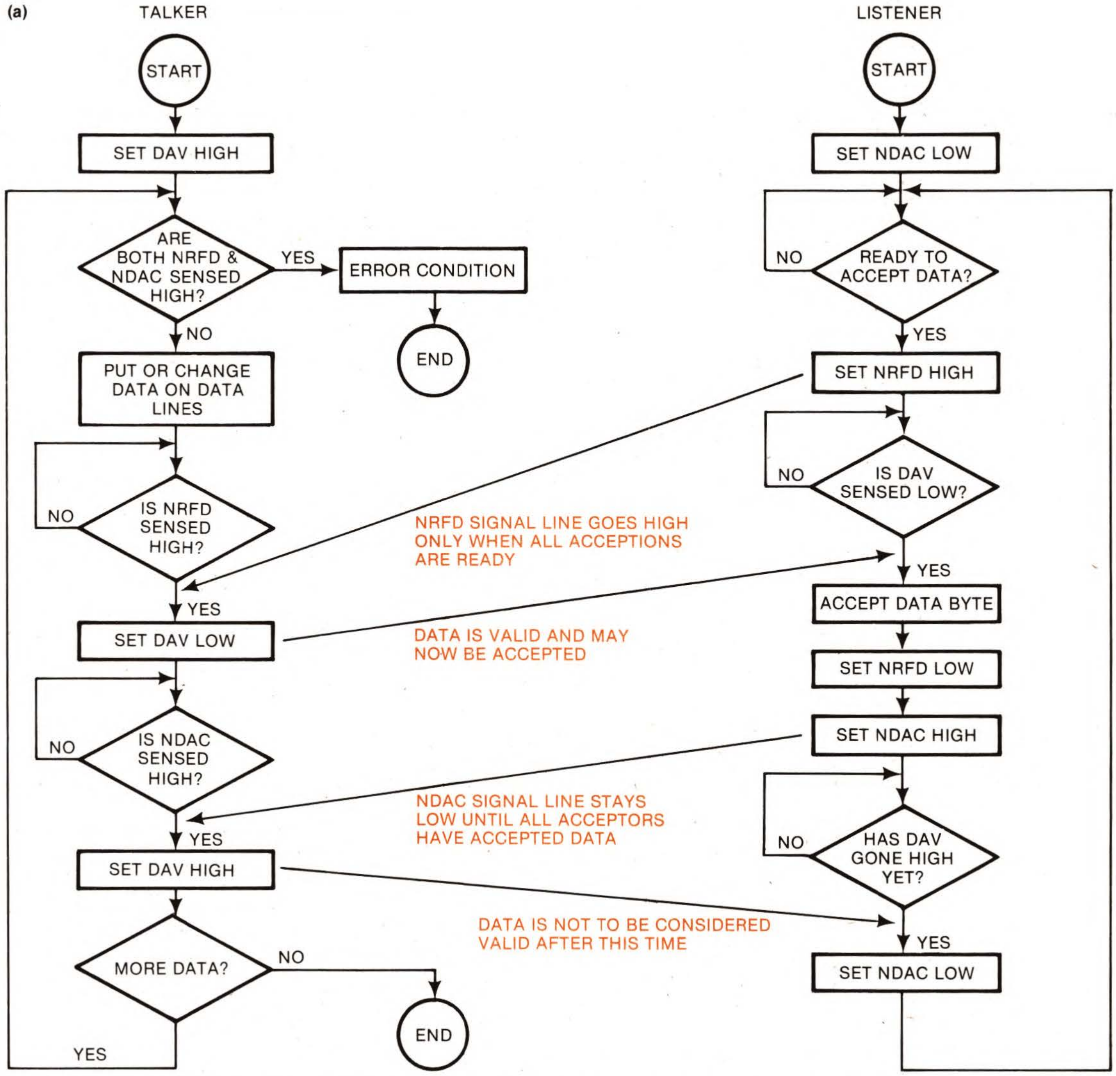
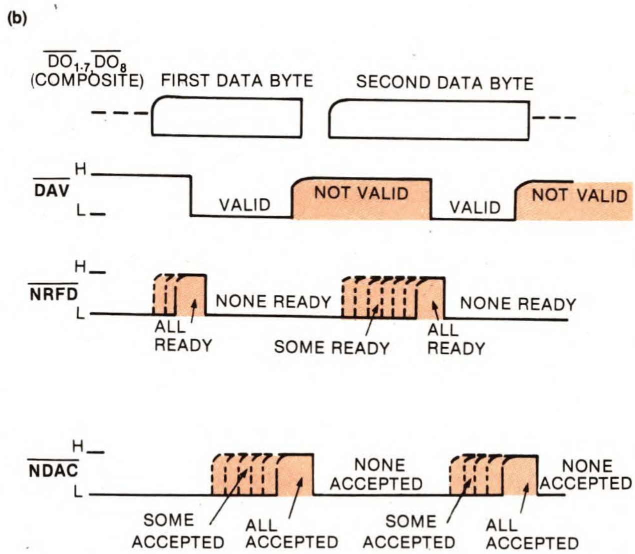


Instruments with differing speed capabilities can communicate on the same bus, *as shown by the flowchart of the source and acceptor handshake logic* ***(a)*** *and the signal-line timing sequence* ***(b)*** *for a 1-talker/multiple-listener arrangement.*

because of an ambiguous clause in the standard.

A second case of misinterpretation points up the unfortunate choice of words sometimes used to describe GPIB functions: The command "take control synchronously" refers to the interruption of a conversation on the bus by the controller in charge and has nothing to do with passing control from controller to controller, as has been erroneously stated in most articles on the subject. A better choice of words, Loughry notes, might have been "interrupt the conversation synchronously."

For more information on the concepts and considerations involved in implementing IEEE-488 (especially with μP-based systems), consult an article published in the *Proceedings of the IEEE,* Vol 66, No 2, February 1978, entitled "IEEE Standard 488 and Microprocessor Synergism."



while the Motorola chip requires only one pair of bus transceivers.

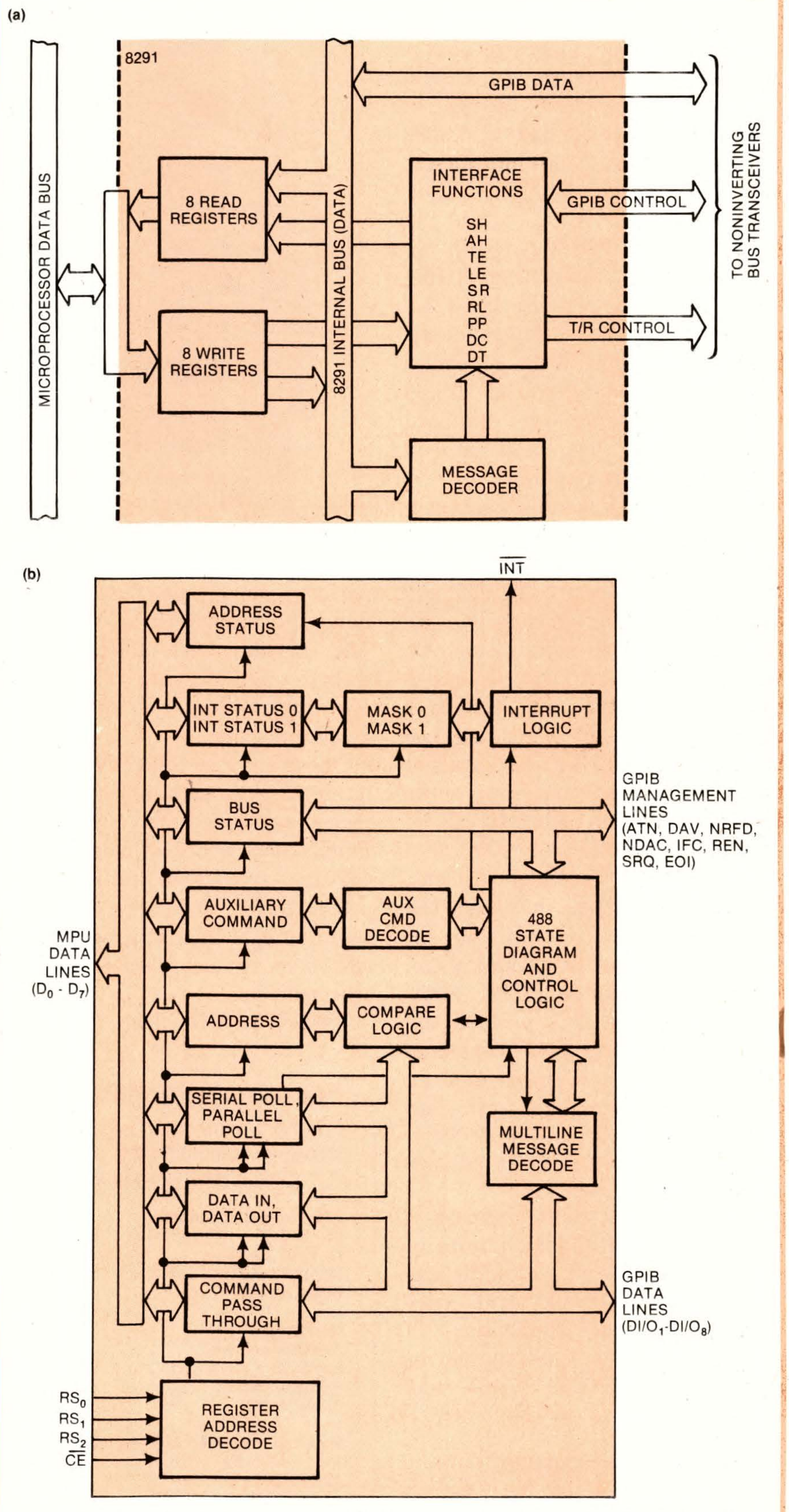
The 4738 doesn't pass data through itself to a μP's data bus, isn't optimized for use with a particular μP family and doesn't require software programming. These qualities place it in a class of μP-independent devices that usually operate in conjunction with only one controller in a multiple-instrument system.

Although not as powerful as some of the more recent market entries, Motorola's 68488 performs well enough to claim the majority of sockets in systems using the GPIB. Its close ties to one μP (the 6800) apparently haven't limited its use—most products that use the GPIB also have at least one μP in them anyway. Prices for the 68488 are at the low end of the spectrum: in the \$18 to \$21 range in quantities greater than 100.

To provide an adjunct to talker/listener functions, Motorola also marketed the first GPIB transceiver (the hex 3448) and has now introduced an octal configuration, the MC3447, which helps implement a talker/listener interface with only three packages.

Motorola's latest efforts in the GPIB field involve using a preprogrammed MC6801 μP to accomplish bus-controller functions — forming a complete GPIB interface with four packages. The firm will introduce this controller μP in response to Intel's 8291 and 8292 chips—a talker/listener and a controller, respectively. The 8291 compares functionally with the 68488, although Intel claims improved performance in areas such as addressing, status recognition and speed (when coupled with a processor, such as the 8086, that uses an 8-MHz clock). In quantities greater than 100, the 8291 costs \$23.75.

Intel's \$21.25 (100) 8292 is a preprogrammed 8041 μP, and the 8291/8292 combination is optimized for use with the processor family



Simplified block diagrams *of Intel's 8291* ***(a)*** *and Texas Instruments' TMS9914* ***(b)*** *show the architectural similarities among the new breed of GPIB LSI chips.*

that includes the 8080, 8048, 8085 and 8086 μPs. The company doesn't offer its own transceivers yet, but it plans to soon announce the 8293, a flexible device that works in conjunction with the 8291 and 8292 ICs to form a complete interface in four chips.

Putting it all together

Another LSI chip that implements IEEE-488 and interfaces to a μP system is Texas Instruments' TMS9914. Taking GPIB-IC evolution one step further, this $25.60 device integrates all standard functions into one chip: It's a talker/listener/controller.

Responding to feedback concerning first-generation parts' shortcomings, TI designed out many of them in the 9914. In one common application, for example, an instrument takes data samples, which then pass over the bus for use by another instrument such as a calculator. If such a reading has been sent to a GPIB chip's Data Out register, but something interrupts that transmission before it can be sent to the GPIB and the data subsequently becomes useless, older ICs can't cancel the data in the out register; it will therefore be sent as soon as the bus' attention-control signal goes false. The 9914, however, solves this problem by providing an auxiliary command that suppresses transmission of the current data byte until fresh data can replace it—an improvement that saves several external logic packages.

The TMS9914, though a part of the TMS9900 μP family, interfaces to almost any μP with no additional logic. And to provide even more GPIB interface flexibility, TI produces its own bus-transceiver set—the SN-75160, -75161 and -75162.

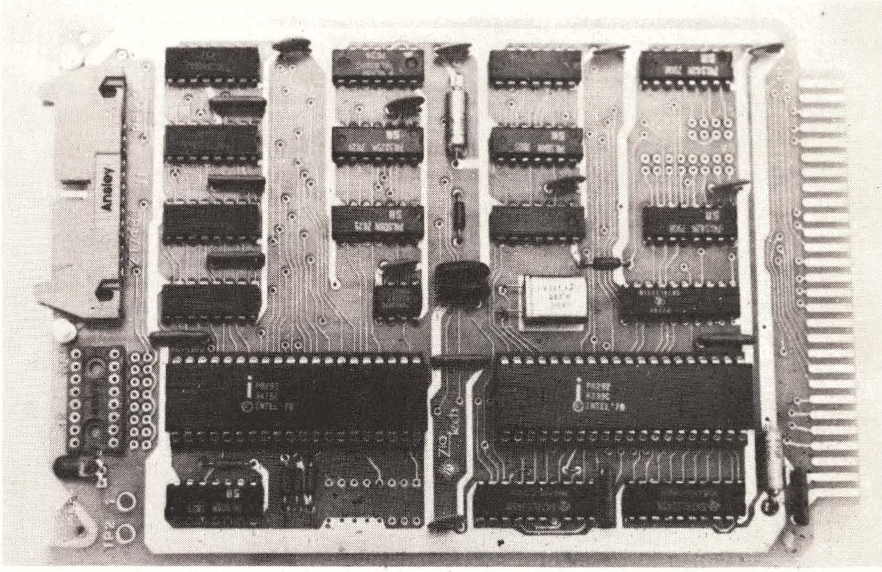
Neither CMOS nor NMOS

The most recently introduced GPIB chip is Fairchild's 96LS488—a device that, like Philips' 4738, performs only talker/listener functions and doesn't tie to a μP bus. The LS488 isn't software controlled, but instead receives its operating-mode instructions via four input pins.

One of the Fairchild device's most interesting aspects stems from the technology used to produce it. Philips' part is CMOS, and all other 488 chips are NMOS, but Fairchild's part utilizes low-power Schottky technology—an approach that allows it to incorporate on-board transceivers.

Using a 10-MHz clock, this 48-pin part transfers data at 1M bytes/sec—the fastest speed specified for the bus. Available for several months only in sample quantities, it is expected to cost $44.50 in quantities of 100 or more when in full production.

The next obvious GPIB step—a talker/listener/controller/driver IC—has yet to appear. Several manufacturers are interested in this market, though, so look for such improved devices in the not-too-distant future as well as for second sources of GPIB ICs already in existence. **EDN**



Utilizing the latest LSI chips, *Ziatech's 7488/18 interfaces the STD Bus to the IEEE-488 bus. Data rates up to 256k bytes/sec, 5V operation, user-selectable port addresses and a $378 price make this board ideal for μP-controlled automatic test equipment.*

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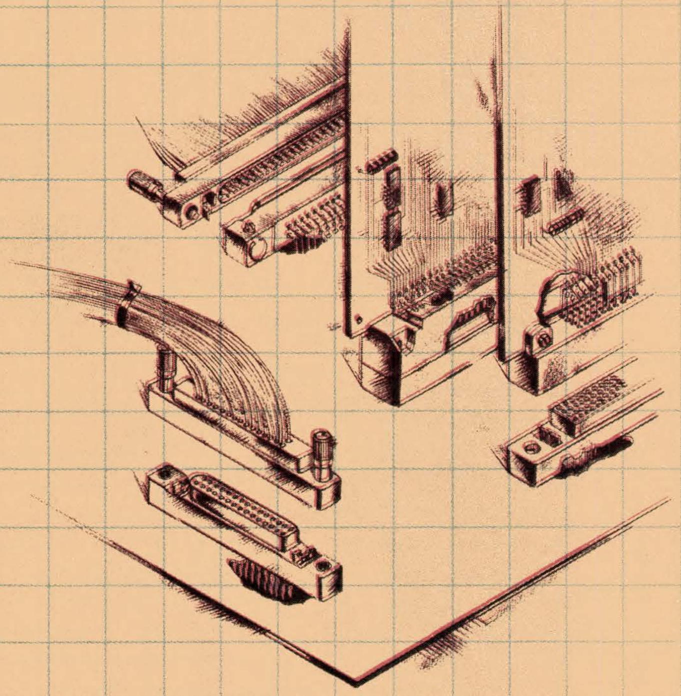

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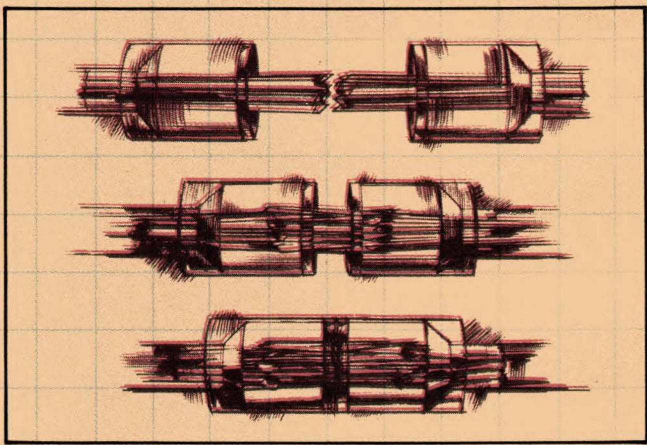

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Low-profile, low-power transformers fill many pc-board-mounting needs

Earle Dilatush, Senior Editor

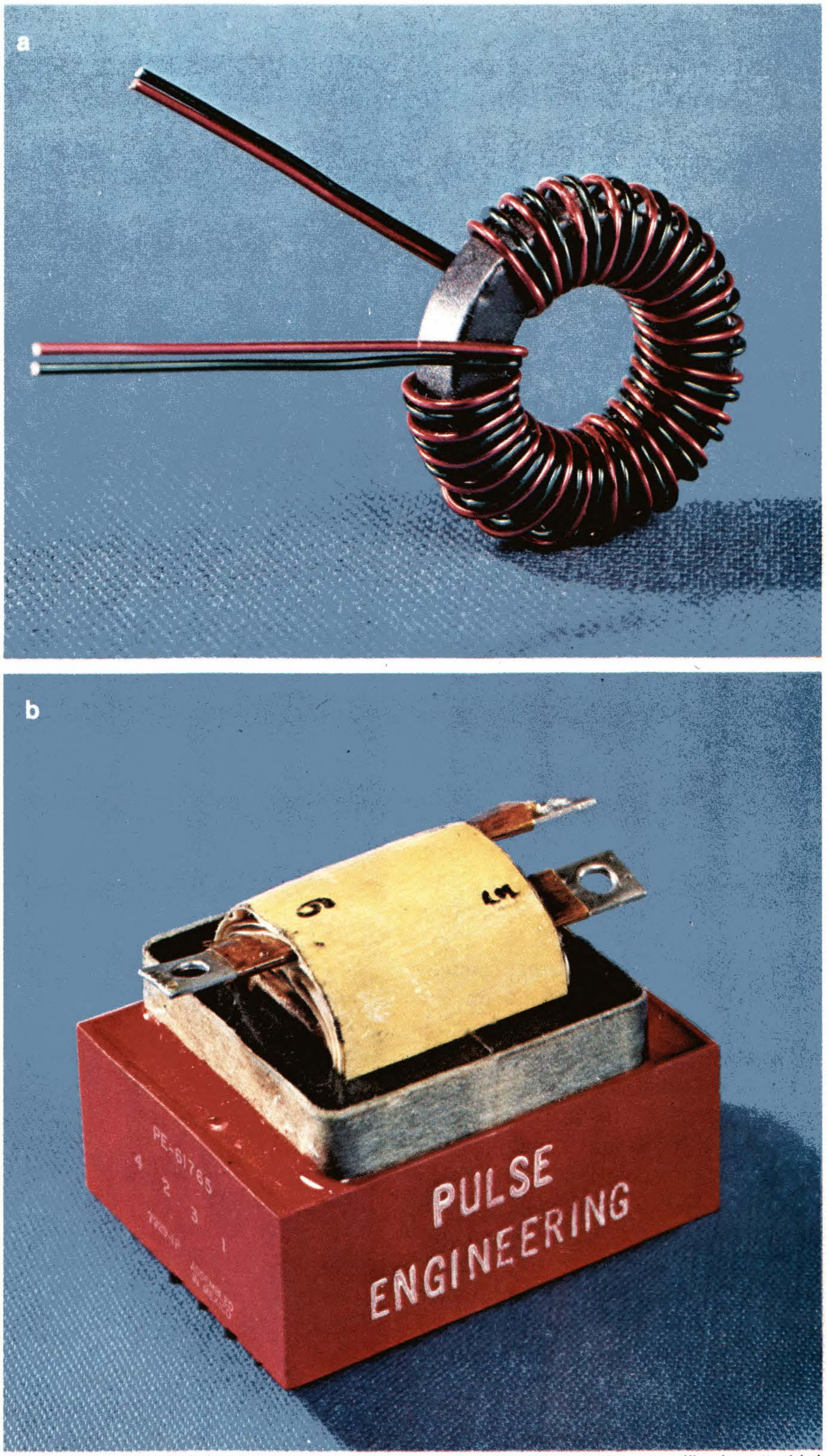
Now that most electronic circuits operate at low voltage and require little power, direct pc-board mounting of power transformers and other transformer types has come into its own. Compatible-size power transformers carry ratings ranging from a fraction of a volt-amp to almost 24 VA. Many of these units still retain the traditional upright-core stance, but low-profile designs are appearing, some with above-board heights of only 0.6 in.

Laminations hold the key

If you were a transformer designer faced with the need to design compact stepdown power units compatible with limited pc-board spacing, you'd soon abandon any idea of ordering custom laminations: The tooling cost is prohibitive. Thus, you'd be forced to design around existing laminations—the industry-accepted approach.

One way to utilize standard parts while achieving a low profile is to reorient the core from vertical to horizontal; manufacturers such as Inductive Components, Microtran and Signal Transformer have followed this route when designing their "flat"-construction lines. Inductive Components' Flatformers come with 1- and 7-VA ratings; Microtran and Signal Transformer offer 6- and 12-VA units (FlatStack and Flathead), and Signal Transformer's MPL models for IC-regulated power supplies deliver approximately 2.5 and 5W at their outputs.

Many design variations tailor these flat-format transformers to reduce cost or furnish special-performance characteristics. In one such variation—utilized in Micro-



Compact magnetics *for off-line switching-regulated power supplies readily handle high power at the commonly used 20-kHz or higher switching frequency. Two units from Pulse Engineering include a common-mode input choke* ***(a)*** *and a 20-kHz output transformer* ***(b).***

tran's FlatStack line—a split bobbin contains transformer windings side by side instead of wound one over another. As a result, interwinding capacitance becomes very low—making an electrostatic shield between windings unnecessary. This winding arrangement also minimizes the transformers' leakage and external field and allows the pc pins to be molded into the bobbin—eliminating much hand labor.

Small equals hot and lossy

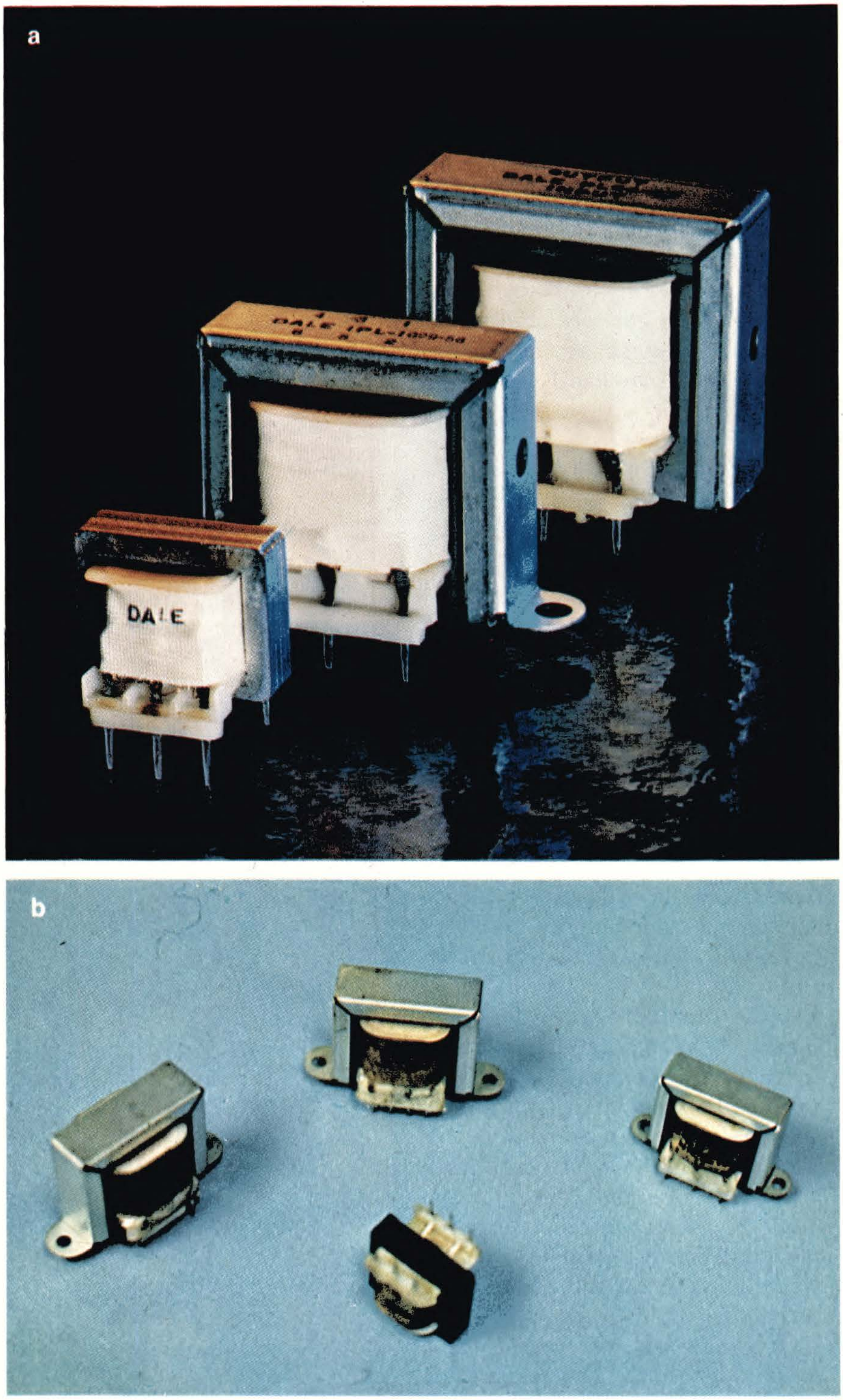
Early in any miniaturized transformer study, you'll realize that the need for small size inevitably produces penalties: reduced efficiency and increased operating temperature compared with standard-size components. Neither low efficiency nor higher temperature need handicap most low-power applications, and both need objective consideration.

Efficiency—though a desirable characteristic—can be overemphasized if you look at percentage figures without thinking through their practical implications. Take the case of a compact 6-VA unit that provides 75% efficiency. Its loss (2 VA) amounts to only half the power drawn by a standard electric clock, so for most applications, this inefficiency figure should cause little concern.

Operating temperature produces two major impacts: effects on the transformer itself and effects on adjacent components or circuitry. Standard construction permits a transformer's hottest part to operate at 105°C max, while special Class S construction raises this figure to 130°C. Don't pay Class S units' premium price, though, unless you need that extra 25°C capability; this arrangement won't provide longer life than standard construction if the hot-spot temperature doesn't exceed 105°C.

Small transformers usually present more temperature-protection problems than their larger cousins. Large-size power transformers can fairly easily incorporate some form of protective device such as a self-restoring thermal circuit breaker or a one-shot thermal-cutoff device. (Basically, a breaker protects a transformer against overheating damage, while a thermal-cutoff device only prevents an already damaged transformer from bursting into flames.)

Small pc-board-mounted transformers generally don't allow enough room for either a breaker or



Conventional upright-stance transformers, *such as these units from Dale* ***(a)*** *and Triad-Utrad* ***(b),*** *readily adapt to pc-board mounting.*

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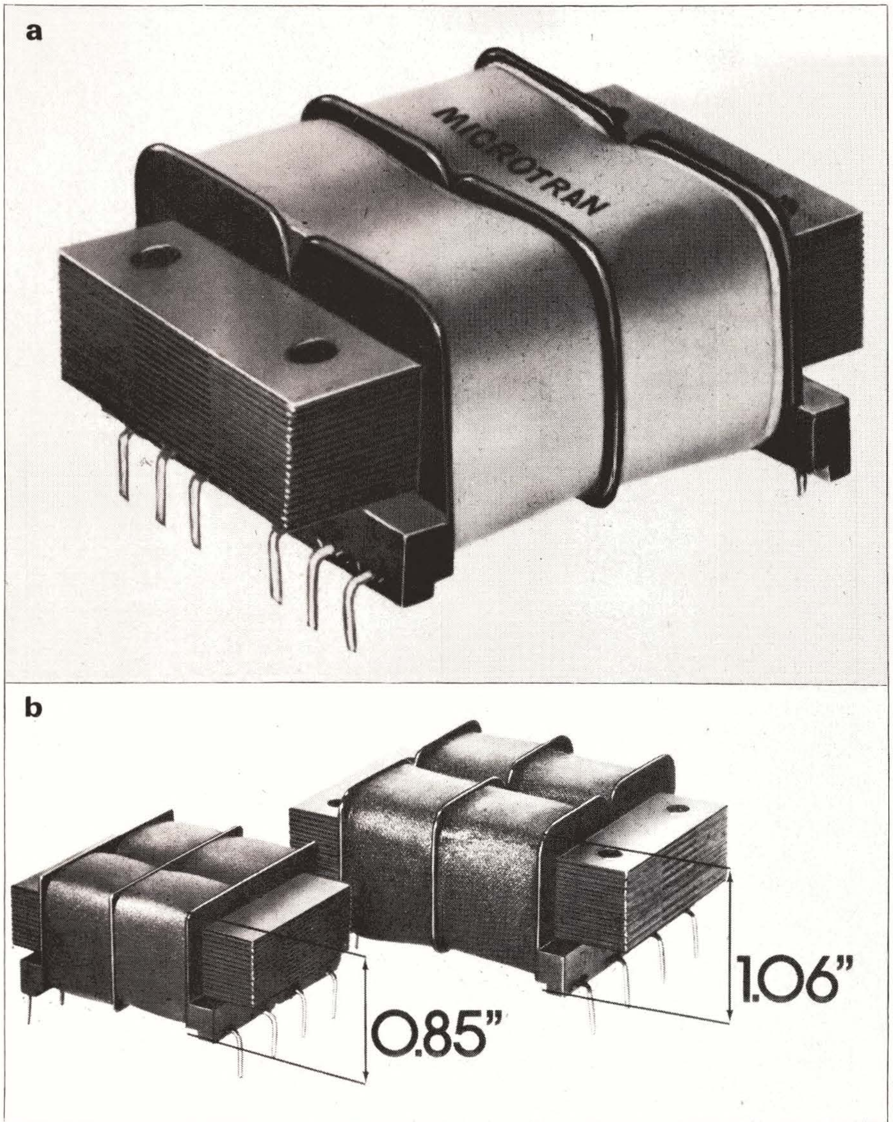

Minimal above-board height and pc pins for connections *suit these flat-format, 0.85- and 1.06-in.-high transformers for plug-in mounting on pc boards: Microtran's 6-VA FlatStack* ***(a)*** *and Signal Transformer's 6-VA and 12-VA Flathead Series* ***(b).***

flame arrester—even if it were desirable. However, some units (particularly very low-power ones that handle about 0.5 VA), do provide safety through inherent self-limiting action. These transformers require so many turns of fine wire to support a 115V field in their tiny cores that their input impedance increases enough to prevent overheating—even with a direct short on the secondary winding. At higher volt-amp ratings, the extent of such self protection decreases, becoming negligible at about the 24-VA size.

Impregnate, seal or...?

When dealing with worst-case environments, the only way to fully protect a transformer is to seal it hermetically. Military specs such as MIL-T-27 have called for sealing since World War II, and its worth for combatting extremes of altitude, pressure or moisture is unquestioned. Fortunately, though, most pc-board-mounted transformers operate in less hostile environments, permitting simpler protection measures such as vacuum varnish impregnation and encapsulation.

Varnish impregnating a transformer and achieving extreme compactness unfortunately are somewhat at cross purposes, because the units must contain

Safety and EMI compliance

Products, such as power supplies, that incorporate transformers must meet several requirements before many countries will allow them to be imported (EDN, January 20, pg 99). Broadly speaking, these requirements concern safety and electromagnetic interference (EMI).

International safety standards require, for example, that primary-circuit magnetics meet strict conductor-spacing and insulation-strength specifications and furnish a 3750V primary-to-secondary withstand capability. (The 220 to 240V line voltage found in most European countries appears partially responsible for making such international standards more strict than those in the US.)

Among the most stringent specs governing safety and conducted EMI are those issued by the West German regulatory agency, VDE. Its safety regulations concern pc-board track spacings, primary-to-secondary circuit spacings, transformer-dielectric withstand capabilities and leakage current to ground. As for conducted EMI, the maximum must be less than that defined by the strict VDE specification 0871b Level A.

Generally, VDE specifications concentrate on voltage, while the US emphasizes temperature. Edward Polen, president of Signal Transformer, believes Europeans plan for safety while US regulators only react to problems. He recommends a marriage of UL/VDE philosophies and requirements to facilitate international product standardization.

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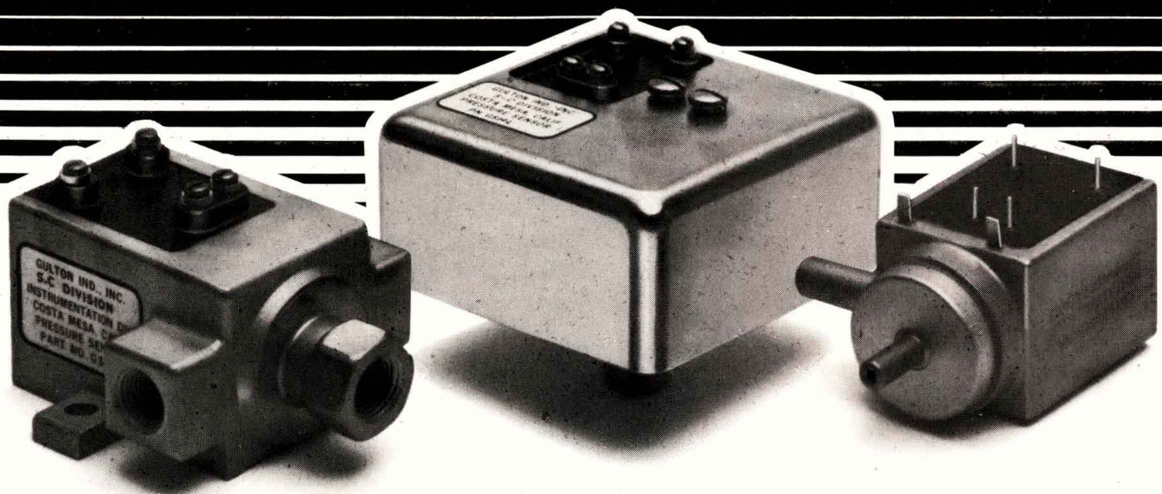

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☐ 0 to 15 psi	☐ 0 to 500 psi
☐ 0 to 20 psi	☐ 0 to 1000 psi
☐ 0 to 30 psi	☐ 0 to 2000 psi
☐ 0 to 50 psi	☐ 0 to 3000 psi
☐ 0 to 100 psi	☐ 0 to 5000 psi

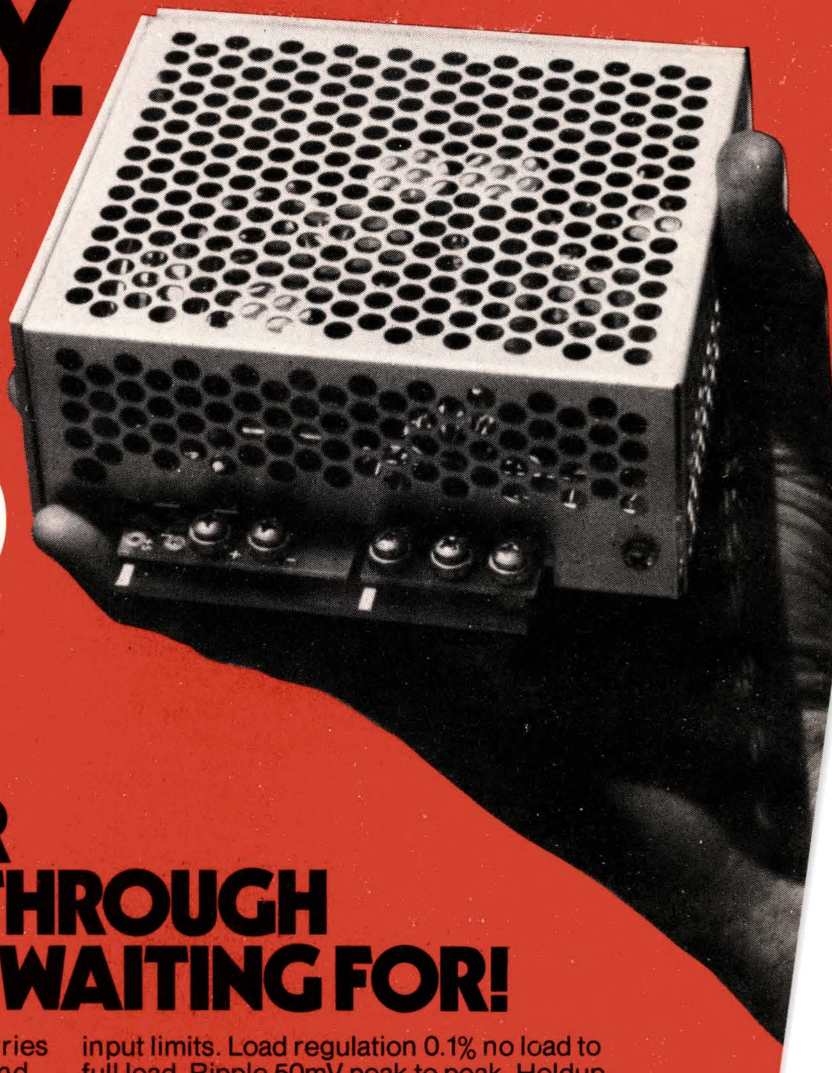
☐ Absolute ☐ Gage ☐ Differential

My ☐ Visa ☐ Master Charge card number is: ____________

NUMBER ______ EXPIRATION DATE ______

For more information, Circle No 33

POWER/MATE MAKES SWITCHER HISTORY.



$89.00
UNIT QUANTITY PRICE

Model ES-E, single output, 50 watts

THE SWITCHER COST BREAKTHROUGH YOU'VE BEEN WAITING FOR!

Thanks to a new monolithic chip that carries all regulation, modulation, comparator and protective circuitry, Power/Mate can now offer top quality switching regulated power supplies at a fraction of the cost of conventional switchers. Even less than quality linear supplies!

Typical parts count is reduced 20% for a much better MTBF...over 50,000 hours... with a two year warranty to back it up.

Specifications are typical of high quality switchers: AC input 85-132 and 170-264 VAC, 47-63 Hz. Line regulation 0.1% within AC input limits. Load regulation 0.1% no load to full load. Ripple 50mV peak to peak. Holdup time 16 milliseconds. Soft start, brownout, overvoltage, overload and short circuit protection standard.

The ES Series switchers come in four models: ES-D, 30 watts; ES-E, 50 watts; ES-F, 100 watts; ES-G, 150 watts. Outputs are 2, 5, 12, 15, 24 and 28 VDC, adjustable ±10%. The entire series is comparably low priced.

See these remarkable new switching supplies at Micon 79, Booths 849-851, or write for full technical details.

POWER/MATE CORP.

514 S. River Street/Hackensack, NJ 07601/201-440-3100

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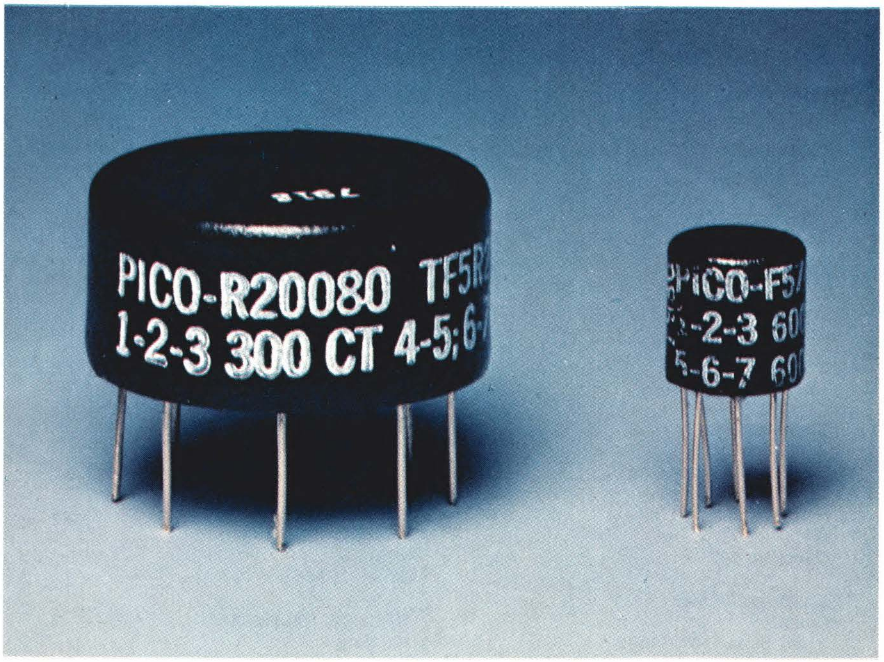


Ultraminiature audio, pulse and 400-Hz power transformers *designed to MIL-T-27 pack surprising capabilities into cases measuring as small as the ¼×¼-in. Pico Electronics unit on the right.*

voids into and through which varnish can flow. In very compact units that pack all available space with windings, bobbins and insulation, however, the varnish must thread its way through very small openings. And despite these impregnation difficulties, the process must be thorough; unpenetrated places (such as at air bubbles) tend to become hot spots during operation and could form moisture traps.

Signal Transformer president Edward Polen, however, believes that varnish-impregnation advocates might have overstated the process' problems. He suggests that many applications don't really require impregnation because of modern bobbins', tapes' and wire coverings' excellent insulating properties.

Magnetics for switchers

Now that off-line switchers have invaded the below-50W power-supply market, the small, low-wattage magnetic components they utilize allow pc-board construction. These switchers commonly employ a 20-kHz operating frequency, but the trend is clearly for switching frequency to rise as improved semiconductors become available (EDN, October 5, pg 84).

Magnetic-device operation at or near 20 kHz permits drastic reductions in both core and winding size compared with 60-Hz designs. And devices operating at high frequencies commonly employ ferrite cores and toroidal construction.

Switcher magnetics appear miniature to anyone accustomed to thinking in terms of 60-Hz chokes or transformers, but don't fall into the trap of thinking they're a snap to design: Switcher magnetics aren't much easier to design than the switchers themselves. (And some expert switcher designers assert that it's easier to design a TV set than a switcher.)

Manufacturers such as Pulse Engineering and Coilcraft now specialize in furnishing the high-frequency magnetics utilized in off-line switchers—magnetics such as switching transformers, base-drive transformers, smoothing inductors and RFI/EMI-suppression components. To aid in applying Coilcraft's driver transformers, high-frequency power transformers, input filter chokes (common-mode and series) and output filter chokes for switchers, this firm furnishes a prototype design kit containing bobbin and

Where the action is in small transformers

Like Rover's fleas, transformers are found just about everywhere. And while pc-board mounting configurations restrict transformer size and power-handling capabilities, they greatly reduce mounting and wiring costs.

The many application areas currently reported for pc-type units (such as power, audio, line-switching and pulse transformers) include:

- Automobiles (in electronic control systems for ignition and carburetion)
- Burglar-alarm systems
- Computers (in home computers and peripherals)
- Energy-conservation devices (for monitoring, controlling, allocating or rationing power)
- Industrial control devices
- Isolation units (dictated by safety/product-liability considerations)
- Medical electronics (for isolation and signal handling)
- Pollution-control equipment
- Solar-power units (in inverters)
- Telephone-dialing equipment.

Technology News

For more information...

For more information about the transformers and other magnetic components described in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Coilcraft
Cary, IL 60013
(312) 639-2361
Circle No 441

Dale Electronics Inc
E Highway 50
Yankton, SD 57078
(605) 665-9301
Circle No 442

Inductive Components Inc
181 Bridge Rd
Hauppauge, NY 11787
(516) 582-9370
Circle No 443

Microtran Co Inc
Box 236
Valley Stream, NY 11582
(516) 561-6050
Circle No 444

Pico Electronics Inc
Box 1206
Mt Vernon, NY 10551
(914) 699-5514
Circle No 445

Pulse Engineering Co
Box 12235
San Diego, CA 92112
(714) 279-5900
Circle No 446

Signal Transformer Co Inc
500 Bayview Ave
Inwood, NY 11696
(516) 239-7200
Circle No 447

Triad-Utrad
305 N Briant St
Huntington, IN 46750
(219) 356-6500
Circle No 448

TRW/UTC Transformers
150 Varick St
New York, NY 10013
(212) 255-3500
Circle No 449

core-set samples plus comprehensive application notes and data sheets. These bobbin and core sets suit designs that furnish up to 300W.

Those superminiature units

Transformer and choke miniaturization has come a long way from the days of the UTC Ouncer (once the industry standard for small size at $7/8 \times 1\,3/16$ in.). Today, hermetically sealed audio and pulse transformers that plug into pc boards or sockets commonly measure about $1/4 \times 1/4$ in. Both Pico Electronics and TRW/UTC currently market units of this size.

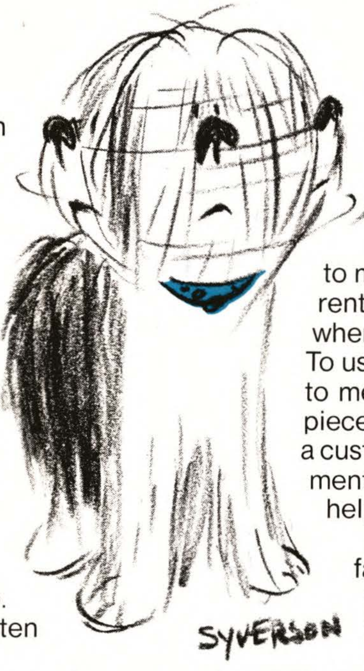
How can these transformers be fabricated in such small sizes, yet provide reliability and relatively low cost? According to Pico Electronics marketing manager Joe Sweeney, the answer lies largely in higher saturation-density magnetic materials and greatly improved techniques for winding extremely small-diameter wire.

Superminiature units' reliability results not only from using quality materials, he explains, but also from construction that enables very fine wire to withstand the shock of exposure to heat and cold extremes. Without such care, wire breakage would often occur after only a few thermal cycles.

Considering another superminiature transformer type, the frequency-range specs for $1/4 \times 1/4$-in. so-called audio units could come as a surprise if you expect them to embrace the usual 20-Hz to 20-kHz span. These minis cover 400 Hz to 250 kHz, so they provide capabilities far above audible frequencies.

EDN

If All Rental Companies Look Alike, How Do You Choose?



Need an oscilloscope or logic analyzer in a hurry? Do you have a short term need for a microprocessor development system? Chances are you've already discovered that renting the electronic equipment you need makes sense. But which rental company?

When you call Rental Electronics, you're tapping a multi-million dollar inventory of electronic equipment from Hewlett-Packard, Tektronix, Intel and every other major manufacturer. So we're sure to have what you need—even the newest equipment.

Our on-line real-time computer lets us give you immediate availability information while you're still on the phone. Even if what you need is at another of our ten stocking centers across North America.

Renting from Rental Electronics makes good economic sense, too. We're big enough to be as flexible as you need us to be, with competitive short term rates, lower rates for extended periods, even a selection of rental/purchase plans.

But there's an even better reason to make Rental Electronics your equipment rental company. It's called service. It starts when our rental experts answer your phone call. To us, service means going that extra step to meet your particular needs—for a special piece of equipment, a tight delivery schedule, a customized rental or rental/purchase arrangement, or just straight answers and a helpful attitude.

When it comes to service we're positively fanatical. And it pays off. During the past twelve months, for example, 92% of our first-time customers have come back for more.

Next time you consider renting, consider Rental Electronics. Give us a shot at your business. We're confident we'll turn you into a repeat customer.

Test and Measurement Instruments

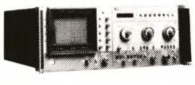
Here is just a small sampling of the test and measurement equipment available today from Rental Electronics. For a complete list, use the coupon opposite.

Hewlett-Packard 1640A Serial Data Analyzer. Identifies and locates failures to the component level; RSC 232C; 2048 characters, monitor buffer, plus 1024 characters transmit message buffer; Sync or Async.

Biomation K 100 D Logic Analyzer. 16 channels; 1024 word memory; clock rates up to 100 MHz; signal timing resolution to 10ns; built-in display and keyboard control.

Honeywell 101 Recording System. 7 or 14 tracks depending on head assembly; ½ in. (7 tracks) or 1 in. (14 tracks) tape; 8 tape speeds from 0.937 ips to 120 ips; direct bandwidth to 2 MHz (wide band) and to 600 kHz (intermediate band); FM bandwidth to 80 kHz (wide band) and to 40 kHz (intermediate band); reel size 10½ to 15 in., coaxially mounted.

Tektronix 465 Oscilloscope. BW 100 MHz; display 8 x 10; 5 mV/div to 5 V/div sens.; sweep rate 50 ns/div to 0.5 s/div; x10 magnifier; dual trace; delayed sweep; x-y operation.



Hewlett-Packard 8565A/100 Spectrum Analyzer. 0.01 to 22 GHz with internal mixer; 14.5 to 40 GHz with 11517 external mixer; 100 Hz and 300 Hz resolution bandwidth; Absolute Amplitude Calibration: −110 dbm to +30 dbm.

Brush 260 Strip Chart Recorder. 1 mV to 500 V; chart speeds 125 mm/sec. to 1 mm/min., incl. four event markers; pressurized ink; response: DC to 100 Hz.

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PRECISION
DYNASCAN CORPORATION
1250 NTSC GENERATOR
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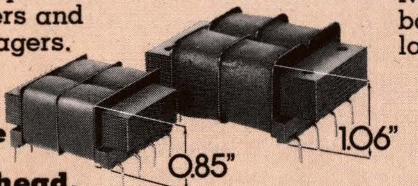
At signal, we transform custom problems into off-the-shelf solutions.

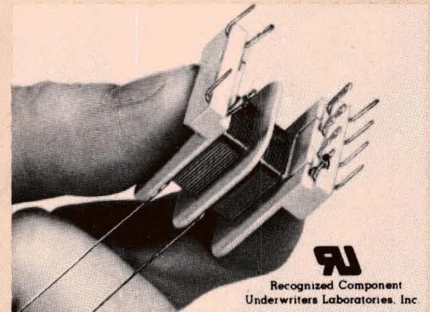
Next time your needs dictate a transformer design that looks like a sure candidate for a time-consuming, budget-busting "special," contact Signal. Chances are we make something very close if not exactly what you're looking for.

And if we catalog it, we stock it. And if we don't catalog it, we'll make it—and ship it pronto, too.

Signal's unique record of having transformers ready for designers when they need them is no accident. Our R&D department goes to great length to keep pace with new design trends so we can anticipate the needs of circuit designers and packagers.



Take our Flathead, for example. We were first in the industry to develop a "flat" power transformer for high density PC board packaging problems. Our 6 VA units are less than 0.85" high, while our 12 VA units require just 1.06" of headroom.



Another example: Split-bobbin makes high-isolation possible in PC board transformers.

New from Signal—miniature PC board transformers with high isolation (2500V RMS HIPOT standard) and low capacitive coupling. All this and lower than standard transformer prices, too. Split/Tran is available with single 115V or dual 115/230V primaries. Secondary windings are split, so they can be series or parallel connected.

We've done something about μP power too.

Our MP line of transformers will give you all the combinations you need for triple-output regulated supplies (+5V, ±12V and +5V, ±15Vdc). Available in standard or Flathead® styles, it can be mounted on your PC board with microprocessor or other components.

The biggest line, the fastest delivery.

Our complete catalog includes over 1,000 standard transformers and chokes, from 1 to 10,000 VA. And all at low, factory direct prices that are made even lower by our enormous volume.

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signal TRANSFORMER

CIRCLE 38 or see eem

Statistical time-division multiplexers grow faster and more flexible than ever

Jim McDermott,
Special Features Editor

The latest statistical time-division multiplexers offer improved data-transfer capabilities and greater flexibility than older units. And advanced options for the older multiplexers also provide them with many of the same advantages.

Highlights of these STDM improvements include:

- Higher aggregate data-input speeds
- Modem-sharing capabilities that eliminate modems in multiple-line environments and provide other line economies
- Load-sharing arrangements that increase efficiency
- Automatic baud-rate recognition that changes line configuration automatically to handle incoming data rates for which the line was not originally configured
- Data-flow control that prevents the shutdown of all receiving channels when only one channel is overloaded
- Diagnostic routines that utilize local CRT terminals to test communication lines as well as local and remote equipment.

Rising bit rates

As data-terminal speeds increase, burst aggregate bit rate — the maximum speed at which STDMs can accept local input data—must also increase. Timeplex meets this challenge in its Series II 4-, 8- and 24-channel models. The $3800 8-channel M8C-2 provides a 76.8k-bps maximum aggregate data-input rate, supported by a 48k RAM, while the M24, an $8500 24-channel system, incorporates a 112k buffer memory for even faster operation at 232k bps.

Established, older designs (EDN, April 20, pg 157) are also improving to meet today's speed requirements. For example, Micom's Micro800 Series' previous basic 9.6k-bps rate has quadrupled to a new maximum aggregate speed of 38.4k bps.

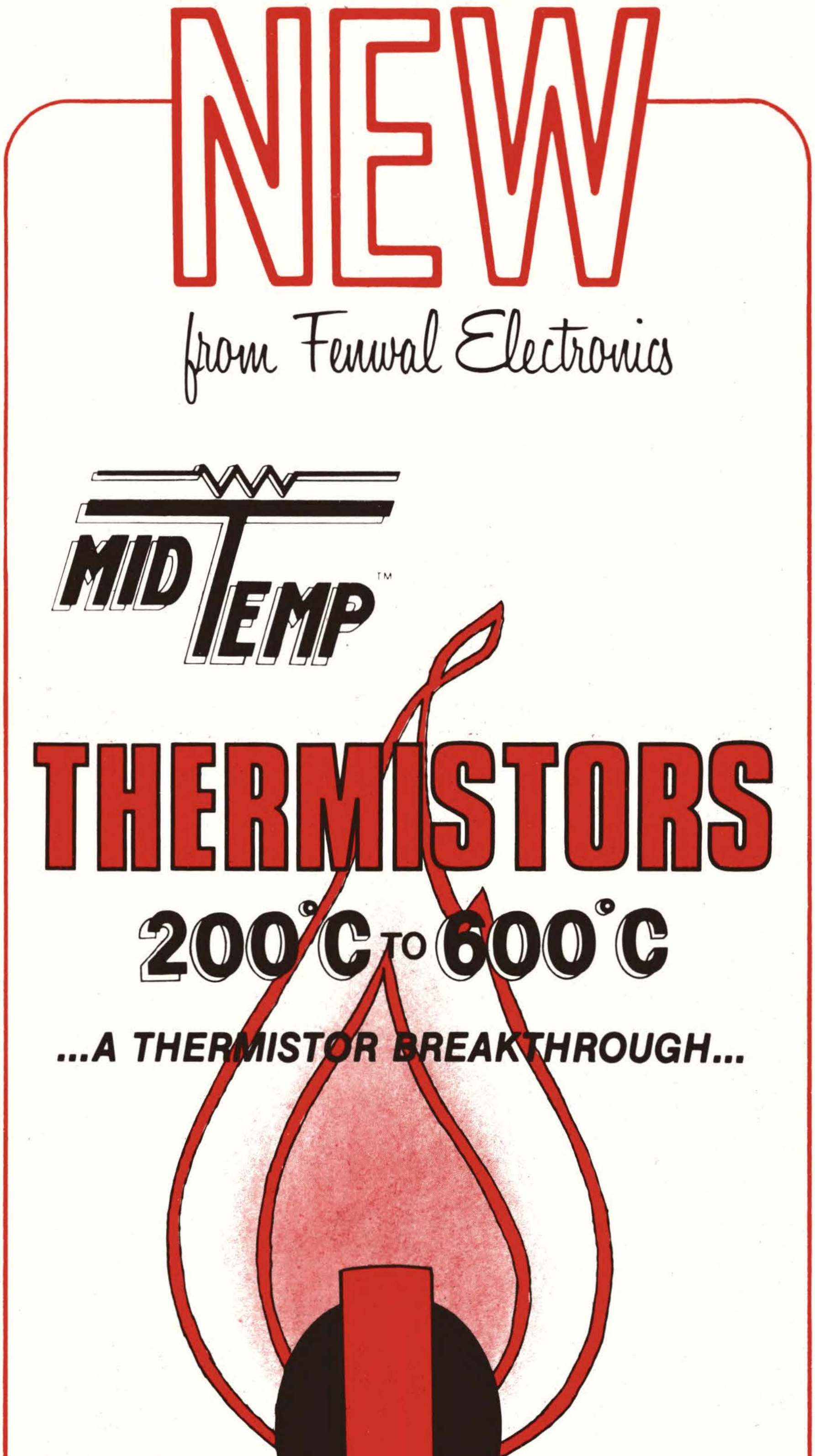
Modem sharing reduces costs

To minimize the number of modems and lines needed for multiterminal installations in the same general service area, several manufacturers provide modem-sharing features. Digital Communications Associates (DCA), for example, offers a built-in modem-sharing arrangement in its System 105 Series that allows two or more STDMs in multipoint configurations to share a single modem rather than employing one modem for each multiplexer.

This series comprises two versions: the 105/4, supporting two or four terminals, and the 105/8, which supports four, six or eight terminals. These units can handle widely distributed terminals (such as those on different floors of a building) connected by daisy-chained cables.

To implement this capability,

Modem-sharing features *in Digital Communications Associates' System 105 allow two or more units to use a single trunk-line modem, thereby reducing system costs.*



News

System 105 incorporates special RS-232 drivers and receivers that act like a digital bridge across the analog telephone line—a function usually accomplished by analog bridges. DCA-system users can thus employ a cluster of polled STDMs in proximity with one another, all sharing a single, polled multidrop modem for access to long-distance telephone lines. (Ordinarily, if you want to save money by using a multipoint telephone line, you have to employ CPU-based polled terminals requiring involved programming. With 105 Series equipment, however, the STDM network itself controls sharing and requires no user intervention.)

The DCA system also makes available, to smaller terminal clusters than previously feasible, the benefits of combining a data-communications network with statistical multiplexing. It employs a character-multiplexed scheme rather than record-multiplexed operation to achieve this flexibility. In contrast to most polled multipoint units, which force users to wait until a full record accrues inside a terminal before it can transmit over the phone line, the DCA system fits individual characters into the transmit bit stream at the earliest opportunity.

Basic 105 Series units (consisting of an enclosure, backplane and power supply) support dual-port cards that are identical for all systems (the units' backplanes are tailored to individual model characteristics). Basic System 105/4s (without cards) cost $1150; 105/8s cost $1395. These units are also compatible with the firm's earlier System 115 32-port STDM.

A somewhat different but nonetheless effective approach to modem sharing appears in a $50 option for Infotron's Supermux 480 system: a current-interface adapter that senses standard 20- or 60-mA terminal current-output signals. The terminal cable that normally connects to a modem goes instead to

Power Supply

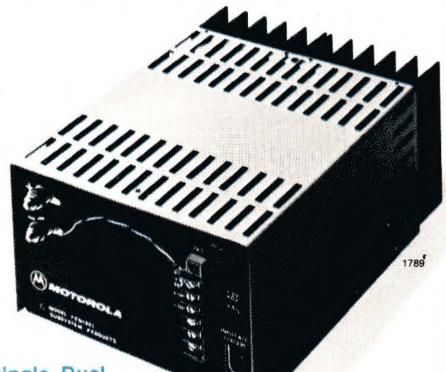
More of what you're looking for in switchers.

Truly top-of-the-line, combining more desirable features than most other comparables, this rigidly-constructed, conservatively-rated, rugged family of 400 W, 25 kHz pulsewidth modulated supplies is designed for users of MPUs, small computers and numerical control equipment.

It offers a host of housekeeping and self-protection advantages that make it virtually foolproof in operation protecting you, and itself, from damage: remote turn-on/turn-off; soft-start circuitry to eliminate voltage overshoot and limit inrush current; overcurrent protection and over-voltage protection with automatic reset.

You can't damage it by turning it on or off. And it's virtually blowout-proof.

Conservative guardbanding and hefty heatsinking provide outstanding efficiency. At 100% rated power output (all outputs simultaneously) and at maximum ambient temperature of 60°C, the power semi-conductors will be operating at 75% or less of their max T_J rating. We've even special-wound the transformer to cut losses.



Single, Dual & Triple Output 400-W ICEMAN™ Switchers.

ICEMAN™ switchers meet not only our own high standards but those who set the industry's: UL specs and EMI requirements (Curve A of VDE 0871/6.78).

No cooling fan is required.

Each unit receives 24-hour burn-in.

Specifications

PSN1801, 5 V/80 A
PSD1802, 5 V/60 A, 12 V/8 A
PST1803, 5 V/60 A, 12 V/4 A, 12 V/4 A

Input. 100–130 Vac/200–260 Vac (Selectable), 45–440 Hz Single Phase

Output. Floating, isolated from each other and from ground, 600 Vdc max

Regulation. Line: ±0.1% Output, for 100–130 or 200–260 Vac. Load: ±0.2% Output, no load to full load

Ripple and Noise. Less than 10 mV RMS, 50 mV p-p, as measured with 50 MHz scope

Temp. Coefficient. Less than 0.2%/°C

Switching Frequency. 25 kHz (Pulse width modulated)

Transient Response. 500 μs to within 1% after a 25% load change at 5 A/μs, main output

The standard warranty period for all Motorola linear and switching power supplies is 1 year.

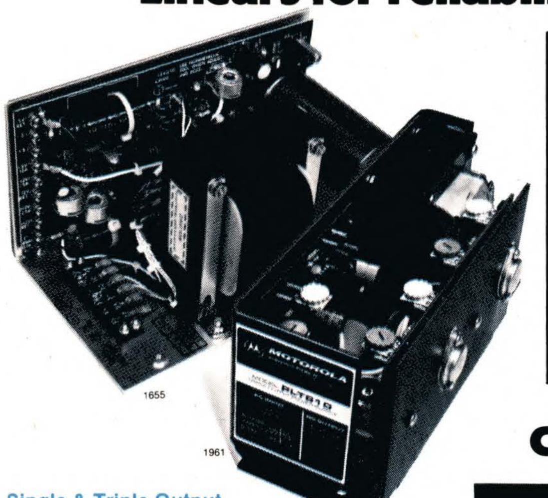
Linears for reliability that won't melt away.

SINGLE OUTPUT PLN SERIES	Model	AC Input	DC Output	Load Regulation†
	PLN800/5	115/230 V ±10%	5 V/2 A	0.1%
	PLN810/5	115/230 V ±10%	5 V/4 A	0.1%
	PLN820/5	115/230 V ±10%	5 V/6 A	0.1%

†No-Load to Full-Load

TRIPLE OUTPUT PLT SERIES	Model	AC Input	DC Outputs	Load Regulation‡
	PLT800	115 V/230 V ±10%	5 V/2 A, 12 V/0.3 A, 12 V/0.3 A	0.1%
	PLT810	115 V/230 V ±10%	5 V/4 A, 12 V/0.7 A, 12 V/0.7 A	0.1%
	PLT820	115 V/230 V ±10%	5 V/6 A, 12 V/1.0 A, 12 V/1.0 A	0.1%
	PLT840	95 to 125 V &	5 V/15 A, 12 V/2.5 A, 12 V/1.5 A	0.05%
	PLT841	190 to 250 V	5 V/15 A, 13 V/2.5 A, 12 V/1.5 A	0.1%

‡Full-Load to No-Load



Single & Triple Output ICEMAN™ Linear Supplies.

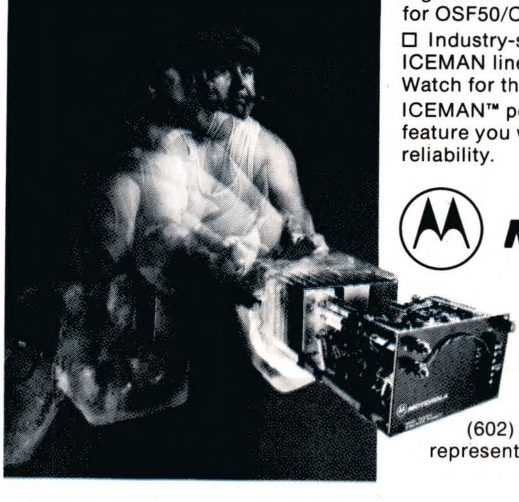
ICEMAN linear supplies represent cooler-running, longer-lasting, lower-cost design. Furnishing 50% to 100% more square heat sink area than others, the units spread power transistor locations over a much greater area so heat is dissipated faster, more efficiently . . . and the supply runs cooler and more reliably.

Power transistors are specifically designed to operate at no more than 75% of their max T_J at 100% P_{out}.

The five dc, series-regulated units are designed primarily for MPU applications and provide OVP protection on all outputs, remote sensing on the +5 V output and foldback current limiting on all outputs with automatic recovery.

Each unit has 100% burn-in and is UL-recognized.

Coming soon!



☐ 50-W and 75-W open-frame switching supplies where economy is a prime parameter. Small, light-weight, high-efficiency for top dollar value . . . ask for OSF50/OSF75!

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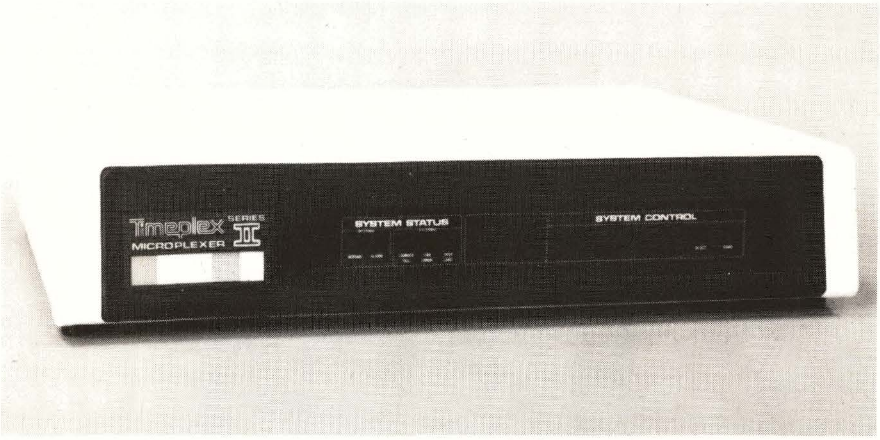
For more information, Circle No 41



User parameters are easily programmed *from the front panel of Timeplex's Series II STDM. A built-in diagnostic capability troubleshoots both remote and local units.*

the 480 STDM, and the arrangement operates reliably over standard system wiring at 1000 ft or more, depending upon ambient noise levels. The current-interface adapter works both with Infotron's $1500 4-channel 480 system and its $2800 8-channel equipment.

Bringing home remote data

Many recent multiplexer improvements handle data streams from remote locations more efficiently than before. High-throughput intercity links that require more than one phone line, for example, could achieve greater line efficiency with load-leveling and load-sharing features such as those included in Timeplex's 8- and 24-channel M8C-2 and M24C systems. These STDMs handle two 9600-bps links simultaneously but can also configure to automatically share the load between two lines by feeding the overflow data from one line into the other's waiting periods—thus providing faster throughput.

Other Series II systems—the 4-channel $1500 M4A; and the 8-channel M8A ($2500), M8B ($2750) and M8C ($3600)—do not include load-leveling features, but the 8- and 24-channel systems can accept asynchronous or synchronous input data, intermixed in any combination. They also provide true statistical bisynchronous-data multiplexing.

For more information...

For more information on STDMs and STDM options mentioned in this article, contact the following manufacturers directly or circle the appropriate number on the Information Retrieval Service card.

Digital Communications Associates
135 Technology Park/Atlanta
Norcross, GA 30092
(404) 448-1400
Circle No 436

Infotron Systems Corp
Cherry Hill Industrial Center
Cherry Hill, NJ 08003
(609) 424-9400
Circle No 437

Micom Systems Inc
9551 Irondale Ave
Chatsworth, CA 91311
(213) 882-6890
Circle No 438

Prentice Corp
795 San Antonio Rd
Palo Alto, CA 94303
(415) 494-7225
Circle No 439

Timeplex Inc
1 Communications Plaza
Rochelle Park, NJ 07662
(201) 368-1113
Circle No 440

News

Marching to different drummers

Old limitations on terminal-network architectures are vanishing under the impact of new developments. One example: the requirement that all terminals assigned to an STDM line operate at the same speed. A feature added to Infotron's Supermux 480 systems—automatic baud-rate detection—eliminates this speed restriction.

Normally, when you assign a communication line to an STDM, you can't install any units on that line that operate at speeds differing from the originally specified one. But the automatic baud-rate detector—a $300 PROM option—analyzes incoming-line signals, determines the type of transmitting bit-pattern envelope used (Memorex or Carriage Return) and automatically adjusts line configuration to handle signal variations. The PROM-based unit also monitors incoming-signal speed as well as block size, stop code and other protocol elements.

The shutdown of data flow from all incoming channels when only one overloads—another undesirable operating limitation—is eliminated by another recent $300 Supermux option: flow control.

Normally, terminals connected to STDM-channel outputs utilize data buffers because the terminals themselves can't keep up with the speed of incoming data. But if for some reason data begins to overload this buffer (when a printer is stopped to change forms, for example), terminals send a signal to the host computer to halt transmission. The computer, upon receipt of this signal, then usually shuts down all channels simultaneously. The flow-control feature, however, notifies the computer to stop sending data only to the overloaded channel and to keep sending it to the others.

Test and control features advance

STDM test and control from a central-site terminal is another

Introducing the first complete, low-power, 12-bit hybrid DAC for $9.95.

The next generation.

A packaging breakthrough from Hybrid Systems can help you make design history.

Check the specs: 12-bit resolution . . . ±11.5 to ±18 volts . . . total power consumption as low as 150mW . . . analog output of ±10V @ ±5mA . . . ±1/2 LSB linearity . . . 25μS settling time . . . linearity tempco of ±5ppm/°C . . . no external components needed to make this complete DAC fully operational.

And the price is at least 40% below anything comparable you've seen before.

The secret is in the packaging: a unique, proprietary 24-pin dual-in-line enclosure[1] designed to take more punishment than it's ever likely to get in actual use . . . including four hours in a pressure cooker, a weekend strapped to the hull of a sailboat on Nantucket Sound, and countless cycles in a standard dishwasher. It also stands up to the toughest conventional environmental tests; leak, temp cycle, temp storage, stabilization bake, solderability, 1000-hour burn-in. It's cost effective, rugged, complete, low power – and yes, it's clean.

[1]U.S. Patent Pending

For fast turnaround, call or write.

Quantity	Price	Quantity	Price
1-9	$19.95	100-249	$13.50
10-24	$17.50	250-999	$12.00
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Crosby Drive, Bedford, MA 01730
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(TWX 710-326-7584 HYBRIDSYS BFRD)

In Germany: Hybrid Systems GmbH.
6100 Darmstadt, Luisenplatz 4, Germany
Tel. 6151-291595 (TELEX 419390 HYSY D)

In France: Hybrid Systems S.A.R.L.
14 Rue du Morvan SILIC 525
94633 Rungis CEDEX TLX: 250 969 HYSYS

In the United Kingdom:
Hybrid (Component) Systems U.K. Ltd.
12A Park Street, Camberley, Surrey
Tel. (0276) 28128 (TELEX 858720 HYBRID G)

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Grayhill's enclosed SMALL switches offer BIG value and BIG selection

Choice of ratings, circuitry, size, and features so you're sure to find a perfect fit!

Quality and Economy
½" diameter, ¼ amp multi-deck

SERIES 71

Value-engineered for premium enclosed switch performance at "open wafer" prices. Available in 30° or 36° angle of throw, 1-12 decks, PC or solder lugs, and many more options.

Want more data? Circle 70

Single Deck
½" diameter

SERIES 50, 51

22½° 30°, 36°, 45°, 60°, or 90° angles of throw—1 thru 4 poles—military and water sealed versions available.

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Power Switch

SERIES 19

For the heavy loads, this 15 amp UL listed husky is the one. Up to 11 positions, 30° indexing, solder lug or "Faston" terminals.

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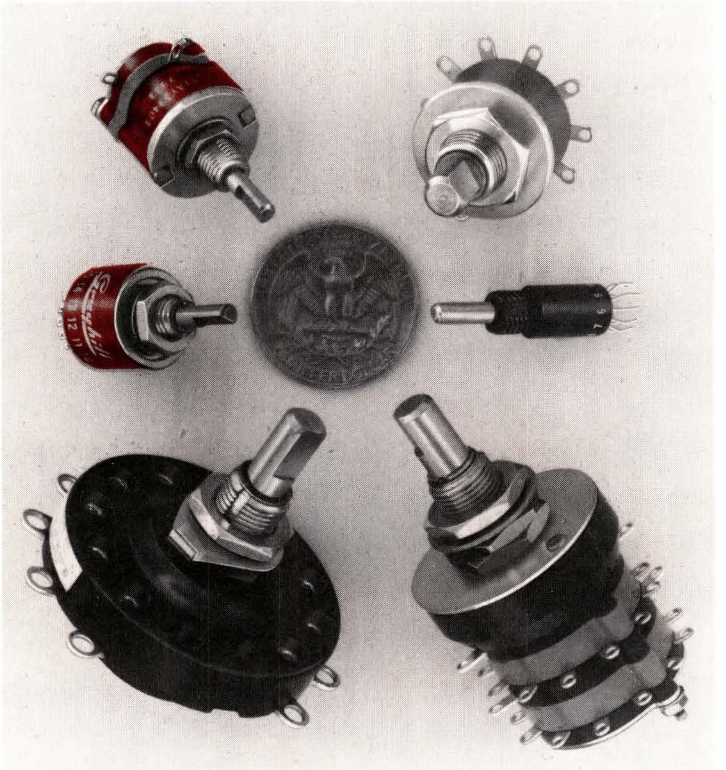

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SERIES 75

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Rugged 1 inch, 1 amp

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Want more Data? Circle 75

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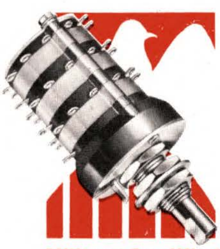

Military Qualified

Grayhill switches meet MIL-S-3786 SR04, SR13, SR20, SR35 and SR36, to provide the military product designer unequaled flexibility.

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and many more.

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And many more

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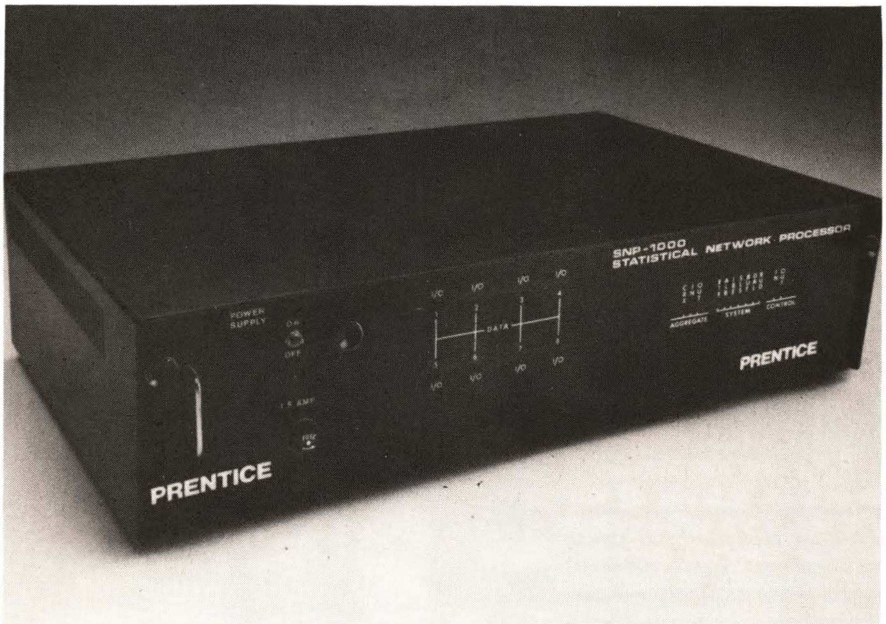
Technology News



A multipoint option *lets you poll several remote sites situated on one transmission line with Prentice's SNP-1000 STDM.*

feature that several manufacturers are inplementing. The latest option for Micom's Micro800 system, the $100 terminal-activated channel test (TACT), for example, allows users to test their own Micro800's operation as well as that of the total STDM system—whether they're dialing into a remote STDM or are colocated with it.

In operation, you can select any of four test functions: Local, Remote, Terminal or System. For local tests, you depress an L key on the terminal keyboard to enter that test mode. From then on, anything entered on the keyboard loops through the local Micro800 and back to the monitor CRT screen.

For remote tests, another keyboard entry causes any characters entered via the keyboard to loop from one end of the hookup to the other and back to the CRT, thus checking out the link. To test the terminal, the keyboard can initiate a "quick brown fox" message from the Micro800 that repeats continuously for a printout or readout at the terminal.

If you want to test the entire system, you hit an S key, generating the "quick brown fox" message in the nearest Micro800, transmitting it to a unit at the end of the link and then retransmitting it back through the link to the terminal screen. The test does not require you to operate any panel switches or interrupt any other user's operation.

For the same basic purpose, Prentice incorporates a command-and-control port in its SNP-1000 system that allows an operator to exercise complete control over all remote SNP-1000 STDMs from a central test site. Utilizing a CRT display and simple English-language commands, operators can test the remote units and reprogram their operating characteristics as well.

Another manufacturer, Timeplex, includes an optional supervisory port in its Series II M8 and M24 models (eight channels and up). You can connect any nonintelligent ASCII terminal to these units for diagnostics and off-line English-language programming. **EDN**

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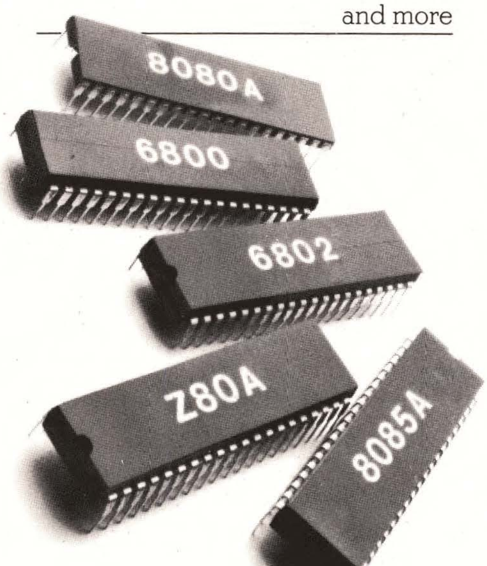

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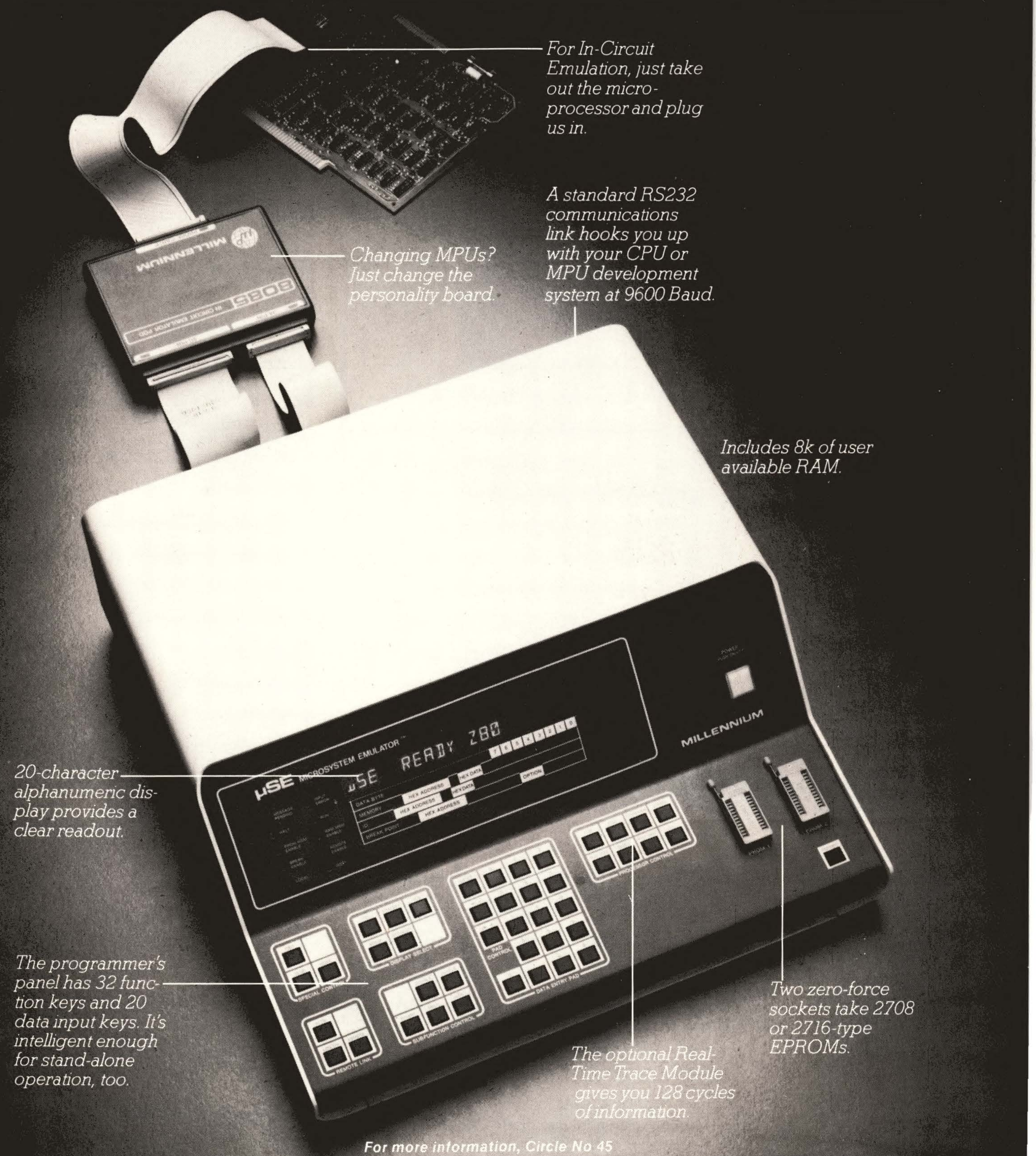


For more information, Circle No 45

No guaranteed memory use for bubbles; fast memory, fixed storage loom brightest

Dale Zeskind, Contributing Editor

In the projected 1980s competition among memory technologies, some of the fiercest battles could occur between magnetic-bubble memory and more traditional semiconductor-memory implementations. This somewhat surprising view, offered by several industry experts, contrasts strongly with previous assumptions that bubble memory's nonvolatility alone will earn it a unique place in many memory-system applications.

Writing in the July issue of *Mini-Micro Systems*, Texas Instruments' J Egil Juliussen and National Semiconductor Corp's James Cunningham, George Reyling and Tony Tuxford emphasize that to establish itself, bubble technology will have to supplant semiconductor memory in microprocessor and minicomputer applications.

That could prove difficult. Juliussen, a member of the Dallas, TX firm's technical staff, points out that semiconductor memories have shown impressive cost and performance gains over the last 10 yrs, and that similar technological advances are forecast for them for the next 10 to 15 yrs.

Developments in dynamic MOS RAM are pacing semiconductor-memory technology; the transition from 16k-bit devices to 64k-bit units is beginning. And other semiconductor-memory technologies are showing similarly impressive capacity gains: Static-RAM chip capacity is increasing from 4k to 16k bits, and mask-programmable ROMs now store 64k bits.

Complacency among bubble-memory manufacturers in the face of these developments could prove dangerous, warn Cunningham, Reyling and Tuxford (respectively director, subsystems manager and operating manager of National's Santa Clara, CA Magnetic Bubble Memory Dept). They cite some companies' experience with CCD memories, which were believed to have unique cost advantages compared with MOS RAM but nonetheless lost out in many competitive applications. Bubbles' competitive position, therefore, will depend heavily on whether the rapid pace of MOS dynamic-RAM technology continues and whether innovation in bubble-memory technology proceeds.

Where will bubbles fit?

To determine the competitive status of bubble memory relative to other memory technologies, Juliussen considers the hierarchical nature of computer memory—its division into main memory, fast auxiliary memory (FAM), fixed mass storage and removable mass storage. Each of these memory classes finds use in mainframe computers, minicomputers and microcomputers **(Fig 1).**

Because of its relatively slow speed and serial organization, bubble memory is unlikely to displace semiconductor and core memories in main-memory applications, says Juliussen. On the other hand, FAM applications represent a significant gap in the memory hierarchy. And although drums and

HOST PROCESSOR	MAIN MEMORY	FAST AUXILIARY MEMORY	FIXED-MEDIA MASS STORAGE	ON-LINE	OFF-LINE
MAINFRAME COMPUTER	CORE BIPOLAR STATIC MOS DYNAMIC MOS	FIXED-HEAD DISC BULK CORE EBAM CCD BUBBLE MEMORY	MULTIPLATTER DISC EBAM CCD BUBBLE MEMORY	MULTIPLATTER DISCTER	AUTOMATED TAPE REEL MAG TAPE
MINICOMPUTER	CORE BIPOLAR STATIC MOS DYNAMIC MOS	FIXED-HEAD DISC BULK CORE CCD BUBBLE MEMORY MOS RAM	SINGLE-PLATTER DISC FLOPPY DISC CCD BUBBLE MEMORY	SINGLE-PLATTER DISC FLOPPY DISC	REEL MAG TAPE FLOPPY DISC
MICROCOMPUTER	DYNAMIC MOS STATIC MOS EPROM PROM ROM	CCD BUBBLE MEMORY MOS RAM	MINI-FLOPPY DISC CCD MOS RAM BUBBLE MEMORY	MINI-FLOPPY DISC BUBBLE MEMORY ROM	CASSETTE MINICASSETTE MINI-FLOPPY BUBBLE MEMORY ROM

SOURCE: MINI-MICRO SYSTEMS

Fig 1—Consider the hierarchical nature *of computer memory as well as the system application when determining the competitive status of bubble memories.*

Technology News

fixed-head discs have traditionally dominated FAM applications, bubble memory and CCDs should become significant competitors in this area in the next few years.

In mainframes, CCDs will dominate FAM applications—there, performance is the key. Because mainframe computer systems always incorporate discs for backup, CCDs' volatility is a minor drawback. (Two recent CCD-based products illustrate the use of CCDs in mainframe FAM applications: Storage Technology's fixed-head-disc replacement and Memorex's disc cache system.)

In minicomputer FAM applications, CCDs and bubble memory appear equally competitive, says Juliussen. Here, CCDs have a performance advantage, but bubble memory's nonvolatility is an equalizer. And in microcomputers,

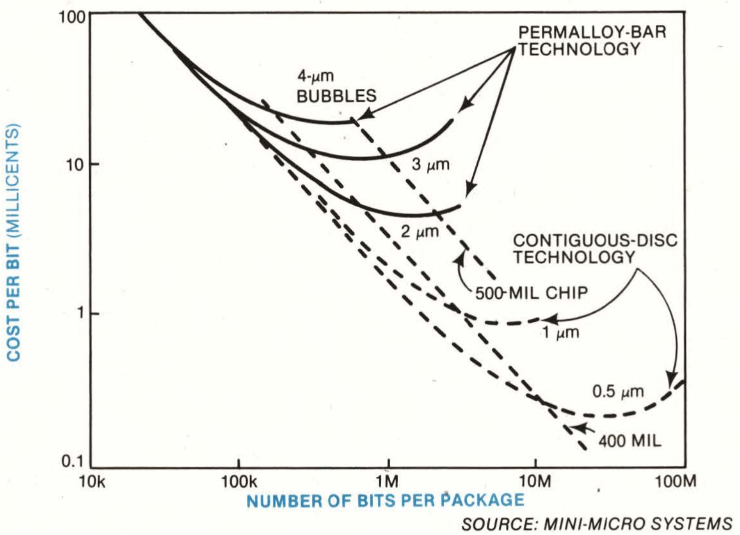


Fig 2—The cost of bubble-memory manufacturing, *estimated here by National Semiconductor, will play a key role in determining which applications the technology finds use in.*

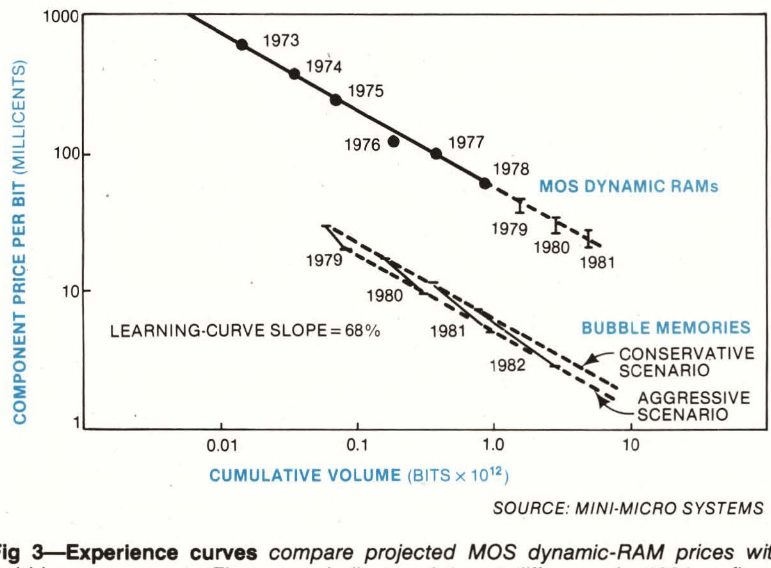


Fig 3—Experience curves *compare projected MOS dynamic-RAM prices with bubble-memory costs. The curves indicate a 3:1 cost difference by 1981—a figure that according to most estimates is sufficient to ensure bubble viability in many applications.*

News

that nonvolatility gives bubbles a strong edge over CCDs as a FAM choice. In this area, moreover, CCDs' performance edge is somewhat nullified by their high transfer rate, which can prove costly for a microcomputer to handle.

But Juliussen emphasizes that despite the apparently optimistic outlook for bubbles in some FAM applications, semiconductor memory remains a strong potential competitor in microprocessor and minicomputer FAM. Indeed, semiconductor RAM with battery backup appears to be a reasonable alternative to bubble memory in implementing small amounts of nonvolatile mass storage.

What about the picture in fixed-media mass storage? There, the growing popularity of the Winchester disc is proving advantageous for bubble memory, because bubble systems are the functional equivalents of fixed-media discs. In the near term, however, bubble memory will not be cost competitive with Winchester discs in mainframe or minicomputer applications, although it will in microcomputer settings.

In those settings, the volatility of CCDs and MOS RAMs is difficult to overcome, and hard discs exhibit the drawbacks of relatively high price and large size. Nevertheless, bubble memory faces tough competition in this market from low-cost floppy discs.

Finally, in the area of removable mass storage, bubble memory will find tough competition, according to Juliussen. Its nonvolatility makes possible the development of a removable bubble cartridge, but the cost of such a device would be very high compared with that of floppy discs or tape cartridges. Bubble memory's superior reliability and maintainability could justify this high cost in some applications, however.

Juliussen thus projects that the primary initial applications for bubble memory will occur in fast

auxiliary memories and fixed-media mass storage in microcomputers (as distributed mass storage for distributed-processing applications, for example). Applications in minicomputer and mainframe systems will then follow.

Production costs the key

The speed at which bubble-memory applications can appear depends in no small measure on the state of the technology's manufacturing processes. National's Cunningham, Reyling and Tuxford have estimated the cost of bubble-memory manufacturing; **Fig 2** shows their plot of cost per bit versus number of bits per package for three bubble sizes. With today's positive photoresist lithography, the 3-μm-bubble curve represents the state of the art in commercial products.

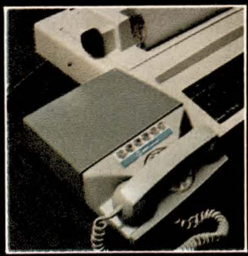
In a relatively mature production environment, a 256k-bit device can be produced for about 12 millicents per bit on a die measuring less than 350 mils square, say the three researchers. A 40% gross margin would then generate a 20-millicent selling price.

Fig 2 also includes a projection of the cost per bit for 1.0- and 0.5-μm-bubble ion-implanted contiguous-disc devices (EDN, August 20, pg 86). In such devices, the minimum-size lithographic feature is two to three times bigger than the bubble diameter. Use of these devices would permit production of 4M- to 100M-bit chips, on dies measuring about 350 mils square, at a per-bit cost 10 to 50 times less than that of today's permalloy-bar 256k-bit devices.

This projection assumes the same wafer cost as the standard permalloy-bar products, but when contiguous-disc products reach the marketplace in the mid-1980s, the cost of their garnet substrate will have fallen to perhaps half of today's value, bringing bubble-memory per-bit price levels within the range of most forms of disc memory, say Cunningham and his colleagues.

The three researchers have also constructed experience curves comparing future MOS dynamic-RAM prices with those of bubble memory **(Fig 3)**. Extrapolation of the MOS curve into the mid-1980s indicates per-bit prices in the 10-millicent range.

A comparison of both technologies' learning curves shows that the dynamic-RAM-to-bubble price ratio can be expected to increase from about 1.5:1 this year to about 3:1 in 1981. And compared with that of cartridge disc drives, bubble-memory pricing could assume a roughly similar ratio by the last half of the next decade. **EDN**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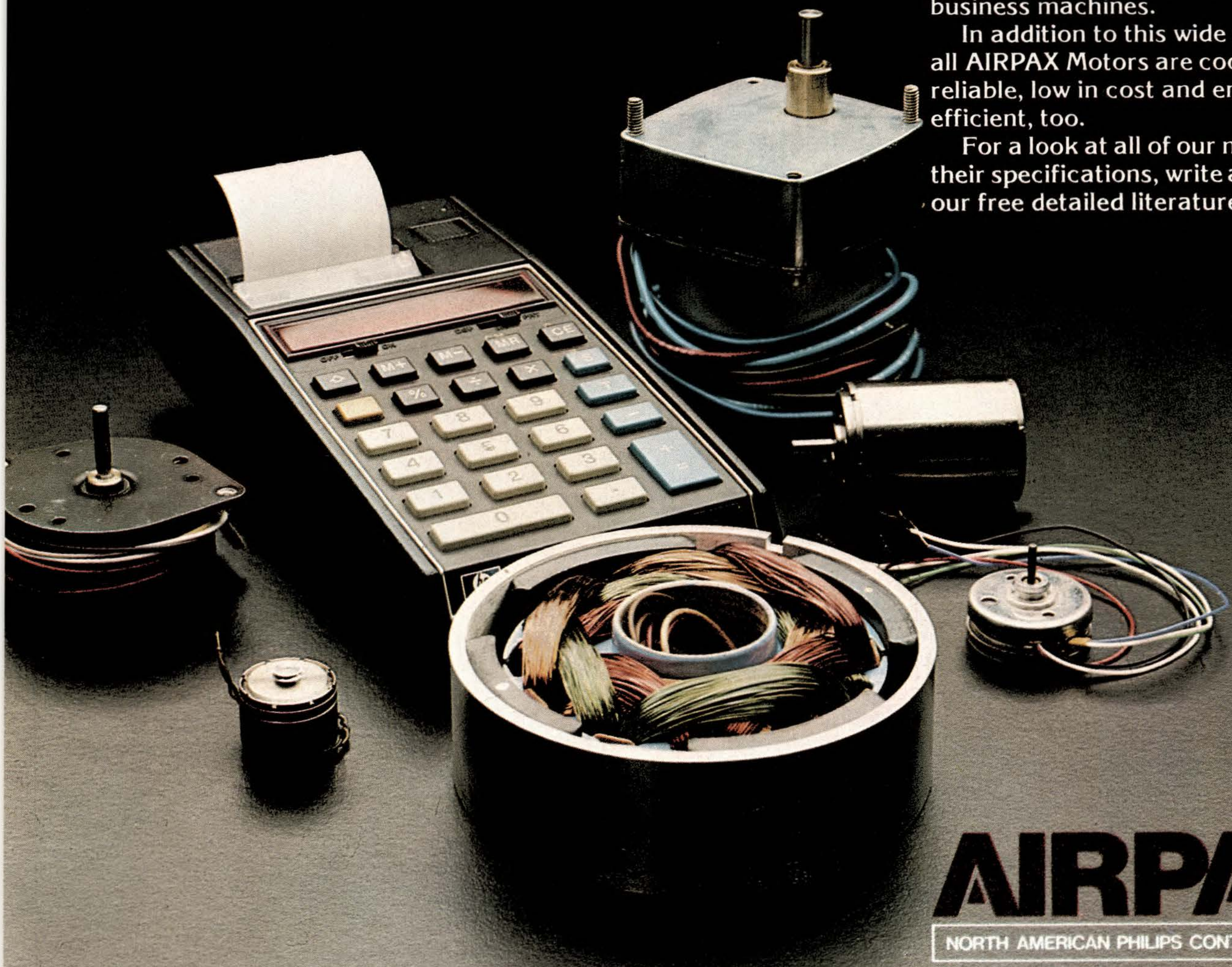

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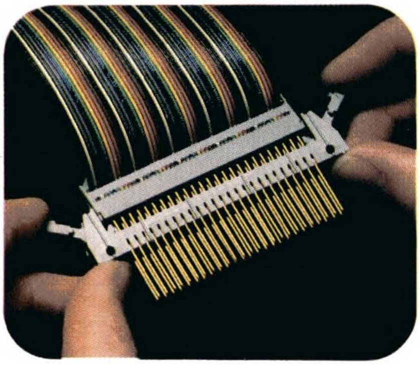
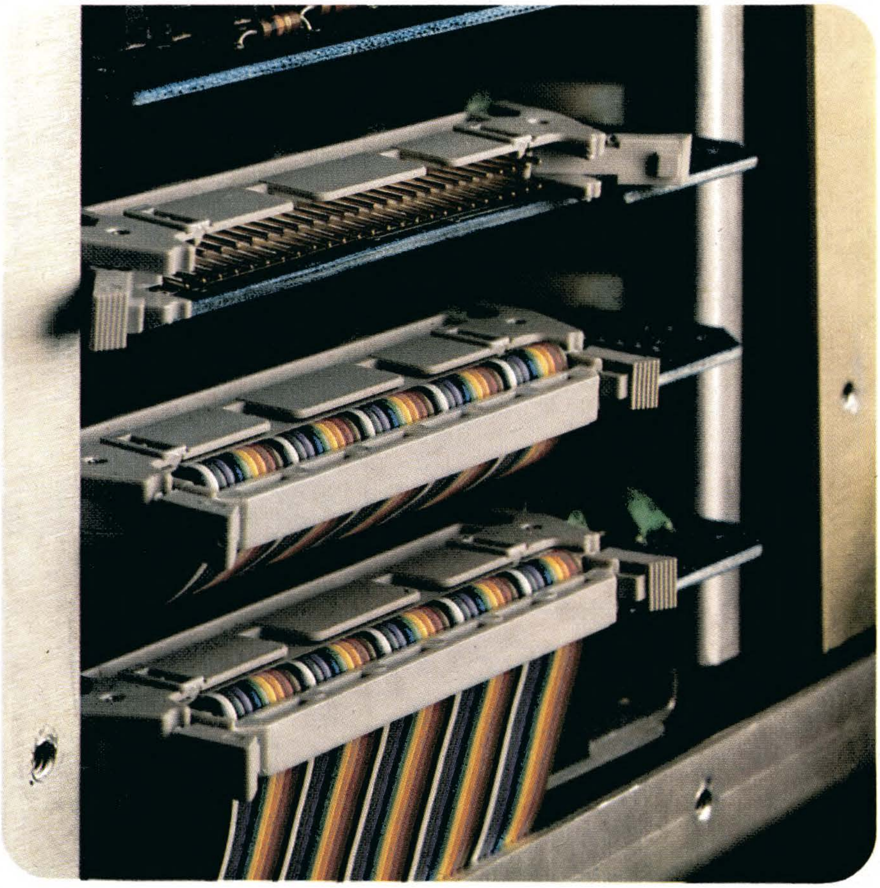


Now from 3M come several important design changes in Scotchflex brand socket connectors and headers. Changes aimed at bringing you faster assembly, increased reliability and reduced maintenance.



Scotchflex headers (.100″ x .100″ grid series) now include built-in retainer/ejector latches that snap up to lock sockets firmly in place and snap down to disconnect them quickly and easily. Latches hold tightly against vibration and shock, and their ejector feature also helps reduce wear and damage from disconnection and reconnection. They work with or without strain relief clips on both new and previous .100″ x .100″ Scotchflex socket designs.

Facts from Fluke on low-

cost digital multimeters.

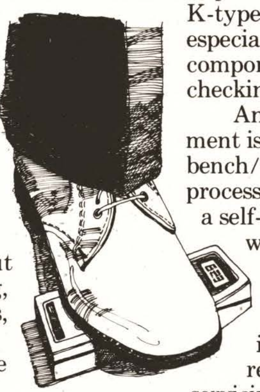
When you're looking for genuine value in a low-cost DMM you have a lot more to consider than price. You need information about ruggedness, reliability and ease of operation. Accuracy is important. And so are special measurement capabilities. But above all, you must consider the source, and that company's reputation for service and support.

Fact is, as electronics become more a part of our daily lives, dozens of new manufacturers are rushing to market their "new" DMM's. In theory, this is healthy; but in practice, crowding is confusion.

To help you deal with this flood of new products, here are some facts you should know about low-cost DMM's.

The economics of endurance.

Even the least expensive DMM isn't disposable. Accidents happen, and test instruments should be built to take the abuses of life as we live it.



Look for a DMM with a low parts count for reliability, and rugged internal construction protected by a high-impact shell. Make sure the unit meets severe military tests for shock and vibration.

Another feature to check out is protection against overloading, whether from unexpected inputs, transients, or human errors.

Just for the record, all Fluke low-cost DMM's meet or exceed military specs, and feature extensive overload protection.

The importance of being honest.

Just because a multimeter is digital doesn't mean it's automatically more *accurate* than a VOM – even though the LCD might give you that impression. The benchmark for accuracy in DMM's is *basic dc accuracy.* The specs will list it as a percentage of the reading for various dc voltage ranges.

Of course accuracy is more critical in some applications than others, and increasing precision and resolution in a DMM usually means increasing price. In the Fluke line, you can choose a model with a basic accuracy of 0.25% (the 8022A), others rated at 0.1%, or the new 8050A bench/portable at 0.03%.

Special measurements: getting more from your DMM.

Actually, for all the variations in size, shape and semantics, most DMM's perform five basic measurements: ac and dc voltage and current, and resistance. Prices vary according to the number of ranges and functions a DMM delivers.

	PRODUCT	FUNCTIONS	RANGES	DIGITS	BASIC DC ACCURACY	CONDUCTANCE	OTHER SPECIAL FEATURES	PRICE
HANDHELD MODELS	8022A	6	24	3½	0.25%		Basic six-function DMM; lowest-priced	$129
	8020A	7	26	3½	0.1%	X	High accuracy ; pioneer in conductance; exclusive two year warranty.	$169
	8024A	9	26	3½	0.1%	X	Direct temperature readings; continuity/ input level detector with selectable audible signal; peak hold capability.	Available soon
BENCH/PORTABLES	8010A	7	31	3½	0.1%	X	True RMS; extra 10A range.	$239
	8012A	7	31	3½	0.1%	X	True RMS; two extra low resistance ranges.	$299
	8050A	9	39	4½	0.03%	X	True RMS; selectable reference impedances with direct readouts in dBm; offset feature.	$329

The Fluke line includes DMM's with from 24 to 39 ranges, 3½ and 4½-digit resolution, and some unique functions you won't find in any other DMM. Additional measurement capabilities like temperature, dB, conductance and circuit level detection.

If your work involves temperature measurements, the new 8024A delivers direct temperature readings via any K-type thermocouple. This is especially useful in testing component heat rise and checking refrigeration systems.

Another talented instrument is our new 8050A bench/portable. The microprocessor-based 8050A features a self-calculating dB mode in which dBm readings are displayed automatically referenced to one of 16 selectable impedance ranges – a real timesaver when servicing audio equipment.

And of course no discussion of DMM's is complete without considering conductance – a Fluke exclusive featured on five of our low-cost DMM's – which allows you to make accurate resistance measurements to 100,000 Megohms. You can't do that with any ordinary multimeter, but it's a must for checking leakage in capacitors and measuring transistor gain.

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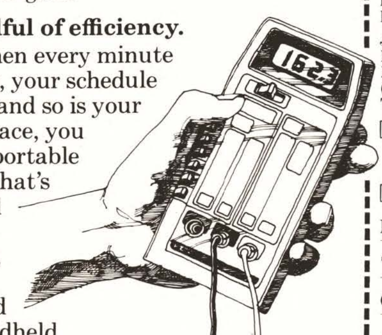

But there's more to convenience than fingertip control. The 8024A, for example, is also designed to function as an instant continuity tester, with a selectable audio tone to indicate shorts or opens. It also has a peak hold feature to capture transients.

A word about warranties.

Last but not least, look closely at the company that manufactures a low-cost DMM. Their service is just as important as their product. Look for no-nonsense warranties, a large family of accessories, an established network of service centers and technical experts you can rely on.

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COMPARISON WITH OTHER 8K PROMS			
MANUFACTURER	PART #	T_{AA} MAX 0-75°C	I_{CC} MAX 0-75°C
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HARRIS	7680/81	60 ns	170 mA
SIGNETICS	82S180/81	70 ns	175 mA
INTEL	3608/28	80 ns	190 mA
MMI	6380/81-1	90 ns	180 mA
FAIRCHILD	93L450/51	70 ns	85 mA
SIGNETICS	82LS181	175 ns	85 mA

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Editor's Choice: New Products

Plug-in boards provide LSI-11s and PDP-11s with EPROM-programming capability

MRV-004 and MR-004 boards operate with the DEC LSI-11 μC and PDP-11 mini. They fit into existing card slots (dual and quad, respectively) in these computers to allow firmware to be developed internally—without the need for an external programmer box.

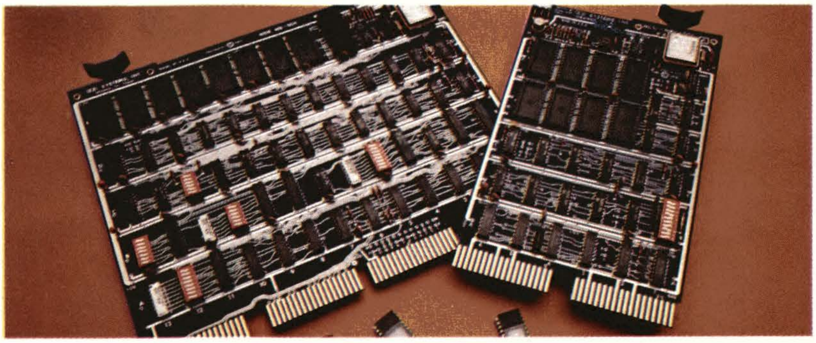
Accommodating up to 16 (MR-004) or eight (MRV-004) EPROMs, the boards can thus save programming time and money compared with DEC's external programmer, which handles only one EPROM at a time and is several times more expensive.

The boards' primary use occurs in the production of firmware for application and bootstrap programs. However, they could also eliminate the need for magnetic-tape or floppy-disc loading in small systems, and they can additionally serve such applications as special bootstrap loading in large systems. All you require is a simple program that executes a data dump from LSI-11 or PDP-11 RAM into the EPROMs.

Such a program should consist of 12 to 20 instructions for the PDP-11 and slightly fewer for the LSI-11. Any programmer familiar with either computer will find it easy to write the EPROM-programming software required.

Jumpers select EPROMs

The LSI - 11 - compatible MRV-004 can program any 24-pin EPROM from the 2716 to the 2732. You select memory-address-range assignments with a DIP switch; jumpers inserted in the card establish the EPROM type to be used. A Write Protect toggle switch prevents burning an already programmed EPROM. The board operates on a single 5V/800-mA supply; an on-board dc/dc converter supplies all other voltages.



With the ability to handle multiple EPROMs simultaneously, *these plug-in boards can save users' programming time and money. The larger MR-004 card is compatible with the PDP-11 and programs 16 EPROMs; the LSI-11-compatible MRV-004 accommodates eight EPROMs.*

The MR-004, in addition to handling the 2716 EPROM family, provides a few more enhancements than the MRV-004. It also has a Write Protect toggle switch, but you can override this switch with system software—a feature that eases EPROM-programming control by not requiring you to reach inside the computer to utilize this function.

A Done-bit feature, which indicates the conclusion of EPROM burning, further simplifies MR-004 use: Transfer of this bit to the PDP-11's status register controls programming; the alternative would be to delay programming for 50 msec before entering new data.

The MR-004 also provides an Interrupt bit that lets you use the computer's interrupt structure to control programming. An on-board DIP switch handles assignment of the interrupt vector address, and selectable jumpers establish the interrupt's priority.

ROM boards add flexibility

Designed to complement their respective -004 counterparts, the MRV-005 (LSI-11) and MR-005 (PDP-11) ROM boards accommodate programmed EPROMs. Although they offer no programming capability, they do provide DIP switches for assigning memory locations, and you can insert as many of them into the host computer as you wish. These boards also allow you to mix RAM, ROM or PROM with the EPROMs.

The MR-005 provides the additional voltages required to accommodate the 2704/2708 family of EPROMs. However, because they contain no programming circuitry, both -005 boards consume less power than their -004 counterparts.

MRV-004, $495; MRV-005, $225; MR-004, $995; MR-005, $575. Delivery, 30 days ARO.

MDB Systems Inc, 1995 N Batavia St, Orange, CA 92665. Phone (714) 998-6900.

Circle No 459

μComputerist Corner

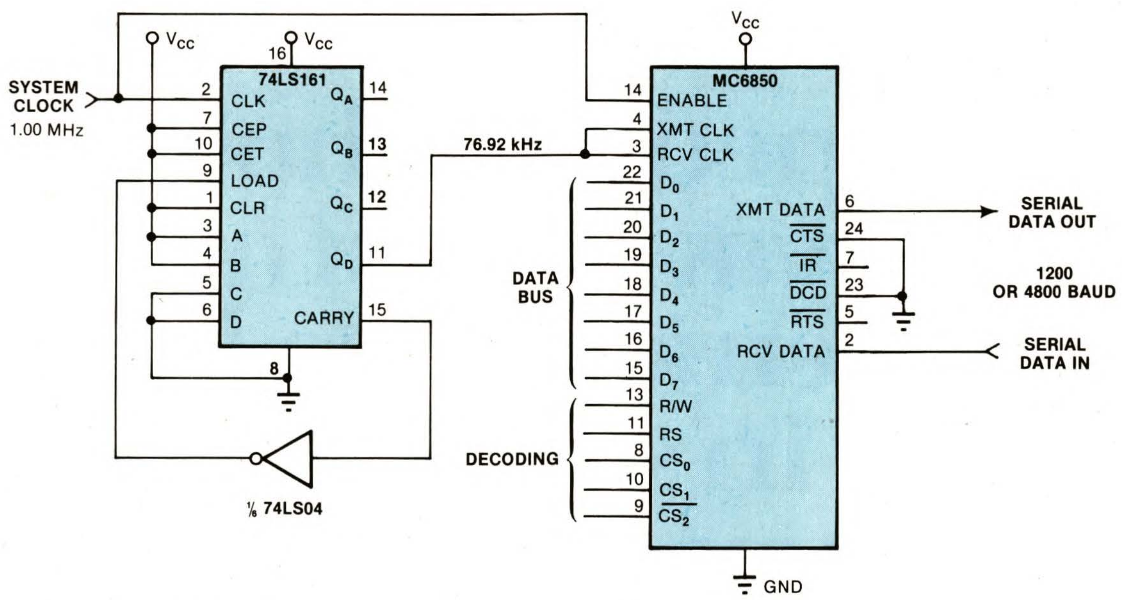
Software switches baud rate

Jeff Volp
Draper Labs, Cambridge, MA

When adding a serial interface to your μP system, you can avoid the adjustment problems inherent in an RC oscillator without having to use a crystal oscillator and baud-rate generator. Specifically, if the system has a 1-MHz clock (or multiple thereof), you can generate the necessary baud rates directly.

A divide-by-13 IC produces 76.92 kHz, which differs from the ideal 76.8 by only 0.15%. Obviously, any error in the system clock adds to this value. The total error, however, should be approximately the same as that for a crystal-oscillator/baud-rate-generator combination.

The circuit shown in the **figure** suits use in a 6800-based system. The baud rate is software selectable—to either 1200 or 4800—through the 6850 ACIA: The μP programs the ACIA to divide by 16 for 4800 baud and divide by 64 for 1200. Other rates can be produced by placing a 2^n counter between the divide-by-13 and the 6850. **EDN**



Provide a 6800-based system *with software-selectable baud rates while using a minimum number of components.*

EDN Software Note #39

Routine displays text strings

Purna Pareek
Varian Associates, Gloucester, MA

Text strings represent one of the most memory-consuming data types; applications involving operator interaction through a CRT terminal can use large numbers of them. Invariably, such applications give rise to a set of messages and phrases that find repeated use.

The routine in **Fig 1** helps utilize memory efficiently in such applications; it displays a series of text strings and integers on a Micronova system's

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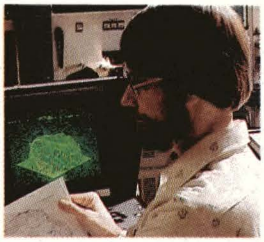

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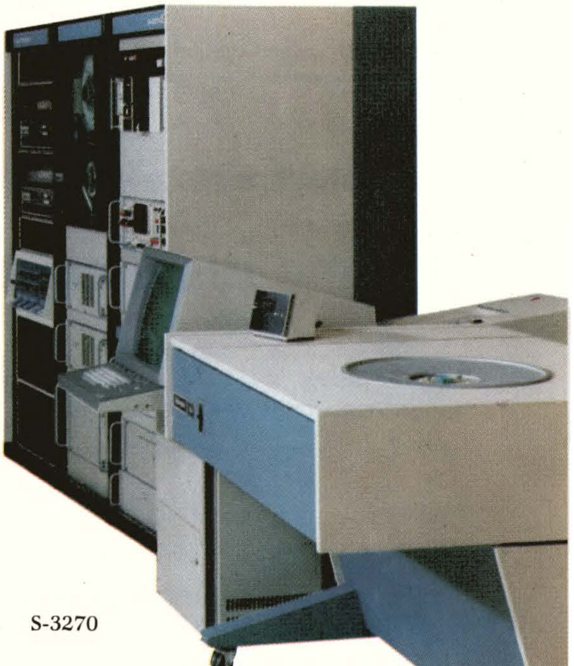

S-3270

μComputerist Corner

```
!0002 DSPLY

            ;        ROUTINE TO DISPLAY A SERIES OF TEXT STRINGS ON CRT
            ;
            ;
            ;
            ;
            ;        CALL SEQUENCE:
            ;                 JSR      @DSPLY   ; DISPLAY THE FOLLOWING
            ;                 TEXT1             ; ADDRESS OF FIRST STRING
            ;                 TEXT2             ; ADDRESS OF 2ND STRING
            ;                 ....              ;
            ;                 ....              ;
            ;                 0                 ; END OF CALLING SEQUENCE.
            ;


00005'054441 .DSPLY: STA     3,DRTN             ; SAVE RETURN ADDRESS
00006'031400         LDA     2,0,3              ; CHECK IF THE NEXT WORD
00007'151015         SXNEO   2,2                ; IS AN EOS (NULL CHARACTER).
00010'000423         JMP     DONE               ; YES, EXIT FROM THE PROGRAM.
00011'151112         MOVL#   2,2,SZC            ; CHECK THE INDIRECT BIT
00012'000423         JMP     ONUM               ; FOR THE OCTAL NO. DISPLAY.
00013'025000 NEXTW:  LDA     1,0,2              ; GET THE WORD AND
00014'020434         LDA     0,MSKU             ; MASK OUT TO RETRIEVE
00015'123700         ANDS    1,0                ; THE 8 BIT CHARACTER.
00016'101015         SXNEO   0,0                ; IS IT AN EOS?
00017'000411         JMP     NEXTS              ; YES, GET NEXT STRING.
00020'004422         JSR     PUTC               ; NO, DISPLAY THE CHARACTER
00021'020426         LDA     0,MSKL             ; MASK OUT THE 2ND
00022'123400         AND     1,0                ; CHARACTER AND CHECK FOR
00023'101015         SXNEO   0,0                ; AN EOS (END OF STRING).
00024'000404         JMP     NEXTS              ; YES, AN EOS.
00025'004415         JSR     PUTC               ; DISPLAY THE CHARACTER.
00026'151400         INC     2,2                ; COUNT UP FOR NEXT WORD
00027'000764         JMP     NEXTW              ; AND LOOP AGAIN.

00030'010416 NEXTS:  ISZ     DRTN               ; POINT TO THE NEXT TEXT
00031'034415         LDA     3,DRTN             ; STRING AND LOOP
00032'000754         JMP     .DSPLY + 1         ; AGAIN.

00033'010413 DONE:   ISZ     DRTN               ; LOOKS LIKE WE ARE
00034'002412         JMP     @DRTN              ; DONE. EXIT.

00035'151120 DNUM:   MOVZL   2,2                ; STRIP OFF THE TOP
00036'151220         MOVZR   2,2                ; BIT OF THE ADDRESS
00037'025000         LDA     1,0,2              ; GET THE OCTAL NUMBER
00040'004411         JSR     BTOC               ; CONVERT TO OCTAL
00041'000767         JMP     NEXTS              ; DISPLAY AND CONTINUE.

00042'063511 PUTC:   SKPBZ   TTO                ; OUTPUT THE CHARACTER
00043'000777         JMP     .-1                ; ON THE CRT.
00044'061111         DOAS    0,TTO
00045'001400         JMP     0,3

00046'000000 DRTN:   0
00047'000377 MSKL:   377
00050'177400 MSKU:   177400
U0051'000000 BTOC:   .BTOC
```

Fig 1—The repeated display of text strings *proves simple with the aid of this Micronova routine.*

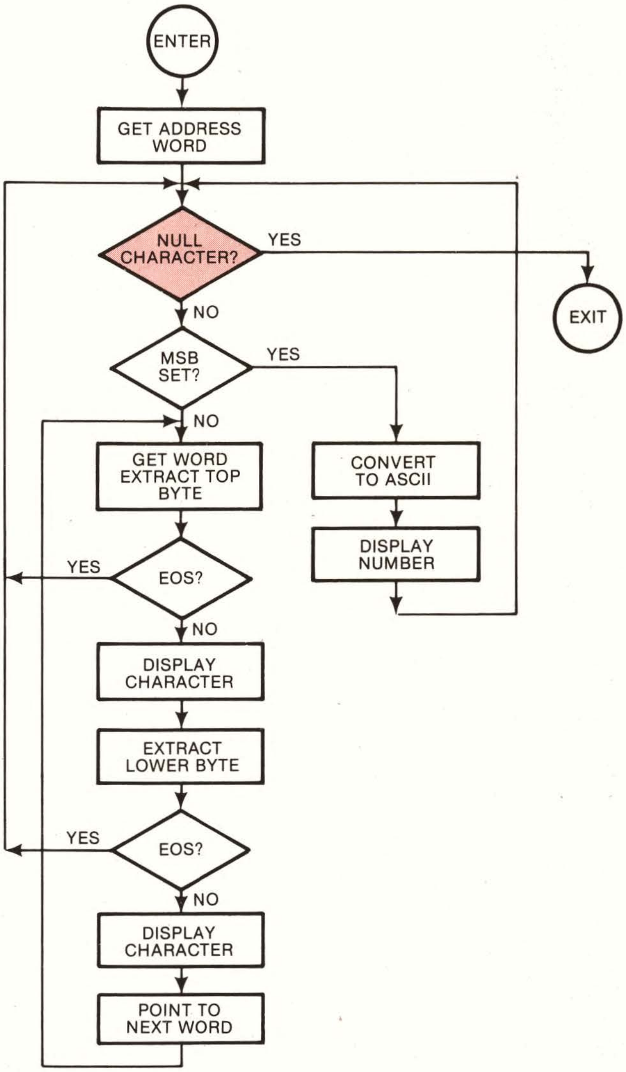

Fig 2—The DSPLY routine *repeats until it finds a null character for an address—it then returns to the calling program.*

CRT terminal. This routine—or one modeled on it for use with another μP—is based on three assumptions:

- Text strings comprise left-to-right packed bytes with end-of-string (EOS) indication denoted by a null (0).
- Integer display is indicated by setting the most significant bit of the integer's address. In Nova computers, the assembler sets the MSB when it encounters an @ sign.
- A binary-to-ASCII conversion routine is available for the integer display. (It's not required, however, if the integer needn't be displayed.)

A flowchart **(Fig 2)** outlines the DSPLY program's operation. Because the subroutine-call sequence ends with a null, the program reads the first address word and compares it with a null. If the address word itself isn't null, it's considered a valid text string, and the first word pointed to by this address is read in.

This 16-bit word contains two 8-bit characters. The routine extracts the first character by masking out the word's top byte and checking again for a null character. The presence of such a null indicates the end of the current text string—the program then begins looking for the next text string.

If the tested byte proves a valid ASCII character, though, the 8-bit code is sent to the CRT for display. The word's second character is then processed by masking the lower byte and repeating the procedure.

This sequence repeats until the program accepts a null character for an address, indicating the end of the data strings. Control then returns to the calling program. **EDN**

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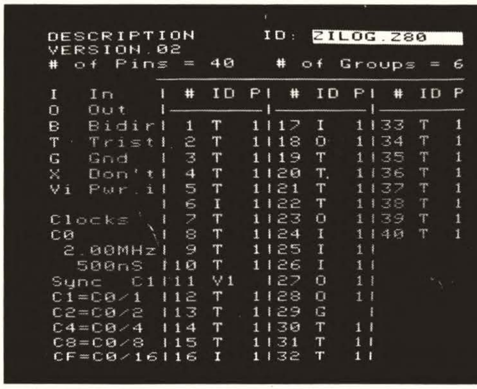

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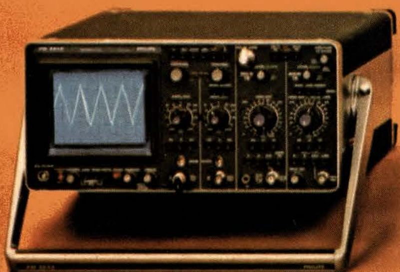

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A virtually endless variety *of IEEE-488-compatible instruments is now available—and it's growing daily. GPIB developer Hewlett-Packard alone offers dozens of 488-compatible instruments and controllers, as well as packaged systems built around the bus.*

IEEE-488-compatible instruments

The swelling ranks of GPIB-compatible instruments promise simpler and more harmonious system integration. But beware: Despite the 488 standard's obvious advantages, you still must approach integration details with care.

Andy Santoni, Western Editor

Whether you call it the general-purpose interface bus (GPIB), the IEC bus or the IEEE-488 bus, it has simplified the job of orchestrating systems out of collections of instruments. Now you no longer need to worry about some of the most tedious and error-prone aspects of system integration—selecting the proper connectors and cables and checking for logic-level compatibility, for example. Just look for the "bus compatible" label on the instruments you're planning to buy, and good part of your job is already done.

But not the whole job. The 488 bus is merely the staff on which you write the notes—in the form of system software—that tell each instrument what to play. Written with care, this software allows a collection of instruments to make beautiful music together. Written sloppily, it only produces dissonance.

Actually designing a 488-based system provides good experience in learning where the clinkers might fall. The first time around, ridding the system of bugs is liable to take several weeks. On the second pass, you can probably cut that time to a few days; for future systems, the process should take a few hours.

The GPIB provides a framework for effective system design

And that's a substantial time savings, compared with the weeks usually required to configure all the cabling and software required for even a relatively simple instrument system. "A good portion of the interface problem has been solved by 488," says Bill Swift, marketing manager for precision instrumentation at John Fluke Mfg Co Inc. Once you hook up your instruments by means of the 488 bus, you can talk to each of them, and that's a good start toward producing a working system, he explains.

The result of this easy start-up? "The GPIB enjoys wide acceptance and usage," says Maris Graube, interface engineer at Tektronix Inc. "It has been designed into hundreds of instruments in both the US and overseas, including the Eastern Bloc countries." Such widespread usage is only possible on an interfacing system that has already solved the fundamental problems of compatibility and configuration, explains Bob Hallissy, product marketing engineer at Hewlett-Packard Co's Desktop Computer Div, Ft Collins, CO. "The IEEE-488 interface bus is a success because of its fundamentally sound design and applicability to many system environments," he adds.

One measure of this success is the number of instruments now available—from well over 100 companies—that include bus compatibility as a standard feature, not merely as an add-on option. Another measure is the growing number of 488-bus support chips available for use by instrument designers (see pg 36 in this issue).

The bus has changed

The IEEE first adopted the 488 bus as a standard in 1975, and it published a revised version of that standard in 1978. Most of the changes were editorial ones—clarifications that made the standard easier to read and understand, says Tektronix's Graube. "The major technical change corrected a possible (though improbable) error condition that can occur in the circuits

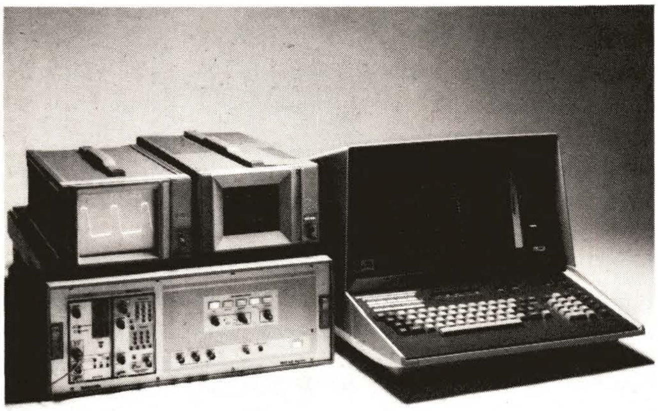
Increasing numbers of instruments *are being designed solely for bus operation. This Jaycor switching system requires minimal operator interfacing; all control occurs via bus transactions.*

If your bus stops, *trace the trouble with a logic analyzer like Gould/Biomation's K-100D. The analyzer itself is controllable via the bus for use in test systems.*

Bus testing is easier *with a logic analyzer that converts the data on the 488 bus' lines into state names as defined in the bus standard. The Dolch/Kontron LAM4850 utilizes a PROM module to handle this conversion.*

implementing the data handshake," he explains. The standard is also being adopted formally by the International Electrotechnical Commission (IEC) with only one change from the IEEE document: a different rear-panel connector. (A simple transition cable makes IEC- and IEEE-compatible instruments compatible with one another.)

Despite its widespread appeal, though, the 488 bus is not without its problems, notes Graube. "To many people, GPIB has become a buzzword that can lull the unwary into thinking that any two instruments



The 488 bus can handle high-speed signals *if the measuring instrument acquiring those signals stores data and transfers it at a slower rate over the interface. Here, a Tektronix 7912AD transient digitizer "talks" to a 4051 desktop computer/488 controller, which manipulates the data acquired by the 7912AD.*

equipped with the standard interface can be connected together and, by some magic, do whatever they must do by themselves. This illusion is quickly dispelled when the supposedly compatible instruments are plugged together and don't work at all, or do so with great difficulty."

Why this misconception? The 488 standard provides a common communication link for data and commands between instruments and controllers, but it does not define how this facility is to be used. Each device can—and often does—use the bus in its own peculiar way, just as two people talking over the telephone—a standard, accepted communication link—can speak in different languages and thereby fail to communicate.

The most important action a first-time 488-bus user can thus take to reduce the time required to implement a system is to learn the software conventions used by the suppliers of the individual system components, says Jim Geisman, corporate marketing-program manager at Tektronix. Each manufacturer has interpreted the written standard slightly differently, accounting for some of the differences in conventions. More importantly, the standard doesn't specify the codes and formats that compatible products must use; two different instruments can require two completely different commands to perform the same function.

Variations in data-handling conventions offer an example of this potential pitfall. When an instrument sends a number (the result of a measurement, for example) across the bus' eight data lines, it usually employs the most commonly used technique: Symbols are coded in ASCII format, and the most significant digit goes out first. The possible variations in technique, however, require that you make sure that the instrument or controller receiving the binary information interprets it as data, not as nonsense. Worse yet, points out Graube, for data other than numbers, no prevalent language exists at all; individual instrument designers each invent their own.

Along with this language barrier, some instruments exhibit variations in the signals required to perform certain bus operations. For example, a measurement instrument must send a termination character down the line after sending data in order to signal the controller that the transmission is complete; usually, this terminator is a Carriage Return followed by a Line Feed. Some controllers, however, accept the CR symbol alone as a terminator and hang up before receiving the LF signal. The result? The LF waits in the measurement instrument until that device is again called on to transmit a message to the controller. When it does, it sends the LF followed by the requested data, but the controller branches to an error routine because it does not understand numbers that start with an LF.

Another potential problem: Even if you figure out how to format the data so that an instrument can understand it, you might not be able to understand the data yourself. For example, a power supply that you want to output 15.7V might require the command string "2314" to perform that task. This string would appear to bear no relationship to the required voltage, but it does: The leading digit tells the supply to go to its second range (50V FS), and the following three characters are the numerator in the expression $(XXX/1000)\times 50$, which determines the fraction of the range to be produced. To interpret this number, a human operator or programmer must make allowances for the power supply's lack of intelligence. The tradeoff, of course, is a simpler and less expensive instrument than one that could produce data more readily intelligible to humans.

Partial solutions are on the way

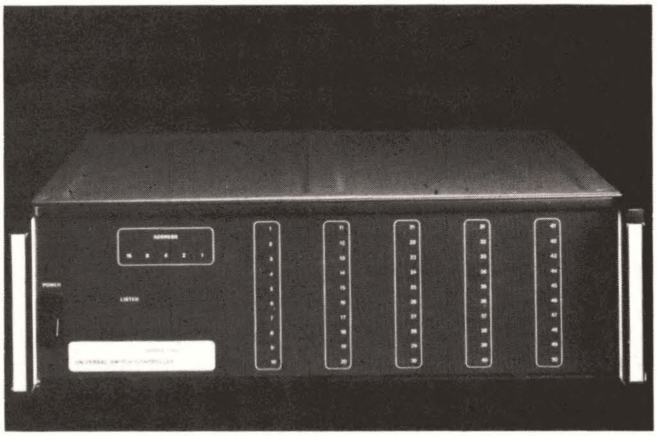
As Tektronix's Graube points out, there are ways to overcome all of these shortcomings of the 488 bus. Here are some current approaches to dealing with GPIB-device incompatibilities:

- Clever users program around the idiosyncrasies of a particular instrument's GPIB usage.
- De facto "standards," which have arisen because only a few computers are commonly used for programmable-instrument control, allow instrument makers to match their devices to these calculators' idiosyncrasies.
- The IEEE committee that developed the 488 standard will soon release a Code and Format Conventions document that should eliminate some of the compatibility problems, provided the

recommendations it contains are incorporated in future instruments.

For their part, major instrument manufacturers such as Hewlett-Packard, Tektronix and Fluke have each developed internal standards for language and command conventions to make their instruments as compatible as possible, at least within their own product lines. Fluke, for example, has surveyed the market and compiled a standard based on a consensus of its findings, says marketing manager Swift, and the firm's Systems Group checks out new-instrument designs to determine whether they conform to this internal standard.

However, this procedure doesn't imply that every Fluke instrument precisely matches (in terms of code and formats) every other Fluke instrument, Swift explains, because newer models might incorporate features not found on older ones. And design engineers can improve on the software within the instruments to make them easier and less expensive to use. Any variance from the internal bus standard, though, must be justified.



Analog signals can't themselves move along the bus, *but Racal-Dana's Series 1200 analog and digital switching unit can guide them to the appropriate instruments. The mainframe accepts plug-ins that switch precise ac or dc signals, high-level signals, power values ranging up to 200 VA or microwave signals up to 18 GHz.*

Your responsibility in the face of these efforts is to take advantage of the literature instrument makers provide. "Read the documentation first," advises Tektronix's Geisman. Get instruction manuals from the company that's supplying your instruments, and determine the units' quirks before you hook your system together. Don't wait until the equipment lands on your loading dock.

Hewlett-Packard provides further help along these lines in the form of underscored program codes on the front panels of some of its latest instruments. This convenience proves especially valuable in configuring benchtop lab systems for a specific project—as opposed to instrument systems you expect to keep together permanently in one form.

Whereas such fixed systems—whether commercial products or in-house units—have stable functions and programs, benchtop laboratory systems change frequently, each time requiring new programs. When generating these programs, all the necessary documentation might not be readily accessible; the manuals for individual instruments might be lost, buried in a previous user's desk drawer or hidden in the Calibration or Maintenance Department's library. With the command code corresponding to each front-panel button written on the panel, though, you can write simple programs without spending hours searching for these manuals. The resulting programs might not be the most efficient ones possible, but at least they take less time to research and write than the potential lifetime of the instrument system.

Instruments learn by themselves

An even more powerful tool for simplifying system programming is the Teach/Learn mode now appearing in some instruments, says Terry Mancilla, applications engineer at Hewlett-Packard's Santa Clara, CA Div. In this mode, you set up an instrument manually for the measurement you want to make, and the controller "learns" your settings as though you had programmed them in. A section of the system controller's memory (about 60 or 70 bytes) is set aside for each instrument setting; the setting data can then be recalled like a subroutine in the system program, so the controller can "teach" the instrument how to make a measurement.

The Teach/Learn mode can even deal with some of the fine differences among similar instruments, Mancilla says. The detailed coding required to set up each instrument is contained in a subroutine, so if you change an instrument in a system, all you need change in your program is the corresponding subroutine, rather than make tedious, detailed changes in the master program itself.

In fact, you needn't even know what codes and formats the instrument requires—they're all accommodated automatically. Thus, you can concentrate on the tests you're trying to perform and on the high-level-language programming required to guide the system. Even in that area, though, things aren't as simple as they should be.

Needed: more effective software

"One of the most trying problems facing engineers designing a 488-bus system is the lack of adequate software to support that system," claims Joe Austin, application engineer at Digital Equipment Corp's Components Group. "The importance of software is frequently underrated or overlooked completely by hardware-design engineers when assembling an instrument-bus system."

To overcome this problem, you must shop for software just like you shop for hardware, says Austin. DEC, for example, provides design-level documenta-

ASCII & IEEE (GPIB) CODE CHART

BITS B7 B6 B5 →	Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
B4 B3 B2 B1	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE	
Ø Ø Ø Ø	0 NUL 0 0	20 DLE 10 16	40 SP 20 32	60 0 30 48	100 @ 40 64	120 P 50 80	140 ` 60 96	160 p 70 112
Ø Ø Ø 1	1 GTL SOH 1 1	21 LLO DC1 11 17	41 ! 21 33	61 1 31 49	101 A 41 65	121 Q 51 81	141 a 61 97	161 q 71 113
Ø Ø 1 Ø	2 STX 2 2	22 DC2 12 18	42 " 22 34	62 2 32 50	102 B 42 66	122 R 52 82	142 b 62 98	162 r 72 114
Ø Ø 1 1	3 ETX 3 3	23 DC3 13 19	43 # 23 35	63 3 33 51	103 C 43 67	123 S 53 83	143 c 63 99	163 s 73 115
Ø 1 Ø Ø	4 SDC EOT 4 4	24 DCL DC4 14 20	44 $ 24 36	64 4 34 52	104 D 44 68	124 T 54 84	144 d 64 100	164 t 74 116
Ø 1 Ø 1	5 PPC ENQ 5 5	25 PPU NAK 15 21	45 % 25 37	65 5 35 53	105 E 45 69	125 U 55 85	145 e 65 101	165 u 75 117
Ø 1 1 Ø	6 ACK 6 6	26 SYN 16 22	46 & 26 38	66 6 36 54	106 F 46 70	126 V 56 86	146 f 66 102	166 v 76 118
Ø 1 1 1	7 BEL 7 7	27 ETB 17 23	47 ' 27 39	67 7 37 55	107 G 47 71	127 W 57 87	147 g 67 103	167 w 77 119
1 Ø Ø Ø	10 GET BS 8 8	30 SPE CAN 18 24	50 (28 40	70 8 38 56	110 H 48 72	130 X 58 88	150 h 68 104	170 x 78 120
1 Ø Ø 1	11 TCT HT 9 9	31 SPD EM 19 25	51) 29 41	71 9 39 57	111 I 49 73	131 Y 59 89	151 i 69 105	171 y 79 121
1 Ø 1 Ø	12 LF A 10	32 SUB 1A 26	52 * 2A 42	72 : 3A 58	112 J 4A 74	132 Z 5A 90	152 j 6A 106	172 z 7A 122
1 Ø 1 1	13 VT B 11	33 ESC 1B 27	53 + 2B 43	73 ; 3B 59	113 K 4B 75	133 [5B 91	153 k 6B 107	173 { 7B 123
1 1 Ø Ø	14 FF C 12	34 FS 1C 28	54 , 2C 44	74 < 3C 60	114 L 4C 76	134 \ 5C 92	154 l 6C 108	174 ¦ 7C 124
1 1 Ø 1	15 CR D 13	35 GS 1D 29	55 − 2D 45	75 = 3D 61	115 M 4D 77	135] 5D 93	155 m 6D 109	175 } 7D 125
1 1 1 Ø	16 SO E 14	36 RS 1E 30	56 . 2E 46	76 > 3E 62	116 N 4E 78	136 ∧ 5E 94	156 n 6E 110	176 ~ 7E 126
1 1 1 1	17 SI F 15	37 US 1F 31	57 / 2F 47	77 UNL ? 3F 63	117 O 4F 79	137 UNT _ 5F 95	157 o 6F 111	177 RUBOUT (DEL) 7F 127
	ADDRESSED COMMANDS	UNIVERSAL COMMANDS	LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS	

KEY

octal	25 PPU	GPIB code
	NAK	ASCII character
hex	15 21	decimal

Get familiar *with ASCII and IEEE-488 codes with the help of this handy table. (Copyright © 1979, Tektronix Inc. All rights reserved. Reproduced by permission.)*

Some instrument makers have developed in-house standards

tion, FORTRAN subroutines and diagnostic programs for systems that connect the 488 bus to the firm's PDP-11 minicomputer family.

HP's Hallissy points out that newer 488 controllers use high-level languages for programming instrument systems, potentially easing the system-software problem. "First-generation controllers are characterized by the exclusive use of program-language statements oriented to the bus-hardware concepts," he explains. "But second-generation controllers reflect program-language constructs representing a message organization on a level above the bus-hardware message concept."

The result? Reduced programming time and program length. Accomplishing a serial poll of the instruments on the bus, for example, requires five lines of program on the HP 9830A desktop computer, but only one on the newer 9835A unit.

But the final answer to the software problem hasn't appeared yet, says Jose Martins, design engineer at Fluke: There's simply no efficient language currently available for programming 488-bus systems. (BASIC, the most commonly used language, isn't very efficient for instrument systems—executing large numbers of instructions written in this language takes too long.)

And it isn't currently either practical or feasible to even define a high-level language specifically for 488 systems, says Don Loughry, interface engineer in HP's Computer Systems Group and a prime mover behind the adoption of the 488 standard. (ATLAS, a programming language developed specifically for test systems, doesn't lend itself to 488 systems because it's so general that it requires a large computer to interpret its statements. Systems using the 488 bus rarely pack the necessary computer power.)

However, "perhaps someday it will be possible to define a high-level language in a device- and system-independent way," says Loughry. Martins agrees, adding that he'd like to see development on such a language begin now, because a convenient high-level language is even more important than standardized 488 codes and formats.

Suppliers provide examples to help you

In the meantime, though, instrument suppliers are writing sample programs to help you get their products up and running in your system. Moxon Inc, for example, provides program listings to show you how to tie its Model 702 IEEE-488 interface or Model 725 data generator to an HP 9825 desktop computer.

Hewlett-Packard offers even more extensive programming aids: The firm is developing introductory Beginner's Guides for each of its instruments and controllers. These programming notes show you how to tie a particular instrument to a particular controller.

Helpful guidelines for configuring an IEEE-488-based system

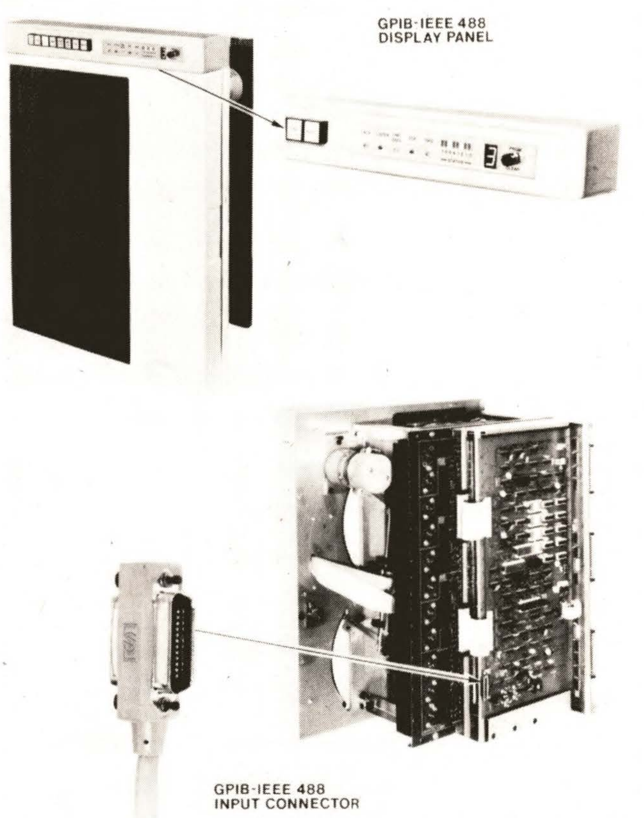
Engineers at John Fluke Mfg Co have developed both 488-compatible instruments and 488-based systems and in the process have amassed a wealth of experience. Here is some of the advice they offer to 488-system integrators:

- Develop a list of candidate devices. Narrow your choices to two or three of each type of instrument you plan to use.
- Determine exactly how each of the candidate devices implements the standard's interface function; not all compatible instruments incorporate all of the features described in the standard. In this respect, refer to two parts of the standard's 1978 version: the Interface Function Repertoire on pg 17 and Appendix C on pgs 72 ff.
- Select devices with compatible repertoires or interface functions, whenever possible, to simplify programming and improve system efficiency. You might have to trade off some of this compatibility, though, to obtain the instrument performance you need.
- Obtain as much information as you can from the vendors of the chosen devices. But don't wait until the products are delivered: Order manuals and other documents as soon as you have chosen the units.
- Develop the specific tests you want to accomplish, including block diagrams of the test system's interconnections and the programming commands needed to perform the tests. You can do this while you're waiting for delivery of the system components.
- Prepare the system's installation site adequately. In this regard, don't forget provision for power distribution, interference protection and such environmental considerations as temperature, humidity, static protection and physical clearances.
- Appoint a system manager who is responsible for maintenance and calibration schedules, operator training, configuration control and system logs and for ordering such consumables as paper, ink, diskettes and cartridges.

HP also provides Quick Reference Guides for some instruments, incorporating general information on tying those instruments into systems. And some HP instruments come with programming reference cards that slide out from their front panels.

These guides all furnish something the IEEE standard itself lacks: While the standard addresses the mechanical, electrical and functional capabilities of the bus interface, it doesn't address the operational aspects of products conforming to the standard. This lack isn't an oversight, though. The standard's developers wanted to leave instrument designers as free as possible to create the best instruments, and they felt that a standard that encroached on instruments' operational aspects would stifle creativity.

One result of this freedom permitted by the standard is that not all bus-compatible instruments exhibit the same interface capabilities—each of the standard's defined capabilities might or might not be adopted by an instrument designer, notes Gary Brock, applications engineer at Gould Inc's Biomation Div. Thus, an instrument equipped with any one of the ten interface functions defined in the standard can be said to comply with IEEE-488—even if the only function it meets is the provision of the appropriate connector on its rear panel.



Computer peripherals *can also talk over the 488 bus. This $9275 Tandberg Data GPIB-1050 recorder is an IBM/ANSI-compatible unit that provides dual-density, 9-track, 45-ips operation and stores more than 30M bytes on a 2400-ft reel of tape.*

Biomation's K-100D logic analyzer, for example, incorporates an IEEE-488 interface with almost all the functions described in the standard, including source and acceptor handshake, service request, remote/local capability with local lockout, and device trigger. But it doesn't provide controller capability, which isn't necessary in a measurement instrument, nor can it handle a parallel poll. (This latter capability allows a controller to call all instruments on the bus at once and receive two status bytes from each simultaneously. A serial poll usually proves more useful, though, because each instrument can send back eight status bytes in this mode. However, while the parallel poll is in fact quicker, this speed difference is usually not important to system assemblers—the reason most instruments don't provide this feature.)

In the face of such interface-capability differences—characteristic of all IEEE-488-compatible instruments—you must read data sheets carefully to make sure you're getting all the functions you need, says Ken Hallmen, design engineer in Fluke's System Group. In this regard, most newer 488-compatible units display (on labels mounted on their rear panels) the particular 488 subset implemented.

Speeding bus transactions

Data rates can also vary among 488-compatible instruments. "Inherently, the bus is incapable of responding in real time because there is no maximum time an instrument can delay a handshake," explains HP's Hallissy. Thus, data buffering, scanner control and alarm detection can all reduce the bus' response time. "It is possible for two devices—one specified with a talk rate of 100k bytes/sec and the other with a listen rate of 100k bytes/sec—to only be able to communicate at 50k bytes/sec," he notes.

The time taken by the controller to manipulate data can also cut throughput, says Tektronix's Geisman. Complicating matters still further, it's difficult even to measure how fast the bus is operating, says Hallissy. "It's obvious that throughput depends both on the application and the implementation of the code. It's thus important to select benchmarks that reflect the application, but test and measurement benchmarks are not readily available today."

As a bus user, you therefore must be careful how you split bus control and computational tasks in your system software to guarantee that the system can operate as fast as required, says Geisman. For their part, instrument makers are incorporating more intelligence in their products to take some of the load off the controller. "The result," notes Bruce Gould, engineer at Wavetek, "is the possibility of more distributed systems with increased performance."

Instruments can read parametric values from a controller in any of three formats, says Gould: fixed with an implied decimal point at the end, floating with an explicit decimal point, or exponential notation. Wavetek's µP-based programmables accept any of these formats, making programming simpler and incurring a speed loss of only 10 to 15%.

Wavetek's Model 172B generator also offers such features as value-range error indication to speed processing. This capability enables the instrument to display "frequency-setting error" if you've entered (via the front panel) a frequency outside its range. And if such an error occurs via the bus, a service request is set, and the generator sends an error-message string describing the parameters for which the error occurred.

Another type of programming error is more complicated. In a pulse generator like Wavetek's Model 859, you can set a pulse width that is greater than the pulse's period. If such a problem is transitory—as when you've changed the first value but haven't yet changed the second—the instrument ignores the change until you issue an Execute command. But if the error occurs after receipt of Execute, it is handled like a value-range error.

Microprocessors add convenience

Aside from performing data manipulations internally to overcome speed problems on the bus, some instruments store data that has been gathered at high speed, then transmit it at bus speed out of a buffer memory.

This convenience feature and others are made possible by incorporating microprocessors into instrument designs. Wavetek's Gould notes, however, that µP-based instruments must be designed from the ground up to take maximum advantage of the µP's capabilities. The results are worth the effort, though: Some instruments provide useful functions that aren't readily apparent to the user. Digital multimeters such as Fluke's Model 8520, for example, offer built-in mathematical functions for conversions, averaging and peak reading. In some cases, these functions can be called up via the bus, but not from the front panel.

In the future, greater numbers of instruments will be designed expressly for bus operation, says Tektronix's Geisman. A good example of this trend is Jaycor's Model 8600 signal-director system, which incorporates plug-in modules for signal switching, timing, reference-voltage generation, triggering or I/O.

Test equipment provides further help

If, after all your preparations and faithful adherence to the warnings cited here, you still can't get your 488 system to work, you might consider another piece of equipment: a bus analyzer. For this purpose, you can use a logic analyzer such as Biomation's K-100D to track down bus transactions. Or try Kontron's $9850 Model LAM4850 logic analyzer, which sports a built-in 488 translator. With a $595 PROM module plugged in, the 4850 converts the status of each line of the bus into bus-state information—the format in which bus transactions are defined in the 488 standard.

A less expensive bus analyzer is Ziatech's Model ZT 488; it operates from 5V dc ($349) or 115V ac ($399). The ZT 488 monitors all 16 lines of the bus and can also operate as a bus controller. **EDN**

Article Interest Quotient (Circle One)
***High* 470 *Medium* 471 *Low* 472**

For more information...

Note: The number of manufacturers offering 488-compatible instruments is very large and, furthermore, continually growing. For more information on the products described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Digital Equipment Corp
Components Group
One Iron Way
Marlborough, MA 01752
(617) 481-7400
Circle No 418

Gould Inc
Biomation Div
4600 Old Ironsides Dr
Santa Clara, CA 95050
(408) 988-6800
Circle No 419

Hewlett-Packard Co
1507 Page Mill Rd
Palo Alto, CA 94304
Phone Local Office
Circle No 420

Jaycor
1401 Camino Del Mar
Del Mar, CA 92014
(714) 453-6580
Circle No 421

John Fluke Mfg Co Inc
Box 43210
Mountlake Terrace, WA 98043
(206) 774-2211
Circle No 422

Kontron Electronic Inc
700 S Claremont St
San Mateo, CA 94402
(415) 348-7291
Circle No 423

Moxon Inc
2222 Michelson Dr
Irvine, CA 92715
(714) 833-2000
Circle No 424

Racal-Dana Instruments Inc
18912 Von Karman Ave
Irvine, CA 92713
(714) 833-1234
Circle No 425

Tandberg Data Inc
4060 Morena Blvd
San Diego, CA 92117
(714) 270-3990
Circle No 426

Tektronix Inc
Box 500
Beaverton, OR 97077
(503) 644-0161
Circle No 427

Wavetek
9045 Balboa Ave
San Diego, CA 92123
(714) 279-2200
Circle No 428

Ziatech Corp
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San Luis Obispo, CA 93401
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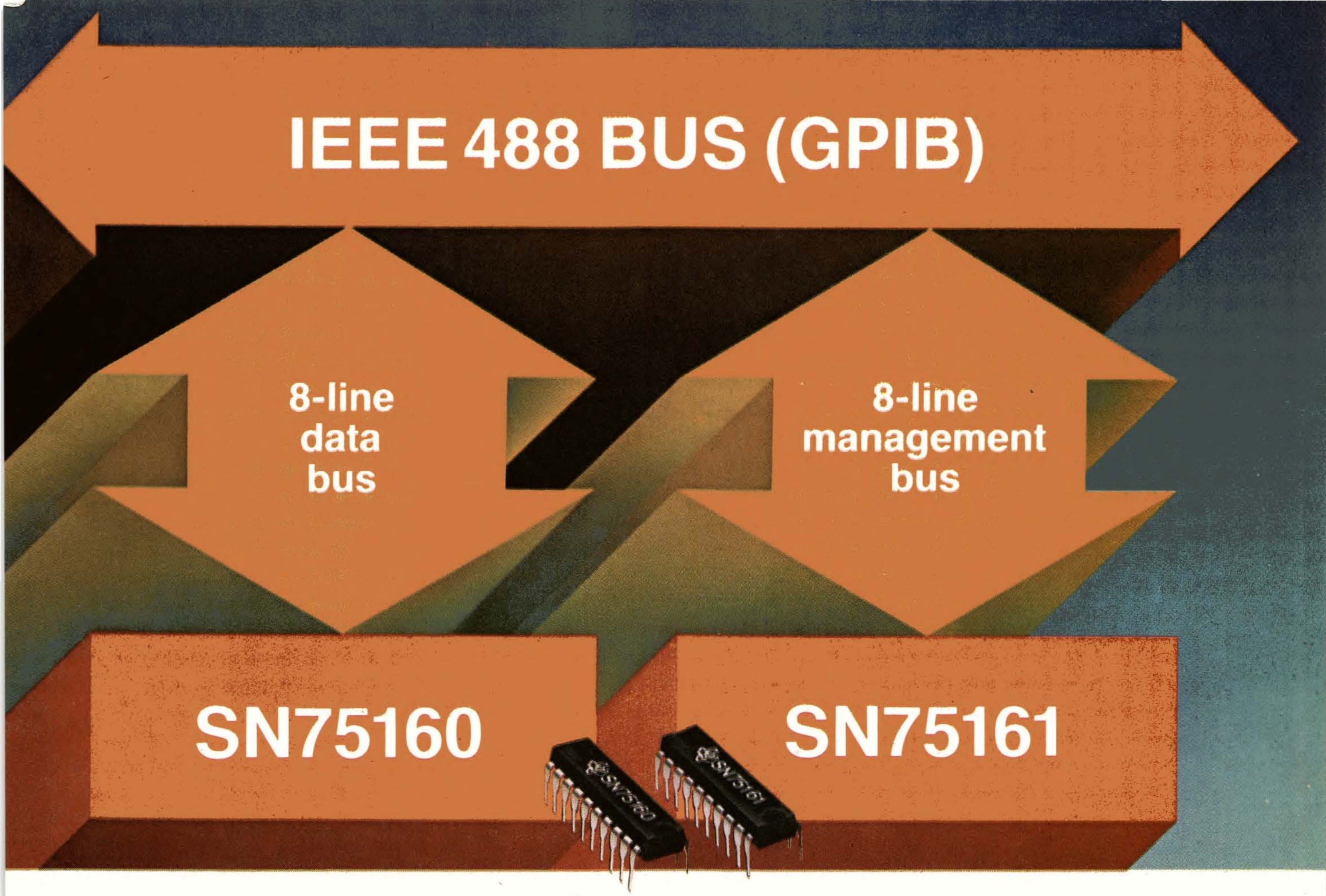

Reduce power and board space 40%. TI's new octal transceivers.

Introducing two new octal, bidirectional bus transceivers that meet the IEEE 488 General Purpose Interface Bus (GPIB) Standard.

The SN75160 data bus transceiver and SN75161 management bus transceiver contain all the circuitry required, yet consume only 95 mW per channel. That's 40% less power than conventional quad circuits.

And you can reduce pc board space required for IEEE 488 applications by replacing 4 quads and associated external logic with 2 octals.

But that's not all. Bus terminating network as specified by IEEE 488 is provided on all driver outputs. It also provides a high impedance even with power off.

In addition, the output structure of the SN75160 data bus transceiver makes it a versatile device suitable for many other octal transceiver applications.

Transceiver features

The SN75160 and SN75161 feature:

- Built-in bus terminating resistors on driver outputs
- High impedance to bus during power down
- Enable control selects 3-state or open-collector driver output (SN75160 only)
- 3-state outputs on receiver
- Hysteresis on receiver inputs
- High impedance PNP inputs
- 20-pin dual-in-line package

The management bus transceiver SN75161 has several additional features:

- Internal logic for proper direction of control signals on management bus
- Properly assigned output structures (active or passive) eliminates necessity for external control
- No external logic required

Powerful combination

The SN75160 and SN75161 combine to yield a complete IEEE Standard 488 16-line bus interface system. A system that allows asynchronous communication between satellite equipment on a bi-directional 8-line data bus. The 8-line management bus provides handshake protocol to assure interlocked communication between talker and listener.

In 100 pieces, the cost for SN75160 is $3.90. The 100 piece price for SN75161, $4.32.

Send for data sheets

For fast delivery call your nearest authorized TI distributor. For data sheet information write: Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265.

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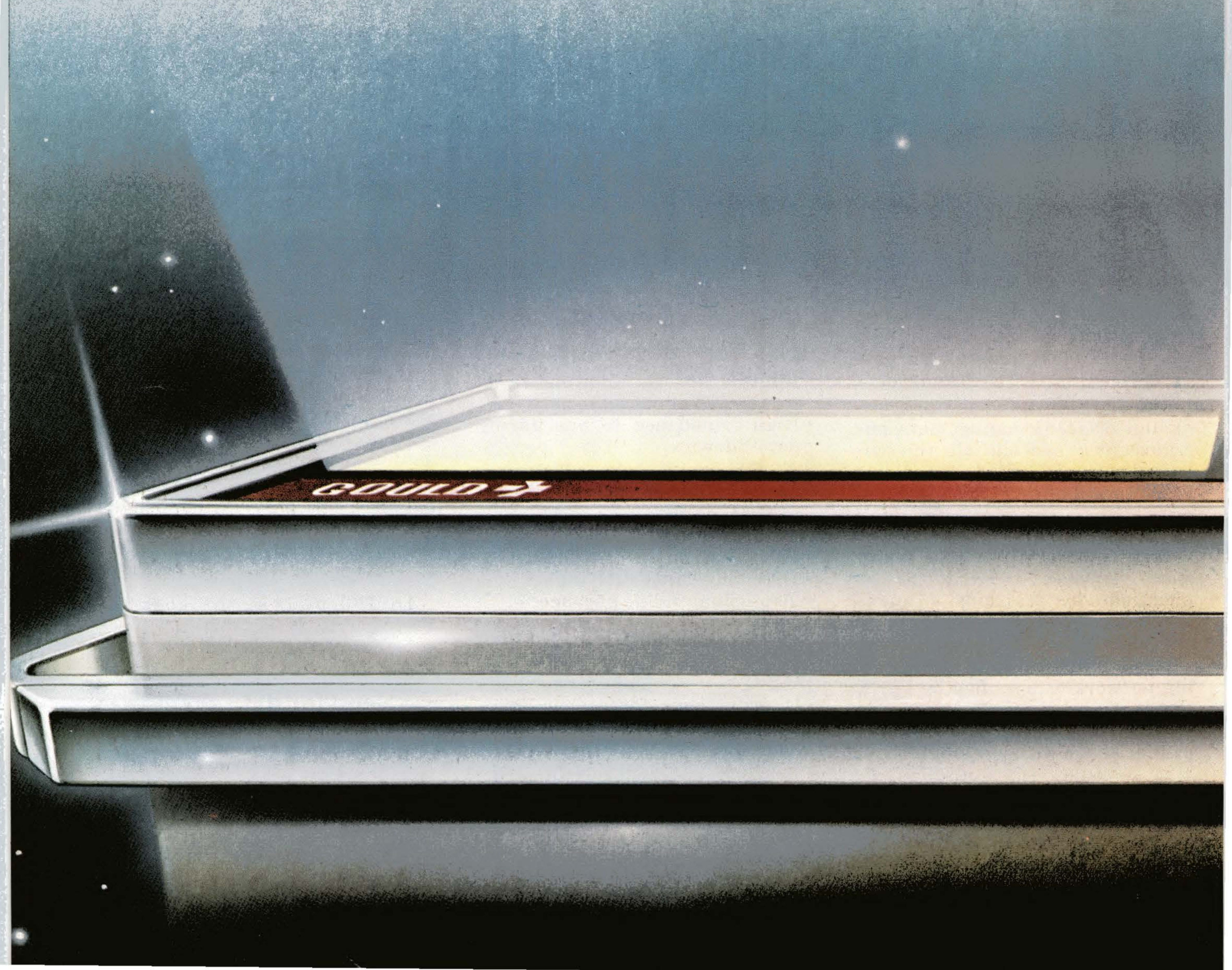

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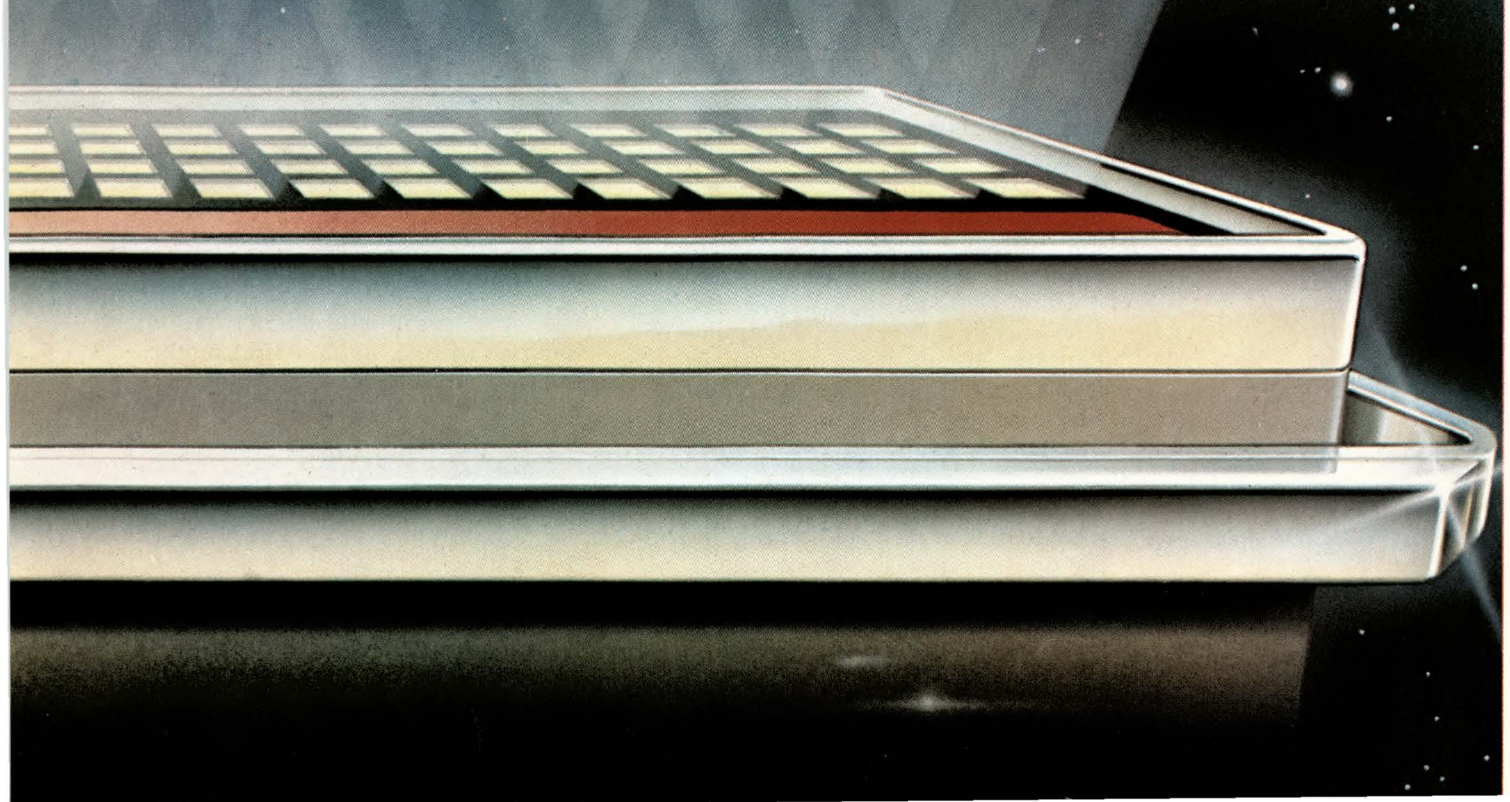

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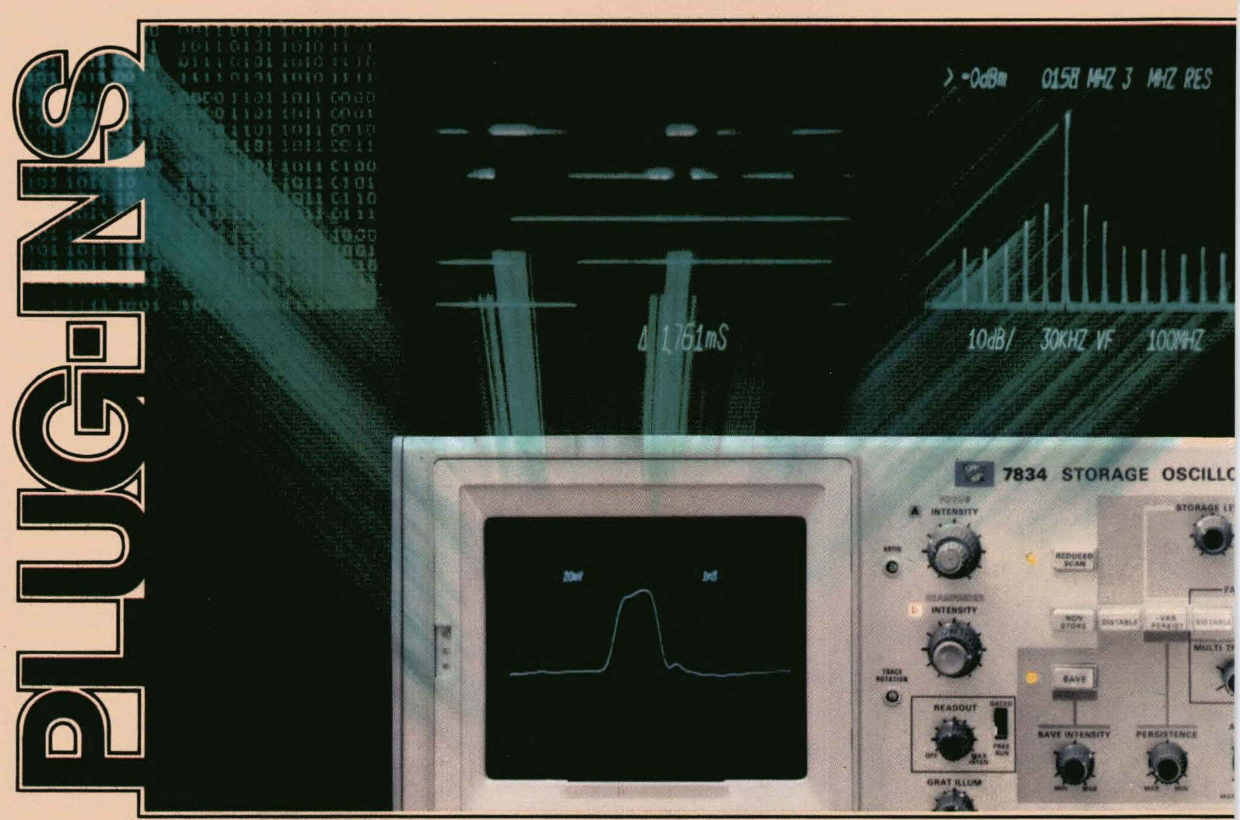

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Switched-capacitor techniques implement effective IC filters

Adding to the repertory of available analog building blocks, integrated filters utilizing switched-capacitor methods simplify analog designs.

A M Davis, San Jose State University

Filters using switched-capacitor techniques overcome a major obstacle to filter-on-a-chip fabrication—the implementation of resistors—by simulating resistors with high-speed switched capacitors. Such an approach thus eliminates the necessity for precise integrated-resistor values—a requirement previously met only by hybrid devices that require costly trimming procedures—and permits fabrication of precise monolithic analog capacitor filters.

Although filters other than switched-capacitor types can also be effectively integrated, they present problems that limit their usefulness. Sampled-data filters such as CCD and bucket-brigade devices, for example, suffer from a low S/N ratio and a need for complex postfilter antialiasing because of their low sampling rate compared with filter bandwidth. Digital filters also suit integration processes, but their complexity and stringent clock-rate requirements currently prevent their consideration as general-purpose filters (although they are becoming more attractive for specialized applications).

As an alternative to these designs, then, switched-capacitor (SC) filters combine many of the advantages provided by digital filters with those of their purely analog counterparts. This article outlines SC filters' advantages by examining these devices' basic operating theory and some of their practical limitations, and by developing two SC filter types.

Substitute capacitors for resistors

An SC consists basically of a capacitor whose charge is transferred from one node to another by a switch. In position 1 (as shown in **Fig 1**), the switch allows C_s to charge to $Q_1=C_sV_1$; in position 2, it discharges to $Q_2=C_sV_2$. An amount of charge equal to $\Delta Q=Q_1-Q_2$ therefore transfers from terminal 1 to terminal 2.

If the switching period is T, this charge transferral represents an equivalent current of

$$I = \frac{\Delta Q}{T} = \frac{V_1 - V_2}{\left(\frac{1}{C_s}\right)T},$$

and the form of this equation indicates that the switched capacitor can be modeled as a resistor of value $R_{eq}=1/f_sC_s$, where $f_s=1/T$ is the switching frequency.

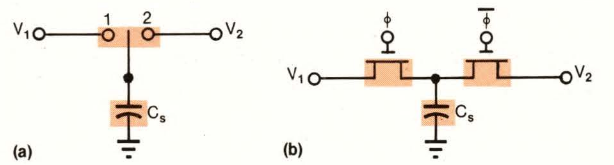

Fig 1—Basic switched-capacitor operation *is illustrated by a switch and a capacitor* ***(a)****; an integrated version* ***(b)*** *utilizes high-speed electronic switches to transfer capacitor charge from V_1 to V_2, thus simulating a resistor.*

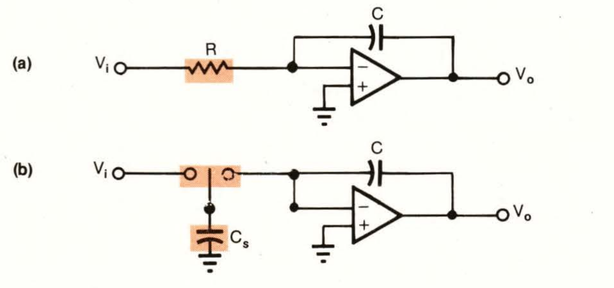

Fig 2—An inverting Miller integrator (a) *suits switched-capacitor design techniques if you replace its resistor with a switched capacitor* ***(b)****.*

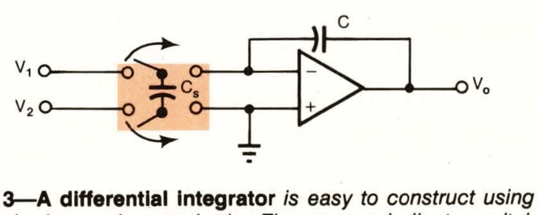

Fig 3—A differential integrator *is easy to construct using switched-capacitor methods. The arrows indicate switch phasing.*

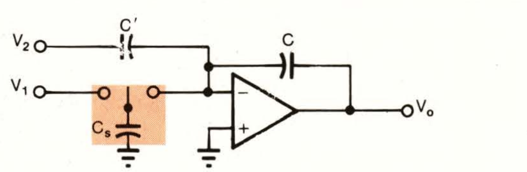

Fig 4—An integrator/summer *allows you to add as many summing inputs as required.*

Precise MOS-IC capacitors substitute for filter resistors

This analysis involves two implicit assumptions. The first lies in relating charge transferral in discrete quantities to current—a relationship that holds only for high sampling rates. But SC filters do in fact utilize high rates to avoid complex analog antialiasing and postfiltering. The second assumption is that the voltages V_1 and V_2 are independent of the transferred charge. The SC integrator to be presented here does indeed implement such a charge-independent circuit.

Construct a switched-capacitor integrator

To understand SC integrators, consider the inverting Miller integrator shown in **Fig 2a.** This common analog-design tool's transfer function is

$$H(j\omega) = \frac{-1}{j\omega RC}.$$

The SC integrator shown in **Fig 2b** replaces the Miller circuit's resistor with a switched capacitor and provides the transfer function

$$H_{sc}(j\omega) = \frac{-1}{j\omega\left(\frac{C}{f_s C_s}\right)}.$$

Examining these integrators' gains makes the advantages of switched capacitors clear. The analog integrator furnishes a gain equal to 1/RC—a factor that determines such parameters as bandwidth or peaking frequency in active-filter circuits. But the SC integrator's gain equals f_sC_s/C—an advantage, because MOS IC technology can implement capacitor ratios to within about 0.1% of specified values (an impossible figure for resistor values to match). The switching frequency f_s isn't difficult to supply with similar precision, so the SC method allows very precise gain specifications without trimming. In addition, you can vary the circuit's gain (and thus tune the filter) by changing f_s.

Utilizing switched capacitors, you can also easily construct a differential integrator **(Fig 3)**—a relatively difficult enterprise in conventional analog form. This integrator differs operationally from the single-switch version in only one way: The differential circuit charges C_s to $V_1 - V_2$ rather than to a single input voltage, resulting in an output voltage given by

$$V_o = \frac{-1}{j\omega\left(\frac{C}{f_s C_s}\right)}(V_1 - V_2).$$

The filter circuits presented later in this article capitalize on this important relationship.

One other circuit that deserves attention is the integrator/summer **(Fig 4).** Analyzing this circuit by superposition shows that

$$V_o = -\frac{-1}{j\omega\left(\frac{C}{f_s C_s}\right)}V_1 - \frac{C'}{C}V_2;$$

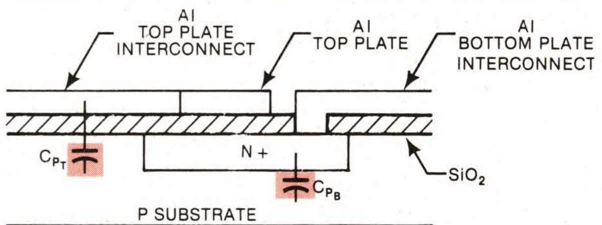

Fig 5—An MOS capacitor *contains two major parasitic-capacitance areas: between the top plate and substrate and between the bottom plate and substrate.*

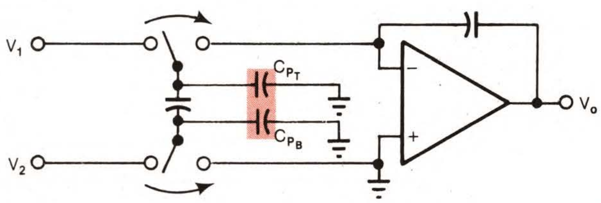

Fig 6—Parasitic MOS capacitance (C_{PB} and C_{PT}), *shown as it would appear in a circuit, either harmlessly discharges to ground (C_{PB}) or is too small to greatly affect circuit performance (C_{PT}).*

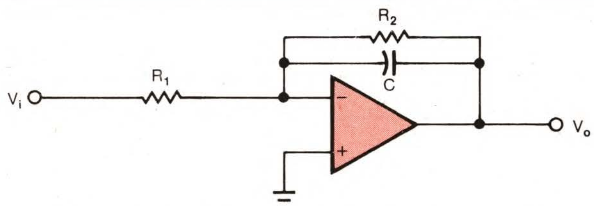

Fig 7—A lossy integrator *suits integrated switched-capacitor implementation.*

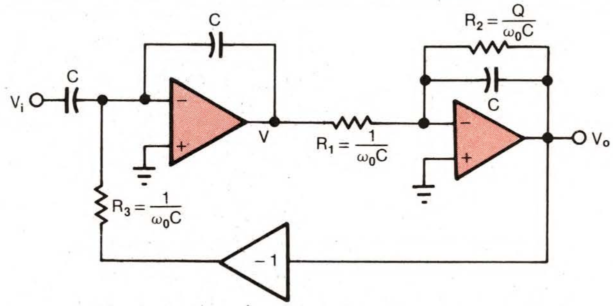

Fig 8—Combining a standard integrator and a lossy one *creates a viable switched-capacitor circuit when resistance values are stated in terms of capacitance and switching speed.*

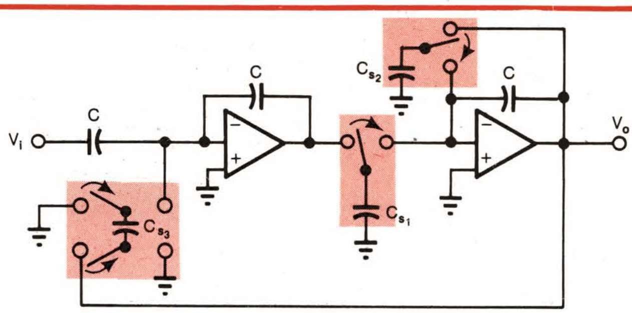

Fig 9—Substituting switched capacitors for resistors *in Fig 8's integrator circuit produces a precise, easily integrated filter.*

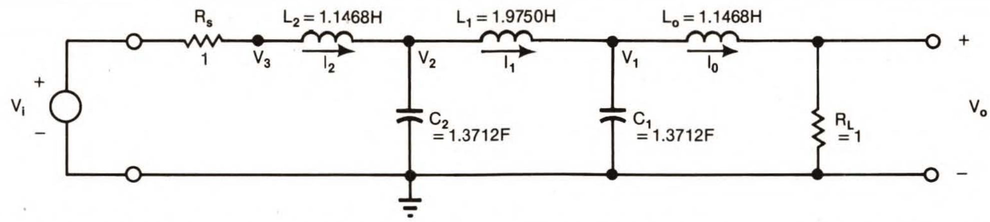

Fig 10—A fifth-order Chebyshev low-pass filter *constitutes a switched-capacitor arrangement that exhibits low sensitivity to its inductor and capacitor values in the passband. (Impedance or frequency scaling of components is not necessary at this initial stage.)*

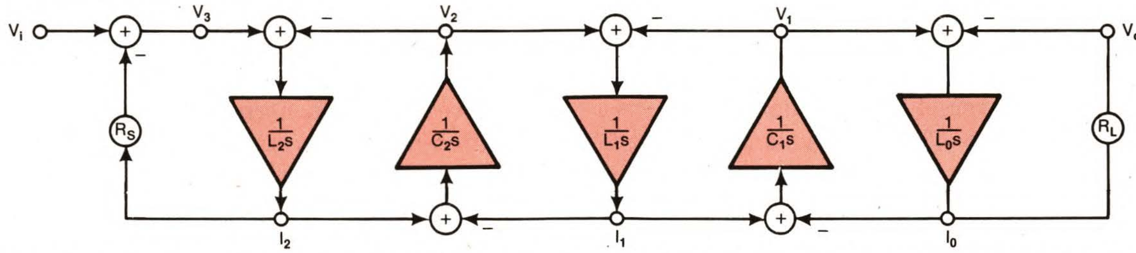

Fig 11—A leapfrog filter *implements* **Fig 10**'*s Chebyshev circuit using only integrators, resistors and summation points. Note that only voltages appear along the top row of nodes, while only currents appear along the bottom row.*

the circuit allows straightforward extention to any number of summing inputs.

The theoretical circuits just described can't be perfectly implemented, of course. An MOS capacitor, for example, incorporates inherent parasitic properties, primarily between its bottom plate and substrate **(Fig 5).** The bottom-plate parasitic capacitance, C_{PB}, varies between 5 and 20% of the capacitor's primary value, while the top-plate figure, C_{PT}, varies between 1 and 0.1% of that value.

To illustrate these parasitic capacitances' impact, **Fig 6** shows how they effectively fit into a circuit. Note that C_{PB} charges from a voltage source (V_2) and discharges into ground, so it doesn't affect performance at all; C_{PT} also charges from a voltage source (V_1), but it discharges into the integrator capacitor, C. However, because C_{PT}'s value is small, it doesn't affect performance in a major way. SC differential integrators can therefore be considered high-performance circuits.

Designing state-variable filters

Basing SC-filter structures on active filters containing integrators makes switched-capacitor benefits readily available. One filter type that takes advantage of these benefits is the state-variable circuit—the generic name for several integrator-based arrangements. The particular circuit considered here involves both a standard integrator and a lossy one.

Suppose you want to design a bandpass filter with the transfer function

$$\frac{V_o(s)}{V_i(s)} = \frac{\omega_0 s}{s^2 + \frac{\omega_0}{Q}s + \omega_0^2}.$$

After cross-multiplying and factoring, this expression becomes

$$V_o(s)\left[s\left(s + \frac{\omega_0}{Q}\right)\right] = \omega_0 s\, V_i(s) - \omega_0^2 V_o(s)$$

$$\text{or}\quad V_o(s) = \frac{\omega_0}{s + \frac{\omega_0}{Q}}\left[V_i(s) - \frac{\omega_0}{s} V_o(s)\right].$$

Now consider a lossy integrator **(Fig 7)** whose corresponding transfer function is

$$\frac{V_o(s)}{V_i(s)} = \frac{-\frac{1}{R_1C}}{s + \frac{1}{R_2C}}.$$

Setting $\omega_0=1/R_1C$ and $\omega_0/Q=1/R_2C$ (or $Q=R_2/R_1$) changes this function to

$$\frac{V_o(s)}{V_i(s)} = \frac{-\omega_0}{s + \frac{\omega_0}{Q}}.$$

Compare this function with the transfer function originally sought, writing the original function as it was previously developed except for sign adjustments:

$$V_o(s) = \frac{-\omega_0}{s + \frac{\omega_0}{Q}}\left[\frac{\omega_0}{s} V_o(s) - V_i(s)\right].$$

To make the conversion to SC form easier to see, utilize a feedback capacitor, C, in both the standard and lossy integrations **(Fig 8).** Note that the first op amp shown in **Fig 8** is an analog integrator/summer that provides the following output voltage:

$$V = -V_i + \frac{1}{R_3Cs}V_o = -V_i + \frac{\omega_0}{s}V_o.$$

Now convert this circuit to SC form by substituting the expression for switched-capacitor (C_s) equivalent resistance: $R_{eq}=1/f_sC_s$. The conversion thus produces $C_{s1}=\omega_0C/f_s=C_{s3}$ and $C_{s2}=\omega_0C/Qf_s$ **(Fig 9).**

Note that C_{s3} connects to the circuit shown in **Fig 9** in an inverting configuration—an especially interesting arrangement because when charged, C_{s3} connects between a voltage source and ground, and upon discharge, its bottom-plate parasitic capacitance discharges to ground. Thus, the C_{s3} portion of the circuit

Switched-capacitor filters suit integrator-type circuits

produces no parasitic-capacitance errors.

Finally, you can assign some practical values to the SC-filter circuit shown in **Fig 9.** Assume that you want this bandpass filter to exhibit a 1-kHz peaking frequency and a Q of 20. Assuming a 20-pF feedback capacitance for each op amp, $C_{s1}=C_{s3}=5$ pF, while $C_{s2}=0.25$ pF. These values indicate the relationship between capacitance-value spread and Q, for the previously derived expression for C_{s2} shows that the ratio of C_{s2} to C is inversely proportional to Q.

State-variable filters offer many advantages, but for high-Q circuits, they can become very sensitive to their components' values—unless they operate at an extremely high sampling rate. Unfortunately, though, op-amp integrators' settling times and slew-rate limitations restrict sampling rates.

However, one way to achieve low component-value sensitivities at moderate sample rates is to utilize leapfrog filters—active implementations of classical LC ladders synthesized with both load and source terminations. Because such filters exhibit low sensitivity to their inductor and capacitor values in the passband, they amply suit SC-filter techniques.

As an illustration of the leapfrog-filter design process, consider **Fig 10**'s fifth-order Chebyshev low-pass filter, whose parameter values set ripple at 0.1 dB and normalize the cutoff frequency to 1 radian/sec. The following equations apply to this circuit:

$$I_0 = \frac{V_1 - V_0}{L_0 s} \qquad V_1 = \frac{I_1 - I_0}{C_1 s} \qquad I_1 = \frac{V_2 - V_1}{L_1 s}$$

$$V_2 = \frac{I_2 - I_1}{C_2 s} \qquad I_2 = \frac{V_3 - V_2}{L_2 s} \qquad V_3 = V_i - I_2 R_s.$$

Note that the only operations indicated by these equations are differential integrations, multiplications by constants and algebraic summations. The operational diagram shown in **Fig 11** can thus embody these same functions in its leapfrog arrangement. To implement all of **Fig 11**'s integrators with op amps, the current nodes shown along the diagram's bottom must be transformed into voltage nodes by multiplying them by an arbitrary scaling resistance R_0, and the integrators' gains must be modified **(Fig 12).**

In this example, $R_s=R_L=1\Omega$, but in any case, the scaling resistance R_0 normalizes both of these values. The differential integrators now suit implementation in SC form as shown in **Fig 13.**

Note that **Fig 13**'s primed capacitors implement inductors; from the normalizations indicated in **Fig 12,** $L/R_0=R_0C'$ or $C'=L/R_0^2$.

This relationship hinges on the fact that the inductance-simulating integrator's gain (or time constant) determined by C′ must be the same whether you express the inductor's transfer function in terms of inductive impedance or RC/op-amp voltage gain. In this example, $R_0=1\Omega$, so $C'=L$.

Working in conjunction with the feedback capacitors shown in **Fig 13,** a constant, α, sets integrator gain. For an inductance simulator, the following expression results:

$$\frac{1}{Ls} = \frac{1}{R_{eq}C's} = \frac{1}{\frac{1}{f_s}\frac{C'}{\alpha' C'}s} = \frac{\alpha' f_s}{s}.$$

Thus, $\alpha'=1/Lf_s$. Similarly, for a capacitance simulator, the result is $\alpha=1/Cf_s$.

Additionally, if you want to scale the filter's frequency response so that it cuts off at f_0 rather than

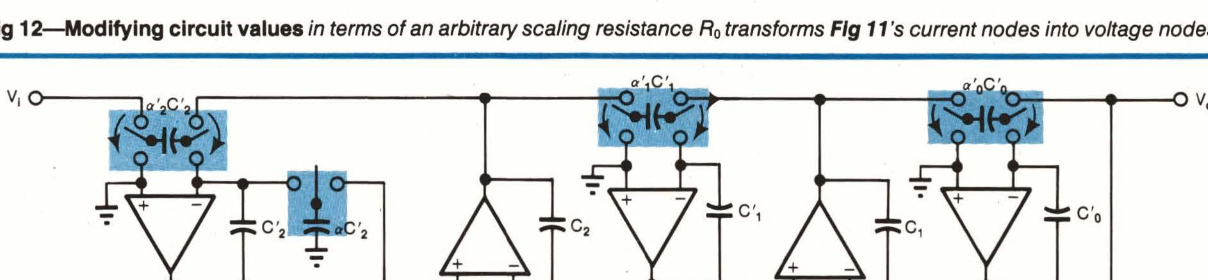

Fig 12—Modifying circuit values *in terms of an arbitrary scaling resistance R_0 transforms* ***Fig 11****'s current nodes into voltage nodes.*

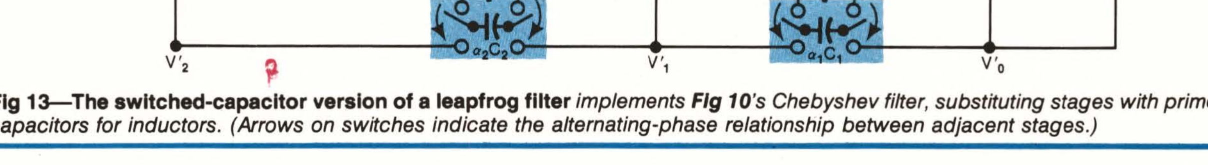

Fig 13—The switched-capacitor version of a leapfrog filter *implements* ***Fig 10****'s Chebyshev filter, substituting stages with primed capacitors for inductors. (Arrows on switches indicate the alternating-phase relationship between adjacent stages.)*

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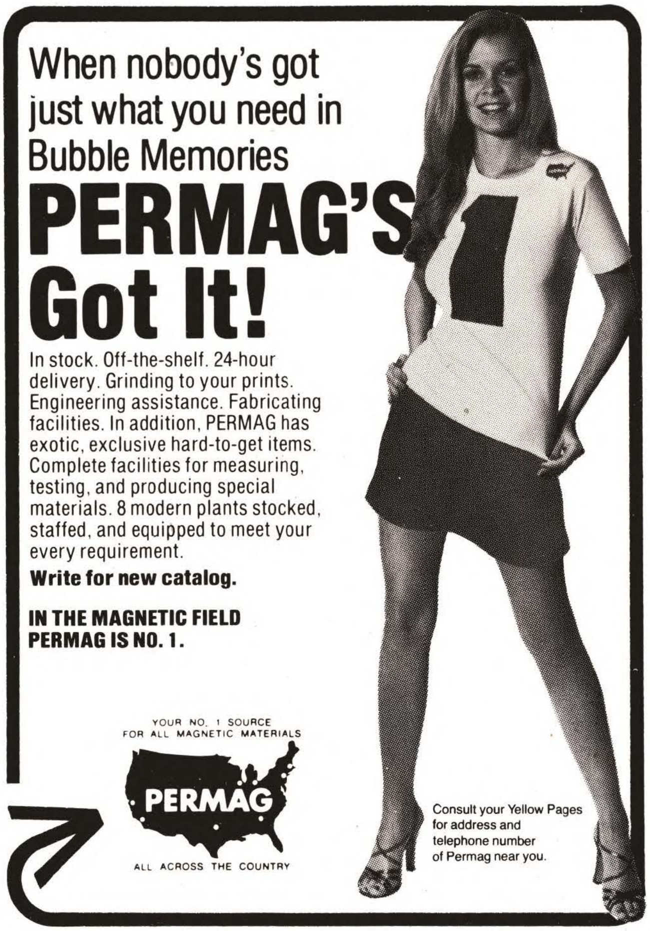

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Leapfrog filters let capacitors simulate inductors in ICs

2π, $s/2\pi f_0$ must replace s. And because inductive impedance equals Ls, $L/2\pi f_0$ must replace all inductor values, and $C/2\pi f_0$ all capacitor values. Combining this frequency scaling with the values for α and α' (for an assumed 1-kHz cutoff and a 25-kHz sampling rate) furnishes the following final values:

$$\alpha_0' = \frac{1}{\frac{L_0}{2\pi f_0} f_s} = \frac{2\pi f_0}{L_0 f_s} = \frac{2\pi \times 10^3}{1.1468 \times 25 \times 10^3} = 0.219$$

$$\alpha_1 = \frac{1}{\frac{C_1}{2\pi f_0} f_s} = \frac{2\pi f_0}{C_1 f_s} = \frac{2\pi \times 10^3}{1.3712 \times 25 \times 10^3} = 0.183$$

$$\alpha_1' = \frac{2\pi \times 10^3}{1.9750 \times 25 \times 10^3} = 0.127$$

$$\alpha_2 = \frac{2\pi \times 10^3}{1.3712 \times 25 \times 10^3} = 0.183$$

$$\alpha_2' = \frac{2\pi \times 10^3}{1.1468 \times 25 \times 10^3} = 0.219.$$

Leapfrog-ladder SC filters are currently employed in a wide variety of products, such as Intel's 2920 PCM filter, Silicon Systems' DTMF telephone chip and Reticon's R5604/R5605/R5606 16-pin-DIP bandpass filters.

To prevent excess phase lag, which can enhance the filter's Q, the switch phasing in **Fig 13**'s circuit alternates between adjacent integrators. This procedure decreases excess phase by creating a ½-period phase lead in one integrator, followed by a ½-period phase lag in the next one. **EDN**

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Author's biography

A M Davis is an associate professor at San Jose State University, CA, where he teaches electronics and circuit theory. He also teaches at the University of Santa Clara, CA, and has worked at Bell Labs and Eastman Kodak Research Lab, in addition to doing consulting work at several other firms. Professor Davis' leisure-time activities include backpacking, ham radio, reading, freelance writing and music.

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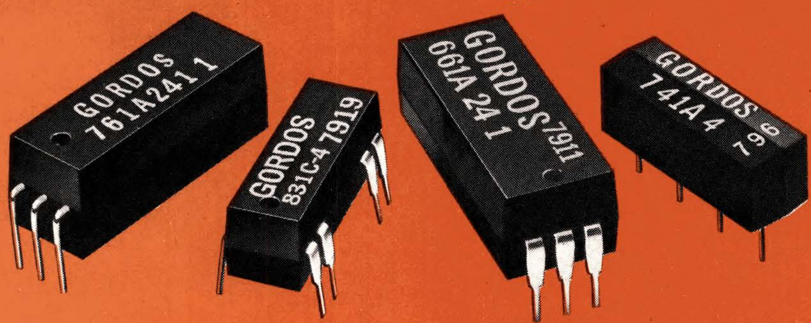

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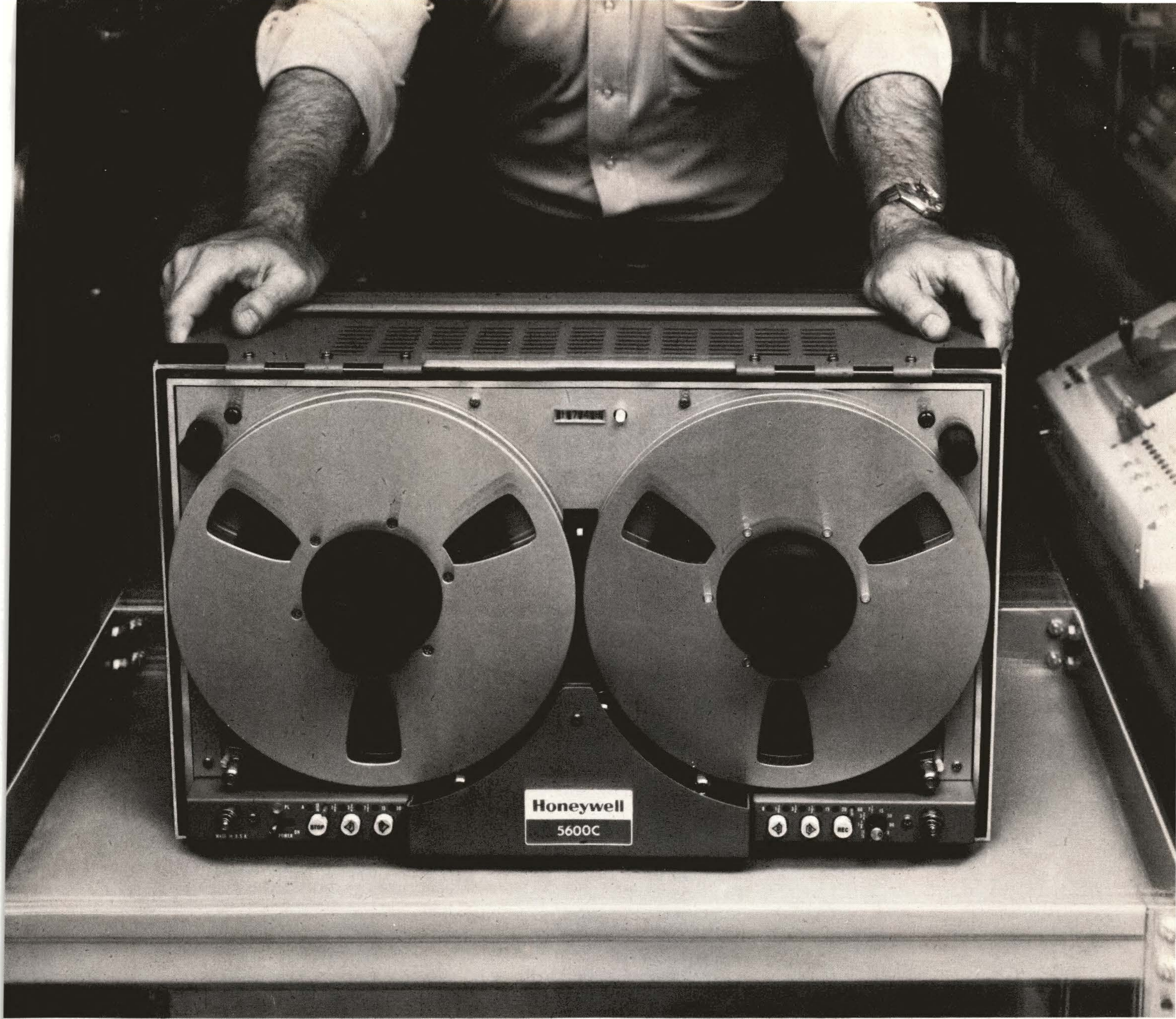

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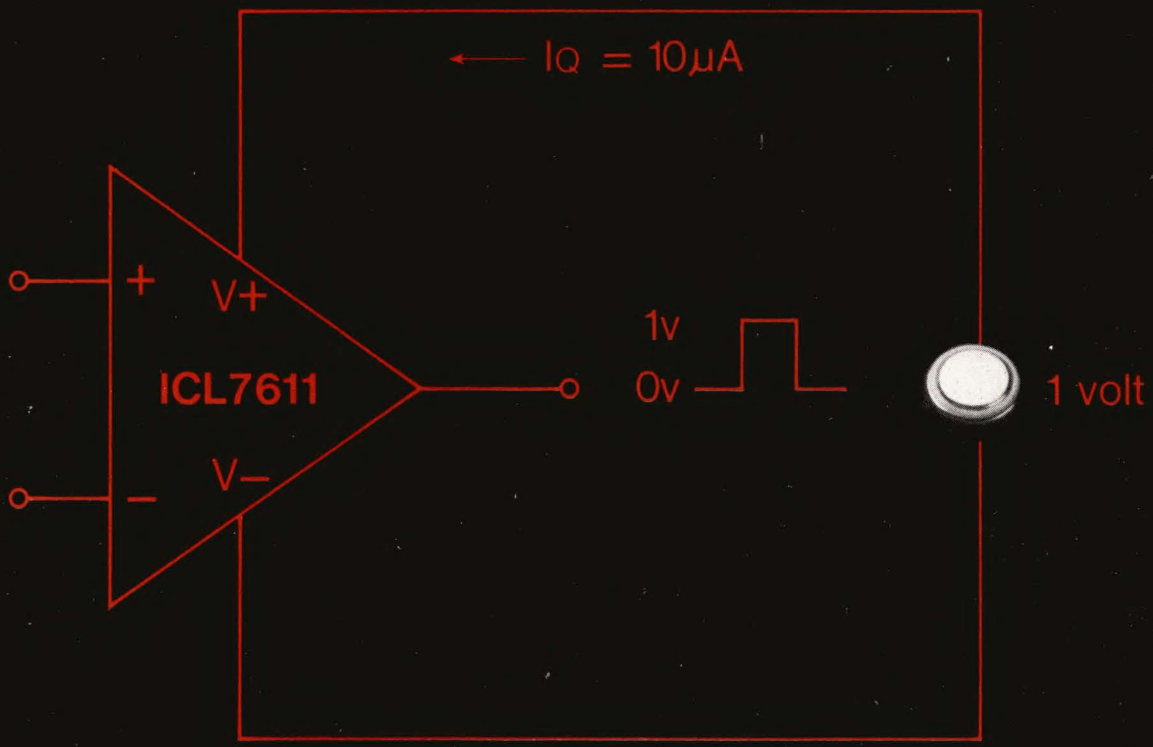

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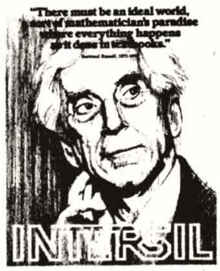

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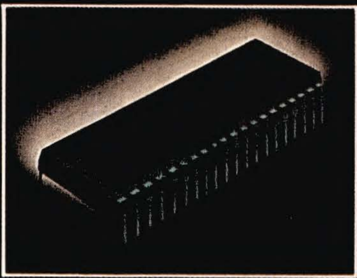

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Well-defined managerial policies optimize R&D productivity—Part 1

The link between expert management and superior creativity cannot be denied. These insightful guidelines ensure high-level R&D productivity at every stage in the game.

Robert M Ranftl, Hughes Aircraft Co

Increases in standards of living originate from fields with their foundations in technology—they are thus direct results of organized research-and-development efforts. Because technology has clearly become the economy's mainspring, improving the productivity of technology-based organizations is the most important challenge facing any professional, whether engaged in management, research, applied technology or support.

This article—Part 1 of a 2-part series—identifies useful techniques for optimizing productivity and incorporates the results of an extensive study which surveyed a broad range of participants in industry, government and education (see **box**). Part 2, appearing in the next issue of EDN, will focus on the problem of technological obsolescence.

The nature of productivity

Excerpts from the study highlight a few of its major findings:

- Productivity can be defined as the ratio of valuable output to input, or the efficiency and effectiveness with which resources—personnel, machines, materials, facilities, capital and time—are utilized to produce a valuable output.
- People, individually and in groups, primarily

Fig 1—25 FACTORS MOST LIKELY TO CAUSE SERIOUS COUNTER-PRODUCTIVITY WITHIN R&D ORGANIZATIONS

1. Ineffective planning, direction and control
2. Overinflated organizational structures
3. Overstaffing
4. Insufficient management attention to productivity and to the identification and elimination of counterproductive factors within the organization
5. Poor internal communication
6. Inadequate technology exchange
7. Insufficient or ineffective investment in independent R&D efforts
8. Poor psychological work environment
9. Lack of people-orientation in management — insufficient attention to employee motivation
10. Misemployment
11. Ineffective structuring of assignments
12. Lack of effective performance appraisal and feedback
13. Insufficient attention to low producers
14. Technological obsolescence
15. Ineffective reward systems which inadequately correlate individual productivity and compensation
16. Lack of equitable parallel managerial and technical promotion ladders
17. Lack of equity in operations
18. Ineffective customer interface
19. Ineffective engineering/production interface
20. Ineffective subcontractor/supplier interface and control
21. Operational overcomplexity — constrictive procedures and red tape
22. Excessive organizational politics and gamesmanship
23. Excessive provincialism
24. Ineffective management development
25. Inadequate investment in, and lack of proper maintenance of, capital facilities

Small productivity increases can have a large impact on profits

The Hughes productivity study

In 1973, Hughes Aircraft Co initiated a productivity study that to date has involved the active participation of 59 organizations in industry, government and education; the services of 28 consultants; surveys of more than 2000 R&D managers; and an extensive literature search.

The result, a book-type study report entitled *R&D Productivity—An Investigation of Ways to Evaluate and Improve Productivity in Technology-Based Organizations,* was published in 1974 and was reissued in a comprehensive 1978 second edition. The report represents a consensus of the study participants, the consultants and the authors researched in the literature. It serves a broad spectrum of managers at all levels—today's managers as well as the managers of tomorrow. And although the report focuses on the R&D community, the majority of its findings apply to all types of organizations.

determine the level of R&D productivity. Study participants stressed the critical importance of the work force's caliber and the effectiveness with which it is managed.

- Personal productivity does not seem to correlate significantly with IQ, excellence of education, grades or courses taken since graduation. While these factors might indicate a person's aptitude and potential, they do not in themselves appear to indicate a person's level of productivity. Rather, most differences in performance can be attributed to variations in attitudes and motivation.
- The overall productivity of an R&D organization depends heavily on its management personnel and the top 5% of the technical staff—people who deal largely in the realm of conceptual and innovative ideas, provide critical judgments and make major decisions. Study participants also recognized the importance of high productivity by all other personnel. They emphasized, though, that management and the top technical staff create the climate and set the pace for effective operation; their ideas, actions, standards and personal examples affect productivity throughout the organization.

Productivity improvement is there for the asking

After determining the nature and origin of productiv-

Fig 2 — 20 R&D MANAGERIAL OBJECTIVES MOST LIKELY TO LEAD TO HIGH PRODUCTIVITY

1. Establish high performance standards and promote personnel and product excellence.
2. Determine what objectives to pursue, based on a thorough knowledge of the technology, market, competition and available resources.
3. Optimize the use of all available resources; be alert for unused and underutilized resources—particularly strive for total involvement of the entire work force.
4. Develop a sense of entrepreneurship throughout the organization, ensuring that everyone is performance oriented.
5. Delegate authority, responsibility, decision making, control and accountability as far down the organization as is practical.
6. Manage time effectively by setting priorities and deadlines and by stopping nonproductive efforts as soon as possible.
7. Invest in future technology through sound basic and applied research and development programs.
8. Be open minded and imaginative, quick to see the potential of new concepts and ideas.
9. Encourage technological innovation and the use of the latest technological aids.
10. Keep the organization "tuned up"; always search for more productive ways of doing things.
11. Be alert for and correct counterproductive factors within the organization.
12. Apply work elimination, simplification and standardization techniques wherever appropriate.
13. Strive for preventive rather than corrective action.
14. Encourage an effective working relationship between R&D and all other related company and customer activities.
15. Assure that no individual or facet of the organization gets shortchanged or overemphasized.
16. Minimize organization politics and gamesmanship—avoid the connotation of "insiders" and "outsiders."
17. Encourage healthy competition between groups or with other organizations, but minimize competition within any one particular R&D work group.
18. Maintain effective, equitable compensation and promotion policies.
19. Review regularly the need and justification for overhead and capital expenditures, keeping both in line with efficient operating practices.
20. Critique past performance—learn from both successes and mistakes of earlier R&D efforts.

Fig 3 — 20 EFFECTIVE SUPERVISORY TECHNIQUES MOST LIKELY TO LEAD TO HIGH PRODUCTIVITY

1. Make a genuine effort to understand subordinates; know their strengths and weaknesses, their primary sources of motivation and their career goals.
2. Effectively integrate the abilities of all individuals within the organization.
3. Match individuals to the jobs for which they are best suited.
4. Involve subordinates in planning, goal setting and decisions that affect them.
5. Let employees demonstrate their capabilities and grow professionally; help subordinates prepare themselves for jobs to which they aspire.
6. Manage by expectation; set high standards and high expectations and encourage subordinates to achieve them.
7. Keep subordinates fully but not excessively loaded with work.
8. Maintain light pressure on subordinates to produce. (This must be done skillfully — mild pressure properly applied can stimulate productivity, but excessive pressure can easily become counterproductive.)
9. Avoid (1) treating all tasks as maximum efforts or special cases, (2) rush and overtime followed by delay and (3) surprises and unexplained changes.
10. Be available to subordinates through an open-door policy.
11. Provide feedback on performance; recognize and reward achievement; cite mistakes fairly and tactfully.
12. Make a special effort to help subordinates who are deficient in certain aspects of their jobs.
13. Represent equitably all subordinates and their work to higher management — whenever possible, have the person who originated a unique idea or did an outstanding job be the one to brief management.
14. Be sensitive to factors that cause employee dissatisfaction and frustration; get to the root of such factors and resolve conflicts in a timely manner.
15. Serve as a buffer to protect subordinates from many of the daily administrative and operational frustrations.
16. Maintain an effective flow of 2-way communication.
17. Serve as a catalyst to ensure effective technology exchange within the organization.
18. Keep employees informed of the broader aspects of company operations.
19. Encourage team-building, but be careful not to create provincialism.
20. Avoid imposing personal standards on subordinates and "oversupervising"

Fig 4 — USING MANAGERS' TIME AND ENERGY EFFECTIVELY

- Plan and budget time and energy effectively — optimize each situation.
- Review pending tasks and problems daily — establish priorities and time limits.
- Ration time and attention in proportion to the importance and urgency of each task — don't waste time on unimportant matters.
- Reserve periods of peak energy for the most important, creative and difficult tasks.
- Tackle each task separately and freshly.
- Focus attention on the task at hand — avoid preoccupation with other matters.
- Conserve time and energy. Group work into optimal time/energy packages and don't try to do more than can be done well.
- Don't vacillate. Be self-starting and take the first step.
- Exercise keen objectivity. Identify and concentrate on the key factors involved.
- Don't exceed your effective attention span. Know when to change pace to stop before fatigue sets in. Learn to make effective use of "minibreaks."
- Avoid extremes of operation.
- Introduce variety into monotonous work.
- Check for unnecessary energy loss resulting from faulty personal-habit patterns.
- Identify and effectively utilize your unique sources and patterns of energy renewal.
- Delegate responsibility by relying on subordinates.

Management must seek out those with leadership potential

ity, the study focused on methods of improving an organization's output level.

Profitable organizations as well as unprofitable ones, and in good times as well as bad, warrant productivity improvement. Significant, untapped and underutilized resources exist in every organization and every individual—all have the potential for improvement, but few capitalize on this unused potential. Even seemingly small individual achievements contribute to significantly increased productivity, and a relatively small increase in overall organizational productivity can have a considerable impact on a company's profits.

The study also pointed out that an organization can deal constructively with counterproductivity by identifying and remedying counterproductive factors within its structure. **Fig 1** lists 25 factors most likely to cause serious counterproductivity within R&D organizations.

Improving managerial output

Skilled, responsible management and superior productivity go hand in hand. Because industry is now entering a demanding era requiring greater professionalism in management, tomorrow's R&D manager, in addition to being technically qualified, must be a respected, people-oriented leader trained in the latest techniques of behavioral science and sound business practices.

The approaches taken and the techniques practiced by management provide tremendous potential for either stimulating or depressing productivity. Management's attitudes, actions and personal examples pervade an organization and directly affect employee attitudes, motivation and actions. Because employees take their cues from management and respond to the perceived reward system, management must clearly convey its positive feelings toward the importance of productivity, its strong desire to see active productivity-improvement efforts throughout the organization and its intention to equitably reward increased productivity.

Management must also create a proper climate for high productivity—an open professional climate where high standards prevail and people can be themselves. Managers should also emphasize effective communication and technology exchange and minimize politics and gamesmanship.

Tips on directing the work force

While the approaches taken by management have a great impact on productivity, any given management technique cannot be expected to stimulate all employees or apply to all situations in the same manner. Therefore, productive managers must exercise acute awareness and perception, continually picking up and interpreting cues and tailoring their approaches and techniques to varying situations.

But the study participants did identify 20 specific

Fig 5 — SOLVING PROBLEMS AND MAKING DECISIONS

- Anticipate problems whenever possible. Head off problems with preventive action before they fully materialize.
- Get into the habit of solving problems and making decisions. Avoid indecision, vacillation, procrastination and rationalization. (One important note: Don't handle problems or make decisions when tired, preoccupied or irritated.)
- Give problems and decisions priority in accordance with their importance.
- Define the problem, strip it of all unnecessary elements and distill it down to its simplest terms.
- Subdivide particularly difficult problems, when appropriate, into related segments. (Often by solving one segment, the other segments more readily lend themselves to solution.)
- Get all the facts — discard irrelevant material, eliminate biases and challenge assumptions — then correlate all relevant material.
- Analyze material carefully — draw affected people into the decision process. (People who share in a decision, even an unpopular one, are more likely to be committed to its success than if they had no part in it.)
- Formulate possible solutions.
- Assess risks and consequences.
- Incubate and set a time limit. Decide as promptly as possible but avoid premature decisions. (Remember that frequently more than one choice will work equally well.)
- Plan implementing action clearly and effectively — consider the need for contingency plans and develop them as appropriate.
- Take timely action and follow up, taking corrective action as necessary.
- Accept responsibility for each decision and its consequences.

management objectives that lead, in their experience, to high productivity (**Fig 2**).

Study results stress that to supervise effectively, managers must exhibit a genuine interest in employees—interest supported by attention to and concern for them and their work. When employees feel that managers respect their abilities and that proper recognition and reward will accompany their efforts, they will usually perform effectively and measure up to management's expectations. In this regard, **Fig 3** provides a list of 20 supervisory techniques that would most likely lead to high productivity.

Cultivating leadership potential

Managers who rate high as leaders are particularly effective at improving productivity. Leaders elicit strong positive emotional reactions, and people tend to fulfill their needs and grow under effective leadership. However, while you can easily recognize leadership, defining the quality poses a problem. No two leadership styles are the same; each style is—and should remain—unique to each individual. Furthermore, a good leader in one situation might not necessarily be a good leader in a different one. Also, while the type of leader required depends specifically on the type of group to be led, even the same group might require a different kind of leadership at different times in its evolution.

Most managers possess some leadership ability, but unfortunately, very few make outstanding leaders. And although much attention has focused on developing leaders, the study showed little support for the concept of providing specialized training in leadership as an entity in itself. Rather, development of a true leader evolves from a lifelong process heavily influenced by early childhood environment. However, while an organization cannot create leadership, it can prove catalytic in enhancing leadership potential.

A point particularly emphasized in the study pertains to this self-development process: Top management must select for advancement to key managerial positions those who show leadership promise, and it must provide the appropriate climate, opportunity, challenge and incentive for those individuals to further develop their leadership abilities.

Use managerial skills to direct the design process

Successful guidance of the design process also yields high productivity. To help ensure design effectiveness, study participants indicated that management should:

- Define a preliminary design, stress simplicity and evaluate alternate approaches and tradeoffs

Fig 6 — CONDUCTING PRODUCTIVE MEETINGS

- Ensure that meetings have useful content. Avoid holding meetings when they are unnecessary and determine if individual conversations would be more appropriate.
- Make meetings timely — hold them promptly after receipt of important information or request for decision, and always soon enough to ensure adequate and timely action.
- Keep meetings as small in size as practical. Select only attendees who are directly involved and able to deal effectively with agenda items.
- Select a convenient time and location for each meeting.
- Be realistic about meeting length — end meetings before fatigue sets in. (Try to limit meetings to 1 hr, and generally never exceed 2 hrs.)
- Inform participants in advance about the purpose, agenda and objectives of the meeting so they can come prepared.
- Open the meeting with effective introductory remarks. Introduce members, ease tensions and encourage participation by all attendees.
- Establish and maintain an open, unstructured climate conducive to a genuine and uninhibited exchange of ideas.
- Keep the meeting in perspective. Focus on objectives and control "hidden agendas." Avoid pressuring, criticizing and preaching.
- Maintain the proper pace. Keep the meeting on schedule.
- Pause at intervals to relate ideas and integrate the discussion up to that point (interim summaries), then proceed with further discussion or move on to the next subject.
- Summarize at the end of the meeting — state conclusions, recommendations and actions — assign responsibility and due dates for action items — close on an encouraging note.
- Evaluate the meeting soon after it has been held.
- Concisely document the meeting when appropriate.
- Follow up on all assigned actions.

Make sure employees' jobs and skills complement one another

- Strike a balance between encouraging the use of proven, reliable designs and components on the one hand, and stimulating creativity and innovation on the other
- Meet requirements in each initial design, thus minimizing costly redesign, manufacturing "fixes" and retrofits
- Avoid overdesign by knowing when to stop a design effort and when a design can't "win"; drop marginal design efforts after a fair trial
- Consider parallel design approaches when time is critical or technical risk is high
- Use design-review techniques (EDN, April 20, 1978, pgs 91-95) at various key points in the complete design cycle (include software as well as hardware items)
- Design quality, reliability and safety into products
- Assure effective application of cost-reduction principles throughout the design process, with particular emphasis on the early phases, where the potential payoff is greatest
- Make sure designs take full advantage of the manufacturing organization's capabilities
- Send engineers into the field to become aware of the environment in which their designs must function, observe their completed designs in use and experience customer reaction first-hand
- Have design corrections/improvements made by those who initiated the original design
- Critique design performance; compile a "good things/bad things" report upon completion of a design effort.

Among the more important—but often taken for granted—factors affecting managers' productivity are the personal skills they apply in everyday operations. The manager's personal contributions directly affect the productivity of subordinates.

Figs 4 through **7** describe many specific recommendations for improving productivity by increasing a manager's skills. Because these recommendations reflect the consensus of a broad spectrum of managerial personnel, they serve as checklists for managers concerned with improving the productivity of their own everyday activities.

The key to improving employee productivity

An integrated staff performance almost entirely determines the output of an R&D organization. The study attributed most differences in performance to variations in employee attitudes and motivation. Therefore, management should be aware of and

Fig 7 — MAKING EFFECTIVE PRESENTATIONS

- Establish your objectives. Clearly identify what you want your audience to know, why you want them to know it and what you want them to do about it.
- Know your subject thoroughly.
- Learn as much as possible about your audience in advance. Relate your material directly to them. Speak in their "language" and try to anticipate their interests, concerns and questions.
- Prepare an outline to objectively keep your thoughts in planned, logical sequence.
- Don't try to cover more material than you have time for.
- Use simple visual aids.
- Be natural and sincere. Don't read or memorize mateial — speak conversationally, as if you're speaking individually to each person in the audience. Slowly scan the audience, developing eye contact with individual listeners.
- Start with an "attention-getter" that leads into the subsequent material. (If an anecdote, ensure that it's relevant to the subject and in good taste.)
- Exhibit confidence. Be enthusiastic about your subject and eager to share it with the audience.
- Tell your audience briefly what you're going to say, say it and then briefly summarize what you've said.
- Change your pace — vary delivery rate, pitch and volume.
- Ensure that the audience absorbs what you're saying, but don't let the presentation drag. Pause briefly after each key point to let it register.
- End with a strong "bottom line" — it's the last and most important chance to get your message across.
- Close on a positive note.
- Distribute any reading material after the presentation, so it will not compete for attention while you are speaking. (Such material, when appropriate, can provide a lasting and accurate transcript or summary of the presentation.)

Fig 8 — 20 EFFECTIVE JOB-ASSIGNMENT PRACTICES THAT ENHANCE PRODUCTIVITY

1. Provide assignments that lead, through successful completion, to a feeling of accomplishment and a sense of contributing/belonging.

2. Ensure that assignments are pertinent to the organization's overall objectives and have management's active interest and support.

3. Assign work in keeping with individual capabilities and interests. Avoid misemployment. Don't get employees in over their heads.

4. Ensure that assignments make effective use of employees' skills and talents while at the same time affording them an opportunity to develop new skills and grow.

5. Keep assignments in scope. Avoid too many simultaneous tasks.

6. Keep assignments from being overspecialized. Jobs should not be divided too finely.

7. Ensure that assignments are clearly defined and involve specific responsibility; avoid open-ended assignments whenever possible.

8. Focus on end results (technical performance, costs and schedules), giving employees as much freedom and opportunity for work planning and decision making as possible.

9. Make schedules tight but realistic; permit adequate time to do the job effectively.

10. Provide employees with the necessary resources to do the job effectively.

11. Use the most capable people for the most critical jobs. (This does not mean continually using the same tried and proven employees; capable but untried people must be given a chance. This is the only way junior employees can develop.)

12. Provide particularly creative people with highly challenging job assignments, minimizing boring, repetitive and trivial tasks.

13. Minimize the amount of nonengineering work done by engineers.

14. Strive for equity of workload among employees; don't overload good people just because they "always come through."

15. Consider special assignments for key people in addition to their primary responsibilities; e g, identify them as consultants in specialized areas in addition to their normal work.

16. Change or expand employee assignments periodically; don't destroy capable people by trapping them in "indispensable" functions that lead nowhere.

17. Minimize loans of employees to other organizations. This is usually an unsatisfying arrangement for an employee.

18. Establish work teams of people who are particularly productive when working together. (Selection of personnel whose backgrounds differ widely often enhances cross-fertilization of ideas and has a synergistic effect.)

19. Maintain an adequate backlog of work. The productivity of people waiting for new assignments is usually relatively low, and existing projects tend to overrun if there are no new assignments in sight.

20. Provide job security consistent with an employee's job performance.

understand these attitudes and be instrumental in creating an environment that maximizes each employee's motivation level—a task that requires strong "people orientation" on the part of management. Management should thus make a genuine effort to understand subordinates—to know their strengths and weaknesses, their primary source of motivation and their career goals and thereby ensure that each person finds his optimum job.

During the completion of tasks, employees must be aware of management's expectations. Lack of sufficient direction and definition when assigning work often results in gross inefficiencies and wasted effort. Furthermore, care should be taken not to fragment responsibility; people usually produce more when they are responsible for a total, clearly identifiable task.

Subsequently, employees should be allowed to plan their own work—an approach that gives them a vested interest in the job and a strong incentive to meet their own commitments. Within broad but practical limits, managers should permit employees to do the job their own way.

In this regard, management should avoid reassigning a person part of the way through an effort unless absolutely necessary. This practice not only demotivates an individual, but a replacement might require considerable time to become familiar with the assignment, usually resulting in a period of decreased productivity. **Fig** 8 highlights 20 practices for enhancing the productivity of job assignments.

The role of misemployment

Misemployment, a prevalent and frequently overlooked problem, plays a large part in reduced productivity. Many employees who are underproductive in their present jobs could be more useful in other positions. In some cases, employees might simply be assigned the wrong tasks. In others, employees might actually be in the wrong type of work altogether. Still other employees might be overqualified for their jobs.

"Moderate misemployment," the most common misemployment problem, causes the greatest drain on overall productivity. In this case, employees perform satisfactorily but don't feel "turned on" by the job.

Parallel ladders prevent employee stagnation

Thus, such employees work far below their potential productivity level, viewing the work merely as "a job with a paycheck" rather than as a challenging segment of an exciting and rewarding career. Frequently, only an appropriate change in assignment will reverse this condition. Constant vigilance by management to place employees in the right jobs should alleviate this hazard.

Most organizations that participated in the productivity study use parallel managerial and technical ladders of advancement. The presence of a technical ladder helps prevent scientists and engineers who are outstanding in the technical field from being needlessly drawn into management, where their performance might prove poor and their careers be eventually imperiled—a classic case of misemployment (EDN, October 20, pg 55). Several observations define the importance of parallel ladders:

- Parallel ladders can and should be developed for all specialty fields (e g, marketing, contracts, finance, materiel, manufacturing and support), not just for the scientific areas.
- Parallel ladders within any given field should have similar salary scales, benefits and status symbols. Except at the very top, each ladder should contain the same number of rungs.
- To preclude premature selection of a career ladder, the first level or two of parallel ladders can be merged, converting the ladders' advancement path into a Y-shaped structure.
- Often, parallel ladders are not properly emphasized or implemented.
- The parallel scientific ladder of advancement should never be used as a "burial ground" for individuals who do not perform adequately in managerial positions.

EDN

Author's biography

Robert M Ranftl, a member of Hughes Aircraft R&D management for the past 26 yrs, works as Corporate Director of Engineering/Design Management. He holds an EE degree from the University of Michigan and has pursued extensive graduate studies in management at UCLA. In addition to his technical-management responsibilities, Mr Ranftl heads Hughes' productivity studies and is responsible for stimulating productivity-improvement efforts within the company. As part of this activity, he has spent more than 1000 hrs teaching voluntary, after-hours courses in personal, managerial and operational productivity to members of Hughes management.

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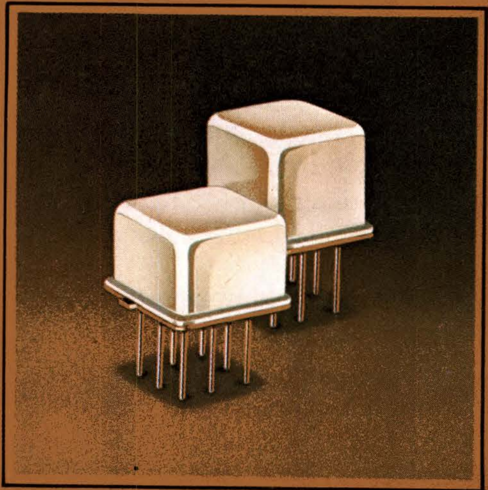

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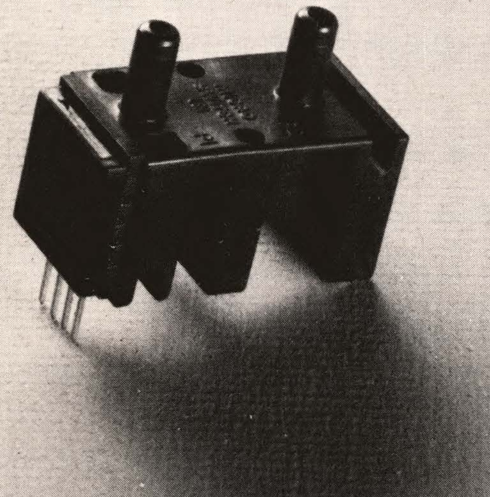

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Magnetic-tape drives meet many storage needs

Tape-drive technology is alive and well. Indeed, the development of high-performance, low-cost drives bodes well for tape makers and users alike.

Bill Barton and **Marty Gray,** Cipher Data Products Inc

Despite predictions of magnetic-tape technology's demise a decade ago, it's still thriving; recent predictions peg the growth of tape use at 20 to 50% per year over the next few years. The need for large-capacity memory for disc backup, along with the recent introduction of low-cost, high-performance tape drives, continues to make tape technology a viable data-storage alternative.

Use tape for high reliability

What types of systems require a tape drive? Those that call for high data capacity, high reliability and low storage-medium cost. A 10½-in. reel of tape stores up to 40M bytes of data and costs about $9: Recording with the phase-encoding (PE) method stores about 3M bytes to the dollar, while with the more sophisticated group-code-recording (GCR) method, this figure improves to 10M bytes per dollar. Compare these values with those of discs (about 0.25M bytes per dollar), and it's clear that for archival requirements exceeding 10^9 bytes, tape is the most cost-effective storage method.

However, keep in mind that the low cost of the medium in tape systems must be weighed against rather substantial initial hardware costs; most high-speed vacuum-column drives utilizing PE cost about $4000. This high cost results from the complexity of tape-drive design: A typical tape drive requires a capstan servo, two tape-reel buffering servos and nine tracks of read and write electronics, compared with one servo system, one channel and serial read/write electronics in a disc drive.

Some of the new tape systems designed specifically for high-speed data-dump applications eliminate some of this high-cost hardware. These systems don't have stop-on-a-record capability, thereby eliminating the costly tape buffering needed for fast stops and starts. Such "streaming" tape drives typically sell for less than $2000 including PE formatting electronics—a very attractive price for the small-systems designer.

Even if you need stop-on-a-record capability and therefore must use a traditional tape drive, you will find that its hardware cost usually becomes insignificant when compared with the resulting storage-medium savings. With a standard tape drive, for instance, it costs only $10 to back up 50M bytes of main memory; performing this function on disc costs more than $400.

Also keep in mind tape's ultrareliability. As **Fig 1** shows, the average reliability spec for tape is one hard error in 10^{10}, and with GCR this number becomes a remarkable 1 in 10^{11}. In real life, this statistic means one unrecoverable read error in more than 500 reels of tape; i e, tape just doesn't generate errors. Among competitive technologies, only Winchester discs can match this error rate—and that's on a nonremovable medium. (Cartridge tape is by specification 100 times less reliable than ½-in. tape.)

Tape employs standard formats

You'll also like the high degree of format standardiza-

TAPE-SYSTEM TYPE	TAPE SPEED (IPS)	POWER (W)	DATA CAPABILITY (10.5-IN. REEL)*	DATA RELIABILITY	MTBF (HRS)	ACOUSTIC NOISE	FORMATTED COST
TENSION ARM	12.5 TO 45	250 TO 500	800-BPI: 20M BYTES 1600-BPI: 40M BYTES 6250-BPI: 156M BYTES	10^9 10^{10} 10^{11}	3000 TO 6000	LOW	$3000
VACUUM COLUMN	45 TO 125	300 TO 2000	800-BPI: 20M BYTES 1600-BPI: 40M BYTES 6250-BPI: 156M BYTES	10^9 10^{10} 10^{11}	2000 TO 5000	MED TO HIGH	$4000
STREAMING	12.5 TO 125	200 TO 400	NO 800-BPI AVAIL 1600-BPI: 40M BYTES	10^{10}	7000	LOW	$2000

*7 IN. = ¼ CAPACITY
8½ IN. = 1½ CAPACITY

Fig 1—Although they're the most cost-effective drives, *streaming-type units do not have stop-on-a-record capability.*

Tape excels in achieving high reliability

tion found in tape systems. Virtually all ½-in. tape on the market is recorded in ANSI- and IBM-compatible formats at 800 bits per inch (bpi) per track in nonreturn-to-zero-inverted (NRZI) encoding, at 1600 bpi in phase encoding or at 6250 bpi in GCR encoding. Even tapes recorded on the new streaming tape drives can be read on standard vacuum-column or tension-arm drives. This standardization gives ½-in. tape an added benefit over competitive technologies such as cartridge tape.

Of course, tape does present a major disadvantage. Compared with disc systems, whose access times are measured in milliseconds, tape can have random-access times measured in minutes. But for large-scale sequential access, such as sorted-file merges and transactional backup, tape can actually improve throughput by avoiding the latency and seek delays experienced in disc systems.

Fig 2 illustrates this point by listing the relative access times of floppy disc, hard disc and two types of tape systems for three operations. (The times indicated are probable; they depend greatly on such factors as CPU architecture, operating-system design and buffer design.) **Fig 3** summarizes the strengths and weaknesses of tape compared with other storage technologies.

SYSTEM TYPE	TIME (SEC) REQUIRED FOR: 100k-BYTE FILE COPY	1M-BYTE COPY	TWO-FILE-SORTED 1M-BYTE MERGE
FLOPPY DISC*	10	100	200
25-IPS TAPE* (1600 BPI)	5	50	50
125-IPS TAPE* (1600 BPI)	1	10	10
HARD DISC**	0.5	5	50

NOTES
*TWO-DRIVE SYSTEM EXCEPT 3-DRIVE IN MERGE OPERATION
**SINGLE 50M-BYTE DISC.

Fig 2—Tape drives aren't as slow *as you might think. A comparison of access times for various operations shows that for large-scale sequential access, such as sorted-file merges, tape drives can actually exhibit better throughput than hard discs.*

Consider the tape alternatives

There are two major types of tape drives—tension (or servo)-arm systems and vacuum-column units. (Streaming tape drives form a subcategory because they have a tension-arm design but handle tape differently than the traditional tension-arm units.) But whatever the technology, tension arms and vacuum columns in a tape drive both serve the same purpose: They store an initial length of tape, which the system reads or writes while the high-inertia reel (which holds the main body of tape) accelerates to speed.

Tension arms are mechanical buffering devices. Besides low cost and quiet operation, they exhibit high immunity to airborne dust particles. You'll find tension arms in all standard tape drives that operate at up to 45 ips. If you require stop-on-a-record capability at speeds greater than 45 ips, though, vacuum-column drives serve your needs. Also, a vacuum column can easily store longer lengths of tape than a tension arm—with a minimum amount of inertia.

Consider the tape path in a tape drive as a spring/mass system **(Fig 4).** The capstan acts as an excitor driving the spring (tape) and mass (tension arm or vacuum column) into resonance. Tape acceleration to 45 ips corresponds to a reasonable 13.6 times the force of gravity. But acceleration to 125 ips corresponds to 108g. In addition, a tension arm with a mass of 0.4 oz increases the tape tension during a 45-ips start by 1.36 oz. And a 125-ips start with the same 0.4-oz tension arm would result in an increase of 10.4 oz, or 130%—a totally unacceptable strain on the tape. Vacuum-column drives, however, when properly designed, relieve this strain on the tape.

Streaming tape drives (IBM 8809, Cipher Microstreamer), operate on a tension-arm principle but achieve 100-ips speed. These drives need not stop and start in the tape's interrecord gap (IRG), as a standard

MEDIUM	COST PER BIT (DOLLARS)	SEQUENTIAL-ACCESS TIME (mSEC)	RANDOM-ACCESS/LATENCY TIME	INTERCHANGEABILITY OF MEDIA	RECORDING-FORMAT STANDARDS	CONCURRENT ERROR CHECKING	LONG-BURST ERROR CORRECTION	NONRECOVERABLE ERROR RATE (READ)
½-IN. TAPE, 800 BPI	9×10^{-8}	4	30 SEC (10M-BYTE FILE)	Y	Y	Y	SOME	10^{-9}
½-IN. TAPE, 1600 BPI	5×10^{-8}	4	15 SEC (10M-BYTE FILE)	Y	Y	Y	Y	10^{-10}
½-IN. TAPE, 6250 BPI	2×10^{-8}	2	5 SEC (10M-BYTE FILE)	Y	Y	Y	Y	10^{-11}
¼-IN. TAPE CARTRIDGE, 1600 BPI	5×10^{-7}	30	15 SEC (1M-BYTE FILE)	Y	Y	Y	N	10^{-8}
¼-IN. CARTRIDGE, 6400 BPI	1×10^{-7}	30	5 SEC (1M-BYTE FILE)	Y	N	Y	N	10^{-8}
TAPE CASSETTE (PHILIPS)	3×10^{-6}	30	15 SEC (0.1M-BYTE FILE)	Y	Y	Y	N	10^{-7}
FLOPPY DISC, SINGLE DENSITY	2×10^{-6}	—	150 mSEC/80 mSEC	Y	Y	Y	N	10^{-8}
FLOPPY DISC, DUAL DENSITY	1×10^{-6}	—	150 mSEC/80 mSEC	Y	Y	Y	N	10^{-8}
HARD DISC, REMOVABLE	5×10^{-7}	—	30 mSEC/ 8 mSEC	Y	SOME	Y	N	10^{-10}
HARD DISC, FIXED	5×10^{-6}	—	30 mSEC/ 8 mSEC	—	—	Y	N	10^{-11}

Fig 3—A feature-by-feature comparison *of various storage media helps put tape in perspective.*

drive must; instead, when recording, they employ a slow ramping acceleration and deceleration and then automatically back up to insert the industry-standard IRG.

Choosing the proper speed

Your choice of tape speed primarily depends on your throughput requirements; tape-drive throughput increases with speed, but data density remains the same. OEM tape drives are available with speed capabilities ranging from 12.5 to 125 ips. (A 25-ips tape speed corresponds to 40k bytes/sec of throughput for data recorded in 1600-bpi PE format, 20k bytes/sec at 800 bpi and 156k bytes/sec in 6250-bpi GCR format. As tape speed increases or decreases, the data rates change linearly.

Bear in mind, though, that the size, design complexity and cost of a tape drive also increase with speed—with the exception of tape drives operating below 25 ips. These drives often cost slightly more than

Glossary of tape-drive terminology

BPI/CPI—Bytes per inch (bits per inch per track). The number of bytes per inch written on a tape. CPI (characters per inch) is used interchangeably.

BOT/EOT markers—The reflective markers on the back (nonoxide) side of a tape; used to locate the beginning of the data (BOT) and provide an early warning of the end of the tape (EOT). Tape-drive sensors optically detect these markers.

CPS/BPS—The number of characters or bytes per second (bits per track per second) written to or read from a tape.

CRC—Cyclical-redundancy character. A trailing character used in GCR and NRZI formats to provide error detection and/or correction.

CRCC—Cyclical-redundancy-check character. CRC used for error detection only.

IRG—Interrecord gap. Erased area between records that allows stop/start and speed standardization when writing or reading data blocks.

ISV—Instantaneous speed variations. Short-term speed changes resulting from nonuniform capstan speed, tension changes caused by start/stop accelerations and longitudinal vibrations caused by the tape's sliding over the heads and tape guides.

LSV—Long-term speed variations. Speed changes resulting from the temperature sensitivity of the capstan-motor tachometer and/or servo.

UL/CSA/VDE—These major safety organizations certify that tape drives and other products meet or exceed electrical and mechanical safety requirements. They usually certify tape drives as "recognized" components. Once properly installed in systems, such recognized tape drives need not be retested as part of the UL/CSA/VDE-system approval.

Air bearing—A means of supporting tape on an air film rather than by means of sliding or rolling contact. Usually, an air bearing is a perforated cylinder; pressurized air flows through the perforations and forms a film that prevents the tape from contacting the cylinder.

Azimuth—The alignment of a drive's read-head gaps with respect to a tape. The read head is usually adjusted with a standard alignment tape or master skew tape—a procedure that permits the interchange of tapes among drives.

Crap in the gap—Unwanted magnetic-flux variations in an IRG, causing false data indication and spurious read signals. New-generation drives eliminate this problem by means of careful formatter and data-recovery techniques.

Dropout—Amplitude loss which in turn causes a loss of read signal. It usually results from small dirt fragments or loose oxide on the magnetic surface. In PE and GCR formats, dropouts activate automatic error correction.

Dynamic skew—Short-term misalignment of the read head as referenced to a master skew tape. It results from variations in tape-path geometry, tape-path alignment and slitting and "snaking" tolerances of tape.

File mark—Also termed tape mark or end-of-file mark. A specially recorded block containing no data but acting as a data-block separator.

Gap scatter—The mechanical misalignment of a head's read/write gaps in the direction of tape travel.

On-the-fly—Recording techniques in which reading, writing and block spacing require no tape stoppage. These techniques require total control over data transmission. For long-length recording, coordination between data supply and tape demand is essential.

Pucker pocket—A small angular vacuum column that isolates the tape and air mass of a vacuum-column drive's main (large) columns from the large accelerations of the tape in the head area.

Ramp—The acceleration profile of the tape in most traditional (nonstreaming) drives during a start or stop operation. Usually, acceleration remains constant over a fixed distance.

Static skew—The long-term or average misalignment of a drive's read head as referenced to a master skew tape. Results from gap scatter and misadjustment.

Write-enable ring—A removable ring that fits into a recess on the back side of a tape reel. This ring must be installed before a tape can be written to; a user protects data tapes from being overwritten by removing it. Tape drives incorporate a sensor that verifies the presence of a ring before enabling the write circuitry.

Noise can be a factor in vacuum-column units

25-ips models because operation at very low speeds requires more complex mechanisms. Therefore, low-speed (12.5- to 25-ips) drives with 7-in. reels are only economical when your system calls for their very small size (they stand 8¾ in. high). As an alternative, the 8½-in.-reel tension-arm drives, measuring 12¼ in. high, generally offer speeds to 37.5 ips and are more cost effective. For speeds ranging to 45 ips, try the 10½-in.-reel models (24 in. high).

The greater-than-45-ips vacuum-column drives often add more than $1000 to a tape system's price. For efficiency and system flexibility, though, these drives can't be beat. They can generally operate at a variety of selectable speeds and can be easily upgraded as requirements demand. However, watch out for hidden costs. For example, on some models, vacuum-system noise and excessive power requirements could necessitate costly special cabinets or air conditioning. Also, if you think you'll someday need to read or record at a speed that your present system can't support, look for a tape-drive line that can be easily retrofitted for increased performance in the field.

Check out these features

While all drives generate industry-standard formatted tapes, employ standard-size reels and even run at standard speeds, the efficiency and reliability with which they perform can vary. Here are some major factors to consider when buying a tape drive:

Microprocessor control. Increasingly popular in today's drives, microprocessors implement a variety of tape-drive functions, including complete servo control (to prevent tape damage during power failure), beginning-of-tape/end-of-tape (BOT/EOT) sensing, file protection and tape positioning. Such microprocessors generally add no cost to the drives and in some cases even reduce their price. Unless properly designed, however, μP-based controllers can create servicing and circuit-troubleshooting problems. (To simplify servicing, some drives employ built-in validity checks and self tests of LSI components. Also, look for extended diagnostic and alignment aids implemented by the microprocessor.)

Acoustical noise. While noise typically isn't a problem with tension-arm drives, it can be a major consideration with vacuum-column units: High-speed vacuum pumps and airflow through the columns can create bothersome noise. In the past, users didn't worry about this noise because drives were installed in soundproof computer rooms. Today, however, you'll often find tape drives in desk-style systems used in office environments. The solution? New-design vacuum drives reduce noise by using low-speed, multistage vacuum pumps and precision mechanics. When the application calls for low noise, therefore, look into these "whisper-quiet" tape drives.

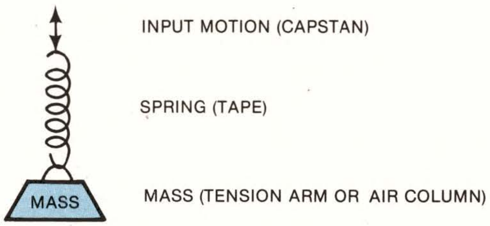


Fig 4—Model a tape path *as a mass/spring system. The tape-drive capstan acts as the excitor, driving the system into resonance.*

Tape-sensing techniques. Tape drives typically employ one of four main techniques to sense the beginning and end of a tape: incandescent/photoresistor, incandescent/photovoltaic, LED/phototransistor and modulated LED. The incandescent/photoresistor method—the traditional approach—features high ambient-light immunity. However, incandescent lamps require frequent replacement, and the photoresistor used in this system suffers from slow response and light-history perturbations. The approach is, however, more temperature stable than other methods. The incandescent/photovoltaic method, on the other hand, overcomes only some of the drawbacks of the traditional approach. And while an LED system offers solid-state reliability, its low light levels make it highly sensitive to ambient-light and thermal effects. Thus, the best current technique employs both an LED and a phototransistor, modulating the LED to eliminate ambient-light sensitivity.

Direct versus belt-drive vacuum motors. If possible, avoid belt-driven vacuum motors. Direct-drive motors reduce setup and maintenance requirements and represent only a small cost increase to the manufacturer. And new-generation drives use multistage, direct-drive vacuum blowers, which match the load to the motor, reduce noise and lower power requirements by more than 50%.

Cooling. New-generation tape drives employ switching power supplies and servos that don't require large heat sinks; they generally don't require forced-air cooling when operating at 125 ips or below. But when mounting any tape drive, make certain you provide adequate convection air flow.

Deck-plate construction. Any tape drive worth its salt employs a sand-cast or die-cast deck plate, which remains totally rigid to maintain tape-path alignment. Avoid so-called "built-up" construction—flat plates with stiffening ribs bolted on.

Tape tension. ANSI specifies acceptable tape tension as 5 to 10 oz, with a nominal 8-oz figure. More important than nominal tension, however, is the dynamic tension change during stops and starts; study these specifications carefully.

Capstan coatings. Most systems today use capstans with high-friction coatings to drive the tape. These

Connecting your tape drive

With few exceptions, all PE- and NRZI-formatted tape drives operating at speeds between 12.5 and 125 ips employ a standard interface with three connectors: one for read data, one for write data and one for command and status lines controlling the tape drive. Each signal in the interface is standardized and exhibits a TTL voltage swing (0.2 to 3.0V) terminated with an impedance of 130Ω. Because the signals travel as much as 20 ft, the cable impedance and terminator impedance should match within 20%.

Formatters have three cables for pc-mount connectors that plug into the tape-drive interface and (usually) one 100-pin or two 50-pin connectors that plug into a mag-tape controller (frequently located in the host computer's chassis).

GCR-formatter-interface definitions have not yet been standardized.

coatings, most often neoprene or urethane, are applied by molding or spraying and might or might not be machined after coating. Check to see whether the coatings' friction characteristics have been evaluated under hot, cold, clean and dirty conditions. Also consider coating resistance to wear and cleaning solvents.

Tape cleaners. Adequate tape-cleaning capability is important to maintain data reliability. You'll find two types of tape cleaners in common use: The first employs a perforated metal plate but is generally losing favor among manufacturers; the second employs more efficient scraping blades. These blades can be ceramic, tungsten carbide or sapphire—the latter provides the longest wear and deposits the least residue on the tape. Some cleaners have an attached vacuum source to remove collected particles. But usually the collected residue adheres to the scraper blade until removed with solvents.

A bright future for tape systems

Several recent developments promise further improvements in tape systems. Steaming tape drives, which could boost future tape usage by 70%, are already appearing in prototype models and will be delivered in production quantity next year. These drives aim specifically at disc-backup applications, particularly in low-cost Winchester systems.

By eliminating traditional drives' stop-on-a-record capability, streaming drives achieve small size (8¾-in. height), high speed (100 ips) and low cost (less than $2000 with PE formatter). For data-dumping applications, which require few stops and starts, they're ideal. In the future, designers will optimize system software to achieve very high performance with these low-cost drives.

The development of GCR encoding will also significantly enhance tape-drive performance. But GCR implementation is still complex; the requisite formatter alone requires 800 to 2000 ICs. And the read/write head and circuitry for a GCR-formatted drive must handle GCR's high density and 0.3-in. interrecord gap. Within 2 yrs, however, GCR will come of age, particularly when combined with streaming-tape technology.

Head life. Today's drives employ either soft Mu Metal/brass heads or hard-faced heads coated with chrome or ceramic; the hard-faced heads are often offered optionally. You'll get about 1000 hrs of service from a standard brass head before renewal; a hard-faced head provides five or 10 times this service. Even more important, hard-faced heads significantly reduce the number of read-level adjustments required during the life of the drive. Clearly, then, select hard heads if you're given the choice.

Operating voltages. Most tape drives operate on various line voltages (90 to 130V or 180 to 260V, 50 or 60 Hz), but the method of line-voltage selection varies. Some units allow you to select voltage from the rear panel; others require internal modification—an obviously more complicated process.

Mechanical adjustments. You shouldn't have to make very many mechanical adjustments on today's tape drives. But the ones that are necessary should require no specialized tools or equipment and should be fully documented in the service manual. All tape drives require some form of head-azimuth and capstan-motor-tilt adjustment, but others should be eliminated by design.

Maintenance and modularity. Your tape drive should be maintainable by electronics technicians and not require attention from skilled electromechanical assemblers. And ideally, these technicians will only need a screwdriver (and sometimes calipers) to maintain the drive. Some manufacturers employ a modular design to simplify maintenance—all major subassemblies, including the data board and head assembly, are prealigned and can be changed in the field by attaching a few screws and adjusting a pot. Such modular design significantly reduces a drive's cost of ownership.

Service manual and documentation. Particularly for OEM use, you'll need top-notch manuals and documentation. A tape-drive service manual should contain schematics, assembly drawings and parts lists for all pc boards; top-assembly drawings and parts lists; documentation of all maintenance procedures and adjustments; identification of any necessary special tools by part number; and theory of operation. Determine before you purchase a drive that all engineering documentation is sufficient to ensure interchangeability of parts and assemblies. Also check that the manufacturer maintains a systematic change-control procedure.

Spares interchangeability. Before selecting a tape drive, assure yourself that all spare parts of a given

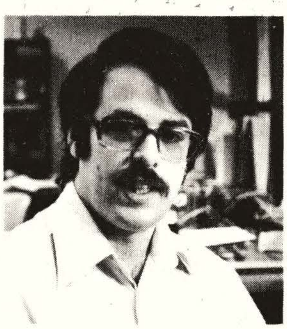
type are interchangeable at all revision levels of a model and among all models. Although this feature might increase the initial cost of spare parts, it significantly reduces spares-inventory requirements.

Upgrades. Upgrading a tape drive—to a higher speed, from nonformatted to formatted operation, from NRZI to PE encoding or from single to dual density—need not be costly. For example, upgrading from 25-ips NRZI to 45-ips NRZI operation should require no new parts—only electrical adjustments. And if you need to convert from nonformatted to formatted operation, you should only have to add a formatter—not a power supply or data board. Similarly, upgrading to dual density from single density should require only a change of the data board.

Formatters. Formatters for tape drives are available in PE, NRZI, dual-mode (providing PE and NRZI on the same board) and GCR dual-mode models. Furthermore, you can specify NRZI encoding in both 7- and 9-track formats. Formatters come either in stand-alone chassis with power supplies or embedded in (physically attached to) the tape drive, utilizing the drive's power. The latter form generally costs less and requires no additional space; it does, however, complicate daisy chaining of multiple drives, because if the host drive fails, the formatter also fails. However, in practice you'll find this a very minor problem. **EDN**

Authors' biographies

Bill Barton is vice president for engineering at Cipher Data Products Inc, San Diego, CA. A member of the Cipher staff for 11 yrs, he previously worked for 3M Corp. The holder of four patents, Bill attended the University of Texas. His hobbies include flying, motorcycles and animals (he owns a live cougar).



Marty Gray is manager of research and development at Cipher Data, where he's worked for 3 yrs. Before joining the firm, he worked at Kennedy Co. Marty holds a bachelor's degree from Cal Tech, is an IEEE member and a Registered Engineer and counts amateur radio, motorcycling and birds among his hobbies.

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Don't court disaster in DTMF signaling systems

Dual-tone multifrequency signal schemes are well proven, and you can buy a number of supposedly foolproof LSI DTMF sources and receivers. However, taking a simplistic approach to DTMF-system design can easily lead to trouble.

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Jay F Helms, PE, Consulting Engineer (Novato, CA)

Because tone signaling over communications channels can be trickier than it initially appears, it's important that designers evaluating dual-tone multifrequency (DTMF) systems understand the basic limitations inherent in all DTMF signaling schemes. The test methodology outlined here aids in such understanding and produces both credible and repeatable data. You can convert this test data into a single figure of merit that proves useful when comparing various DTMF-system designs within the envelope of specific worst-case application conditions. Using the methodology, you're left only with the problem of selecting the worst-case system-performance parameters that you feel best apply to your application.

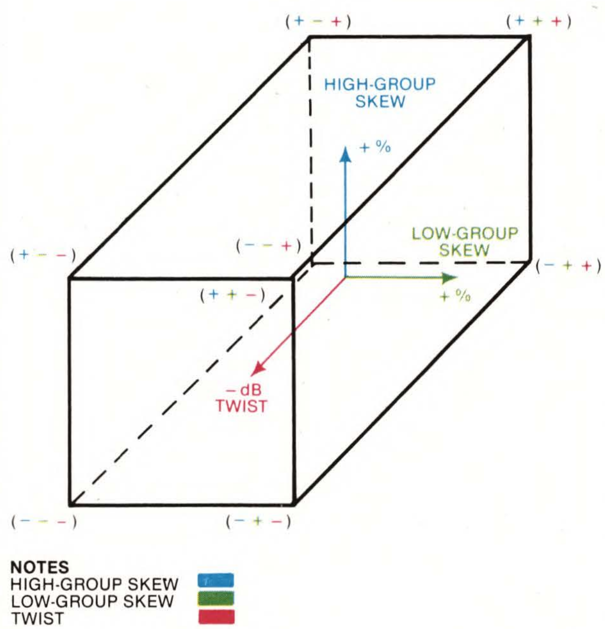


Fig 1—Multiple worst-case limits *evolve from the fact that DTMF high- and low-group skew and twist parameters can assume both negative and positive values.*

Telecommunications terms can be confusing

Selecting such worst-case performance limits for a DTMF system will catapult you into a world containing confusing and contentious criteria, which have evolved from the use of DTMF signaling in the telephone industry. Transmitting DTMF signals over the domestic and international telecommunications networks involves dealing with transmission impairments as well as the vagaries of facility switching accomplished by means of automatic traffic routing within the switching hierarchy. For example, it's not uncommon to acquire two totally different transmission paths—possibly over entirely different physical routes—upon making two successive calls between the same two points.

When testing a DTMF system used in such applications, you have to make judgments that deal with both worst-case limits and probabilities of reaching those limits. These judgment calls have long concerned experts within the telephone industry and are one of the factors behind the mystique that surrounds most discussions of DTMF signaling requirements. Buried in many published criteria are fudge factors for impedance discontinuities, echo-signal energy, component tolerances within the DTMF signal source and receiver, short- and long-term environmental conditions and component aging. Unfortunately, the exact flavor and amount of fudge plugged into the published criteria is highly subjective and seldom if ever revealed by its creators. The test methodology developed in this article helps deal with these problems.

One signal isn't enough

When testing a DTMF system, the specification and use of just one worst-case input signal would be ideal. However, the basic DTMF signaling scheme provides for the use of up to 16 tone pairs, and any test must explore the worst-case signal limits for each tone pair of interest. Additionally, experience has shown that DTMF systems might not respond identically for each DTMF frequency pair, compounding the problem. These potential pitfalls further emphasize the need for a comprehensive testing program.

The four basic parameters associated with a DTMF system are sensitivity, tone-ON/tone-OFF intervals, twist and skew. These parameters divide into two categories—those having single limits and those with dual limits.

The single-limit quantities are sensitivity (minimum signal amplitude), minimum tone-ON time and minimum tone-OFF time; the dual-limit items are skew and twist. Skew is placed in this category because any tone can deviate in either a positive or negative direction from its nominal value. Twist is considered a dual limit because the DTMF high-group signal level can either be greater than (positive twist) or less than (negative twist) the low-group signal level. Because skew and twist have dual limits, there is no single point characterizing their worst-case values. Instead, there are eight potential worst-case points **(Fig 1).**

You might think that the combination of +1.5% high-group skew, −1.5% low-group skew and −8-dB twist is no worse than the combination of −1.5% high-group skew, +1.5% low-group skew and +8-dB twist. In practice, though, a DTMF system can exhibit markedly different responses when tested at these two sets of limits—all the more reason for developing an effective testing methodology.

Classifying system operation

Work within the telecommunications industry has produced four categories of DTMF-system performance (see **table**), classified according to anticipated service.

Type 0 includes specialized services over a dial-up transmission facility generally involving four or more switching machines, and where transmission-multiplexing equipment can considerably shift the DTMF signal's frequency. End-to-end DTMF signaling used over the North American public switched telephone network typifies Type 0 service.

Type I covers general service over cable pairs of considerable length which occasionally might include switching equipment in the DTMF signaling path. A 1-kHz attenuation of 8 dB represents worst-case transmission for this service. DTMF signaling from subscriber telephones to the local central office is a typical example of Type I service.

Type II describes service over intermediate lengths of nonloaded cable which includes no switching equipment in the DTMF signaling path. For this category, 5600 ft of 26 AWG cable represents a worst-case transmission facility. DTMF signaling used in private-branch-exchange (PBX) systems typifies Type II service.

Type III involves limited service over short lengths of nonloaded cable having essentially zero loss at 1 kHz. A worst-case transmission facility of 1200 ft of 26 AWG cable represents Type III service.

The criteria values cited in the **table** are the most applicable to testing by means of the methodology proposed in this article. Their values represent an evolving synthesis of telephone-company and telecommunications-systems experience—based in some cases on specific and specialized applications. The figures represent current performance objectives for DTMF receiving devices, based on the generation of DTMF signals by a telephone set and transmission over paired conductors. You can use these values to establish general boundaries for your design requirements.

PARAMETER	CRITERIA			
	SERVICE			
	TYPE 0	TYPE I	TYPE II	TYPE III
SENSITIVITY: SINGLE-FREQUENCY DTMF LEVELS, MEASURED AT Z = 600 Ω.	−32 dBm	−25 dBm	−17 dBm	−13 dBm
SKEW: PERCENTAGE DEPARTURE FROM NOMINAL f_0				
MUST RESPOND	f_0 ± 1.7% ± 5 Hz	f_0 ± 1.5%	f_0 ± 1.5%	f_0 ± 1.5%
MUST NOT RESPOND	UNSPECIFIED	f_0 ± 3.5%	f_0 ± 3.5%	UNSPECIFIED
RESPONSE TIME				
TONE ON ≥	40 mSEC	40 mSEC	40 mSEC	40 mSEC
TONE OFF ≥	40 mSEC	40 mSEC	40 mSEC	40 mSEC
CYCLE TIME ≥	85 mSEC	85 mSEC	85 mSEC	85 mSEC
TWIST	+4 TO −10 dB	+4 TO −8 dB	+4 TO −1 dB	+4 TO −1 dB
DESENSITIZATION: SYSTEM PERFORMANCE MUST NOT DEGRADE IN THE PRESENCE OF 350/440-Hz PRECISE DIAL TONE AT LEVELS OF	NOT APPLICABLE	−16 dBm	−16 dBm	UNSPECIFIED
GAUSSIAN NOISE: SYSTEM PERFORMANCE MUST NOT DEGRADE IN THE PRESENCE OF GAUSSIAN NOISE BAND LIMITED 0-3 kHz & GENERATED BY A 600Ω SOURCE AT A LEVEL OF	65 dBrnC	53 dBrnC	37 dBrnC	35 dBrnC
SIGNAL ECHOES: SYSTEM PERFORMANCE MUST NOT DEGRADE IN THE PRESENCE OF ECHO SIGNALS HAVING A DELAY OF	≤20 mSEC	≤20 mSEC	NOT SPECIFIED	NOT APPLICABLE
AND A MAGNITUDE RELATIVE TO THE INCIDENT SIGNAL OF	≤10 dB	≤10 dB	NOT SPECIFIED	NOT APPLICABLE
ROSENBERG VALUE	NOT SPECIFIED			

Explore worst-case limits for each tone pair of interest

Experience has shown that as a signal approaches the limits of a DTMF device's performance (which might or might not coincide with the manufacturer's specifications), the device begins to "miss" a certain number of input pulses. For example, when a device experiences a serial train of 100 pulsed test signals embodying a specified set of worst-case criteria, it might respond to only 85 of those pulses.

To conduct this type of test, you can record the DTMF system's output from a Data Present or Strobe lead, which any well-designed DTMF device should provide. This lead produces a logic output when a valid DTMF signal pair is received—without regard to the digit value assigned to that pair—and remains active in that logic state so long as a valid DTMF signal remains present at the system input.

Fig 2 shows a chart recording resulting from tests in which Strobe-lead response was monitored while a system was exposed to 10 combinations of twist and skew for the same DTMF frequency pair. In this case, the DTMF input signal was set at the manufacturer's specification of −20-dBm sensitivity. Additionally, tone-ON and tone-OFF times were set at 40 and 50

Reviewing some basic DTMF concepts

Telephone networks employ DTMF (dual-tone multifrequency) signaling to pass address information from a telephone set to the local central office. With this method, oscillators in the phone set generate a unique pair of tones (see **table**) for each button depressed on the set's dial.

Because of the technique's roots, many DTMF signaling-system definitions might appear strange to most electronic designers. Here's a rundown on the performance parameters critical to a viable DTMF-system design.

Twist—The difference (in decibels) between the DTMF high-group and low-group signal levels, mathematically defined as 10 log [(high-group power) / (low-group power)]. Measured at the DTMF receiver, it's a function of both the level difference generated by the signal source and the gain-frequency characteristic of the transmission facility.

Skew—A measure (expressed in percent) of the departure of each individually received signal frequency from its nominal value. A function of component tolerances, aging, environmental conditions and certain types of transmission-multiplexing equipment, skew is measured at the DTMF receiver.

Sensitivity—Generally expressed in dBm at a specified impedance (usually 600Ω), sensitivity is a measure of the lowest DTMF signal level that a receiver can detect. It represents an absolute threshold below which detection of a single frequency is not generated.

Tone-ON/tone-OFF intervals—The tone-ON and tone-OFF intervals, along with the repetition rate of the total ON/OFF cycle, have a major impact on DTMF-system performance. DTMF signals must be present long enough to allow the receiver to differentiate between a solid signal and a false noise burst. Tone-ON/OFF times are generally expressed in milliseconds; repetition rate, in pulses per second.

Noise immunity—A measure of a DTMF receiver's ability to prevent valid signals from being rejected as noise. It is sometimes specified as the ability of the receiver to operate under conditions of gaussian noise in dBrnC.

Talk-off—The tendency of a DTMF system to respond falsely to other-than-valid DTMF signals. Talk-off criteria are generally specified very subjectively—sometimes in such broad terms as "good" or "poor."

Desensitization—The tendency of a receiver to fail to recognize valid DTMF signals in the presence of such factors as dial tone, pilot signals or data signals.

Additional factors—These factors affect the successful reception of DTMF signals, although to date no one has established the exact magnitude of each of their impacts. *Impedance discontinuities* at the transmitter and receiver transmission-medium interfaces have been known to affect system performance. And *echo signals* returning from a distant impedance discontinuity within a long-haul transmission path can also change signal reception. Additionally, *phase jitter* of either or both DTMF tones can apparently affect the performance of certain receiver designs.

LOW-GROUP TONES	HIGH-GROUP TONES 1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

← TWO-OUT-OF-SEVEN CODE → (1209–1477 Hz)
← TWO-OUT-OF-EIGHT CODE → (1209–1633 Hz)

NOTES

TELEPHONE-SYSTEM ADDRESSING IS GENERALLY RESTRICTED TO THE TWO-OUT-OF-SEVEN CODE, AND TELEPHONE SETS ARE SUPPLIED WITH 10- OR 12-BUTTON DIALS.

DATA AND SPECIALIZED SIGNALING APPLICATIONS OFTEN MAKE USE OF THE FULL TWO-OUT-OF-EIGHT CODE

TABLE 1 — DTMF PERFORMANCE

DIGIT	0-dB TWIST					MAXIMUM TWIST					
	0	+1.5%	+1.5%	−1.5%	−1.5%	0	+1.5%	+1.5%	−1.5%	−1.5%	HIGH-GROUP SKEW
	0	+1.5%	−1.5%	−1.5%	+1.5%	0	+1.5%	−1.5%	−1.5%	+1.5%	LOW-GROUP SKEW
1	100	99	99	100	100	100	98	98	97	96	
2	99	90	85	96	99	100	85	82	98	98	
3	100	66	75	100	99	100	67	67	100	94	
4	100	100	99	100	100	100	99	99	99	99	
5	100	90	93	98	97	97	90	80	98	96	
6	100	88	87	100	100	100	85	84	86	100	
7	100	100	100	98	100	100	94	98	100	98	
8	99	86	88	93	96	100	52	54	81	99	
9	94	100	84	87	98	100	83	75	100	99	
0	100	89	84	94	100	85	86	82	90	91	
	99.2	90.8	89.4	96.6	98.9	98.2	84.9	81.9	94.9	97.0	AVERAGE SKEW RESPONSE
	94.98					91.38					AVERAGE TWIST RESPONSE
	93.18										ROSENBERG VALUE

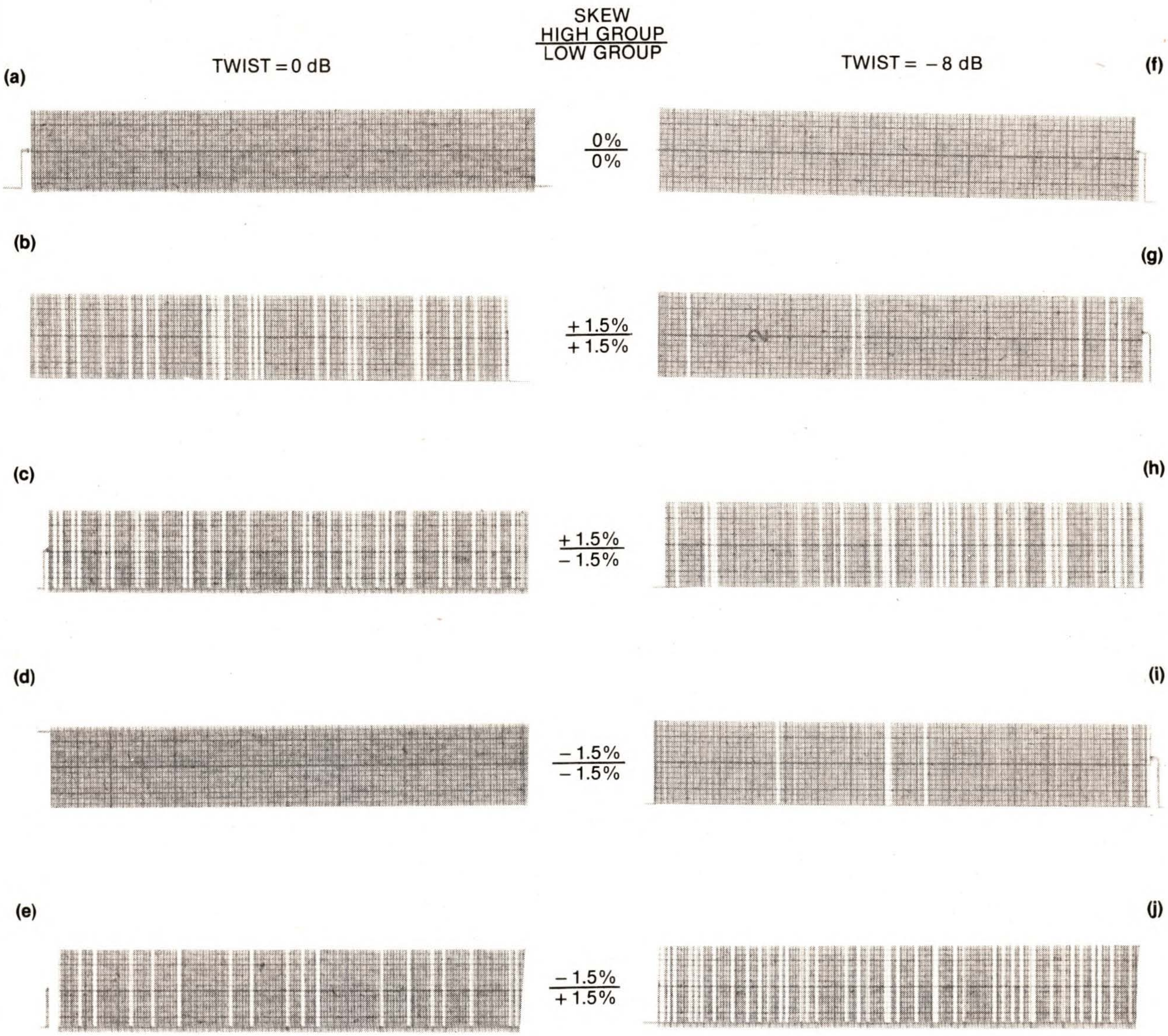


Fig 2—System response varies measurably *when different combinations of possible worst-case signal conditions are used for receiver inputs.*

Select test combinations to best represent required system needs

msec, respectively.

The data generates several conclusions. First, different worst-case signal combinations do indeed produce dramatic and measurable differences in system response. Second, there is a marked lack of clarity with regard to the manufacturer's specifications. Further tests on the signal recorded in **Fig 2h** reveal that system response can be increased to 100% by either reducing the twist by 2 dB, increasing the tone-ON time by 2 msec, or reducing the twist by 1.5 dB while simultaneously increasing the tone-ON time by 1 msec.

Device specs don't reflect the worst case

This experiment and similar ones make it obvious that most DTMF-device manufacturers specify limits with all parameters except one fixed at nominal values, then determine the range of the one value not fixed in this manner. And manufacturers do not specify a "miss rate" at any set of input limits, although other data-system-component manufacturers always specify an error rate associated with their components' input signals. The result? The DTMF devices' rather meaningless specifications leave system designers unsure of how they will actually operate.

Eliminating this uncertainty calls for an approach that can quantify DTMF-system performance either at the manufacturer's specified performance limits or at the limits characterizing the intended application. For

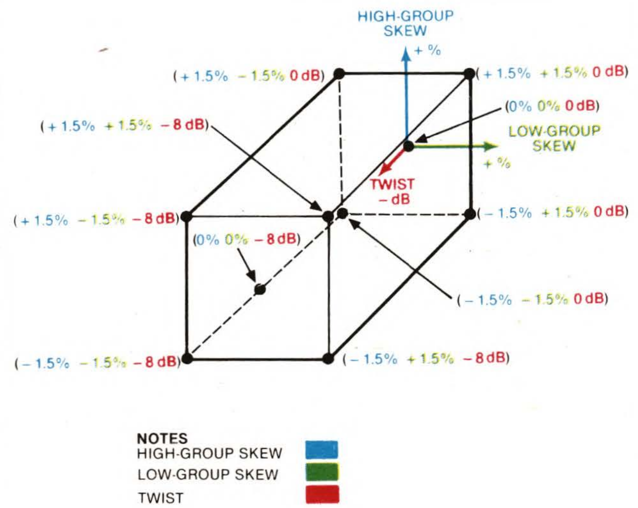
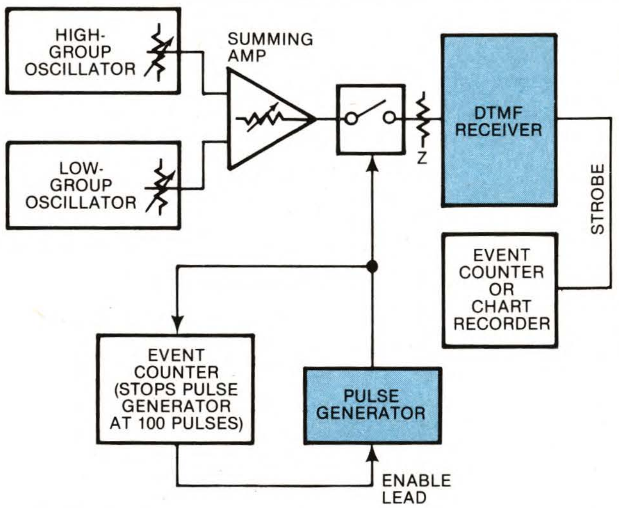


Fig 3—A good measure of system performance *in low-level telecommunications applications results when you conduct tests at the ten specified points. The chosen twist values of 0 and −8 dB are valid limits in such applications.*



TEST-SETUP NOTES

1. FOR FREQUENCY ACCURACY, OSCILLATORS SHOULD BE SETTABLE TO AT LEAST 1 Hz AND HAVE MINIMUM STABILITY AFTER WARMUP OF AT LEAST 0.05%.
2. PULSE GENERATOR SHOULD HAVE STABILITY AFTER WARMUP OF AT LEAST 1%.
3. BECAUSE MOST DTMF RECEIVERS HAVE HIGH-IMPEDANCE INPUTS, Z USED AS A PURELY RESISTIVE REFERENCE LOAD — USUALLY 600Ω.

Fig 4—Miss-rate testing *provides a good indication of system performance as worst-case signal combinations vary. This test system generates 100 DTMF tone pulses for each worst-case combination for each digit used in a system.*

TABLE 2 — DTMF PERFORMANCE

DIGIT	0-dB TWIST					MAXIMUM TWIST					
	0	+1.5%	+1.5%	−1.5%	−1.5%	0	+1.5%	+1.5%	−1.5%	−1.5%	HIGH-GROUP SKEW
	0	+1.5%	−1.5%	−1.5%	+1.5%	0	+1.5%	−1.5%	−1.5%	+1.5%	LOW-GROUP SKEW
1	100	95	100	99	100	100	7	9	40	20	
2	100	97	100	100	100	100	80	82	98	99	
3	100	96	100	100	95	100	0	0	2	2	
4	100	97	100	98	100	100	3	2	3	4	
5	100	100	100	100	100	85	80	75	76	85	
6	100	99	97	100	100	100	0	3	2	0	
7	100	93	88	97	90	100	12	12	10	3	
8	100	98	100	98	100	100	35	25	45	0	
9	70	100	88	100	100	94	48	0	0	0	
0	99	98	100	99	100	100	99	90	90	90	
	96.9	97.3	97.3	99.1	98.5	97.9	36.4	29.8	28.5	30.0	AVERAGE SKEW RESPONSE
	97.82					44.52					AVERAGE TWIST RESPONSE
	71.17										ROSENBERG VALUE

A lack of clarity exists in the true meaning of specifications

example, some systems can tolerate a miss, and the probability of their having to handle a signal with all parameters at their worst-case limits is quite low. Such systems can utilize less expensive DTMF devices.

Obviously, the permissible miss rate varies with different worst-case combinations. But experience in evaluating DTMF systems for telecommunications applications has shown that testing at the points specified in **Fig 3** yields a very good measure of system performance.

Note that these points reflect dual-limit twist values of 0 and −8 dB—the +4-dB case occurs only on high-level signals; the −8-dB case, only on low-level signals. This particular testing situation is concerned primarily with low-level signals. Because the minimum single-tone level here never goes below −20 dBm, the −8-dB twist value results in the low-group signal's falling at −12 dBm. Likewise, you can improve response on some receivers by increasing the signal level of one of the tones even though the twist might be increasing. Thus, for the application illustrated in **Fig 3**, 0-dB twist also proves a valid test limit.

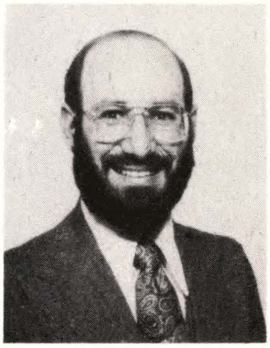
To expand this approach, consider the test configuration depicted in **Fig 4.** Each worst-case parameter combination for each digit to be used in the system is represented by 100 generated DTMF tone pairs; the test configuration counts and records the number of Strobe-lead hits. **Tables 1** and **2** list data recorded by means of this test setup for two DTMF systems. As shown, each system responds differently, and neither is perfect. The problem is how to choose the receiver with the best performance for the intended application.

As a first step, add the digit response for a given skew combination and divide by 10; do this for each skew combination. Once you calculate this average for each skew combination, obtain the average zero-twist and maximum-twist responses by summing the zero-twist skew-response averages and the maximum-twist skew-response averages and dividing each sum by five. Finally, add these average zero-twist and maximum-twist responses and divide by two to calculate the receiver's average response. This "Rosenberg Value" allows you to compare the relative performance of several receivers.

What about other system parameters?

You might well ask how you can use this technique to evaluate other transmission impairments such as desensitization, noise and impedance discontinuities. No problem. Merely run the same test sequence again in the presence of the requisite signal perturbations; the Rosenberg Value might then change, and the magnitude of this change is a measure of the system's performance under the degraded conditions. **EDN**

Authors' biographies



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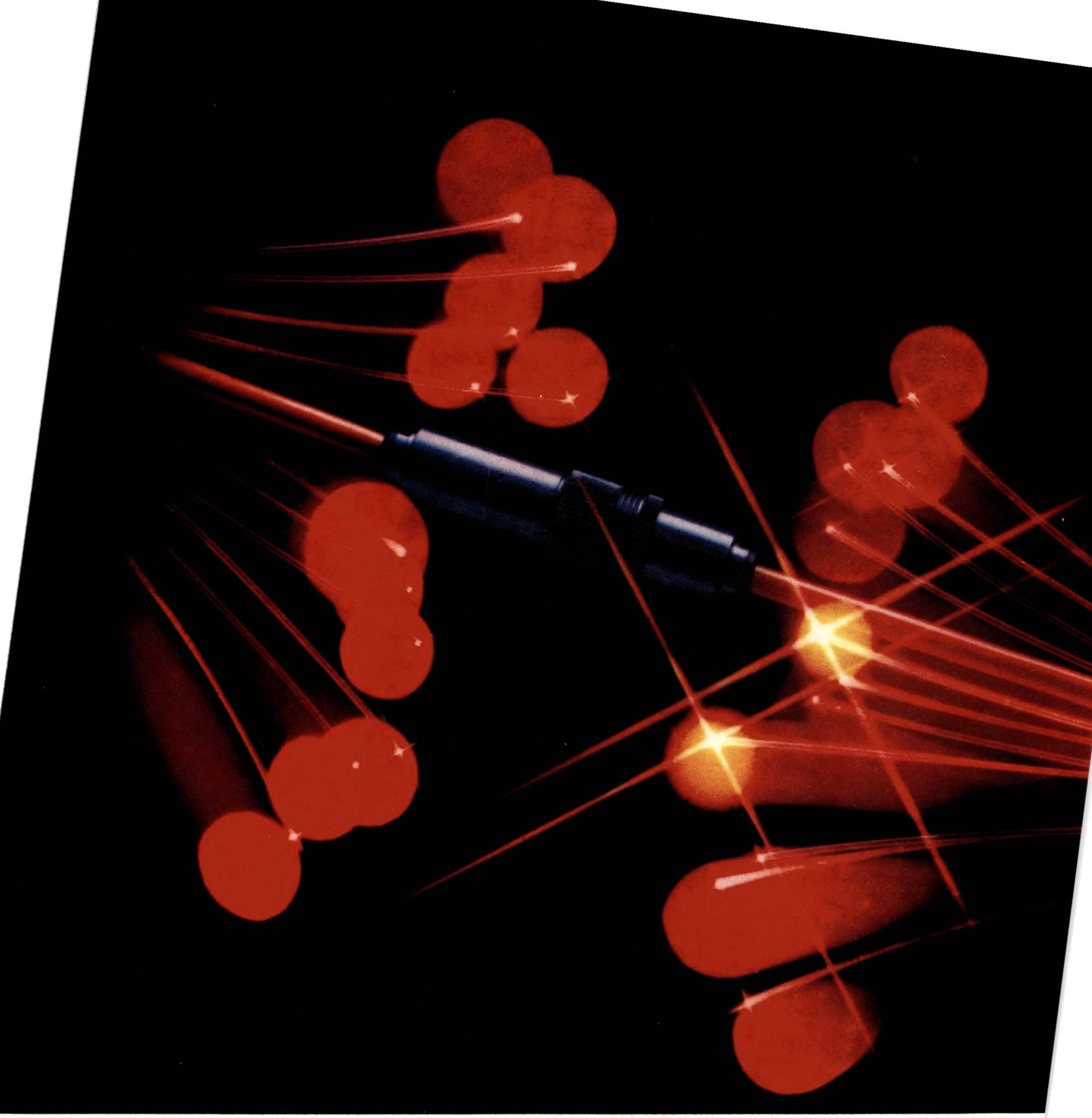

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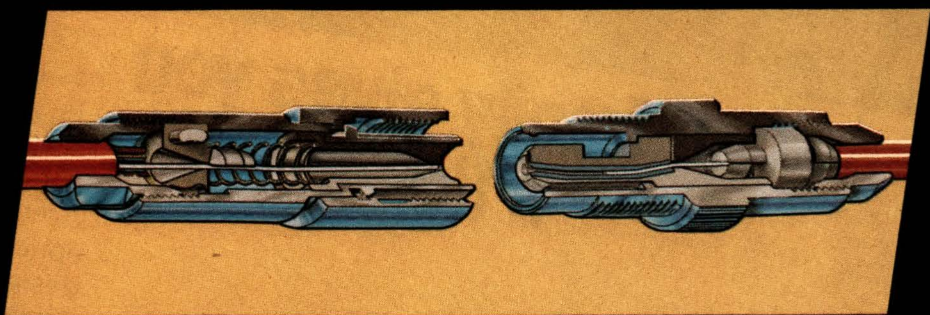

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An 8 × 8 multiplier and 8-bit μP perform 16 × 16-bit multiplication

A special algorithm implemented in software doubles an 8×8-bit multiplier's usual capabilities, permitting efficient 16×16 multiplications of signed, unsigned or mixed two's-complement numbers.

Shai Mor, Fairchild Camera and Instrument Corp

Teaming an 8×8-bit multiplier with a suitable software algorithm provides faster, more code-efficient 16×16-bit multiplications than software-only schemes in 8-bit-μP-based systems. And although not as fast as 16×16-bit multipliers, 8×8 devices cost less—representing an efficient hardware/software tradeoff. This article presents the requisite multiplication algorithm as it is implemented on a Z80 μP utilizing an MMI67558/57558 multiplier (from Monolithic Memories), but you can apply the same procedure to other processors and 8×8-bit multipliers (such as the pin-compatible Raytheon 67558 and AMD 25S58 or roughly equivalent devices such as TRW's MPY-8 or AMD's 25LS2516).

Break 16-bit words into two bytes

The multiplication algorithm handles two signed 16-bit operands, both represented in two's-complement form. Because an 8×8-bit multiplier performs the operations, the algorithm treats each of the 16-bit numbers as two bytes—the most significant byte is signed; the least significant, unsigned. One operand (X) comprises the two bytes X_m (most significant) and X_l (least significant); the other operand (Y) similarly comprises Y_m and Y_l **(Fig 1).**

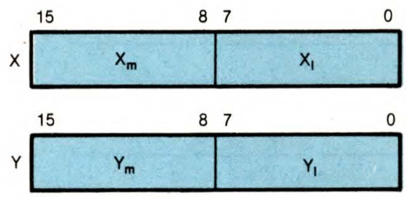


Fig 1—Two 16-bit operands *(X and Y) are treated as two pairs of bytes for processing by an 8×8-bit multiplier.*

Performing 16×16-bit multiplications with an 8×8-bit multiplier requires four 8×8-bit multiplications (each of which produces a 16-bit product that is again treated as two bytes):

- X_l (unsigned)×Y_l (unsigned)$=X_lY_l=(X_lY_l)_m(X_lY_l)_l$
- X_m (signed)×Y_l (unsigned)$=X_mY_l=(X_mY_l)_m(X_mY_l)_l$
- X_l (unsigned)×Y_m (signed)$=X_lY_m=(X_lY_m)_m(X_lY_m)_l$
- X_m(signed)×Y_m(signed)$=X_mY_m=(X_mY_m)_m(X_mY_m)_l$.

Software then adds and accumulates the partial products produced by this process according to the procedure shown in **Fig 2.**

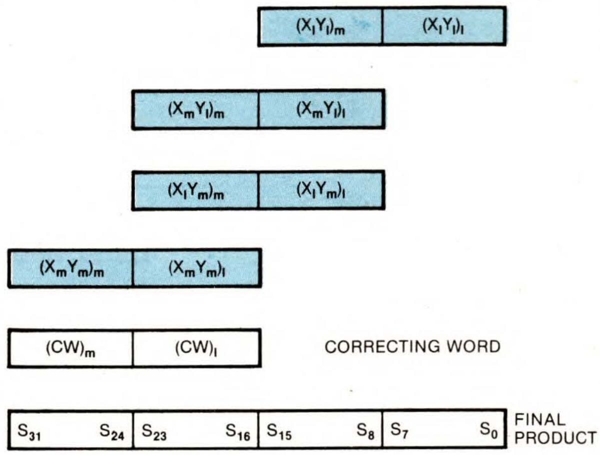


Fig 2—Software adds the partial products *(produced by multiplying bytes) in a weighted fashion.*

When adding the partial products, the software must account for three products' signs: $(X_mY_l)_m(X_mY_l)_l$, $(X_lY_m)_m(X_lY_m)_l$ and $(X_mY_m)_m(X_mY_m)_l$. The $(X_mY_m)_m(X_mY_m)_l$ product presents no problem because its MSB represents the final product's sign. The other two partial products' MSBs, however, carry weights of -2^{23} and must be subtracted from the final product.

The software therefore tests these partial products' sign bits—resetting them if negative—and subtracts 2^{23} if one of them is negative or 2^{24} if both are. This factor to be subtracted is the correcting word (CW) in **Fig 2.**

The complete algorithm thus consists of the following

A software-implemented algorithm controls 16-bit multiplications

steps (**Fig 3**):

- Multiply X_l (unsigned) and Y_l (unsigned) and store the two 16-bit products, $(X_lY_l)_m$ and $(X_lY_l)_l$
- Multiply X_l (unsigned) and Y_m (signed) and store the two 16-bit products, $(X_lY_m)_m$ and $(X_lY_m)_l$
- Multiple X_m (signed) and Y_l (unsigned) and store the two 16-bit products, $(X_mY_l)_m$ and $(X_mY_l)_l$
- Multiply X_m (signed) and Y_m (signed) and store the two 16-bit products, $(X_mY_m)_m$ and $(X_mY_m)_l$
- Move $(X_lY_l)_l$ to the eight least significant final-product bits (S_{0-7})
- Test the sign of $(X_lY_m)_m$. If it's negative, reset the MSB and add 2^{23} to the correcting word (which initially equals zero)
- Test the sign of $(X_mY_l)_m$. If it's negative, reset the MSB and add 2^{23} to the correcting word
- Add $(X_lY_l)_m+(X_mY_l)_l+(X_lY_m)_l$ to construct the final product's S_{8-15} byte
- Add $(X_mY_l)_m+(X_lY_m)_m+(X_mY_m)_l$+CARRY (from last addition)+negative of the least significant correcting-word byte ($-(CW)_l$) to construct the final product's S_{16-23} byte
- Add $(X_mY_m)_m$+CARRY+negative of the most significant correcting-word byte ($-(CW)_m$) to construct the final product's S_{23-31} byte.

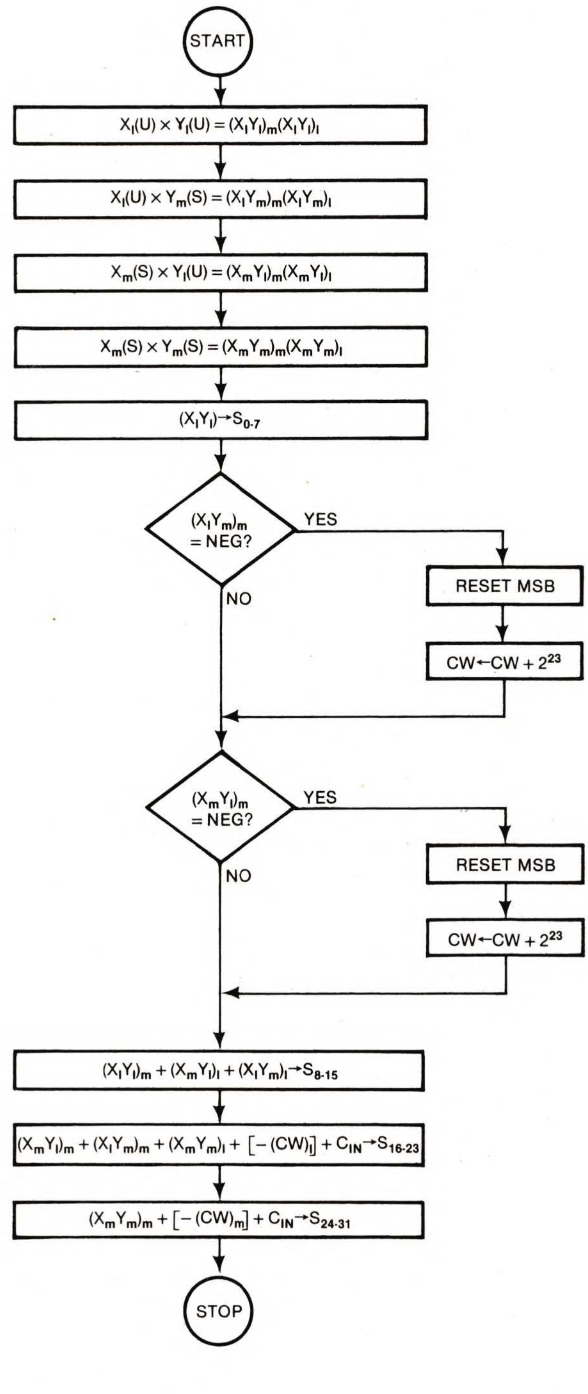


Fig 3—A 16×16-bit multiplication algorithm's flowchart *shows the steps that hardware and software implement.*

Hardware takes care of the multiplication

An 8×8-bit multiplier IC performs the multiplication required by the algorithm. The MMI67558 combinatorial logic array multiplies numbers in unsigned, signed-two's-complement and mixed notations. It provides the

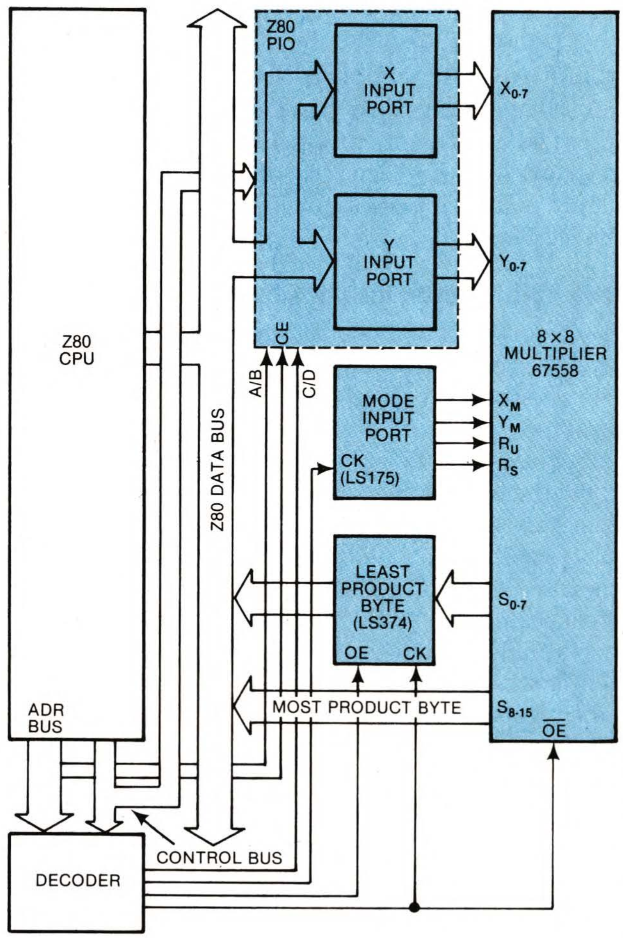


Fig 4—Multiplication hardware *consists of an 8×8 multiplier, a Z80 PIO and two sets of latches.*

following inputs and outputs:

- X_{0-7}—8-bit X-operand input
- X_M—X-mode input (signed/unsigned)
- Y_{0-7}—8-bit Y-operand input
- Y_M—Y-mode input (signed/unsigned)
- R_S—Signed rounding input

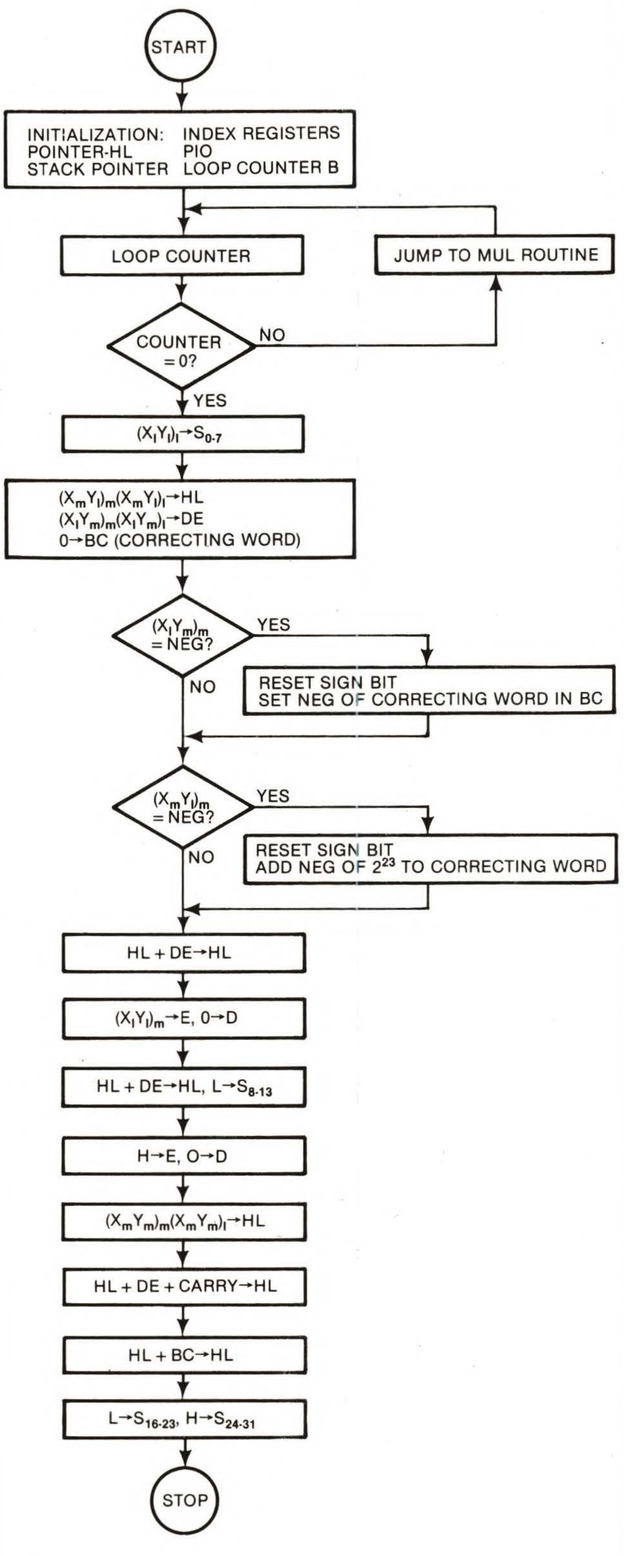


Fig 5—The 16×16-bit multiplication program *described here incorporates the algorithm depicted in* ***Fig 3.***

- R_U—Unsigned rounding input
- S_{0-15}—16-bit product output
- $\overline{S}_{15}$—Inverted MSB of product
- $\overline{OE}$—Output enable.

The multiplier presents five I/O ports (or five memory addresses, if you treat I/O lines in a memory-mapped fashion) to the Z80. Three of these are output ports: Two ports receive the operands (X, Y) from the Z80, and one receives a mode word (X_M, Y_M, R_U, R_S) that controls the multiplication operation. The multiplier's two input ports provide the 16-bit product's two bytes—the eight most significant bits from one port and the eight least significant bits from the other.

These I/O ports connect with three 8-bit latches and one 4-bit latch. Two of the 8-bit latches and the 4-bit unit (all of which are fed by the Z80's data bus) hold the X operand, the Y operand and the mode word, respectively.

The remaining 8-bit latch (whose outputs feed the Z80's data bus) holds the 16-bit product's eight least significant bits. Because the multiplier generates the complete 16-bit product (when $\overline{OE}$ goes LOW) at one time, the processor must read the product in two steps: First it reads the most significant byte directly from the multiplier, then it reads the other byte from the latch.

You can implement these latches with octal (LS374) and quad (LS175) latches or with Z80-family programmable I/O devices (PIOs) that furnish two 8-bit ports per device—each changeable to either input or output mode under program control. The example shown in **Fig 4** utilizes a PIO for the X and Y ports and an LS374 and LS175 for the other two ports.

The 8×8-bit multiplication hardware performs the following steps (for signed, unsigned or mixed numbers, rounded or not):

- Output X to the multiplier (X port)
- Output Y to the multiplier (Y port)
- Output the mode word (X_M, Y_M, R_U, R_S) to the multiplier
- Input the product's most significant byte (S_{8-15}) and latch its least significant byte (S_{0-7})
- Input the product's least significant byte (S_{0-7}) from the latch.

If you need a truncated product, you can skip the last step.

A Z80 routine controls multiplication

Software implements the multiplication algorithm by multiplying two 16-bit operands residing in an array of four successive memory locations (each operand occupies two successive locations). It stores the resulting 32-bit product in another 4-location memory array.

The software comprises three basic stages: **(Fig 5;** see also the nearby **box):**

- **Initialization:** In this stage, the routine sets the processor pointers, loop counter, index registers and PIO to their initial values
- **Multiplications:** Now, a subroutine directs the

hardware to execute four 8×8-bit multiplications and temporarily stores the four resulting 16-bit partial products in a memory array for further processing

Final processing: The routine adds the partial products according to their weights and signs (when signed).

A multiplication subroutine handles hardware

The actual multiplication process is controlled by the MUL subroutine, which transfers two 8-bit operands from memory to the 8×8-bit multiplier and reads two product bytes into memory. It utilizes two pointers—the main pointer and the mode-word pointer—pointing to the X_i and Y_i operands (i can be either l or m) and the mode word, respectively **(Fig 6).**

One of the Z80's index registers (IY) implements the mode-word pointer. The initialization stage sets this pointer to the first mode word's address; then the pointer increments each time the MUL subroutine is called to point to subsequent mode words. (The first mode word is 00 because both operands are unsigned and no rounding is needed.)

The main pointer—contained in Z80 register pair HL—initially holds the first operand (X_l) address. After transferring the operands to the multiplier, the pointer is set to the memory address where the current multiplication product's least significant byte $(X_iY_i)_l$ will be stored. (The subroutine sets the pointer by adding to it the E register's contents—set initially to 3.) The next address stores the product's most significant byte $(X_iY_i)_m$.

At the end of one multiplication, the MUL subroutine sets the main pointer to the location of the operand pair to be multiplied in the next call—accomplished by subtracting 3 plus the E register's contents from HL's contents. The subroutine reads the operands in an overlapping fashion: The first call's second operand is the second call's first operand, and so on **(Fig 7).**

By duplicating the first operand (X_l) at the end of the operand array, the subroutine can simply multiply X_l and Y_l in the first call, then Y_l and X_m, X_m and Y_m, and finally Y_m and X_l in succeeding calls. The mode word specifies how the multiplication in each call will be performed.

Applying instruction power

The MUL subroutine utilizes two powerful Z80 I/O instructions: OUTI and INI. The OUTI instruction—an autoincrement output command—transfers the memory-location contents pointed to by register pair HL to the output port whose 8-bit address is held in the C register **(Fig 8).** The instruction then increments

CROSS-ASSEMBLER LISTING OF THE 16-BIT MULTIPLICATION PROGRAM

```
ADDR   OBJECT    STMT  LABEL    OPCD  OPERAND        COMMENT
                   1            ORG   OD
0000   210004      2   START    LD    HL, MP         ;SET MAIN POINTER
0003   FD210003    3            LD    IY, MWP        ;SET MODE WORD POINTER
0007   0614        4            LD    B, 20D         ;SET LOOP COUNTER
0009   1E03        5            LD    E, 3D
000B   3E0F        6            LD    A, 0FH         ;PIO CONTROL WORD
000D   D346        7            OUT   (XCON), A
000F   D347        8            OUT   (YCON), A
0011   31FF04      9            LD    SP, STACK
0014   DD210604   10            LD    IX, AXL YLM
0018   CD5900     11            CALL  MUL            ;PERFORM 4 MULTIPLICATIONS
0018   10F9       12            DJN2  -5
001D   3A0504     13            LD    A, (AXL YML)
0020   320D04     14            LD    (AS07), A      ;FINAL PRODUCT BYTE S0-7
0023   ED5B0784   15            LD    DE, (AXMYL)
0027   2A0B04     16            LD    HL, (AXL YM)
002A   AF         17            XOR   A
002B   4F         18            LD    C, A
002C   2F         19            CPL                  A
002D   47         20            LD    B, A
002E   CB7A       21            BIT   7, D           ;TEST SIGN
0030   CA3700     22            JP    Z, POS1
0033   CBF9       23            SET   7, C           ;BC=-2**23
0035   CBBA       24            RES   7, D           ;RESET SIGN BIT
0037   CB7C       25   POS1     BIT   7, H           ;TEST SIGN
0039   CA4000     26            JP    Z, POS2
003C   0E00       27            LD    C, 0           ;BC-BC-2**23
003E   CBBC       28            RES   7, H           ;RESET SIGN BIT
0040   19         29   POS2     ADD   HL, DE         ;ADD XMYL TO XLYM
0041   DD5E00     30            LD    E, (IX+0)
0044   1600       31            LD    D, 0
0046   19         32            ADD   HL, DE         ;ADD (XL YL) M
0047   DD7508     33            LD    (IX+B), L      ;FINAL PRODUCT BYTE S8-15
004A   5C         34            LD    E, H
0048   1600       35            LD    D, 0
004D   2A0904     36            LD    HL, (AXMYM)
0050   ED5A       37            ADC   HL, DE         ;ADD XMYM
0052   09         38            ADD   HL, BC         ;ADD -(CORRECTING WORD)
0053   220F04     39            LD    (AS1631), HL   ;FINAL PRODUCT BYTES S16-23, S24-31
0056   C30000     40            JP    START
0059   0E44       41   MUL      LD    C, X           ;MULTIPLICATION ROUTINE
0058   EDA3       42            OUTI                 ;X TO MULTIPLIER
005D   0E45       43            LD    C, Y
005F   EDA3       44            OUTI                 ;Y TO MULTIPLIER
0061   0E58       45            LD    C, MODE
0063   FD5600     46            LD    D, (IY+0)
0066   ED51       47            OUT   (C), D         ;MODE WORD TO MULTIPLIER
0068   FD3400     48            INC   (IY+0)         ;INCREMENT MODE WORD POINTER
006B   7B         49            LD    A, E
006C   85         50            ADD   A, L
006D   6F         51            LD    L, A
006E   D850       52            IN    A, (MOST)      ;DUMMY INSTRUCTION TO LATCH
                                                      LEAST BYTE
0070   0E4C       53            LD    C, LEAST
2072   EDA2       54            INI                  ;INPUT PRODUCT LEAST BYTE
0074   0E58       55            LD    C, MOST
0076   ED82       56            INI                  ;INPUT PRODUCT MOST BYTE
0078   7B         57            LD    A, E
0079   C603       58            ADD   A, 3D
007B   ED44       59            NEG                  A
007D   85         60            ADD   A, L
007E   6F         61            LD    L, A           ;ADJUST POINTER FOR NEXT CALL
007F   1C         62            INC   E
0080   C9         63            RET
                  64            ORG   0300H
0300   00         65            DEFB  00H            ;XM=0, YM=0
0301   08         66            DEFB  08H            ;XM=1, YM=0
0302   0C         67            DEFB  0CH            ;XM=1, YM=1
0303   04         68            DEFB  04H            ;XM=0, YM=1
>0400             69   MP       EQU   0400H
>0300             70   MWP      EQU   0300H
>0046             71   XCON     EQU   46H
>0047             72   YCON     EQU   47H
>04FF             73   STACK    EQU   04FFH
>0406             74   AXL YLM  EQU   0406H
>0405             75   AXL YML  EQU   0405H
>040D             76   AS07     EQU   040DH
>040B             77   AXL YM   EQU   040BH
>0407             78   AXMYL    EQU   0407H
>0409             79   AXMYM    EQU   0409H
>040F             80   AS1631   EQU   040FH
>0044             81   X        EQU   44H
>0045             82   Y        EQU   45H
>0050             83   MOST     EQU   50H
>004C             84   LEAST    EQU   4CH
>0058             85   MODE     EQU   58H
 0304             86            END

TOTAL ASSEMBLER ERRORS = 0

                          SYMBOL TABLE

AS07      040D    AS1631   040F    AXL YLM  0406    AXL YM  040B
AXL YML   0405    AXMYL    0407    AXMYM    0409    LEAST   004C
MODE      0058    MOST     0050    MP       0400    MUL     0059
MWP       0300    POS1     0037    POS2     0040    STACK   04FF
START.    0000    X        0044    XCON     0046    Y       0045
YCON      0047
```

HL's contents and decrements B's contents. The INI instruction performs input functions in a similar manner.

In order to use in final processing the Z80's 16-bit load instructions (which transfer two bytes from memory to a register pair), the MUL subroutine reads the product's least significant byte first, then the most significant byte. The first byte loads to the least significant register (L); the second byte, to the most significant one (H). Because the product's least significant byte is latched while the processor reads the most significant byte, the program sequence must include a dummy input instruction (for the most significant byte) before inputting the least significant byte.

The complete MUL subroutine includes the following steps:

(1) Set the C register to the X port's address
(2) Output X from (HL) to the X port and increment HL, which points to the Y operand's address
(3) Set the C register to the Y port's address
(4) Output Y from (HL) to the Y port and increment HL
(5) Add the E register's contents to the L register to point to the address where the product's least significant byte, $(X_lY_l)_l$, will be stored
(6) Read the mode word from register IY, and increment IY
(7) Perform a dummy output instruction to prepare the product's least significant byte in the least significant port
(8) Set C to the least significant port's address
(9) Input the least significant byte, $(X_lY_l)_l$, from the multiplier's least significant port to the memory address pointed to by HL, and increment HL
(10) Set C to the most significant port's address
(11) Input the most significant byte, $(X_lY_l)_m$, to HL, and increment HL
(12) Subtract (E)+3 from L to adjust the HL pointer to the next multiplication's first operand.

The system performs four of these multiplication procedures, each in its proper mode, and the entire 4-part process produces an array of four partial products in memory, occupying eight successive locations.

Note that the B register, which serves as a loop counter to keep track of the four multiplications, is initialized to 20. This value results from the four parasitic B-register autodecrements caused by the two OUTI and two INI instructions in every multiplication; the complete sequence's 16 autodecrements require 20 loop counts.

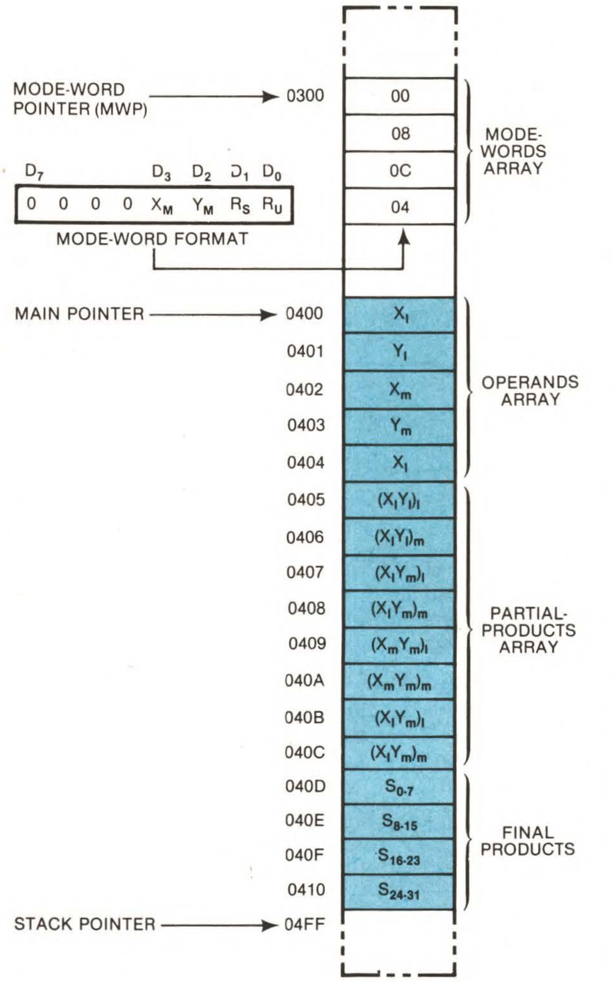


Fig 6—A memory map *shows the storage locations for crucial elements in the 16×16-bit multiplication process; it also indicates pointer action.*

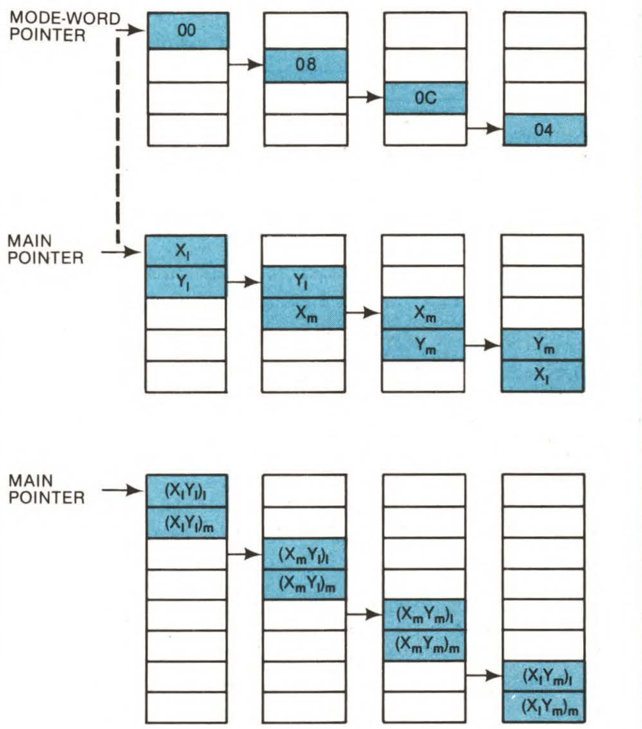


Fig 7—The mode-word and main pointers *keep track of operands and products during the four hardware operations required to multiply 16-bit numbers with an 8×8-bit multiplier.*

Weighted additions transform partial products into answers

Process the partial products

The multiplication program's final processing stage consists of the following steps:

(1) Load $(X_mY_l)_m(X_mY_l)_l$ and $(X_lY_m)_m(X_lY_m)_l$ into the HL and DE register pairs, respectively

(2) Test these products' signs; if they are negative, reset the MSB and add 2^{23} to register pair BC (which contains the correcting word) for each negative sign. After this step, BC actually contains the negative of the correcting word. (The bit manipulations performed in this step utilize Z80 instructions that permit testing (BIT), resetting (RES) and setting (SET) any bit in any register or memory address)

(3) Add the corrected $(X_mY_l)_m(X_mY_l)_l$ and $(Y_mX_l)_m(Y_mX_l)_l$ products and store the results in HL. (No carry is expected in these additions because both operands consist of unsigned 16-bit words with zero in the MSB)

(4) Add $(X_lY_l)_m$ to HL to produce the final-product byte, $S_{8\text{-}15}$, in L; move H's contents to E

(5) Load $(X_mY_m)_m(X_mY_m)_l$ from memory into HL; add E's contents (the previous addition's most significant byte) to HL as a least significant byte plus the carry bit produced by the previous addition

(6) Add the negative of the correcting word to HL to produce the final product's two most significant bytes, $S_{16\text{-}23}$ and $S_{24\text{-}31}$. **EDN**

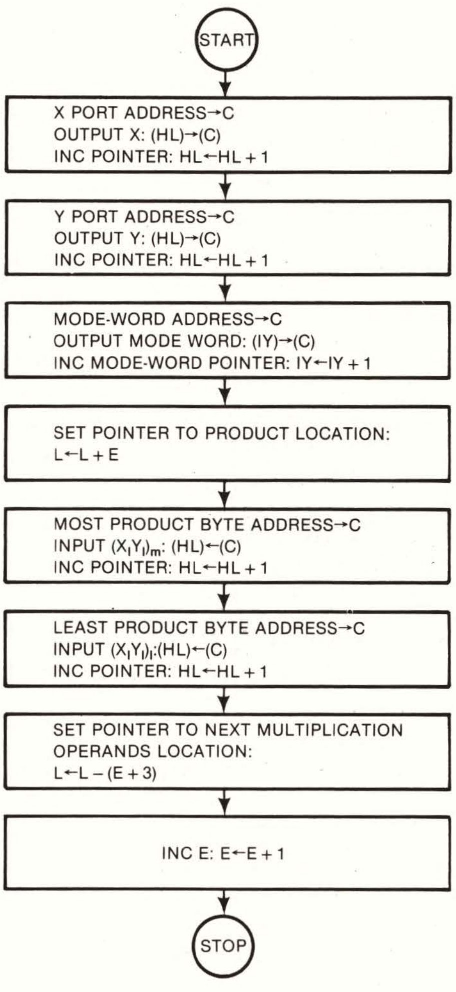
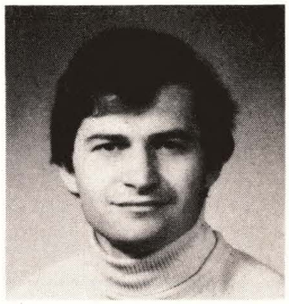


Fig 8—An 8×8-bit multiplication subroutine *directs hardware-multiplier actions.*

Author's biography



Shai Mor, involved in 16-bit-μP design at Fairchild Camera and Instrument Corp, Mt View, CA, is currently on sabbatical leave from Raphael, Haifa, Israel. His spare-time interests include jazz and soccer.

Article Interest Quotient (Circle One)
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6.3V

Design Ideas

Circuit controls 3-phase inverters

Serban Birca-Galateanu
Polytechnical Institute, Bucharest, Romania

Logic that supplies control pulses for inverter SCRs must generate direct firing-pulse sequences (1-2-3-4-5-6-1-...) for one running sense, or reverse sequences (6-5-4-3-2-1-6-...) for the opposite sense. The simplest way to implement these sequences is to feed a clock to a modulo-six counter, phase the three binary outputs properly through reverse-control logic, then feed the outputs to a 1-of-6 decoder (**Fig 1**). Although a more compact design results with the use of 74161 or 74191 binary up/down counters, the circuit shown is less expensive and avoids the problem of loading the counter with starting signals.

For 3-phase inverters requiring X, Y, Z, $\overline{X}$, $\overline{Y}$, $\overline{Z}$ firing signals plus inputs [A], [B], [C] and the auxiliary signal E=B+C, you must use the special decoder shown in **Fig 2**. **EDN**

To Vote For This Design, Circle No 450

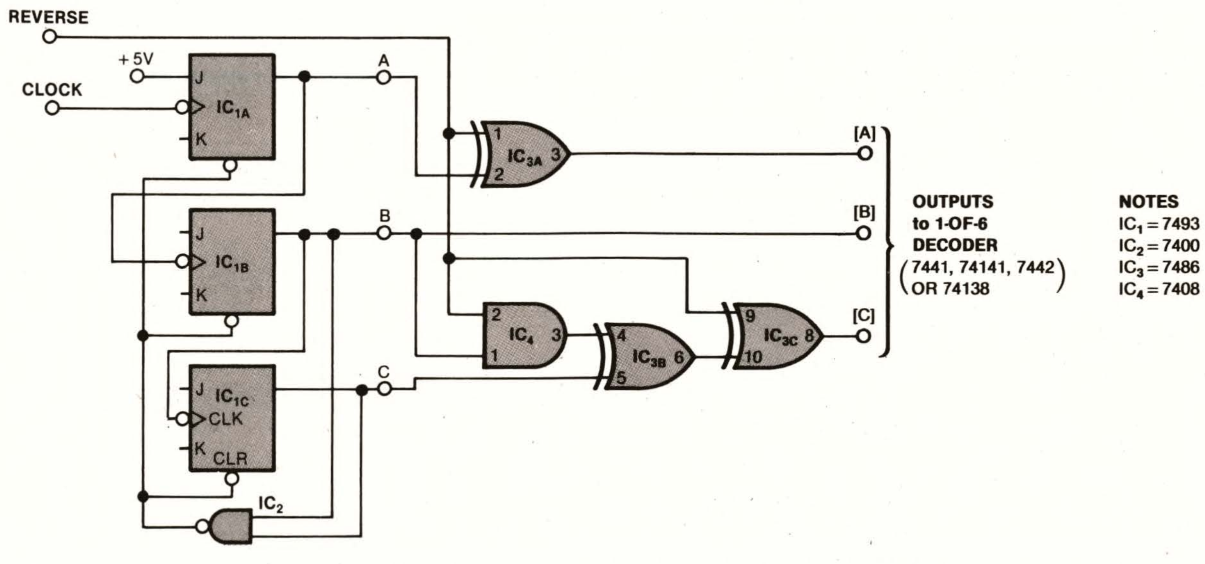
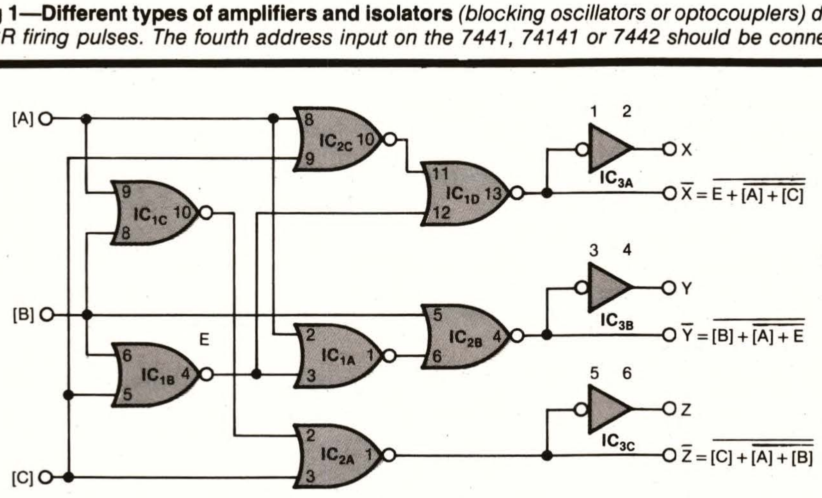


Fig 1—Different types of amplifiers and isolators *(blocking oscillators or optocouplers) determine the best decoder IC to generate SCR firing pulses. The fourth address input on the 7441, 74141 or 7442 should be connected to ground.*



DIRECT ↓ / REVERSE ↑

[C]	[B]	[A]	E	X	Y	Z
0	0	0	1	1	0	1
0	0	1	1	1	0	0
0	1	0	0	1	1	0
0	1	1	0	0	1	0
1	0	0	0	0	1	1
1	0	1	0	0	0	1

NOTES
$IC_1 = IC_2 = 7402$
$IC_3 = 7404$

Fig 2—A special decoder *serves 3-phase inverters requiring X, Y, Z, $\overline{X}$, $\overline{Y}$, $\overline{Z}$ firing signals.*

Up/down counter can't overflow or underflow

Gerald Buurma
National Semiconductor, Santa Clara, CA

A coincidence flip flop is a state machine whose state is defined by the last set of unanimous input levels. Its output becomes ONE when all inputs are ONEs, and it remains at the ONE level until every input is ZERO. With all inputs at ZERO, the flip flop switches to ZERO until all inputs are ONEs again, and so on. A common application of this device occurs in a maximal-length binary up/down counter that counts up to all ONEs and then down to all ZEROs without ever overflowing or underflowing—a circuit useful in waveform synthesizers to address a ROM that controls a D/A converter.

In a typical maximal-length up/down counter, separate AND and OR gates control a flip flop to detect the upper and lower limits. But to simplify the circuit, use a programmable gate such as a CD4648 for detection; the output state controls the gate function (see **figure**). As an added benefit, this approach can be easily expanded by using the gate's Expand (EXP) input. Higher counter stages use programming between OR- and NAND-gate functions, with the outputs feeding the Expand inputs of lower stages.

In the circuit shown, Schmitt triggers drive the programmable gate's control inputs to prevent the feedback loop from biasing itself in the active region.

EDN

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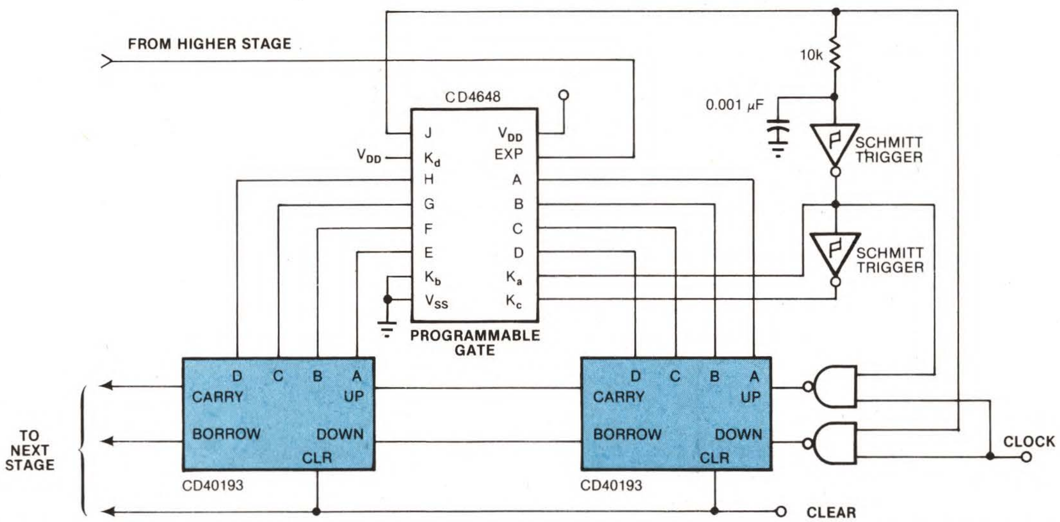
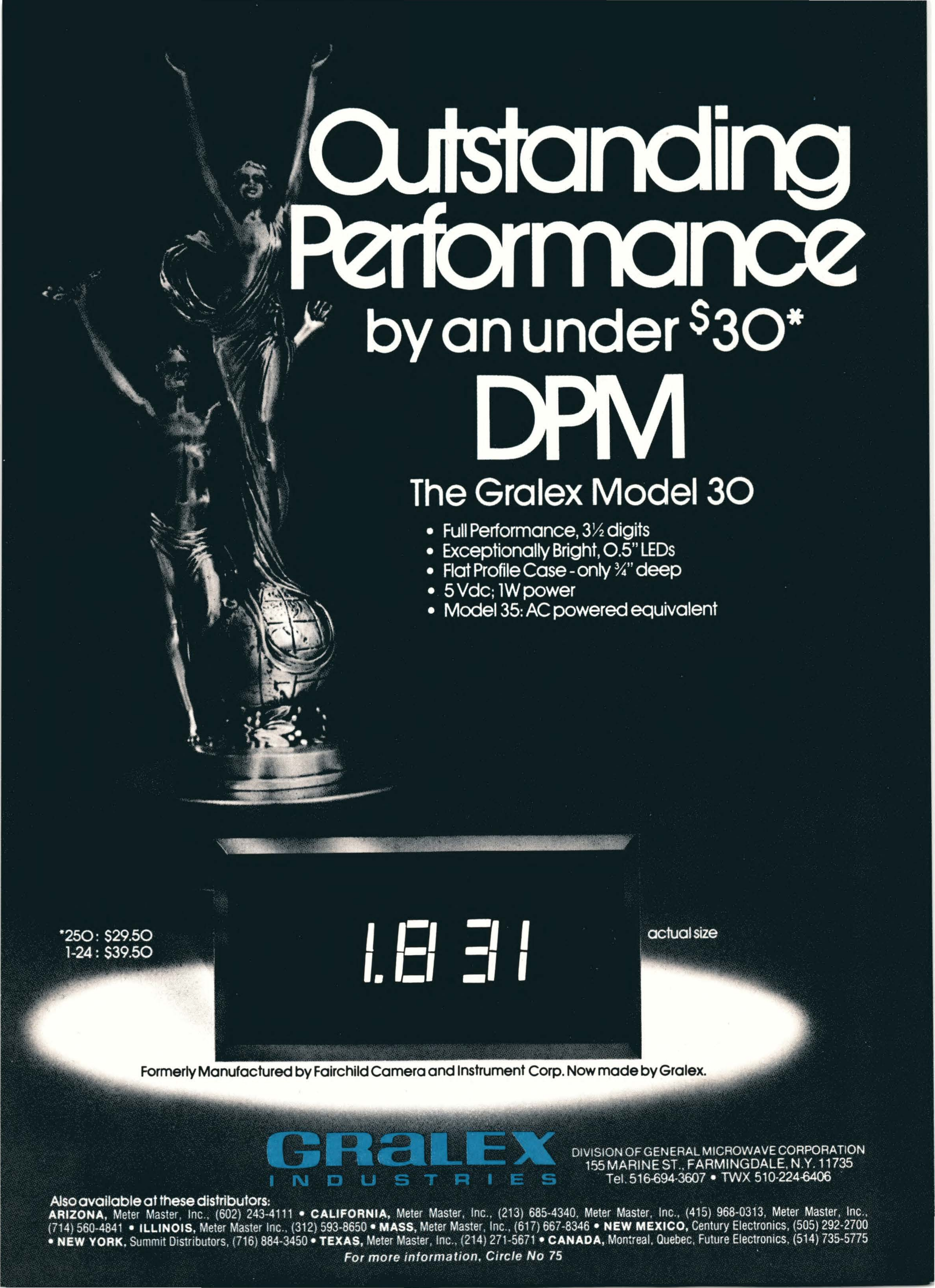


The coincidence flip flop *in this maximal-length binary up/down counter sets the upper and lower count levels and prevents overflow and underflow. The resistor and capacitor provide delay in the feedback loop; the forward propagation delay through the circuit isn't altered.*

Relate noise figure to noise temperature

Ed Oxner
Siliconix Inc, Santa Clara, CA

Johnson noise, defined as a nonperiodic ac-voltage fluctuation and in reality an effect of electron agitation, places a limit on the ultimate sensitivity of amplifiers, mixers and similar equipment. All high-frequency transistors, whether FETs or bipolar devices, as well as all passive elements, reach a well-defined performance based on this effect.



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Historically, transistors have been categorized by their *noise figure* (NF)—the lower the value, the better the device. But two decades ago, within the confining technology of ultralow-noise parametric amplifiers and hydrogen masers, another measure of performance was developed. This parameter, termed *noise temperature,* is finding increased acceptance in the trade. But what does it mean, and how can you convert back and forth between noise-temperature specifications and noise-figure specs?

At absolute zero (−273.18°C), Brownian movement—hence electron agitation—ceases, so Johnson noise equals zero. (Normal ambient (room) temperature is generally regarded as 20°C, but universal scientific consent has established the standard noise temperature (T_0) at 290°K.) Active components such as transistors, however, can exhibit noise temperatures *different* from their operating or ambient temperatures; this exhibited noise temperature is termed the device's *effective input noise temperature* (T_E).

Another term relevant to this discussion, *input available noise power* (P), is calculated as

$$P=kTB$$

where k is Boltzmann's constant; B, bandwidth in hertz; and T, absolute temperature in degrees Kelvin.

Now the *total noise output* (N_{POWER}) of an active transistor is, in effect, the sum of the input noise plus the noise contributed by the device. Thus,

$$N_{POWER}=GkB(T_{IN}+T_E)$$

where G is the device's gain.

Because a device's noise figure is by definition the ratio of the total noise power to the input noise power, when the input termination is at the standard temperature of 290°K,

$$NF=N_{POWER}/GkBT_0.$$

Combining the previous two equations produces an expression for the relationship between noise figure and effective noise temperature:

$$NF=1+T_E/T_0.$$

Finally, noise figure is generally expressed in decibels, so when expanded, this expression yields

$$NF_{dB}=10\log(1+T_E/T_0)$$

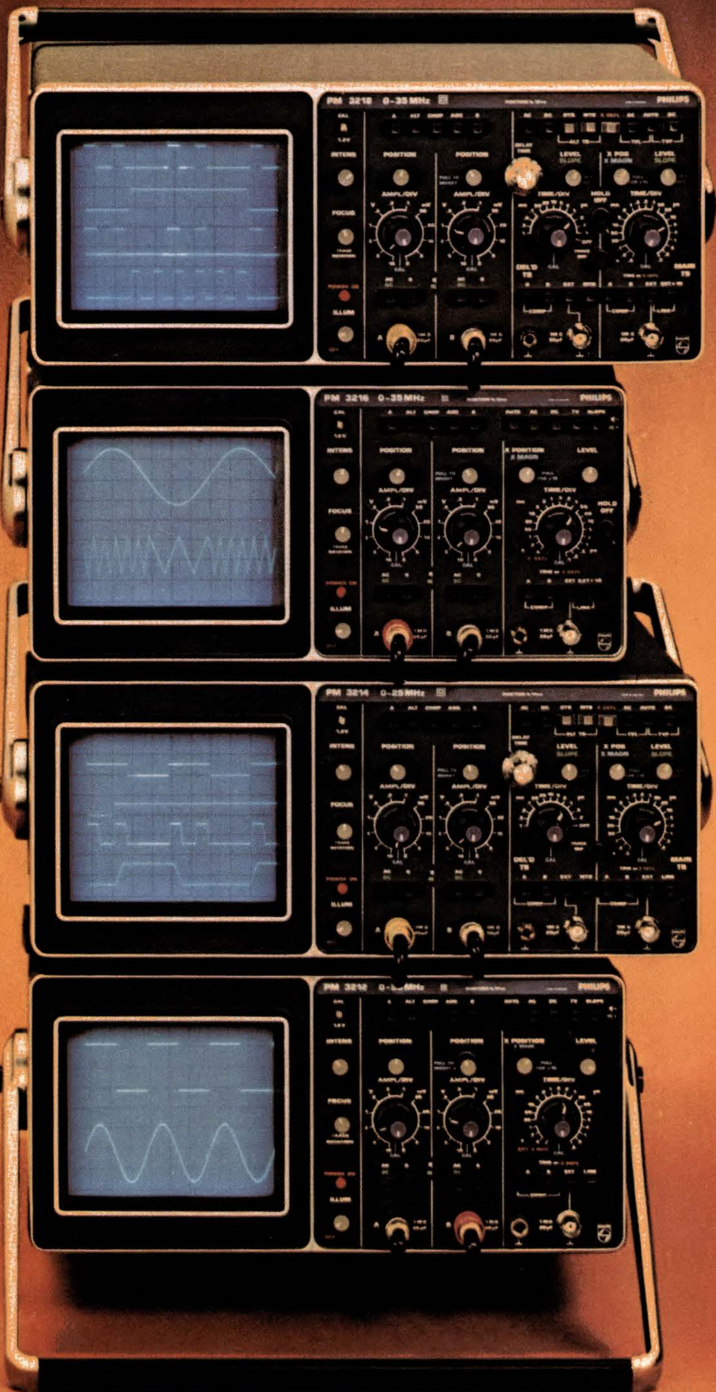
or

$$T_E=290\ [\text{antilog}(NF/10)-1]°K.$$

To put this final expression into perspective, consider the Siliconix U310/NZA. This transistor specs a noise figure of 2.7 dB at 450 MHz. What is its noise temperature? (Answer: T_E=250°K.) **EDN**

To Vote For This Design, Circle No 452

Multiple choice test.



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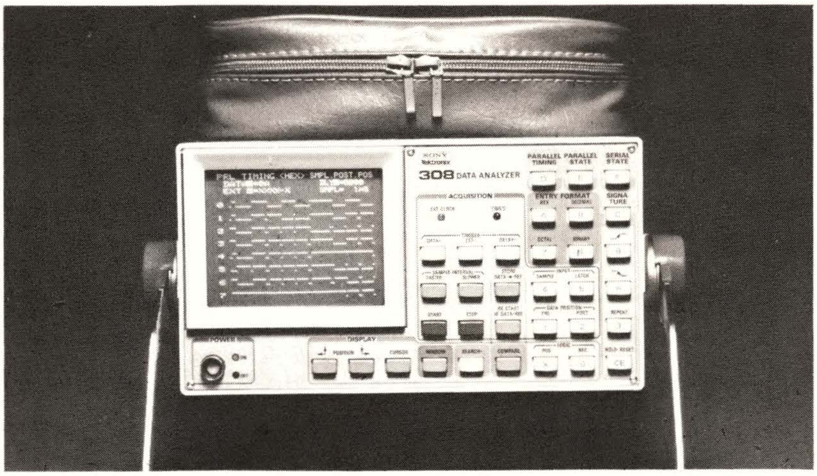
Feature Products

Low-cost logic-state/timing analyzer checks parallel/serial data, signatures



Inexpensive, lightweight and compact, *Model 308 performs logic-state, logic-timing and signature analysis of serial or parallel-configured systems.*

Logic-state, logic-timing and signature-analysis capabilities now combine in a single instrument that weighs just 8 lbs and costs only $3000. Model 308 can examine serial data streams or parallel data lines up to eight bits wide, with optional triggering on up to 24 channels; its maximum clock frequency is 20 MHz.

The 308's flexibility eases fault detection in different parts of a digital system. For example, you can examine clock and control signals with logic-timing analysis, data and address buses with logic-state analysis and communications lines with serial analysis. And quick checks on individual lines might call for the instrument's signature-analysis capability.

In the parallel timing mode, the 308 provides an 8-channel-wide input, 20-MHz clock speed and 252-bit/channel memory space. An 8-channel parallel word recognizer (P6406) is built in; its probe expands triggering to 24 channels. A digital-delay capability holds off triggering by up to 65,535 clock cycles.

You can store data before or after the delayed trigger at sample intervals ranging from 50 nsec to 200 msec. Storing data in a reference memory and comparing it with incoming data allows you to trigger when a failure occurs—a "babysitting" mode that lets you, in effect, search out random faults while the analyzer is unattended.

A variable viewing window of data stored in the acquisition memory magnifies timing displays to make comparison of edges easier and allows you to view 168, 84 or 42 words of the memory. And a glitch-catching latch mode permits the 308 to capture pulses narrower than the sample interval—down to 10 nsec.

Pick your language

Parallel-state analyzer functions are similar to the timing functions, but in this mode, the timing-diagram display is replaced with a binary, octal, decimal or hexadecimal one.

Serial state-analysis data acquisition can be synchronous or asynchronous—either an internal or external clock can transfer data into the analyzer. You can specify 5-, 6-, 7- or 8-bit incoming-word lengths (in RS-232 format) and can store two words for comparison with incoming data to trigger the analyzer. A digital delay counts up to 65,535 words, and data before or after the delayed trigger can be stored at 50 to 9.6k baud.

The 308 displays stored data on its CRT screen in binary, hexadecimal or ASCII format. Depending on the incoming data's format, you can select odd, even or no parity to simplify word recognition.

Self test at power-up

The instrument's signature-analyzer circuitry provides data input, start/stop gating inputs and clock rates up to 20 MHz, converting a sequence of data between start- and stop-gate signals into a 4-digit alphanumeric code. In Repeat mode, the circuitry compares successive input streams and detects changes. And in Hold mode, it stores and displays up to eight signatures.

At power-up, the 308 performs a self-test procedure: Seven built-in diagnostic routines allow you to check the instrument in depth without external test equipment.

Tektronix Inc, Box 500, Beaverton, OR 97077. Phone (503) 644-0161. **Circle No 453**

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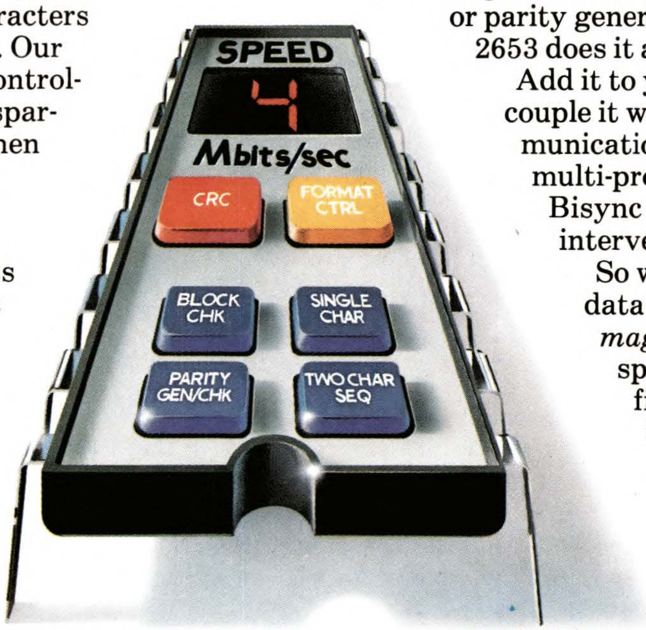

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Single-board processor provides universal interface

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Uniface uses 2901 bit-slice technology, implementing a 32-bit-microword instruction set. Its 200-nsec instruction rate provides computational power that compares favorably with that of the host computers it offloads.

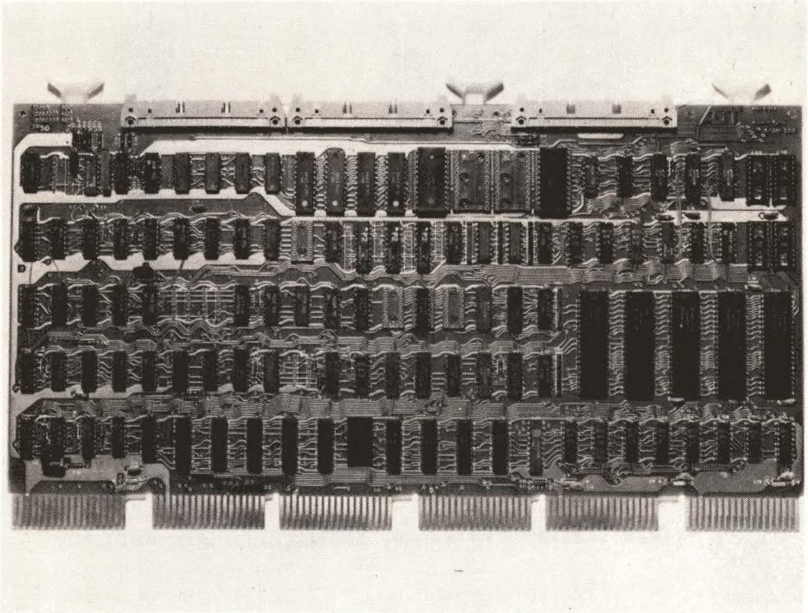
A Unibus-compatible microconsole and a microassembler allow you to write the specialized software needed to drive the Uniface and perform your interface task. The processor board then stores these programs in ROM.

You can install more than one Uniface per Unibus CPU; one board can drive 32 communications channels at 19.2k baud/channel with full modem control.

The Uniface board measures 8.5×16.5 in. and requires +5V at 4A. Available 1st quarter 1980. $45 (100).

Able Computer, 1751 Langley Ave, Irvine, CA 92714. Phone (714) 979-7030.

Circle No 454

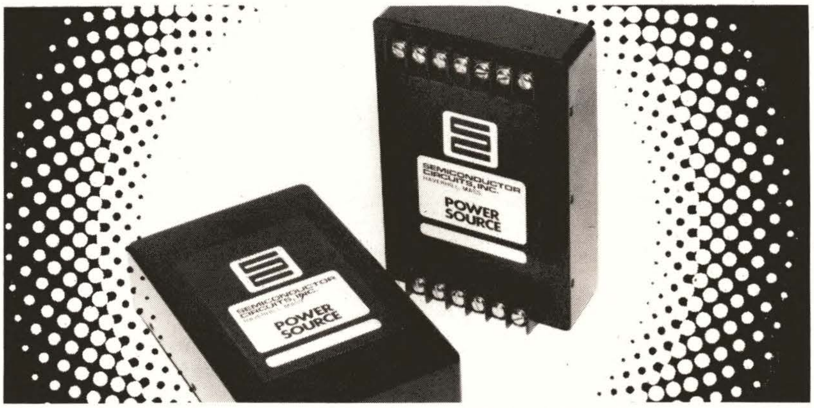


Offloading Unibus systems, *Uniface allows you to add controllers, preprocessors and intelligent Unibus channels to those systems as required.*

Universal-input 25W off-line switchers hold peak inrush current below 10A

External user connections allow standard USE and CSE Series power supplies to accept either 70 to 140V or 140 to 180V, 47- to 440-Hz ac input, as well as 200 to 400V dc. In each of the modules' three input modes, performance holds over a 2:1 input range, suiting the units for operation from most common line voltages, both domestic and foreign.

Peak inrush current, often a weak spot in switcher performance specs, never exceeds



Whether for plug-in or screw-terminal connection, *each of these universal-input switchers outputs 25W at up to 71°C ambient—without derating.*

10A. USE models plug directly into a pc board, while CSE versions bolt to the mounting surface and connect to circuits through dual barrier strips.

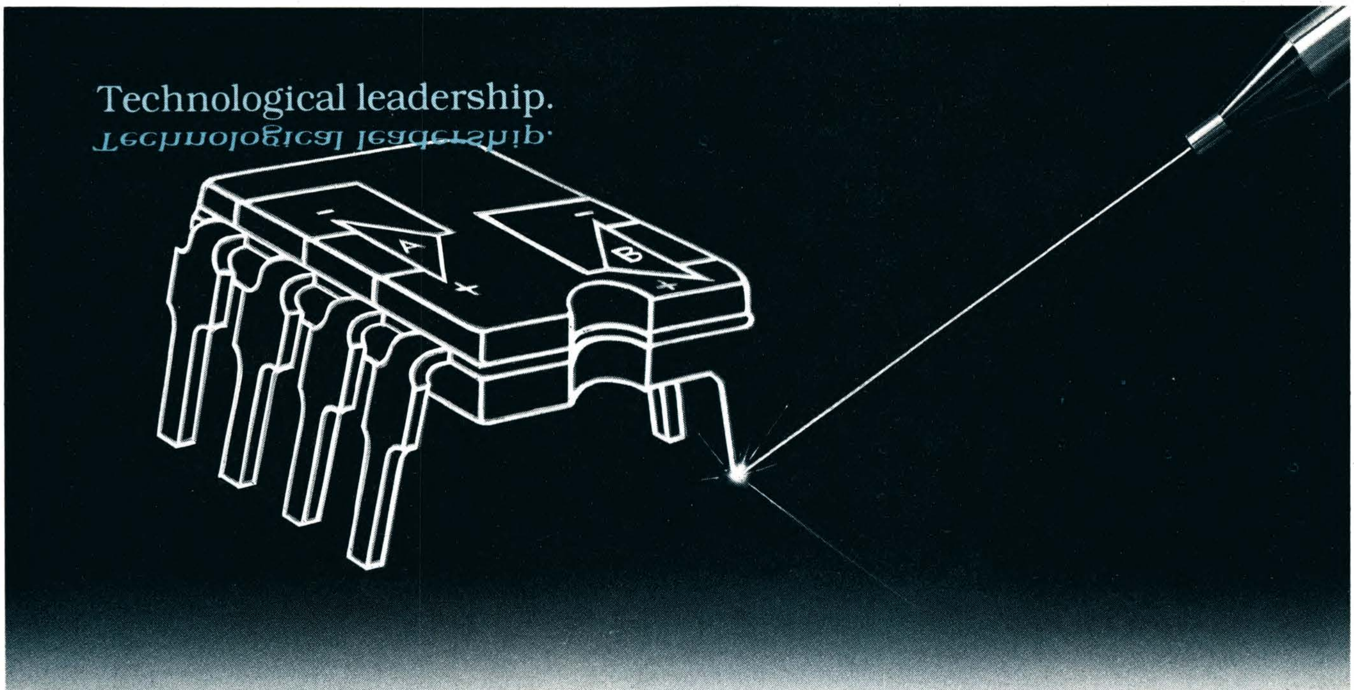
All versions, whether single-, triple- or quadruple - output units, measure 5.5×3.5×1.25 in., have a pi input filter to reduce input reflected ripple, offer 2500V I/O isolation and incorporate a noteworthy and relatively unusual feature: self-resetting input overvoltage shutdown. Furthermore, all modules employ 40-kHz switching to produce the primary output; the additional isolated outputs come from a multiple-output dc/dc converter.

Continuing the manufacturer's policy, each USE or CSE supply carries a 71°C *ambient* rating for full power. The supplies carry full protection, including foldback overcurrent protection on the primary output, current limiting on the derived outputs and overvoltage crowbarring of the primary output.

Also standard are optoisolated remote power shutdown using standard logic-load signals, greater than 70% efficiency on the primary output and 30-msec holdup time at nominal line with full load.

Specs show line and load regulation of 0.2/0.2% for the primary output and 0.1/0.15% for derived outputs. Ripple and noise on the primary output run 0.1% of output voltage and 50 mV p-p or 0.5% of output voltage, whichever is greater (3 mV rms and 30 mV p-p for derived outputs). \$175.95 to \$269.95. Delivery, 2 to 6 wks ARO.

Semiconductor Circuits Inc, 218 River Rd, Haverhill, MA 01830. Phone (617) 373-9104.
Circle No 455



Cut a new edge in accuracy with the first dual precision BIFET op amps.

Just as we introduced and still lead with the industry-standard, MC1458 dual bipolar op amp, Motorola Linear's first to offer state-of-the-art, dual, precision TRIMFETs™.

They're about as error-free and accurate as you can get any dual op amp to be . . . and an optimum combo of precision, performance and economy.

Super-accurate, laser-trimmed TRIMFETs

The secret's in the laser trimming—our kind of laser trimming. It accurately adjusts resistor values by cutting aluminum shorting bars (links) in an ultra-clean, remarkably stable process. The technology involves trapping the laser energy in a small, finely-controlled area so the metal is correctly vaporized, not splattered or cratered affecting adjacent areas. A cut above the rest.

Of course, TRIMFET technology offers 4 MHz bandwidth, 13 V/μs slew rate (about 25 times better than bipolars), 30 pA input bias and 10 pA input offset.

It's perfect for fast D/A, A/D; sample-and-hold; high-speed integrators; high-impedance buffers; low-current amplifiers.

Meet the whole family

Combining all the advantages a monolithic marriage between linear JFET and bipolar technologies can offer, the Motorola TRIMFET family's available in plastic, metal, ceramic, single, dual and quad varieties.

FUNCTION	TRIMFET SERIES	V_{IO} RANGE (max) mV	TEMP RANGE °C	PACKAGE
Single	MC34001	2, 5, or 10	0 to 70	Metal, Plastic, Ceramic
	MC35001	2 or 5	-55 to 125	Metal, Ceramic
Dual	MC34002	2, 5, or 10	0 to 70	Metal, Plastic, Ceramic
	MC35002	2 or 5	-55 to 125	Metal, Ceramic
	MC34022	0.5, 1, or 2	0 to 70	Metal, Plastic, Ceramic
	MC35022	0.5 or 1	-55 to 125	Metal, Ceramic
Quad	MC34004	2, 5, or 10	0 to 70	Plastic, Ceramic
	MC35004	2 or 5	-55 to 125	Ceramic

Motorola TRIMFETs are 100% compatible with industry-standard MC1741, MC1458 and the MC3403/LM324 bipolar devices. Call or write us about any of them: Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036. We'll send precisely what you need for

Innovative systems through silicon.

MOTOROLA INC.

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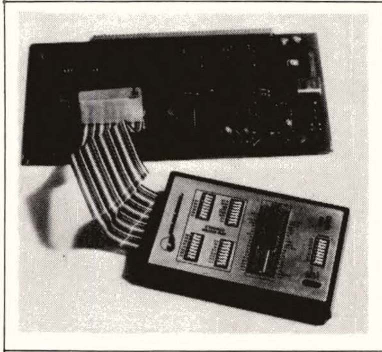
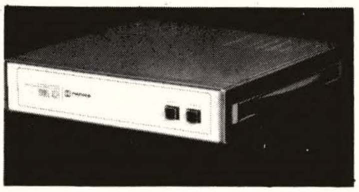
New Products

INSTRUMENTATION & POWER SOURCES



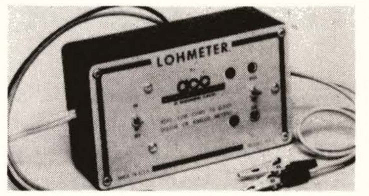
IN-CIRCUIT EMULATORS. SSMs (signature stimulus modules) provide simplified stand-alone signature-analysis diagnostics of difficult bus, μP-kernel and system-fault problems. With them, you can perform "forced-opcode" μP stimulation and free-run generation. Full testing of all address, data and control lines results from using the manufacturer's LS100, 120/140 signature analyzers in conjunction with an SSM—without writing any test or stimulus software.

An SSM allows verification of correct μP-system bus performance and operation, including major portions of the unit under test. Removing the kernel μP from the UUT or target system and placing it in the zero-insertion test socket of the SSM, then opening all address, data and control lines with SSM switches, allows you to take signatures from the μP to verify full-speed operation and proper clocking. SSMs currently available serve the 6800, Z80, 8080, 6500, 6802, 6502 and 6512. From $216.50. **Phoenix Digital Corp,** 3027 N 33rd Dr, Phoenix, AZ 85017. Phone (602) 278-3591. **Circle No 195**



32-CHANNEL DATA LINK. Multichannel digital data handling over distances up to 6500 ft — without modems — makes Model 4359 fiber-optic data link attractive for a variety of uses. For asynchronous applications, the 32 channels operate independently at up to 50k bps (or to 100k with 16 channels, 200k with eight). For synchronous applications, externally clocked byte-parallel rates are 500k bps for 32 bits (or 1M bps, 16 bits; 2M bps, 8 bits). Configured for full-duplex operation, the link costs $12,000 plus cable. **Harris Corp,** Fiber Optic Systems, Box 37, Melbourne, FL 32901. Phone (305) 724-3518. **Circle No 196**

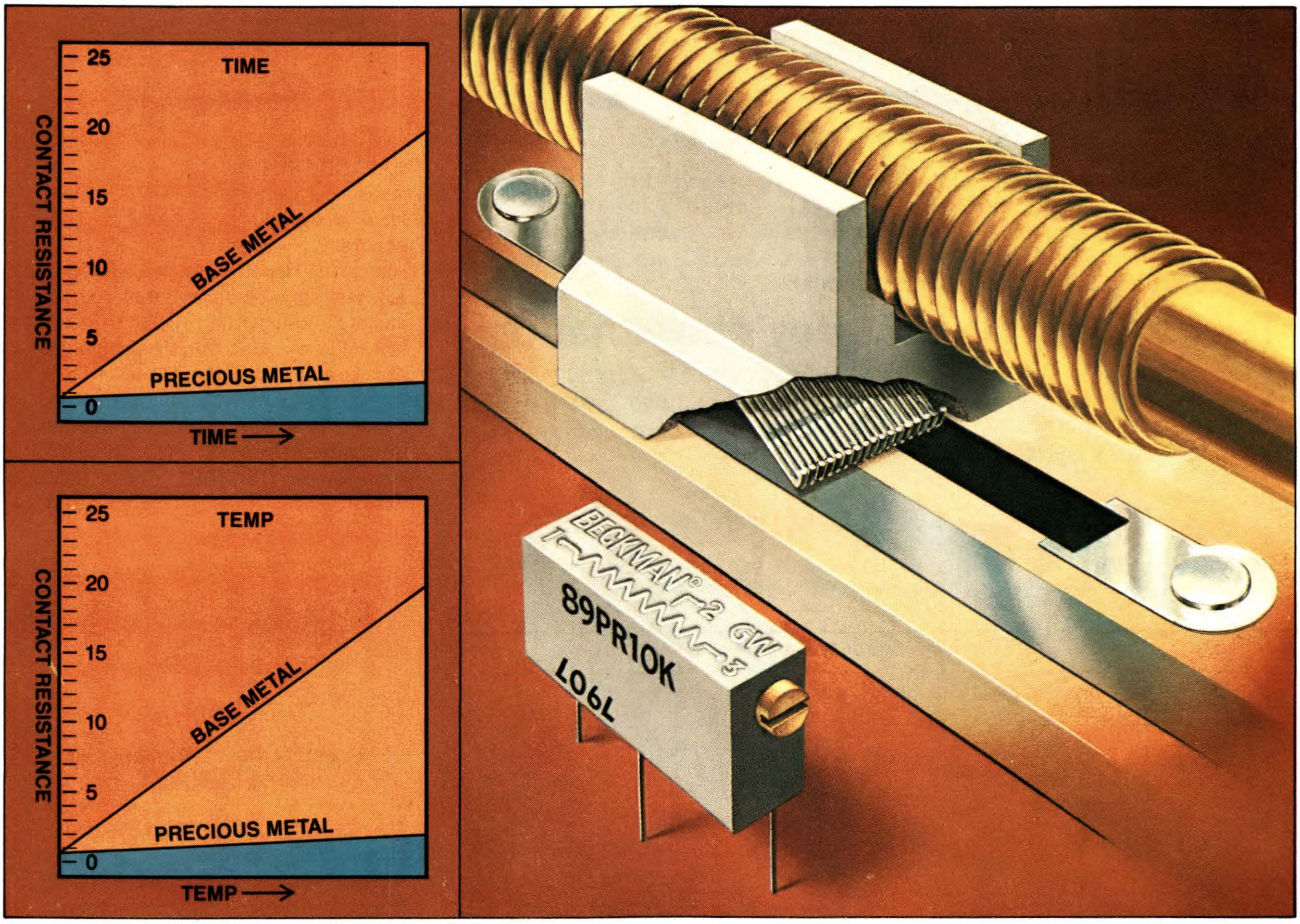
QUAD-OUTPUT SWITCHERS. All members of the RQ Series 300W supplies utilize the same 5×8×10-in. case and feature convection cooling. They also accept inputs of 90 to 132V, 47 to 63 Hz (internally changeable to 180 to 264V), regulate within 0.1%+5 mV from no load to full load, and hold up for 30 msec after line dropout. Load rating holds to 40°C, derated to 50% at 71°C. Main output on all models is 5V/30A, plus various combinations of 5, 12 and 24V. $625. **ACDC Electronics,** 401 Jones Rd, Oceanside, CA 92054. Phone (714) 757-1880. **Circle No 197**



MILLIOHMMETER. A true 4-terminal measuring device that plugs into an analog or digital multimeter, Model RX-2 Lohmeter measures resistance from 100Ω to 0.001Ω with the accuracy of the meter used. Line powered, it indicates (on LEDs) the range in use (×10 or ×100). $39.95. **Alpha Components Corp,** Box 306, El Segundo, CA 90245. Phone (213) 322-7780. **Circle No 198**

RF COMPARATOR. Using the 16100A Series RF comparator heads and their Model 1610A control unit (plus an ac voltage calibrator), you can directly measure high-frequency voltages in 50Ω systems at frequencies between 100 kHz and 1 GHz (with Model 16101A head, from 10 mV to 3V rms between 100 kHz and 1 GHz; with Model 16102A head, 3V to 20V from 100 kHz to 10 MHz). The 1.03-VSWR measurement air line may either be used as a throughput device or terminated. Model 1610A, $985; Model 16101A, $850; Model 16102A, $695. **Ballantine Laboratories Inc,** Box 97, Boonton, NJ 07005. Phone (201) 335-0900. **Circle No 199**

DESIGN BECKMAN TRIMMERS IN. DESIGN PROBLEMS OUT.



Our precious metal contacts let you set and forget.

There are many reasons to make Beckman your trimmer choice. But there's one that's actually worth its weight in gold. It's our precious metal brush contact. Unique to the industry. And invaluable to your application needs. With it, you can forget about long term drift.

In the rheostat mode, our precious metal brush contact would drift from its original setting typically less than 2 ohms with time and temperature changes. A base metal stamped contact would drift typically as much as 20 ohms under the same conditions. That makes our precious metal contact 10 times better in setting stability alone! This is particularly important in low resistance settings.

In addition, our brush contact offers low noise and high overall reliability. So when you specify Beckman, you get a superior product in every way. All at a competitive price.

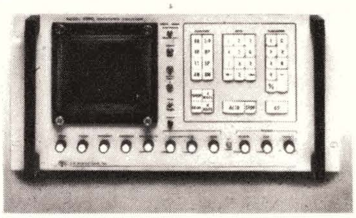
To find out more about the trimmers you set and forget, contact your local Beckman distributor. Or write: Helipot Division, Beckman Instruments, Inc., 2500 Harbor Boulevard, Fullerton, California 92634. In Europe write: Beckman Instruments (Belgium) S.A., 14, Avenue Hamoir, 1180 Bruxelles, Belgium. Phone: (02) 275.44.30. Telex: 23577.

BECKMAN

For more information, Circle No 82

New Products

CAPACITANCE METER. In addition to measuring capacitance values ranging from picofarads to 0.2F with 0.1% accuracy, Model 3001 features a companion Model 333 Tri-Mode comparator that provides settable thresholds to permit the categorizing of devices under test into Low, Good and High groups. Annunciator lights and a TTL-level signal identify the group status. Model 3001, $190; Model 333, $290. **Continental Specialties Corp,** 70 Fulton Terrace, New Haven, CT 06509. Phone (203) 624-3103. **Circle No 201**



WAVEFORM ANALYZER and recorder, Model 1060, features an automatic waveform-search mode and sampling capability. It also provides high accuracy, wide dynamic range, fast measurement capability and convenient programming. Bandwidth equals 1 GHz for sampling or 200 kHz in real time. Samples (1000 from each channel) are digitized and stored for recall. $18,750 plus probes. **E-H International,** Box 1289, Oakland, CA 94607. Phone (415) 834-3030. **Circle No 202**

FREQ/AMPLITUDE STANDARD. Specified on a worst-case basis, Model 4100 delivers sine waves from 10 Hz to 111.1 kHz with 0.001% frequency accuracy. Amplitude, settable from 100 μV to 111.1110V, is accurate to 0.04%, and distortion and noise stay below 0.3% of setting+20 μV. Frequency and amplitude remain stable to 0.001% and 0.01%, respectively, for 6 months. $3595. **Electronic Development Corp,** 11 Hamlin St, Boston, MA 02127. Phone (617) 268-9696. **Circle No 203**

HP's computer-controlled logic analyzers...they love the jobs you hate.

Now you can give those tedious development tasks to an HP computer-controlled logic analyzer and free yourself for the challenges of problem solving.

In interactive situations, a desktop computer can simplify analysis and extend a logic analyzer's capabilities. In routine or repetitive measurements, the computer can control and monitor analyzer operation while you work elsewhere.

Interfacing one of HP's logic analyzers to an HP desktop computer is simple via the HP-IB*, and programs are easier to write for most development applications. Your small up-front investment in time will be paid back over and over again with time saved in data reduction, documentation, analysis and monitoring.

For example:

Data reduction. Now you can have a desktop computer process analyzer data and display results on the analyzer CRT. Store your microprocessor's instruction set, for example, and display mnemonics beside op codes on the analyzer data listing.

Documentation. Couple an HP logic analyzer to an HP-IB compatible printer and you can save hours documenting analyzer listings and setups. With HP's 1615A Logic Analyzer and 7245A Plotter/Printer, you can obtain timing displays (including glitch information) in hard copy for lab notebooks. In many applications the HP-IB "talk only" mode lets you do this without a computer.

Babysitting. Now the computer can watch for intermittent problems while you concentrate on system solutions. The computer/analyzer combination can take "snapshots" of program flow, make comparisons with stored data, then stop a program, restart a test or reprogram itself to gather different data.

Characterization. Repetitive measurements are a natural for these systems. Applications include determining failure rates for component evaluation or to establish field maintenance schedules. Or plotting execution times as a function of data values. And because the analyzer and computer are external to the system under test, you can characterize it in its true operating mode.

Four analyzer choices. Combine an HP desktop computer with the 1602A Logic State Analyzer ($2100**) for low cost systems. A 1610A Logic State Analyzer ($11,800**) is ideal for tailoring to your microprocessor based system applications. For synchronous/asynchronous interaction problems the 1615A Logic Analyzer ($7200**) is your choice. And for computer networks, select the 1640A Serial Data Analyzer ($6275**).

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Heinemann has it—in ratings. With the widest choice of current ratings in the industry, it's no wonder Heinemann is number 1 in OEM circuit breakers. Whatever you need in circuit protection, you'll find it in a Heinemann breaker—in a variety of voltage, current, and frequency ratings.

Heinemann has it—in styles. No one has more breaker styles than Heinemann. Whether you need one pole or six, time delays, or special internal circuits, Heinemann has what it takes. Our **Types J and AM** are the most popular OEM circuit breakers ever made. And you won't find a better E-frame magnetic breaker than our low-cost **CF Series**—at any price. The 3-pole **GH** breaker is UL-listed for 14,000A interrupting capacity at 480Vac and 10,000A at 250Vdc, while our **GJ Series** has an interrupting capacity of 18,000A at 240V 50/60 Hz and 25,000A at 65Vdc. For low-current requirements, we've got a direct replacement for those old-fashioned glass fuses and fuseholders—the resettable **Re-Cirk-It** protector. This inexpensive pushbutton breaker, available in current ratings to 15A, fits in the same panel space as conventional ⅝" cylindrical fuseholders.

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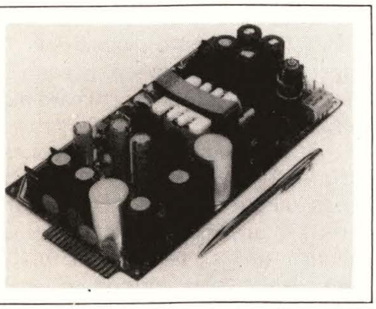
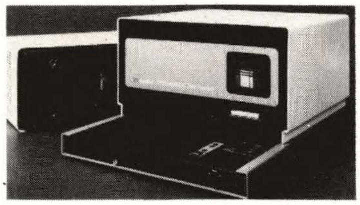
New Products

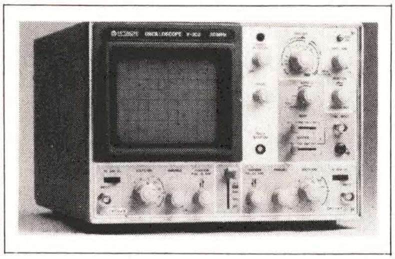


µP/FLOPPY-DISC SWITCHER. Model AC-65 supplies maximum outputs of +5/6A, −5V/0.5A, +12V/2.5A, −12V/1A and +24V/1.5A for total power of 65W. Designed to meet UL478, CSA22.2 #154 and VDE 0804 and 0730 specs, it is mechanically interchangeable with, and meets or exceeds all specs of, the Boschert OL-65. Line input (user selectable) can be 80 to 140V or 160 to 264V. $182. **Conver Corp,** 10631 Bandley Dr, Cupertino, CA 95014. Phone (408) 255-0151. **Circle No 204**



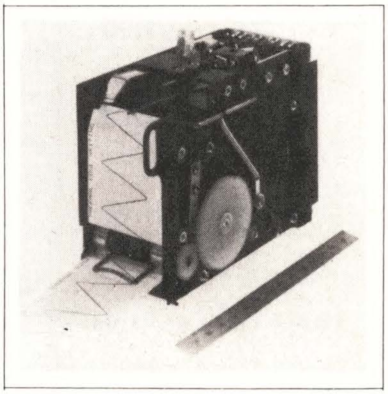
DIGITAL-IC TEST SYSTEM. The µP-controlled Model 1732 tests such devices as SSI, LSI and memories; it handles CMOS, TTL, ECL, HTL, I²L, PMOS and NMOS technologies. A Z80 µP with 48k of RAM provides control and operates the CRT; a second processor operates the mag-tape mass storage, and a third applies test patterns to the DUT. $32,000. Delivery, 12 to 14 wks ARO. **GenRad Inc,** 300 Baker Ave, Concord, MA 01742. Phone (617) 369-4400. **Circle No 205**

WORD GENERATOR/timing simulator is claimed the first such instrument to integrate the intelligence of a µP-based controller with a high-speed signal generator for use in both word generation and timing simulation. Model RS-660 features an interactive CRT display and front-panel keyboard to handle control functions as well as data entry, verification and editing. Data rates reach 20 MHz. $5945. **Interface Technology,** 150 East Arrow Hwy, San Dimas, CA 91773. Phone (714) 599-0848. **Circle No 206**



30-MHz SCOPES. Each a 5-in. model, the single-trace V-301 and dual-trace V-302 offer automatic, normal and TV triggering; time-base sweep speeds from 0.2 µsec/div to 0.2 sec/div (19 calibrated steps) and up to 1-mV sensitivity (with ×5 vertical magnifier). Other features include a TV sync-separator circuit, ×10 sweep magnifier, trace rotation, front-panel X-Y operation, Z-axis modulation and an internal signal delay line. V-301, $745; V-302, $945 (probes included). **Hitachi Denshi America Ltd,** 175 Crossways Park West, Woodbury, NY 11797. Phone (516) 921-7200. **Circle No 207**

DUAL-OUTPUT SWITCHER. Modular construction makes the fan-cooled Model MM-22 Mighty-Mite easy to service. Its major output of 5V/75A is augmented by a second of 2V/12A, 5V/12A, 12V/10A, 15V/10A, 18V/8A, 24V/5A or 28V/5A (375W max total drain). Performance specs show 0.4% line or load regulation, 1% or 50 mV p-p ripple, full output to 40°C (derated to 60% at 71°C), 42A inrush current, 20-msec holdup and 70 to 80% efficiency. Input filtering, remote sensing, overheating shutoff, overvoltage protection and reverse-voltage protection come standard. $525. **LH Research,** 1821 Langley Ave, Irvine, CA 92714. Phone (714) 546-5279. **Circle No 208**



OEM STRIP-CHART MODULE. Consuming <5W, the battery-operated, 3.8×2.5×4.88-in. Model 4141 recorder uses a thermal stylus to write on 40-mm paper. It provides 50-Hz frequency response, ±1%-of-FS linearity, 100-mV to 1V sensitivity and 5- and 25- or 10- and 25-mm/sec chart speeds. An event marker, alphanumeric printhead, driver electronics and other speed combinations are optional. $400. **MFE Corp,** Keewaydin Dr, Salem, NH 03079. Phone (603) 893-1921. **Circle No 209**

ICs & SEMI-CONDUCTORS

F/V CONVERTERS. The CS-2917 family of frequency-to-voltage converters particularly suits speedometer, tachometer, motor-control and anti-skid brake-control applications. It consists of a regenerative-input comparator, a frequency-doubling charge pump, a general-purpose differential-output op amp and a shunt voltage regulator.

The input signal, which can be single ended, ground referenced or differential, is applied to the regenerative comparator. 30 mV of hysteresis provides noise rejection, permitting the comparator to operate from signals as low as 20 mV pk. The charge pump is triggered by the comparator output, converting the input-frequency information into a dc output voltage. The output op amp is unity-gain compensated and can serve as an output-voltage follower or as an active filter for additional ripple reduction. Because of its output configuration and 50-mA current capability, the output op amp can drive a variety of loads either from its emitter or collector. The CS-2917-1 version of the FVC incorporates an additional feature: An open-collector transistor provides a buffered high-level output signal equal to the input frequency. This auxiliary output makes possible applications not possible with converters from other manufacturers.

Typical characteristics at 25°C and 12V supply include: ±15-mV input threshold, 0.1-μA input bias current and 0.3% output nonlinearity. Operating range spans −40 to +85°C. CS-2917-D8 (8-pin DIP), $1.16; CS-2917-D14 (14-pin DIP), $1.21; CS-2917-1-D-14 (14-pin DIP), $1.25 (1000). **Cherry Semiconductor Corp,** 99 Bald Hill Rd, Cranston, RI 02920. Phone (401) 463-6000.

Circle No 231

LOW-COST PRESSURE SENSOR. Housed in a TO-5 package, the LX0503A produces an output voltage proportional to applied absolute pressure. Because this IC contains only the basic piezoresistive chip, without signal conditioning, scaling or buffering circuit-

ry, it offers high design flexibility. A single inlet tube allows the working medium to make contact with the circuit side of the device's diaphragm, which is covered with a thin, compliant layer of parylene. The LX0503A is temperature compensated with respect to voltage sensitivity and features a low offset temperature coefficient of 0.015 psi/°C from −40 to +105°C. Device sensitivity equals 2 to 8 mV/psi in the unit's 0- to 30-psi range. Applications include residential, commercial and industrial controls and automotive or medical diagnostics. $20 (100). **National Semiconductor,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 737-5854.

Circle No 232

There are still some customs in this country well worth observing.

Good things can still come to you in small packages . . . whether it's a clever and trusty little data go-between, or the company that makes it.

We're small enough to chat with, but we're also large enough to respond quickly. No matter if the job's small or large, we'll take the design burden off your shoulders. After all, who's going to pass up the chance to get the custom product they want in a smaller size, in half the time, for a lot less money.

Besides our bulging shelves filled with already proven standard items, we also have produced over 500 custom designs for industrial and military applications.

Drop us a line or call. We'd love to tell you all about our customs that are well worth observing.

intech/function modules, 282 Brokaw Road, Santa Clara, CA 95050. (408) 244-0500. TWX: 910-338-0254

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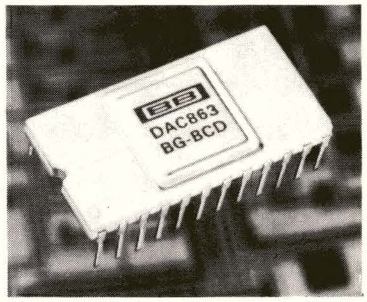
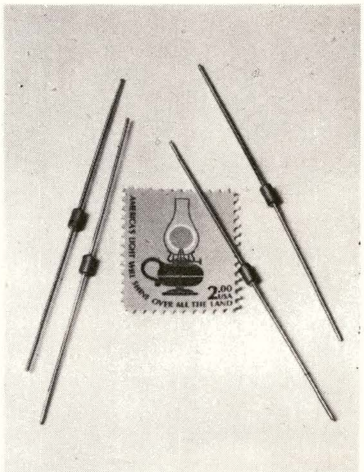
New Products



12-BIT CURRENT-OUTPUT DAC. Pin compatible with 563-type converters, the DAC 863 offers ¼-LSB nonlinearity, ±5-ppm/°C maximum gain drift and ±4-ppm/°C bipolar offset drift. The 24-pin-DIP device, a 2-chip hybrid, is monotonic over 0 to 70°C and −25 to +85°C, depending on version. It requires −15V and either +5 or +15V supplies but does contain its own internal reference. Used as a multiplier, the DAC exhibits a minimum accuracy of ±0.005%. From $29 (100). **Burr-Brown,** Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. **Circle No 233**



1A SCHOTTKY DIODES. These low-leakage diodes are available in hermetically sealed DO-41 packages, which resemble the epoxy packages of the JEDEC 1N5817 devices. Designated SPD5817 to SPD5819, the diodes have PIVs of 20, 30 and 40V with forward voltage drops of 0.55, 0.65 and 0.70V, respectively. Reverse leakage equals 100 μA at 25°C, with a maximum of 1000 μA at 100°C. The units operate to 125°C; single-cycle surge is 100A pk. SPD5817, $1; SPD5819, $3 (100). **Solid State Devices Inc,** 14830 Valley View Ave, La Mirada, CA 90638. Phone (213) 921-9660. **Circle No 234**

Your Marketing department wants a new black box design. They want it to handle 37 bytes of information. It has to be solar energized. It has to fly. It has to speak. It has to reproduce. Naturally, it'll need special cable configurations. Call Belden.

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You see, Belden's capabilities in wire, cable and cord are comprehensive. Sure, we make thousands of standards, but we can also provide just about any custom that you can imagine. And our technical knowhow ranges from innovative packaging to in-depth value analysis.

Just imagine a wire, cable or cord—and we'll come through with it. Belden Corporation, Electronic Division, P.O. Box 1327, Richmond, IN 47374; 317-966-6661. Out West, contact our Regional Sales Office in Irvine, CA at 714-833-7700. 8-7-9A

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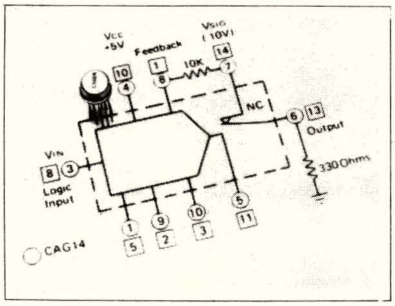
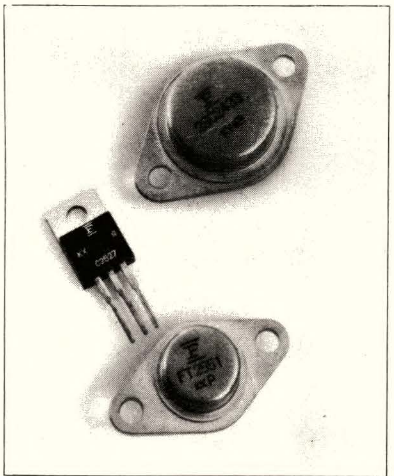
New Products



HIGH-SPEED ANALOG GATE. The CAG14 is a spst switch and driver circuit suitable for use as a high-speed S/H or general-purpose analog gate. It features a turn-on time of 12 nsec and a low ON resistance of 35Ω. The device comes in a hermetically sealed can; its operation is guaranteed over a −55 to +125°C range. $30.55 (100). **Teledyne Crystalonics,** 147 Sherman St, Cambridge, MA 02140. Phone (617) 491-1670.
Circle No 335

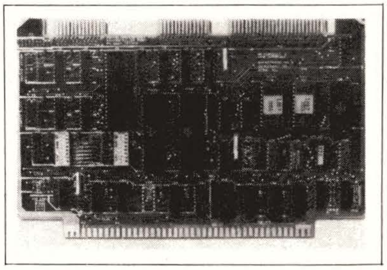
QUAD LINE DRIVER. A second source of the AM26LS31, this quad differential RS-422 line driver sports NAND-enabled 3-state outputs. Intended for digital data transmission over balanced lines, it meets all of the EIA RS-422 and federal 1020 standards. It features complementary, short-circuit-protected 20-mA outputs and operates on 5V. PNP inputs provide MOS compatibility. $2.25 (100) for AM26LS31PC (plastic). **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-6900. **Circle No 336**



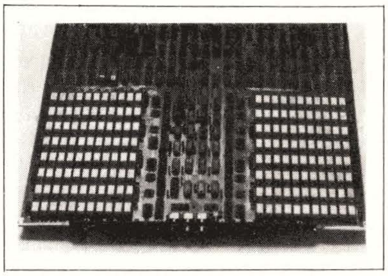
FAST POWER TRANSISTORS. This family of ring-emitter transistors (RETs) permits high-voltage, high-speed switching in inductive circuits. The devices offer a range of $V_{CEO(SUS)}$ ratings up to 400V and maximum I_C ratings of up to 30A. The units' high gain-bandwidth product (80 MHz), low switching speed (0.3 μsec) and high I_{SB} (>1A) particularly suit them for use in dc/dc converters, ultrasonic oscillators, relay and hammer drivers and switching regulators. The ring-emitter design concept embodies many small-geometry, high-frequency devices integrated on one chip to provide high-power capability. These ring-shaped emitters connect to a common electrode through diffused ballast resistors—an arrangement that ensures uniform current density at each emitter site. Devices come in TO-3, TO-66 and TO-220 packages with power ratings of 25 to 150W. $1 to $8.15 (100). **Fujitsu America Inc,** 2945 Kifer Rd, Santa Clara, CA 95051. Phone (408) 727-1700.
Circle No 337

New Products

COMPUTER-SYSTEM SUBASSEMBLIES



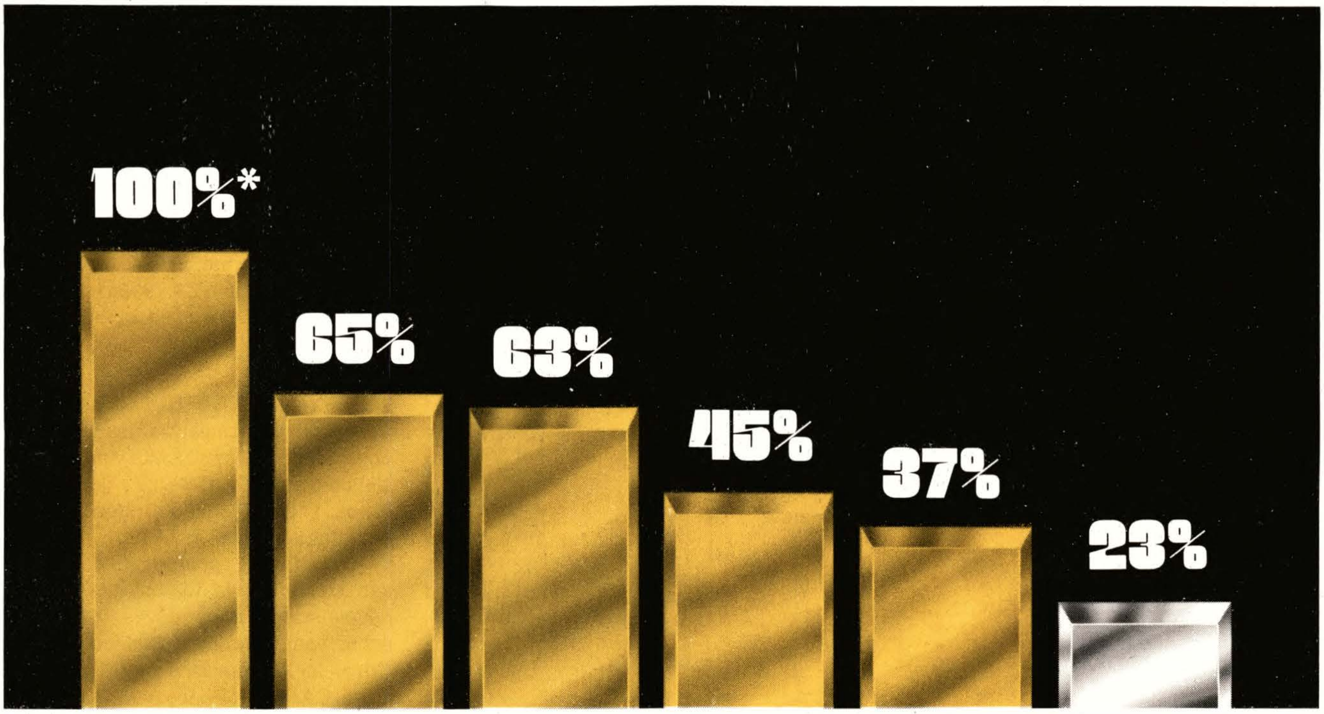
GPIB MODULES. These two monoboard subsystems provide all the hardware needed to implement an interface between a μP and one or more test instruments in accordance with the IEEE Standard 488-1978 General-Purpose Instrument Bus. The M68MM12A listener/talker board allows a system to send and receive data bytes, request service and respond to parallel and serial polls. The M68MM12 listener/talker/controller provides the same functions as the 12A plus the ability to send commands and conduct parallel/serial polls. $305 for the M68MM12A; $795 for the M68MM12. **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-6900.
Circle No 166



ADD-IN MEMORY. Compatible with Data General's Nova 3 minicomputers, the Model 5160 memory board furnishes a 128k-word capacity as well as parity generation and checking. Optional on-board features include memory management and protection, error checking with single-bit correction/double-bit detection and error logging and display. $8950, with all options. **Intel Corp,** 3065 Bowers Ave, Santa Clara, CA 95051. Phone (408) 987-8080. **Circle No 167**

12-BIT D/A CONVERTER. Featuring a 2-μsec maximum conversion time, the ZAD100 utilizes low-TC thin-film resistors to ensure that no codes are missed over a 0 to 70°C operating range.

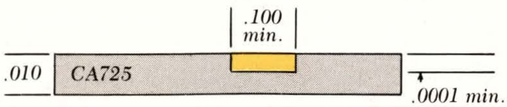
HOW INLAY-CLAD GOLD ALLOYS CAN SAVE YOU MONEY



24Kt	W.E. #1	18Kt	14Kt	12Kt	Palladium
100% Au	69Au	75Au	58Au	50Au	100%
	25Ag	25Ag	42Ag	50Ag	
	6Pt				

** Calculations based on precious metal content and appropriate density plus market price as shown.*

Au $240/oz.
Ag $7.50/oz.
Pd $90.00/oz.



As this chart illustrates, there are options in gold and gold alloys which can be selected to provide the performance specifications called for in the design and manufacture of electronic contacts. TMI offers a wide variety of gold alloys in a range down to .000020″ thickness and as narrow as .055″. In addition to the alloys shown in the above chart, many other combinations of gold alloys, which cannot be electroplated, are available for specific requirements.

Some of the technical advantages of wrought gold alloys are:

- Excellent formability
- Low porosity
- More dense
- More consistent properties
- Wide range of hardness

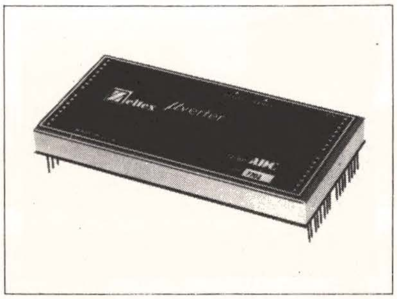
The use of gold alloys not only reduces the gold content but significantly reduces the density of the precious metal providing an additional economic advantage.

In addition, TMI supplies inlays of pure palladium and its alloys, providing the most economical replacement for gold while still retaining a noble alloy's advantages.

Ask for the TMI report "Properties of Inlay Gold Wrought Alloy" or ask TMI to help you make the most effective use of gold in clad inlay metals.

TMI TECHNICAL MATERIALS, INC.
5 Wellington Rd., Lincoln, Rhode Island 02865
Telephone: (401) 333-1700

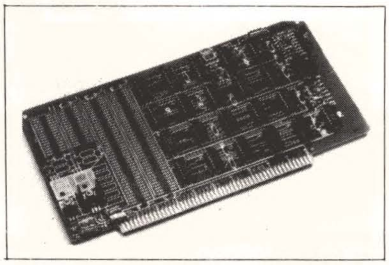
For more information, Circle No 99



Contained in a diallyl phthalate package, it provides ±½-LSB quantizing error and ±0.012% relative accuracy. $299. **Zeltex Inc,** 940 Detroit Ave, Concord, CA 94518. Phone (415) 686-6660.

Circle No 168

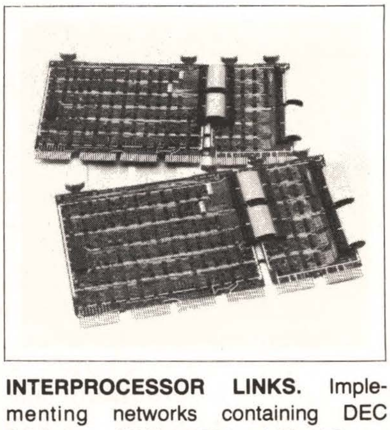
VIDEO DIGITIZER. This fast-scan 1-board unit converts output from a video



camera—or other composite-video source—into 8-bit gray-scale information for use by S-100-bus-based systems. System software can transfer this data to either a memory-mapped high-resolution video board or to main memory for subsequent retrieval. The board comes with a complete driver program. $175. **Vector Graphic Inc,** 31364 Via Colinas, Westlake Village, CA 91361. Phone (213) 991-2302. **Circle No 169**

FLOPPY-DISC CONTROLLERS. These two Multibus-compatible single-board units interface directly with a variety of standard- and mini-size floppy-disc drives. The BLC-8221 provides buffered data transfer; the BLC-8201 replaces Intel's SBC 201 controller. Either board can control up to four single- or two double-sided floppy drives. $995 for either board. **National Semiconductor Corp,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 737-5000.

Circle No 170



INTERPROCESSOR LINKS. Implementing networks containing DEC PDP-11, VAX-11/780, LSI-11/2 or LSI-11/23 computers, MDB-DA11BJ subsystem links provide differential-driver/receiver modules for high-speed parallel data transmission up to 3000 ft; DA11BOI links furnish differential receivers and optically isolated receiver modules for transmission up to 1000 ft. From $3295. **MDB Systems Inc,** 1995 N Batavia St, Orange, CA 92665. Phone (714) 998-6900. **Circle No 171**

There's a giant behind J-B-T miniatures!

The giant, no less, is Cutler-Hammer. Because with every J-B-T miniature switch ordered, you have the backing of a reliable company with 86 big years of experience in switches.

Quality control, on-time delivery and dependable service are standard with us. Here's one example of what we mean by service:

Depending on your application requirements, send us your test specs and we'll conduct functional analysis at our own expense—and furnish a certified test report of the results. Cutler-Hammer has one of the finest testing labs in the country. We will also supply you with a free sample upon request. You don't have to be a giant to qualify. Just contact your local Cutler-Hammer sales office for details.

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Milwaukee, WI 53201

For more information, Circle No 102

When you need rockers & toggles or more than rockers & toggles...

Come to the people who've always been specialists in having more good ways to solve problems: Dialight. What we've done in indicator lights, illuminated switches, readouts and LEDs, we're doing now in miniature rockers and toggles.

This new Dialight family of switches, which comes in a full range of sizes is, we're proud to point out, all-American made.

When you consider all the configurations of styles, sizes, life and safety ratings, colors and mountings, you'll find there are literally hundreds of thousands of design combinations. Such a number of possibilities can in itself be a problem, except that the new Dialight catalog is specifically designed to prevent confusion and help you quickly and easily find the most advantageous combination of features for your applications.

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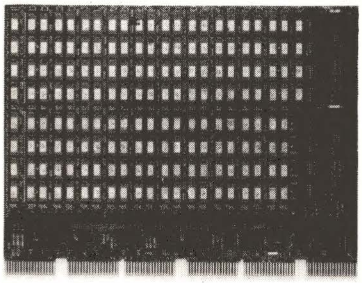
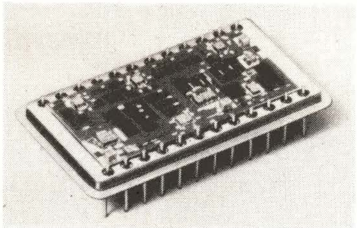
Dialight, 203 Harrison Place, Brooklyn, N.Y. 11237 (212) 497-7600

For more information, Circle No 106

New Products



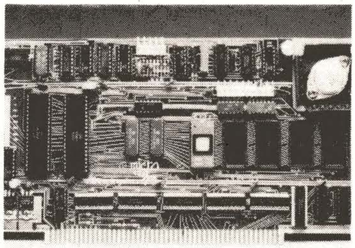
ADD-IN MEMORY. Designed to expand the DECsystem 2020's main memory, the DR-120S utilizes 16k dynamic RAMs to provide a 64k×43-bit capacity. (The 43-bit word comprises 36 data and seven error-correcting bits.) This hex-size board offers 1050-nsec cycle time and 600-nsec access time and can replace DEC's M8629. $5600. **Dataram Corp,** Princeton-Hightstown Rd, Cranbury, NJ 08512. Phone (609) 799-0071.
Circle No 175



12-BIT D/A CONVERTER. For use with medical-instrumentation systems, CRT displays and avionics systems, the 450-mW DAC-SL settles in 5 μsec for the ±10V output range and even faster for lower voltages. Processed to MIL-STD-883 and screened according to methods 5004/5008, the converter (with optional burn-in) provides a 2,200,000-hr MTBF for ground-fixed conditions and 25° case temperature. From $275. **ILC Data Device Corp,** Airport International Plaza, Bohemia, NY 11716. Phone (516) 567-5600. **Circle No 176**

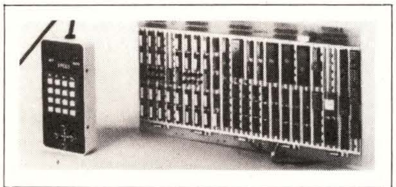
GRAPHICS INTERFACE. The Super Dazzler Interface allows displays of color or black-and-white images with up to 756×484-point resolution. Utilizing DMA to display the contents of either a 12k or 48k memory, this 2-board interface maps each display pixel from one nibble or one bit under software control. $595 for basic model; $795 for a 2-port unit. **Cromemco Inc,** 280 Bernardo Ave, Mt View, CA 94043. Phone (415) 964-7400.
Circle No 177

ONE-BOARD CPU. S-100 bus compatible, the MD960b incorporates the 6809 μP and thus utilizes its 16-bit instructions and internal registers, extended-addressing capability and hardware-multiplication power. This unit integrates I/O functions, RAM, PROM-based monitor and cassette interface for instant use. $299 ($239 for kit). **MicroDaSys,** Box 36051, Los Angeles, CA 90036. Phone (213) 935-4555. **Circle No 178**



New Products

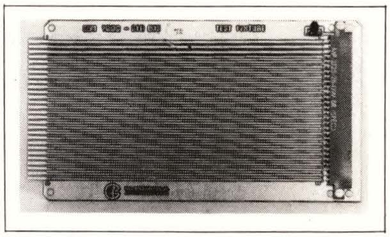
PROM/RAM BOARD. In addition to accommodating up to 12k of 2708- or 2704-type PROM and 1k of 2114 static RAM, this board allows you to utilize one of its sockets for PROM programming. It comes with programming software; jumpers control addressing options, and special circuitry handles reset-and-go and write functions. $215. **Vector Graphic Inc,** 31364 Via Colinas, Westlake Village, CA 91361. Phone (213) 991-2302. **Circle No 179**



PLOTTER CONTROLLER. Removing an incremental plotter's computational burden from host computers, Model IF-751 can generate, scale and rotate 96 ASCII characters from memory, as well as produce slant and mirror lettering. Other features include vector and arc generation, curve smoothing, self test, speed control and operator-selected windowing and zero reference. **Data Technology Inc,** 4 Gill St, Woburn, MA 01801. Phone (617) 935-8820. **Circle No 180**

GRAPHICS AID. The ROM-based Teksim allows Apple II computers to emulate Tektronix 4010 Series graphics terminals. This system requires no modification of host-resident programs to display or input graphical data. Features include multicolored display capabilities, selectable erasing and a standard video output that permits any TV set to function as a monitor. $795. **Cybersoft Systems,** 301 S Livernois, Rochester, MI 48063. Phone (313) 652-9008. **Circle No 181**

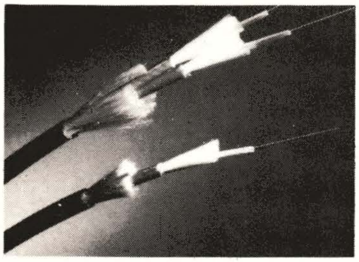
TEST BOARD. Suiting monitoring or card-extension requirements, the COM-7000 brings out a STD Bus backplane's 56 lines to the card-cage's front. One card side provides labeled test points while allowing adequate clearance for



adjacent cards. The card incorporates neutral planes that oppose and guard each trace, as well as an LED power indicator. $75. **Giuli Microprocessing Inc,** Box 23100, San Jose, CA 95153. Phone (408) 298-3426. **Circle No 182**

DISC OPERATING SYSTEM. Suiting Rockwell International's Aim-65 computer, the Daim system includes a controller board with a 3.3k operating system in EPROM, a power supply and one or two disc drives. The controller board plugs directly into the Aim-65 expansion mother board. $850, with one disc drive. **Compas Microsystems,** Box 687, Ames, IA 50010. Phone (515) 232-8187. **Circle No 183**

COMPONENTS & PACKAGING



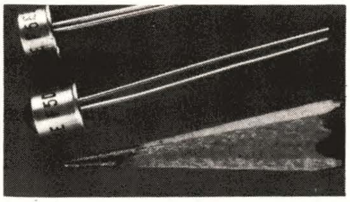
FIBER-OPTIC CABLES. Fat Fiber and Super Fat Fiber cables are designed for data-communication applications over distances of 1000 and 500m, respectively. Both designs feature all-glass fibers, are readily terminated with low-cost connectors and are compatible with inexpensive sources and detectors.

Fat Fiber units are available in both single- (type 242) and dual-fiber (242) versions. The fibers have a large 100-µm core and a high 0.4 NA. Optical specs include attenuation (at 820 nm) of 10 dB/km and a predictable and stable minimum bandwidth (at 900 nm) of 20 MHz-km.

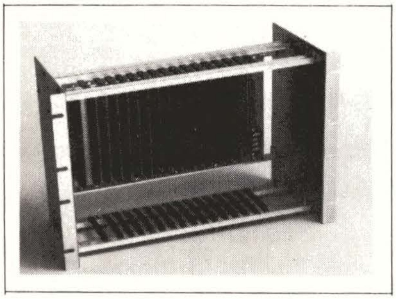
Super Fat Fiber cables are also offered in single- (type 155) and dual-fiber (255) designs. The fibers have a 200-µm core and an NA of 0.3. Attenuation and bandwidth (at 840 nm in both cases) are spec'd at 35 dB/km and 5 MHz-km, respectively.

Both cables can be installed in trays, conduits and ducts for indoor and outdoor applications. $1.95/m (type 142), $3.90/m (type 242). **Siecor Optical Cables Inc,** 631 Miracle Mile, Horseheads, NY 14845. Phone (607) 739-3562. **Circle No 210**

IR EMITTERS. Models F5D and F5E are GaAlAs diodes fabricated by means of a liquid-epitaxial process. They have a peak emission wavelength of 880 nm and output up to 120 mW when driven with 80-µsec pulses. The devices are packaged in a TO-18-type hermetically sealed metal can and are compatible with AMP Optimate connectors. The integral light windows come in either flat or lensed versions. $2.27 (1000). **General Electric Co.** W Genesee St, Auburn, NY 13021. Phone (315) 253-7321. **Circle No 211**

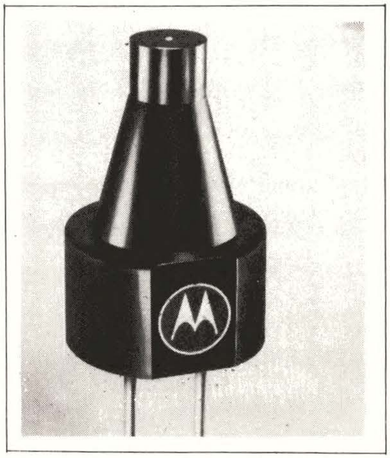


RELAYS. Unlike conventional mercury wetted devices, W1728 relays operate in any mounting position. At loads ranging from 1 pA to 2A, these units are spec'd for 2 billion operations (at 90% confidence level). The relays withstand shocks of 30g and evidence $<0.02\Omega$ change in contact resistance over operating lifetime. Pins are arranged on a standard 1×0.2-in. grid. $1.80 (OEM qty). **Fifth Dimension Inc,** 707 Alexander Rd, Princeton, NJ 08540. Phone (609) 452-1200. **Circle No 212**



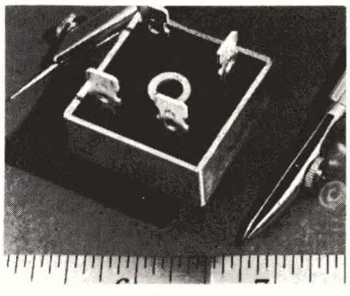
CARD CAGES. Providing S-100 compatibility, these units are constructed of 12-gauge anodized aluminum and mount in standard 19-in. racks. They are offered in 6-, 8-, 10-, 12- and 16-slot versions and allow card insertion/withdrawal without use of tools. Motherboards are constructed of 0.125-in. FR4 epoxy glass; 10- and 16-slot cages are available with shielded motherboards. $65 for 16-slot unit. **Artec Electronics Inc,** 605 Old Country Rd, San Carlos, CA 94070. Phone (415) 592-2740.

Circle No 213



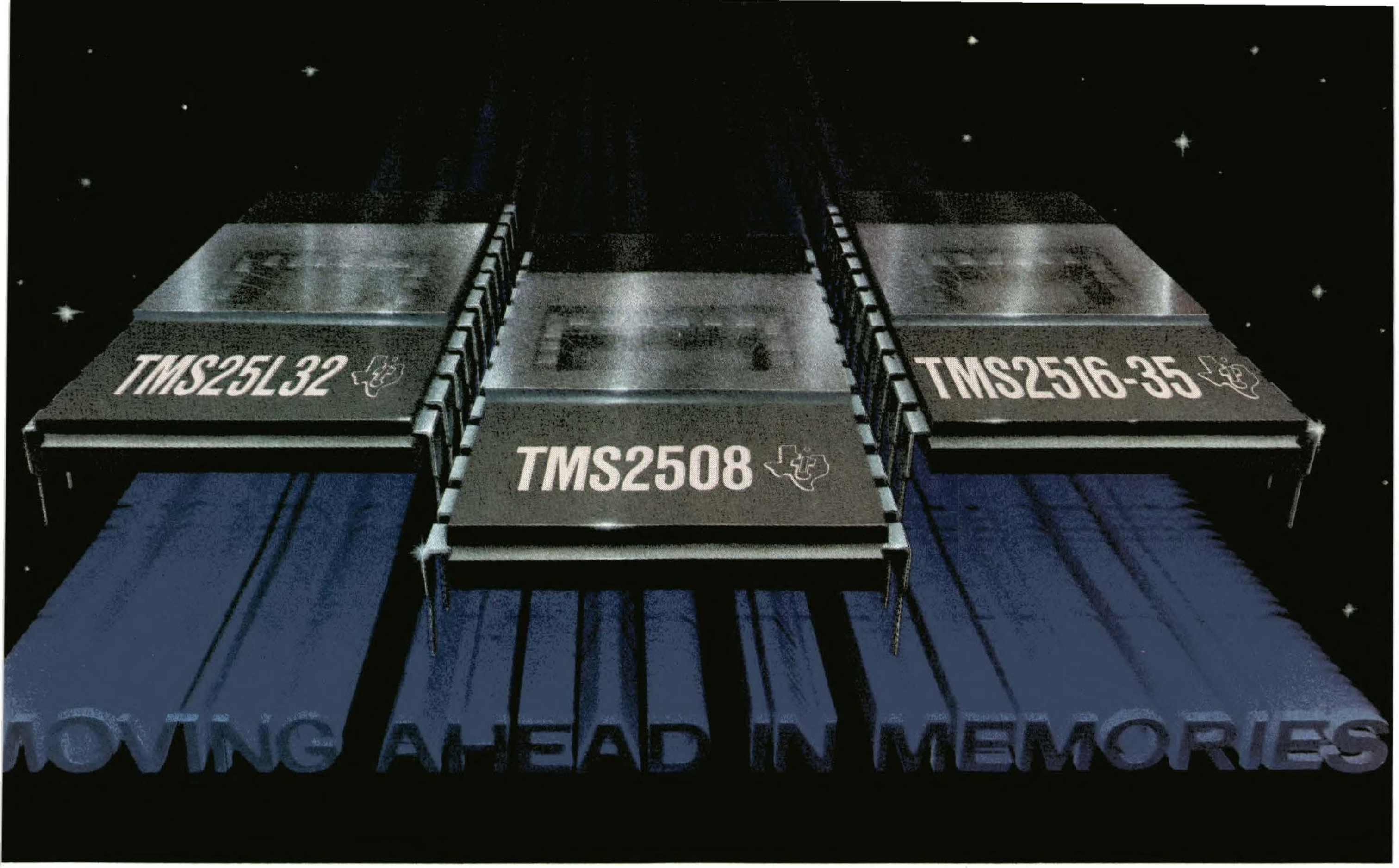
F-O DETECTOR. For use in medium-distance, medium-bandwidth systems, the MFOD402FB is a monolithic IC containing both detector and preamplifier. It operates on 20V, is usable up to 30M baud, has a dynamic range of greater than 100:1, a pulse response of 20 nsec and responsivity of 1.5 mV/μW. Packaged in a case which contains a 200-μm fiber with an NA of 0.48, the MFOD402FB fits into AMP connectors providing good RFI immunity. $52. **Motorola Semiconductors,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-4556.

Circle No 214



RECTIFIERS. MB12 Series rectifier assemblies are offered in ratings of 10, 25 and 35A. They feature a single-phase bridge circuit, positive terminal polarity keying and an electrically isolated case. Specs include a voltage drop of 1.2V (at 17.5A/cell at 25°C for 35A model), 10 μA/cell reverse leakage at 25°C, and surge-current ratings ranging to 400A. $3.35 to $5.80 (100) for 35A models. **Westinghouse Electric Corp,** Youngwood, PA 15697. Phone (412) 925-7272.

Circle No 215



Fastest EPROM ever.
Plus a low-power 32K...a faster 16K.
All new from Texas Instruments.

At 250 ns max access, TI's new TMS2508 is the fastest EPROM on the market. It's made to order for state-of-the-art microprocessor systems. Reduces wait states, virtually eliminates the need for additional circuitry.

The TMS2508 is a true single 5-V supply, 8K device. Designed for speed, it provides all the outstanding characteristics of TI's 5-V EPROMs: 8-bit word configuration. Automatic chip select power down. Fully static operation. Simplified programming — singly or in blocks, sequentially or at random.

A very low power 32K also joins TI's growing EPROM family. The new 5-V TMS25L32 requires 40% less power than its standard counterpart. Active power dissipation is only 500 mW max — the lowest power per bit yet for EPROMs. Input noise immunity: 400 mV, high and low ends.

A high-performance 16K EPROM is now available from TI. The new 5-V TMS2516-35 features 350 ns max access time versus 450 ns for the standard 16K with no increase in power.

Compatible, available family: All TI EPROMs are pin compatible in rugged 24-pin dual-in-line ceramic packages. Upgrading is simple, since the family concept is designed into every new EPROM.

All offer state-of-the-art performance and all are in production.

To get the new, super fast 8K, or any other member of TI's EPROM family, call your nearest TI distributor. Or for more information, write Texas Instruments Incorporated, P. O. Box 1443, M/S 6955, Houston, Texas 77001.

TI's Growing EPROM Family

Device	Description	Power Supply	Max Power (0°C) Operating	Standby	Access Time	100-piece Price
TMS25L32	32K	5 V	500 mW	131 mW	450 ns	$102.00
TMS2532	32K	5 V	840 mW	131 mW	450 ns	53.80
TMS2516-35	16K	5 V	525 mW	131 mW	350 ns	55.40
TMS2516	16K	5 V	525 mW	131 mW	450 ns	36.92
TMS2508-25	8K	5 V	446 mW	131 mW	250 ns	36.90
TMS2508-30	8K	5 V	446 mW	131 mW	300 ns	30.80
TMS2716	16K	+12, ±5 V	720 mW	—	450 ns	24.60
TMS27L08	8K	+12, ±5 V	580 mW	—	450 ns	16.90
TMS2708	8K	+12, ±5 V	800 mW*	—	450 ns	12.30
TMS2708-35	8K	+12, ±5 V	800 mW*	—	350 ns	15.40

*T_A = 70°C

TEXAS INSTRUMENTS
INCORPORATED

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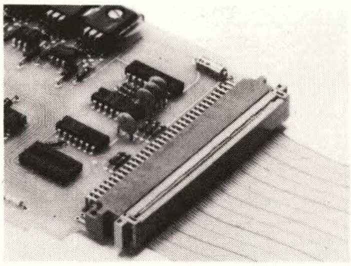
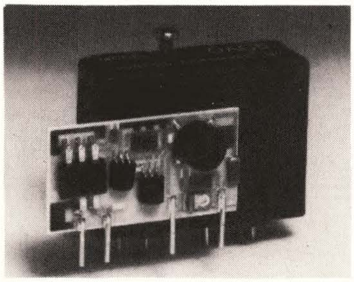
85121

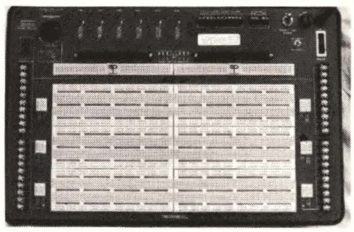
New Products



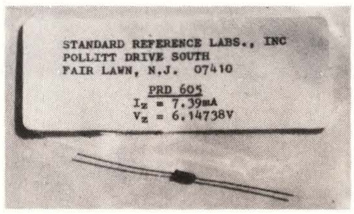
CONNECTORS. European Standard Interface devices are insulation-displacement connectors designed for use with DIN headers. Two versions are offered: one with a 0.1×0.1-in. contact grid and another with a 0.1×0.2-in. grid spacing. Both are 64-position units and come with or without snap-on strain reliefs. Termination is quite simple—you insert a flat cable into the connector and terminate all 64 contacts with one crimping cycle. $0.08/contact (OEM qty). **T&B/Ansley Corp,** 3208 Humboldt St, Los Angeles, CA 90031. Phone (213) 223-2331. **Circle No 216**



I/O MODULES. These thick-film hybrid I/O systems interface with any 5V logic units. The two output modules (ac and dc) drive 3A loads, while the two input modules (ac or dc) translate their respective loads into logic levels. Four pc module boards are also offered—4-, 8-, 16- and 24-position. The last three boards feature plug-compatible logic contacts; the 4-position unit has screw-terminal connections. All boards feature circuitry for pull-up resistors, 5A fuses and LED status indicators. **Gordos Arkansas Inc,** 1000 N Second St, Rogers, AR 72756. Phone (501) 636-5000. **Circle No 217**

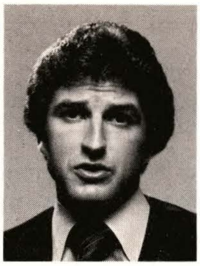


BREADBOARDS. Model 100 and 200 electronic breadboards offer users significant time savings in setting up, debugging, modifying and testing circuit designs. They feature a 13×7-in. working area, three regulated supplies (±5V and switch selectable ±12V or ±15V dc), six 117V-ac solid-state relay outputs, up to 108 positions of I/O capability and an adjustable-frequency clock. Model 200 betters Model 100's supply regulation and provides finer clock adjustability and stability. $595 (Model 100); $695 (Model 200). **Dynamation Inc,** Box 3191, Richmond, VA 23235. Phone (804) 794-7667. **Circle No 218**



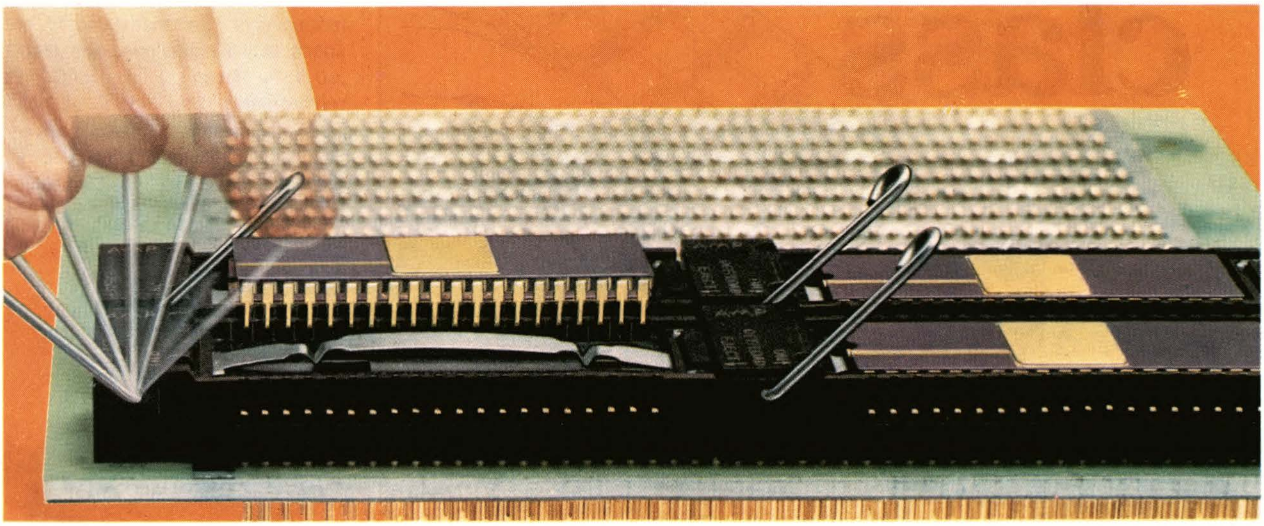
REFERENCE DIODES. Within an operating range of 25 to 45°C, PRD 600 Series diodes have TCs of 1 to 3 ppm/°C (at a specified 0-TC operating current between 5.5 to 9 mA). Peak to peak and rms noise are <1 ppm and 0.1 ppm respectively, and stability ratings range between 5 to 40 and 30 to 240 ppm. Other standard specs include input voltage of 6.2V and impedance of 10Ω—both at 7.5 mA. Additional stability ratings include 30 to 240 ppm/yr and 1 to 3 ppm/8 hrs. $15.50 to $40 (50). Delivery, stock to 8 wks ARO. **Standard Reference Labs Inc,** Pollitt Dr South, Fair Lawn, NJ 07410. Phone (201) 797-3907. **Circle No 219**

DELAY LINES. The three models in the Series 6000 line of microminiature SAW delay lines cover a frequency range of 70 to 80 MHz. Delay times of 0.6, 1.1 and 1.6 μsec are provided and accuracy is better than 2% from −18 to +60°C (the units operate to +85°C with slightly degraded accuracy). The devices are hermetically sealed and meet a number of MIL specs. $225 (50). Delivery, 6 to 8 wks ARO. **Microsonics,** 60 Winter St, Weymouth, MA 02188. Phone (617) 337-4200. **Circle No 220**



"We must find a way to stop LSI package lead damage during burn-in and testing."

Good news. AMP LIF Eject.



Give the kid glove treatment to the leads of your microprocessors, ROMs, PROMs and EAROMs during plugging and unplugging. The new AMP LIF-Eject Connector combines the advantages of a Low Insertion Force design with a unique eject mechanism that lifts the LSI for utmost handling ease. No screwdrivers. No prying up. Nothing else is needed to assure damage-free insertion and extraction.

A three-position arm handles everything. One cams the contacts open. Another position cams them closed with a contact force of 150 grams. And the third position activates a leaf spring that pushes the package out of the contact area.

Two types of LIF-Eject Connectors are available from 24 to 40 positions, one rated at 105°C maximum and 25,000 cycles for electrical testing and programming, and another rated at 150°C maximum and 1,000 cycles for burn-in applications.

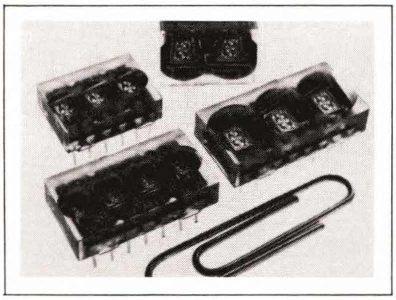
Sound interesting? Call the AMP LIF-Eject Information Desk at (717) 564-0100, Ext. 8400. Or write AMP Incorporated, Harrisburg, PA 17105.

AMP has a better way.

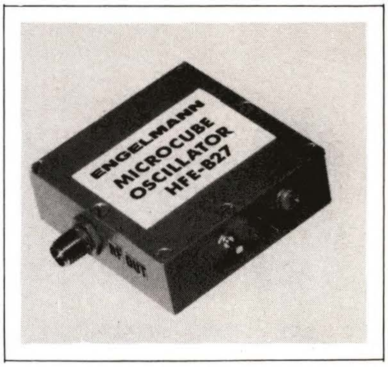
AMP

For more information, Circle No 115

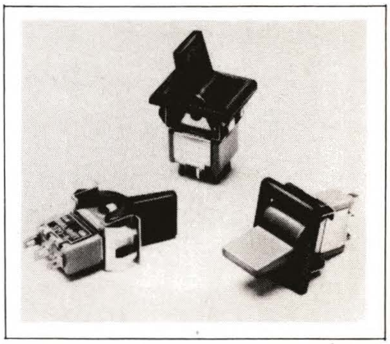
New Products



DISPLAYS. An alternative to LCDs, these LED devices draw <1 mW/segment. Four versions are offered: DL-440M, with 2 digits 0.15 in. high; DL-430M, with 3 digits 0.15 in. high; DL-330M, with 4 digits 0.11 in. high and the DL-340M, with 4 digits 0.11 in. high. All have typical luminance of 1.5 mcd at 5 mA. The units are encapsulated and hermetically sealed in plastic packages with high-impact plastic lenses. $3.90 to $5.70 (1000). **Litronix,** 19000 Homestead Rd, Cupertino, CA 95014. Phone (408) 257-7910. **Circle No 221**



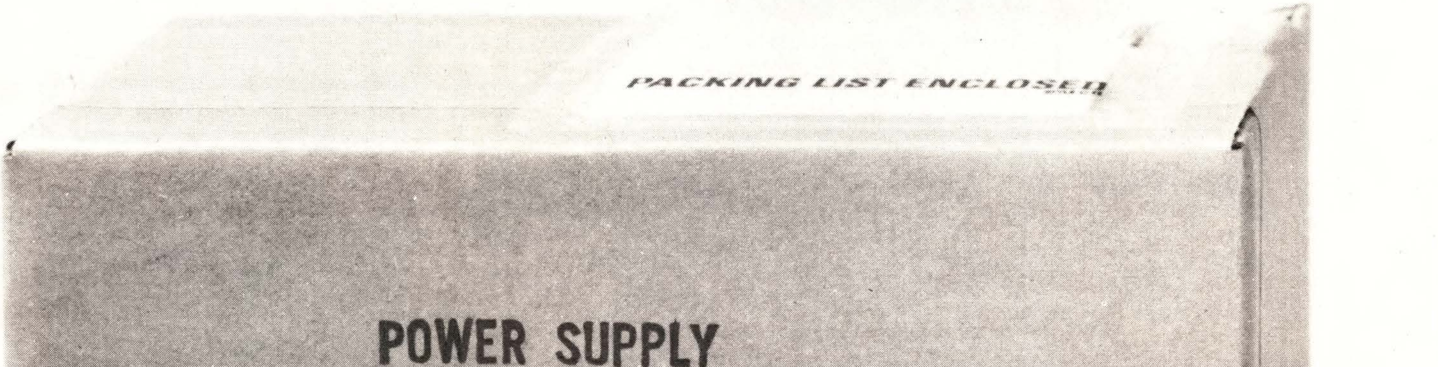
OSCILLATOR. A fundamental transistor cavity-stabilized device, Model HFE-B27 covers from 4.8 to 5.3 GHz. Mechanically tunable, it has 500-kHz resolution and +13 to +16 dBm RF output. In a 1-Hz bandwidth, typical phase noise is −55, −90 and −115 dBc at 1, 10 and 100 kHz, respectively. Second-harmonic content specs at −20 dBc min, and stability is ±0.05% from 0 to 50°C. Power requirements are −15V dc/120 mA. $325. **Engelmann Microwave Co,** Skyline Dr, Montville, NJ 07045. Phone (201) 334-5700. **Circle No 222**



LEVER SWITCHES. The 572 Series offers nine combinations of spdt and dpdt switching functions. Contacts are rated at 0.4 VA for low-level and 5A at 120V-ac/28V-dc resistive load or 2A at 250V ac for high-level applications (a third option satisfies both high and low levels). The switches come with solder and pc terminals with or without epoxy seal, as well as two lengths of wire-wrappable terminations with epoxy seal standard. Molded nylon actuators and bezels are available in nine colors. $1.42 (1000). Delivery, 4 to 6 wks ARO. **Dialight,** 203 Harrison Pl, Brooklyn, NY 11237. Phone (212) 497-7600. **Circle No 223**

DC POWER

What You Need, When You Need It



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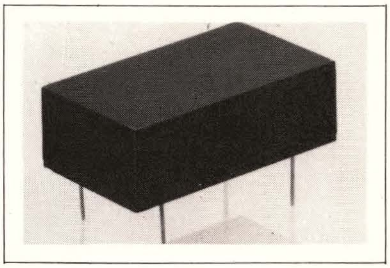
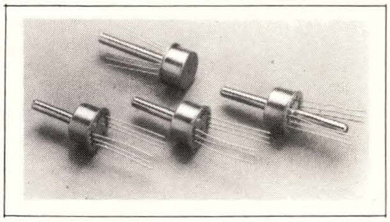
New Products



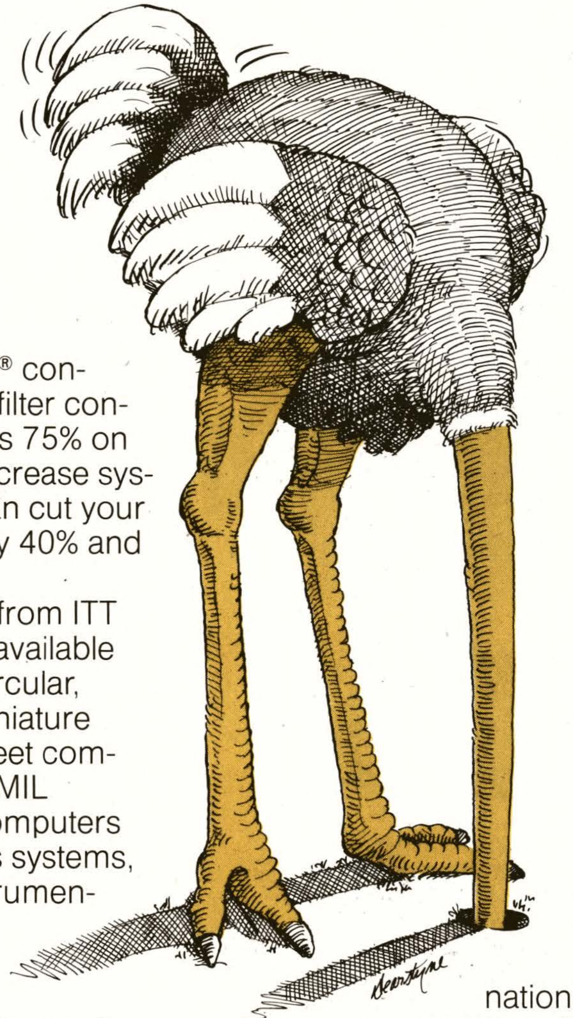
SS RELAYS. Midi-SS Series units feature opto-isolation, zero-voltage switching, internal RC snubbers and 80A single-cycle surge-current ratings. The pc-board-mountable devices have output ratings of 3 to 5A at 120 or 240V ac and input control-voltage ranges of 3.5 to 10V or 10 to 32V dc. Thermal cutoff and transient-suppression features are optional. $8.65 (10,000). **Computer Components Inc,** 88-06 Van Wyck Expressway, Jamaica, NY 11418. Phone (212) 291-3500. **Circle No 224**



PRESSURE SENSORS. Series 6400 solid-state piezoresistive devices measure absolute, differential and gauge pressure from 2 to 300 psi with ±0.25% FS nonlinearity. All units feature infinite resolution over a 140-mV-dc output span and operate from −55 to +125°C. The basic sensors can be temperature compensated for zero and span to ±1% over a 100°C range; the zero-pressure output can be level-shifted to any desired value. $25 (OEM qty). **Cognition,** 765 Ravendale Dr, Mt View, CA 94043. Phone (415) 969-8300. **Circle No 225**

LCDs. Model FE0801 features 3½ 0.4-in. digits, 3 decimal points, a minus sign, an over-range arrow, a low-battery indicator and annunciators for ac, dc, A, mA, V, mV, Ω, kΩ, MΩ, °C and °F. The display is available in transmissive, reflective and transflective modes and comes with DIP connector pins attached, or in pinless versions. Materials are available with 0 to 55°C and −5 to +80°C operating ranges. Red, blue and green readouts can be supplied on special order. $10.29 (100). **AND,** 770 Airport Blvd, Burlingame, CA 94010. Phone (415) 347-9916. **Circle No 226**

It has come to our attention that some designers are still using discrete EMI/RFI filters

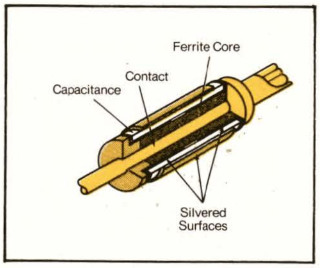


And that's a shame.

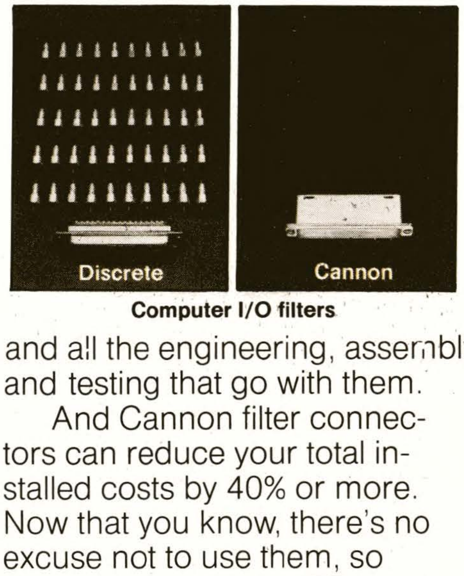
Because Cannon® connectors with integral filter contacts save as much as 75% on space and weight. Increase system reliability. And can cut your total installed costs by 40% and more.

Filter connectors from ITT Cannon Electric are available in rectangular and circular, miniature and subminiature configurations. To meet commercial, ARINC and MIL specifications. For computers and communications systems, medical and test instrumentation, aerospace and automotive applications.

Filtering is available on all or any contacts within the connector. A ferrite tube surrounding the contact forms a series inductor within a concentric, selectively-coated ceramic tube which forms the capacitors of a pi-filter.



Completed connectors, like the computer I/O configuration shown, aren't much larger than the standard connector, yet provide typical attenuation of 70 dB. They eliminate the components, wires and "dog box" that you've had to deal with,

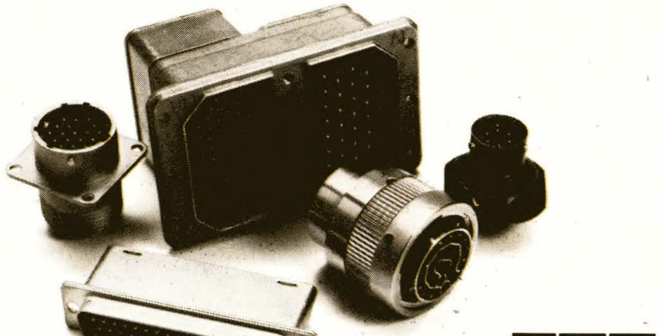


Computer I/O filters

and all the engineering, assembly and testing that go with them.

And Cannon filter connectors can reduce your total installed costs by 40% or more. Now that you know, there's no excuse not to use them, so contact your nearest ITT Cannon field office today.

ITT Cannon Electric, International Telephone and Telegraph Corporation, 2801 Air Lane, Phoenix, AZ 85036, telephone (602) 275-4792.



CANNON ITT

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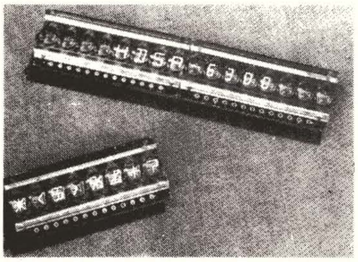
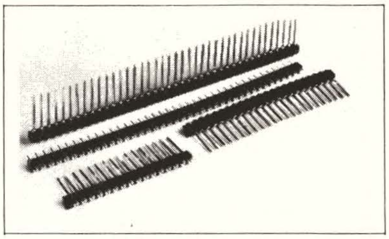


DISPLAY. An 8-character, alphanumeric LED design, the HDSP-6300 has a 16-segment font, plus colon and decimal point. The red GaAsP diodes are magnified by an internal lens to provide a character size of 0.14-in. The display offers full 64-character ASCII capability. Characters draw only 1-mA average current/segment and can be read at a distance of 1.5m. The unit's characters are spaced five to an inch and can be mounted directly on pc boards or in standard IC sockets. $24 (125). **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 856-4105. **Circle No 227**



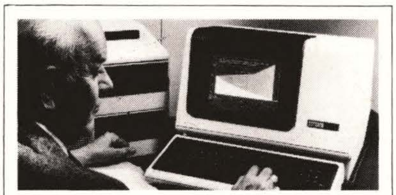
SOCKETS. Series 2000 SIP headers have 0.1-in. center-to-center contact spacings and are available with from 3 to 40 positions. Mountable on 0.1-in. centers, the devices are molded of Valox glass-reinforced thermoplastic material (94V-O UL rating). Terminal options include wire-wrappable styles and a variety of solder-cup, slotted and feed-through designs. $0.50 to $3 (OEM qty). Delivery, 2 to 4 wks ARO. **Garry Mfg Co,** 1010 Jersey Ave, New Brunswick, NJ 08902. Phone (201) 545-2424. **Circle No 228**

SOCKETS. Designed as carriers for 4-pin crystal oscillators, these devices feature 2-piece tapered-entry terminals with gold-plated beryllium-copper inner contacts; they come with gold- or tin-plated outer sleeves in a thermoplastic-polyester UL-rated 94V-0 insulator. The 4-finger inner contact securely holds the oscillator leads, while the outer sleeve's closed-end construction eliminates solder or flux wicking problems. **Augat Inc,** Box 779, Attleboro, MA 02703. Phone (617) 222-2202. **Circle No 229**

SLIDE SWITCHES. Series 1100 devices are offered with two to 12 spst positions with either extended or flush actuators—both with a tape-seal option. Specs include 100-mΩ max contact resistance, $10^{11}\Omega$ insulation resistance, 500V-dc min dielectric breakdown voltage and 5-pF circuit capacitance. Housing material is Type 6/6 30% glass-filled nylon, and the sliders are made of polyester thermoplastic. $1.20 (1000) for 8-position unit without tape seal. **Stanford Applied Engineering,** 340 Martin Ave, Santa Clara, CA 95050. Phone (408) 988-0700. **Circle No 230**

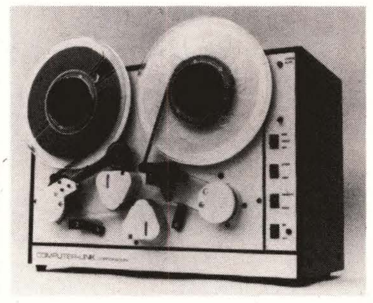
New Products

COMPUTERS & PERIPHERALS



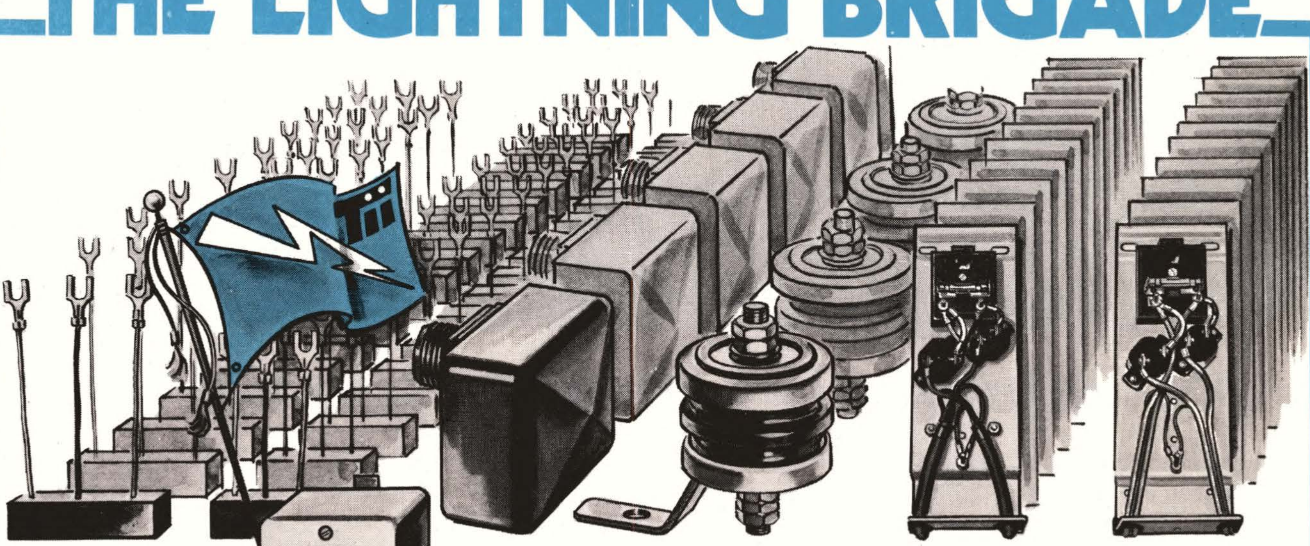
DESKTOP COMPUTER. Miniminc, a desktop analysis tool for use in scientific, engineering and management problem solving, also serves for data reduction of laboratory information. It accommodates up to three serial-line inputs; instrument data in serial form is readily accepted and processed. Miniminc is a full development-level system, operating under an enhanced version of BASIC; users can create and save their own application programs. The system's communications capability also enables it to function as part of a distributed system.

Incorporating an LSI version of the manufacturer's PDP-11 computer family, the system has 64k of RAM and dual floppy discs with a capacity of 512k bytes. The computer uses the VT105 video terminal and provides a communication port with modem control for synchronous or asynchronous information transfer, as well as a serial printer port: Both handle communications to 9600 baud. $9900. **Digital Equipment Corp,** Maynard, MA 01754. Phone (617) 493-9797. **Circle No 238**



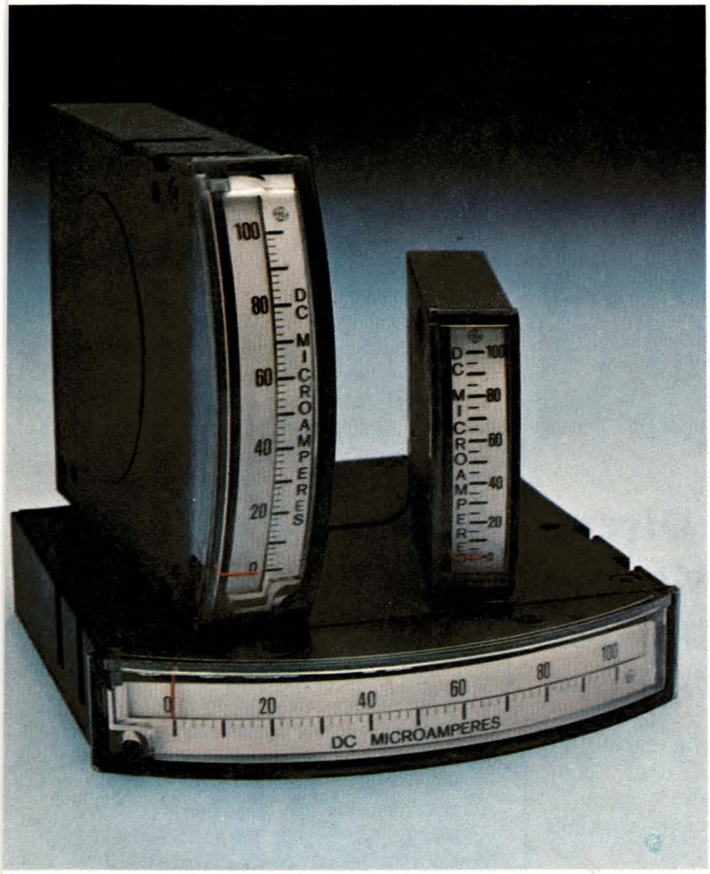
TAPE CLEANER/REWINDER. Model 1011 cleans and rewinds magnetic tape while its optional physical-defect scanner locates permanent damage not removed by the cleaner or found by software. Identifying defects 0.020 in. in diameter, the optical scanner eliminates persistent tape-oriented reruns. A combination of sapphire blades and tissues removes foreign particles from a tape's front and back surfaces; winding and cleaning tensions are controlled independently to eliminate cinching damage. $3400. **Computer-Link Corp,** 40 Ray Ave, Burlington, MA 01803. Phone (617) 272-7400. **Circle No 239**

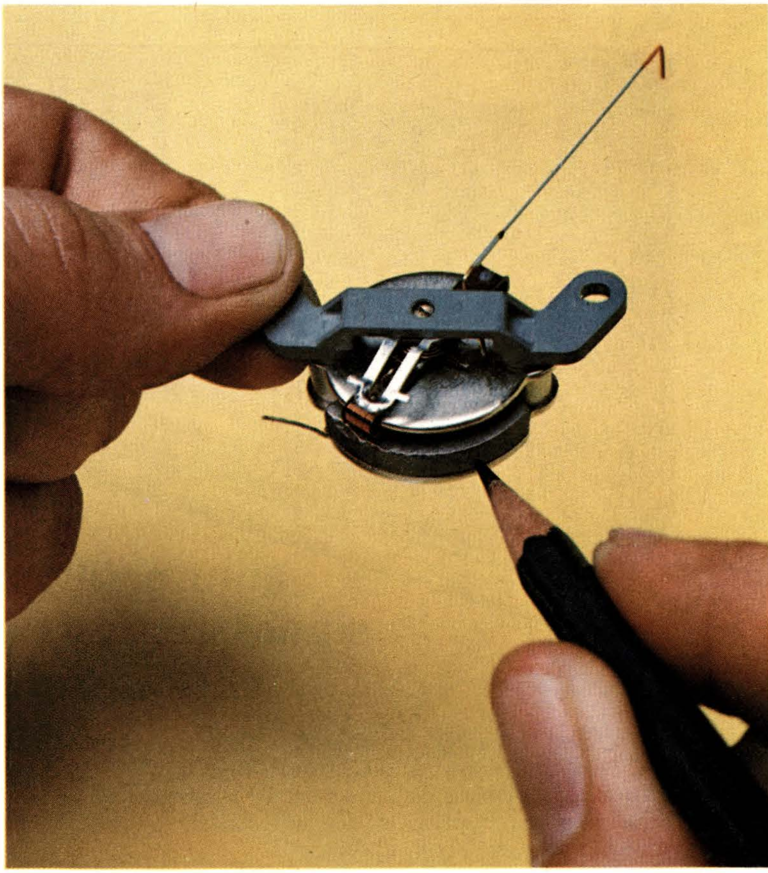
μC PASCAL. PASCAL/M combines the language power of PASCAL with the extensive file-handling capabilities of CP/M. Standard PASCAL/M is available for 8080/85 or Z80 μPs; a special Z80 version takes advantage of the Z80's extended instruction set. The package includes a diskette with P-code compiler, interpreter, and run-time library; "PASCAL User Manual and Report" by Jensen and Wirth; and "PASCAL/M User's Reference Manual." $350 on an 8- or 5.25-in. floppy diskette. **Digital Mktg,** 2670 Cherry Lane, Walnut Creek, CA 94596. Phone (415) 938-2880. **Circle No 240**



What makes GE thin edgewise instrument readings so accurate?

Alnico 8 power.





A high strength Alnico 8 magnet puts extra torque into every mechanism. This makes GE thin edgewise instruments less susceptible to reading errors caused by friction or static. They will continue to meet or exceed all applicable ANSI C39.1 specifications for years.

Available in both vertical and horizontal models, these compact instruments save valuable panel space in all three sizes— 1½, 2½, and 3½ inches. All are attractively housed in virtually unbreakable LEXAN® resin cases. General Electric thin edgewise instruments are interchangeable with most competitive models and are easily modified for special applications.

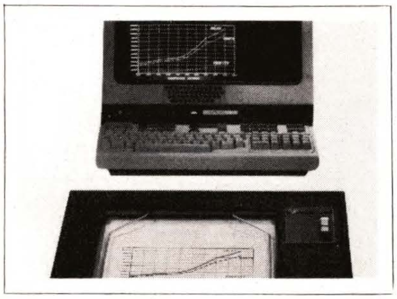
For full information on General Electric's complete line of ac and dc thin edgewise ammeters (from microamps up) and voltmeters (from millivolts up), write to Section 592-94, General Electric Co., Schenectady, NY 12345, or call your nearest GE sales office or distributor.

There's more to any GE instrument than meets the eye.

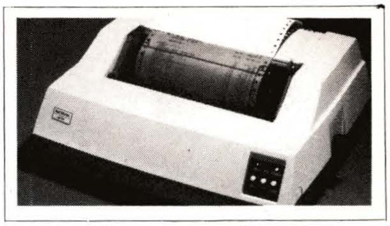
GENERAL ELECTRIC

For more information, Circle No 139

New Products



VIDEO HARD-COPY SYSTEM. The 1641A video hard-copy system provides archival-quality hard copy from popular raster-scan display terminals and video sources within 20 sec, 132-column computer printout at 1000 lpm and computer graphics at 6 pgs/min. One system can serve up to eight terminals. The 1641A accepts video signals conforming to EIA standards RS-170, 330, 343A, 375A and 412A, as well as various CCIR standards. Options provide for composite-sync and external-clock inputs. $10,500. Delivery, 90 days ARO. **Versatec,** 2805 Bowers Ave, Santa Clara, CA 95051. Phone (408) 988-2800. **Circle No 241**



µP-CONTROLLED PRINTER. The MT-80, a 125-cps printer, contains a 240-character buffer; optional data buffers to 4k are available in 1k increments. The printer's pin-feed paper-handling system accepts fan-fold forms varying from 4.5 to 9.5 in. wide. Its vertical format unit features top-of-form control, 10 vertical-tab settings and a skip - over - perforation capability. The MT-80P Centronics-compatible parallel-interface version is priced at $562.50 (100-499); the MT-80S (RS-232) version costs $626.25 (100-499). **Microtek Inc,** 7844 Convoy Ct, San Diego, CA 92111. Phone (714) 278-0633. **Circle No 242**

REAL-TIME READER. The DEP-80 reads up to 48 bits of information from standard paper stock, data which can be preprinted or entered on paper by using a standard pencil. When operated in a real-time mode, the unit can process each entry at the moment of its application. $195 (100). **Turnex International,** 1800 16th St, Newport Beach, CA 92663. Phone (714) 642-3332. **Circle No 243**

WORD-PROCESSING SOFTWARE. A menu-driven system, WORD-II provides for the interactive creation, editing and printing of documents by PDP-11 computers. In addition to standard word-processing features, it offers text search and replace, as well as powerful sort and transfer utilities. A system of program modules operating as one job under an RSTE/E time-sharing executive results in efficient use of memory. A single CPU license costs $7500, including support, installation and training. **Data Processing Design Inc,** 181 W Orangethorpe, Suite F, Placentia, CA 92670. Phone (213) 472-4476. **Circle No 244**

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Low level switching for dry circuits

For years, EAO Series 01 and 31 Lighted Pushbutton Switches have been supplied for applications in control panels, instrumentation, telecommunications, computers and medical electronics.

Now both the 01 and 31 Series are available with low level switching elements that can handle the dryest of dry circuits . . . from micro-volts and micro-amps up to a maximum of 100 mA at 60 volts. This is made possible by our unique contact design . . . 4 gold plated contact fingers of different length . . . contact bounce less than 100 micro-seconds.

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Low level lighted pushbuttons come with round, square and rectangular bezels, momentary or maintained action with universal terminals for soldering, P.C. board mount, or quick connect termination.

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EAO Switch, you can feel the difference.

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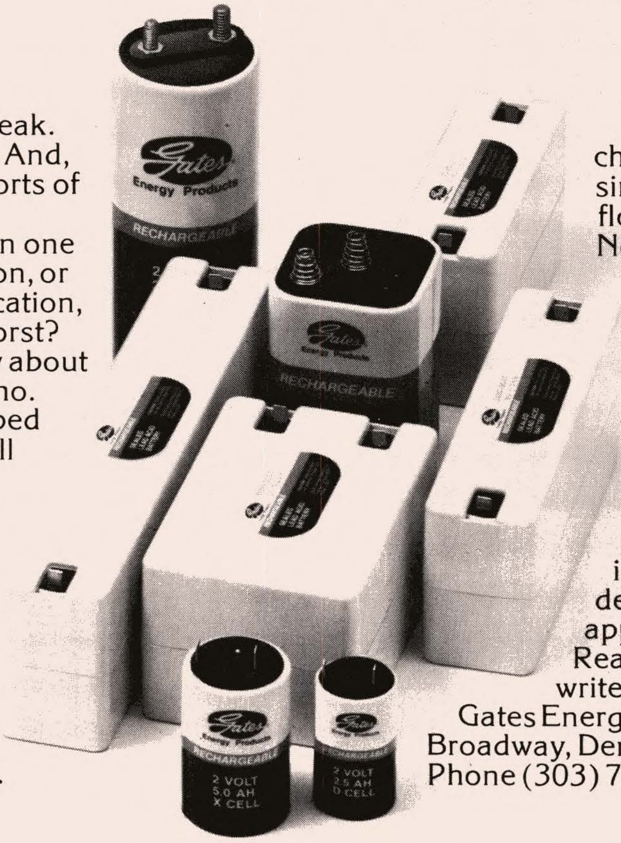
Midcon: Booth 237, 9

For more information, Circle No 141

WHO IN HIS RIGHT MIND WOULD PUT A LEAD-ACID BATTERY IN A TV?



Lead-acid batteries leak. And gas. And corrode. And, traditionally, have all sorts of bad habits.

So, who'd ever design one into a portable television, or any other critical application, where it could do its worst?

Designers who know about Gates Energy, that's who. Because we've developed the sealed lead-acid cell to the point where it's almost faultlessly safe and reliable.

Our cells operate in any position without leaking. They're safe and predictable in temperatures ranging from −65°C to +65°C.

Performance, frankly, is outstanding.

Expect hundreds of discharge cycles. Dependable, simple charging for both float and cyclic applications. No memory problems.

It all adds up to overall product reliability.

Just what every designer in his right mind has in mind when he tackles a new product's design.

Learn more about Gates Energy cells and batteries. Send for our comprehensive information packet full of design data, spec sheets and application notes. Circle our Reader Service number, or write us directly.

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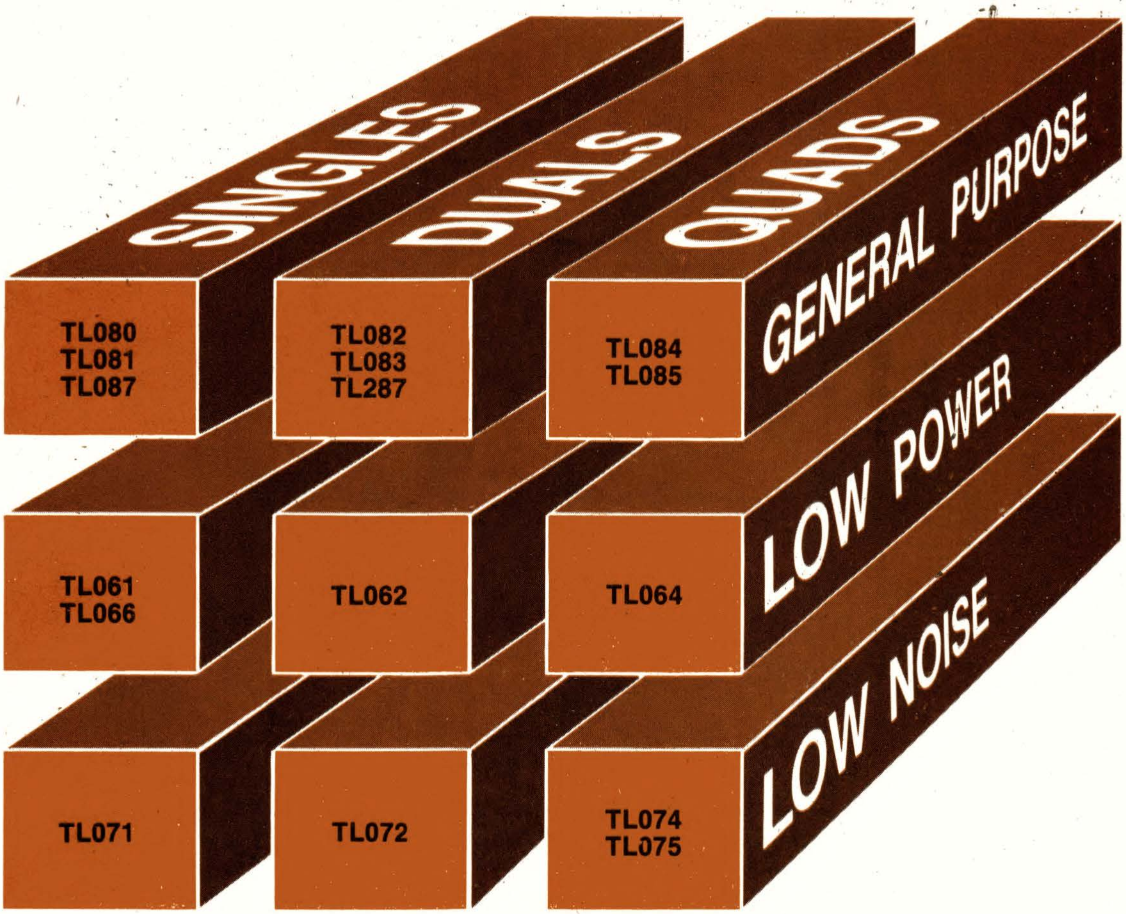
GATES ENERGY



From Texas Instruments...

Industry's broadest line of BIFET op amps.

Let's face it. The new standard in op amps is BIFET. In performance and cost-effectiveness, they obsolete conventional bipolars such as µA741's and others.

Texas Instruments makes the industry's broadest line of BIFET op amps. Whether you require low-price, low-offset, low-noise or low-power, you get what you need from one of TI's three families.

Low-price

If costs are critical, you can't do better than the TL081 family, with prices ranging down to 29 cents each in 100's.

You get high-impedance JFET inputs and low-distortion bipolar outputs. Unity gain bandwidth is 3 MHz. Slew rate is 13 V/µs. Yet price is comparable to the lower performance µA741's.

Low-offset

If you are involved in precision instrumentation, you'll want the TL087 to replace expensive discrete or hybrid amplifiers. Offset is only 0.5 mV, yet price is only $3.93 in 100 piece quantities.

Low-noise

The TL071 series adds lower noise (18 $nV/\sqrt{Hz}$) and lower input offset voltage (10 mV) to the other excellent characteristics of the TL081 series.

Low-power

For power critical applications, the TL061 series op amps require only 0.25 mA max supply current...less than one tenth that of the µA741.

The TL066 features an exclusive power programming capability. It can operate on mere microwatts at supply voltages as low as ±1.5V.

Duals and quads

All three series include duals and quads as well as singles. Regardless of your requirements, you'll find a TI BIFET op amp to fit your needs.

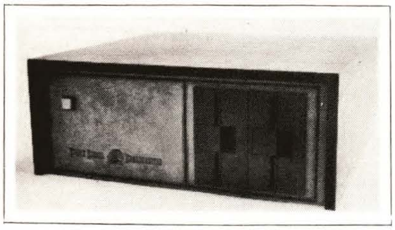
For more information, see your authorized TI distributor or write Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265.

TEXAS INSTRUMENTS
INCORPORATED

For more information, Circle No 142

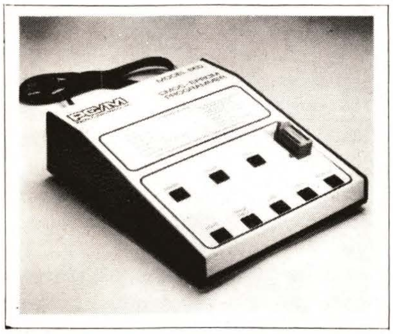
82136A

New Products

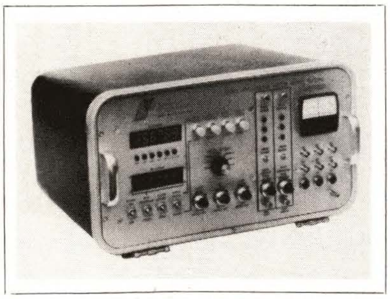


6809-COMPATIBLE μC. An SS-50-bus μC, the 6800-based Chieftain provides upward compatibility with the 6809 μP. The system includes 64k of RAM, a 2k EPROM monitor, two serial I/O ports, a 9-slot mother board, two floppy-disc drives and a disc operating system with Disk-File BASIC. Four different configurations allow a disc capacity ranging from 160k to 48M. From $2595 to $3895, depending on configuration. **Smoke Signal Broadcasting,** 31336 Via Colinas, Westlake Village, CA 91361. Phone (213) 889-9340. **Circle No 245**

VIDEO TERMINAL. Engineered for demanding commercial applications, the WH19 features a keyboard, a video display that's sharp and easy on the eyes, Z80-μP control and keyboard-selectable baud rates up to 9600. Thirty-two separate functions can be controlled from the keyboard or the host computer. A 12-key numeric pad in calculator format allows easy entry of arithmetic programs. Eight user-definable keys program special functions. $646.75 (100). **Heath Data Systems,** Box 167, St Joseph, MI 49805. Phone (616) 982-3361. **Circle No 246**

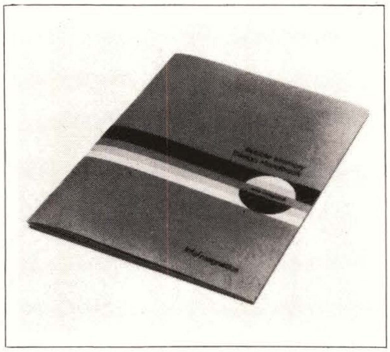


CMOS-EPROM PROGRAMMER. Model 660-A specifically suits programming 6653 and 6654 devices. It contains its own μP and 4096-bit RAM buffer and can be operated as a stand-alone device from its own front panel or interactively with an ordinary TTY or CRT terminal. Model 660-A can also communicate with a human programmer and/or automatic integrated-circuit test equipment for automated on-line EPROM programming. $795. **PC/M Inc,** 3120 Crow Canyon Rd, San Ramon, CA 94583. Phone (415) 837-5400. **Circle No 247**



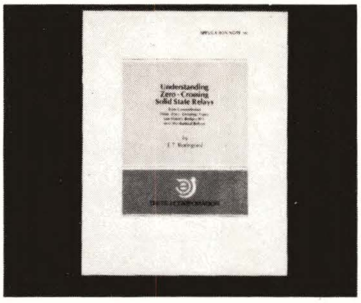
CLOCK/SECTOR WRITER. The PM2390 can write Winchester-type timing and servo tracks in many applications. It writes custom sector and address patterns as well as open clocks with any gap length up to 100 μsec. The PM2390 is capable of measuring frequencies to 25 MHz, clock period, amplitude and/or frequency modulation. It also detects area or pinhole defects and measures spindle rpm. $9950. **Pioneer Magnetics Inc,** 1745 Berkeley St, Santa Monica, CA 90404. Phone (213) 829-6751. **Circle No 248**

Literature



Bubble-memory design handbook

This 64-pg catalog presents features, descriptions and functional characteristics of the 7110 1M-bit bubble memory and its support-chip family. The publication includes specs, diagrams and tables for the manufacturer's magnetic-bubble memory, controller, current-pulse generator, dual formatter/sense amplifier, coil predriver, quad VMOS drive transistors and development board. The catalog also describes the BPK-71 bubble-memory prototype kit and details design considerations for working with bubble memories, as well as providing a system-interconnect diagram. **Intel Magnetics,** 3065 Bowers Ave, Santa Clara, CA 95051. **Circle No 184**



Choose SSRs for low-RFI applications

"Understanding Zero-Crossing Solid State Relays" details the relationship of solid-state and mechanical relays to radio-frequency interface. The 8-pg app note 102 provides an in-depth understanding of switching phenomena and noise suppression for various types of loads. It also includes complete descriptions of zero-crossing SSR circuits and describes prevalent industry misconceptions about solid-state switching devices. **Theta-J Corp,** 208 W Cummings Park, Woburn, MA 01801. **Circle No 185**

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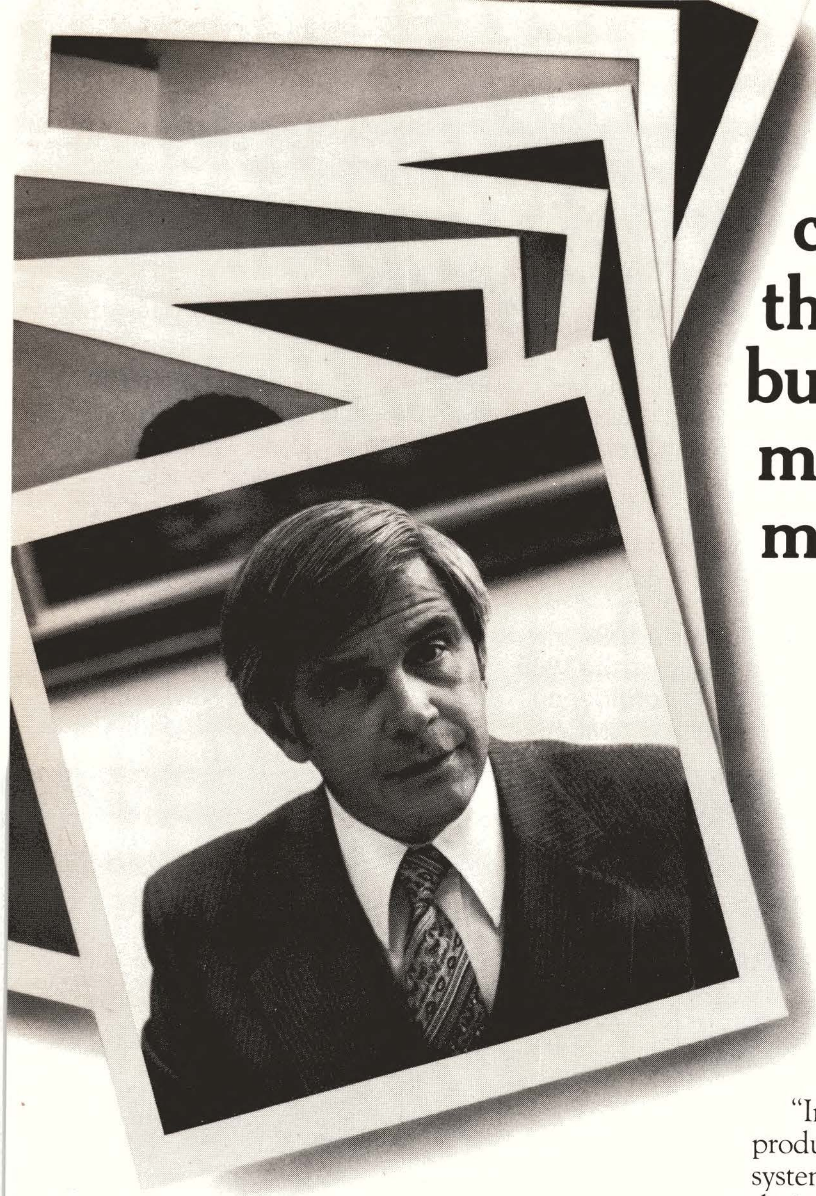

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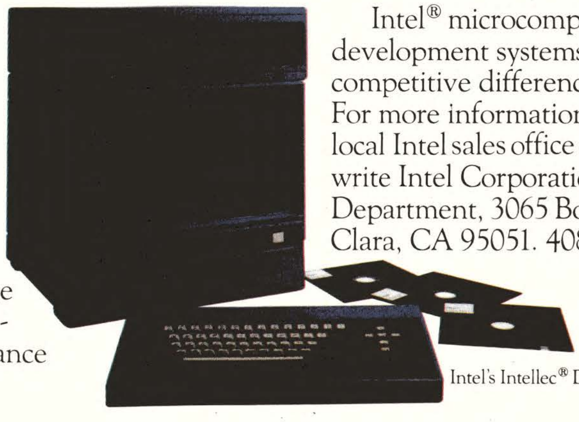

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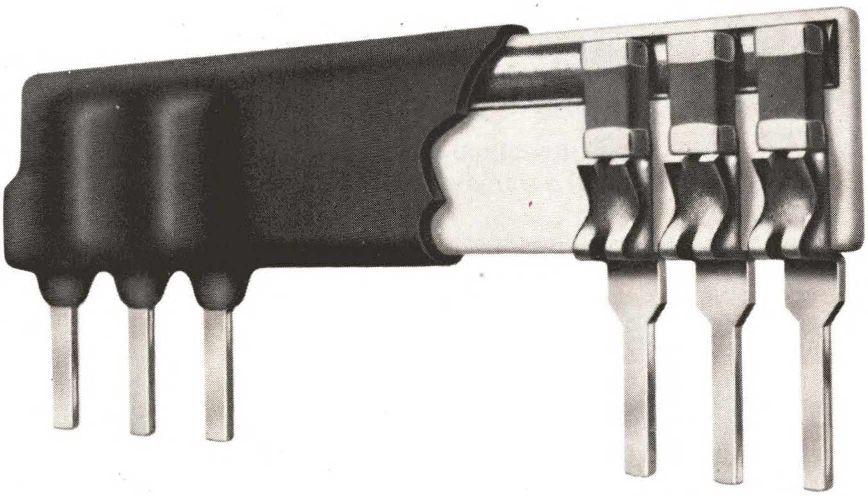

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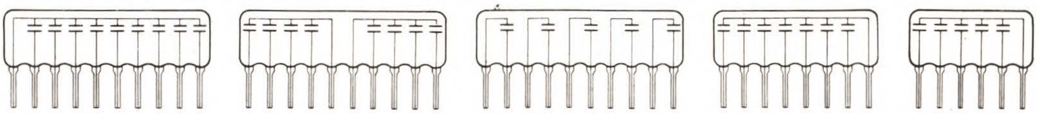

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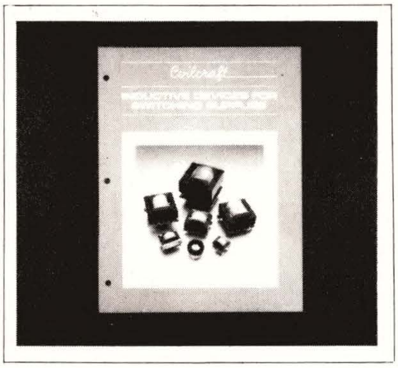
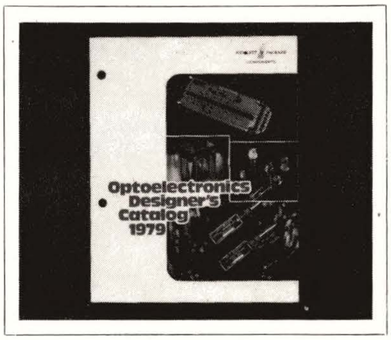


Inductive devices for switching supplies

Two 4-pg app notes (AN-P100 and AN-P101) describe the structured design of switching power magnetics and the design and spec requirements for a 35W, 3-output switching power supply. The four design sheets present electrical and mechanical specs for the company's ferrite power inductors. The manufacturer also offers, at a nominal cost, a prototype design kit, which includes these data sheets and samples of actual transformer structures. **Coilcraft,** 1102 Silver Lake Rd, Cary, IL 60013. **Circle No 186**

Instruments measure very small parameter values

The "Scientific Instruments Selector Guide" presents detailed performance features and key specs for more than 30 models of electrometers, picoammeters, nanovoltmeters and milliohmmeters, as well as high-stability, low-noise current and voltage sources. Comprehensive charts show the instruments' features, input connections and current- and voltage-measurement ranges. The 4-pg brochure also includes a table listing standard symbols. **Keithley Instruments Inc,** 28775 Aurora Rd, Cleveland, OH 44139. **Circle No 187**



Complete technical info on optoelectronic products

A 384-pg catalog includes the company's latest optoelectronic application notes and contains sections on fiber-optic components, LED displays, solid-state lamps, optocouplers, PIN photodiodes and emitter/detectors. Photographs, package dimensions, features, operating characteristics and performance graphs contribute to complete descriptions of these optoelectronic components. Other catalog features include an alphanumeric parts-number index and an introductory capabilities section on each product line. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. **Circle No 188**

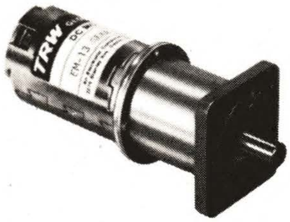
Precision miniature motors:
minimum space/maximum performance

Type SS gearmotor
DC permanent magnet.
Planetary gears.
Power source: up to 50 v.d.c.
Max. rated torque: 300 oz. in.
Standard gear ratios: 21.
Diameter: $\frac{7}{8}$″ (22 mm).
Max. length: 3$\frac{29}{64}$″ (88 mm).

Type LL
DC permanent magnet.
Power source: up to 75 v.d.c.
RPM: to 19,000.
Max. rated torque: to 1.8 oz. in.
Standard gear ratios: 83.
Diameter: 1.25″ (32 mm).
Max. motor length: 2.09″ (53 mm).

Type CMM
DC permanent magnet.
Power source: up to 50 v.d.c.
RPM: to 22,800.
Max. rated torque: to 1.00 oz. in.
Standard gear ratios: 83.
Diameter: 1.25″ (32 mm).
Max. motor length: 1.75″ (45 mm).

Type EM-13
DC permanent magnet.
Power source: up to 30 v.d.c.
RPM: to 6,000.
Max. rated torque: to 3.0 oz. in.
Diameter: 1.25″ (32 mm).
Max. motor length: 1.85″ (47 mm) and 2.17″ (55 mm).



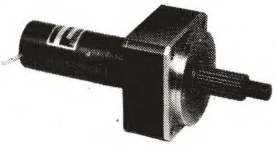
EM-13 gearmotor
DC permanent magnet.
Planetary gears.
Power source: up to 30 v.d.c.
Standard gear ratios: 30.
Max. rated torque: 1250 oz. in.
Diameter: 1.25″ (32 mm).
Max. length: 4.75″ (120 mm).

Type EM-15
DC permanent magnet.
Power source: up to 30 v.d.c.
RPM: to 6,000.
Max. rated torque: to 5.5 oz. in.
Diameter: 1.5″ (38 mm).
Max. motor length: 2.3″ (58 mm) and 2.5″ (64 mm).

EM-15 gearmotor
DC permanent magnet.
Planetary gears.
Power source: 6, 12, 24 v.d.c.
Standard gear ratios: 30.
Max. rated torque: 1250 oz. in.
Diameter: 1.5″ (38 mm).
Max. length: 5.15″ (130 mm).

Type CFC
AC hysteresis synchronous and induction.
Power source: 115 v.a.c., 60 Hz.
RPM: to 3,600.
Max. rated torque: to 2.0 oz. in.
Diameter: 1.7″ (43 mm).
Max. motor length: 2.8″ (71 mm).

Type CFC gearmotors
AC hysteresis synchronous.
Planetary gears.
Power source: 115 v.a.c., 60 Hz.
Max. rated torque: 1250 oz. in.
Standard gear ratios: 83.
Diameter: 1.7″ (43 mm).
Max. length: 5.18″ (132 mm).



BD/BL gearmotors
DC permanent magnet.
Planetary gears.
Power source: up to 115 v.d.c.
Max. rated torque: 550 lb. in.
Standard gear ratios: 19.
Diameter: 1$\frac{1}{2}$″ (38 mm).
Max. length: 5.72″ (145 mm).

Mil-spec motors and gearmotors
Available in DC permanent magnet, AC hysteresis, synchronous, and AC induction motors.
RPM: to 26,000.
Max. rated torque: up to 28.0 oz. in. w/o gearing; up to 550 lbs. in. with gearing.
Standard gear ratios: 143.
Diameter: 0.625″ to 3.75″ (17 mm to 95 mm).
Max. motor length: 1.32″ to 4.35″ (34 mm to 110 mm).

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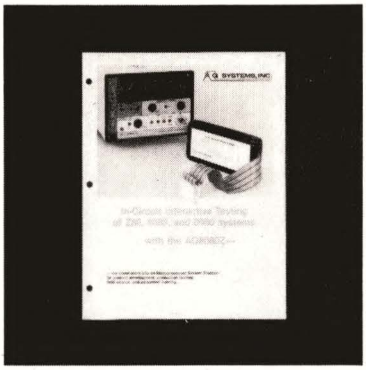


A stand-alone, interactive μP analyzer system

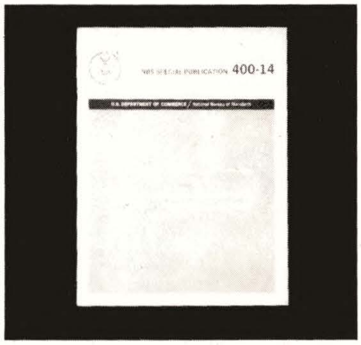
A 6-pg brochure shows how developers, builders and users of Z80A, 8085A and 8080A μP systems can improve productivity by using the company's μP system analyzer for product development, production testing, field service and personnel training. It provides complete operational data, specs, ordering information and details on the AO8080Z and its buffered, clip-on probes. **AQ Systems Inc,** 1736 Front St, Yorktown Heights, NY 10598.
Circle No 189

Instrument catalog focuses on new products

Catalog T202G covers a complete line of optical multichannel analyzers, lock-in amplifiers, signal averagers, boxcar integrators, low-noise preamps, light choppers, photon counters and magnetometers. The 24-pg booklet also shows how to choose and when to use boxcar averagers, multipoint averagers, lock-in amps and photo counting systems. **EG&G Princeton Applied Research,** Box 2565, Princeton, NJ 08540.
Circle No 190

The fine art of designing digital and linear ICs

Brochure No CS-743 guides you through the three phases of custom-IC design and production: design and breadboard, layout and prototype, and circuit review and production release. The 12-pg catalog provides a pictorial overview of custom-IC production and a comparison of custom ICs with semicustom devices. **Cherry Semiconductor Corp,** 99 Bald Hill Rd, Cranston, RI 02920.
Circle No 191



Thermal resistance of power transistors

NBS Special Publication 400-14 briefly explains the idealized concept of thermal resistance and explores the problems encountered in applying that concept to power transistors. The 62-pg booklet addresses the advantages and disadvantages of various electrical techniques for measuring junction temperature. It also outlines a standard technique for measuring the thermal resistance of conduction-cooled power transistors. $2.40. **US Government Printing Office,** Superintendent of Documents, Washington, DC 20402. **INQUIRE DIRECT**

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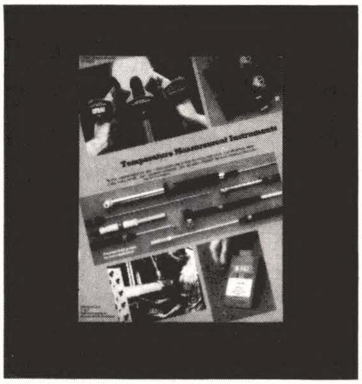
Switches for the computer and instrument industries

Catalog AS-479 consolidates all of the company's switch families into one volume. It pictures and describes an extensive line of pc mountables, including miniature and subminiature toggles, slides, pushbuttons and rotaries. The 159-pg publication emphasizes the expanded TT Series of subminiature custom switches and describes a variety of LED and incandescent-light products. **Alco Electronic Products Inc,** 1551 Osgood St, North Andover, MA 01845.
Circle No 192

Short-form catalog of precision temp instruments

Featuring a wide range of temperature-measuring instruments, this 8-pg catalog describes the company's Heat-Prober platinum-RTD and thermocouple digital thermometers, its Heat Spy digital and analog noncontact thermometers and its miniature, self-adhesive temperature recorders. Specs, features, applications and prices are included for all product descriptions. **Wahl Instruments Inc,** 5750 Hannum Ave, Culver City, CA 90230. **Circle No 193**



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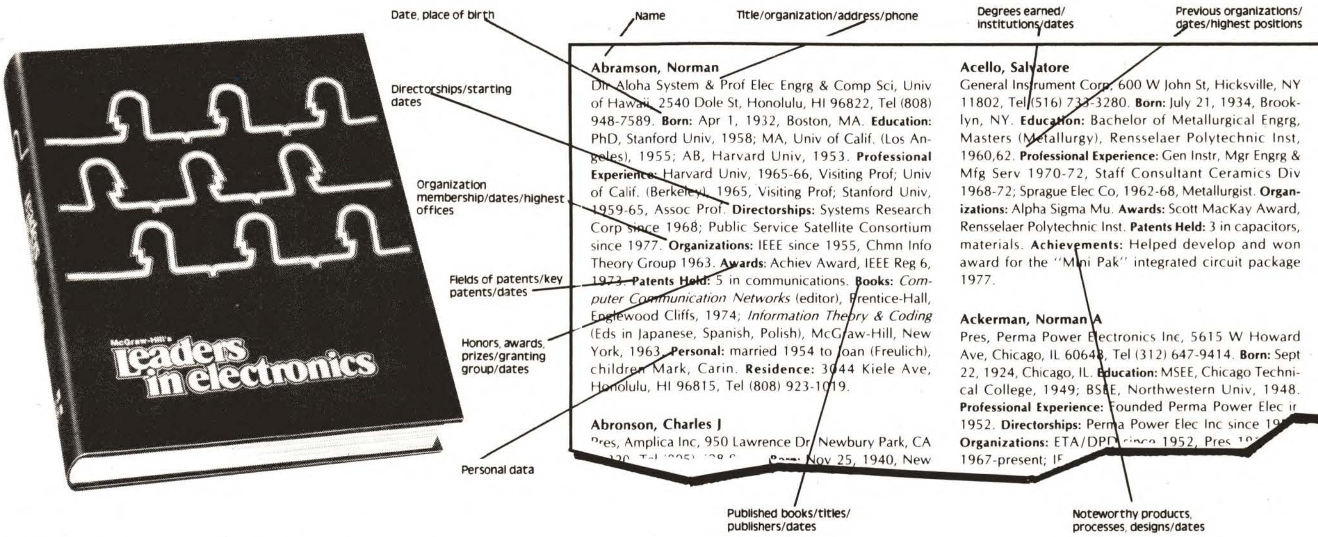

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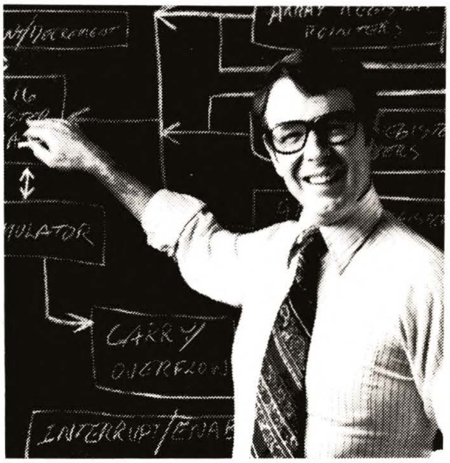

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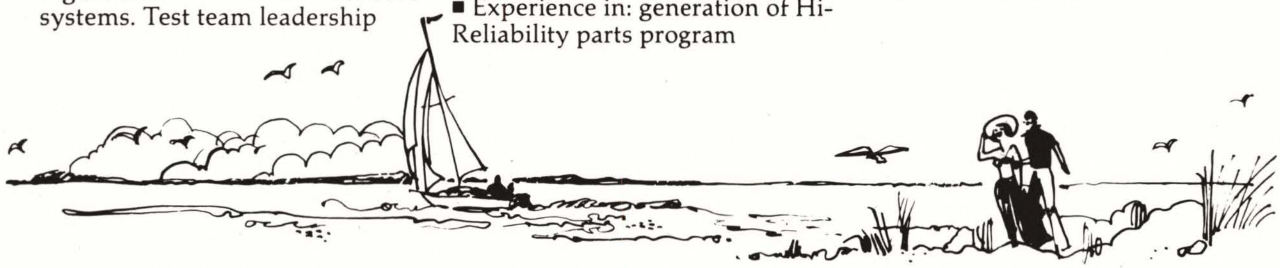

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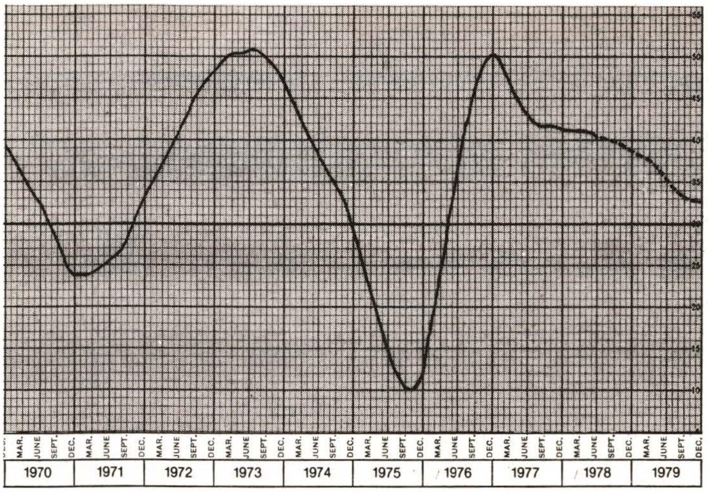
A 12/12 rate-of-change curve shows the percent change in the 12-month moving average or total — this year compared to one year ago — of any series of monthly or quarterly numbers. When it is above 100, whatever the curve is measuring — Industrial Production in this case — was better in the year just ending than one year earlier. *This is true even though the curve may be pointing down.* Projecting this curve, based on what has already happened to similar curves for leading indicators, we foresee Industrial Production gaining 4.3% in 1978 over 1977; 1.3% more in 1979; then rising steadily in the early 1980's.



This is a rate-of-change curve, sometimes called a "12/12 pressure" curve, based on the FRB's Index of Industrial Production. From a similar curve, based on your own new orders or shipments, you can make an accurate forecast of 1978 orders or shipments, and a good forecast for 1979.

CAN YOU MAKE A FORECAST FROM THIS CURVE?

More than 600 companies, including divisions of many of Fortune's 600, are forecasting new orders or shipments, or both, from rate-of-change curves like this. We have written a Forecast Manual that will show you how.

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- Second, by projecting the curve based on what *has already happened* to leading indicators, you can make highly accurate one-year forecasts, and reasonably accurate forecasts of two years out.
- Third, by plotting an industry curve on top of your own (assuming industry figures are available), you can see, visually, what is happening to your share of market — and what is likely to happen in the next year or two.

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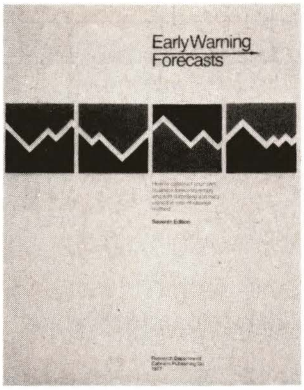

Early Warning Forecasts

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Looking Ahead: Trends and Forecasts

Bright future predicted for '80s solar-cell market

Propelled only by current applications, worldwide sales of solar cells (photovoltaics) by US firms could grow from last year's $11 million mark to a potential $500 to $750 million (in 1979 dollars) by the end of the 1980s, according to Strategies Unlimited, Mt View, CA. And although silicon photovoltaics are now only cost effective in areas where no power grid exists, opportunities for this promising alternative electric-power source will multiply during the next decade as prices continue to decrease and technology broadens.

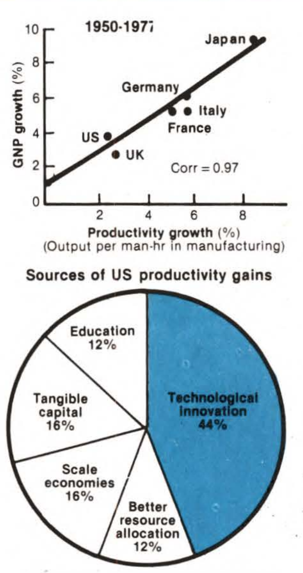
Four application areas, which now represent the bulk of current use, will continue to dominate the market for US firms through the late 1980s, Strategies Unlimited predicts. These usage categories include remote communications (30% of sales) — including battery-powered systems such as mountaintop repeaters and devices for the collection of precipitation and pollution data; low-level water pumping (10%) and rural electrification (major forces in market growth); and cathodic protection. The remainder of the market includes US-government purchases (40%), as well as uses in navigational aids and in consumer products.

Solar cells have already been successfully employed on the Navajo reservation in Sweetwater, AZ, to operate a 2400-peak-watt community water-pumping system and to furnish power for lights, a small refrigerator and a TV or radio in each of many widely scattered homes. Because solar-energy costs have been effectively halved in these systems since the first system was constructed nearly 2 yrs ago (declining from $20 per watt in 1977 to $15 per watt by late 1978, to between $7 and $10 per watt today), the Indian Health Service branch of the US Public Health Service has begun construction of 47 more community systems and 500 additional home systems.

But although the price gap between fossil-fuel energy and solar power is narrowing at a fairly rapid pace (and some solar-cell manufacturers hope to achieve within the next decade the $0.50- to $1-per-watt price range required for photovoltaics to be competitive with current energy grids), fuel prices must rise considerably before solar cells find widespread use.

Electronics' advances can boost productivity

Technological innovation in electronics can contribute strongly to future increases in productivity, and as a result, can also help to boost this country's gross national product (GNP), according to Charles N Clough, vice president of Texas Instruments Inc, Dallas.



SOURCE: TEXAS INSTRUMENTS INC

Technological innovation in turn has been greatly accelerated by digital-computing applications that make it possible to place computing power at the point of use—a development that Clough predicts will increase productivity in factories, laboratories and offices. Advances in semiconductor technology also have contributed to productivity gains.

In the industrial sector, pressures for improved productivity should accelerate spending for electronics, resulting in a possible doubling in the 1990s of the percentage of private investment in electronics.

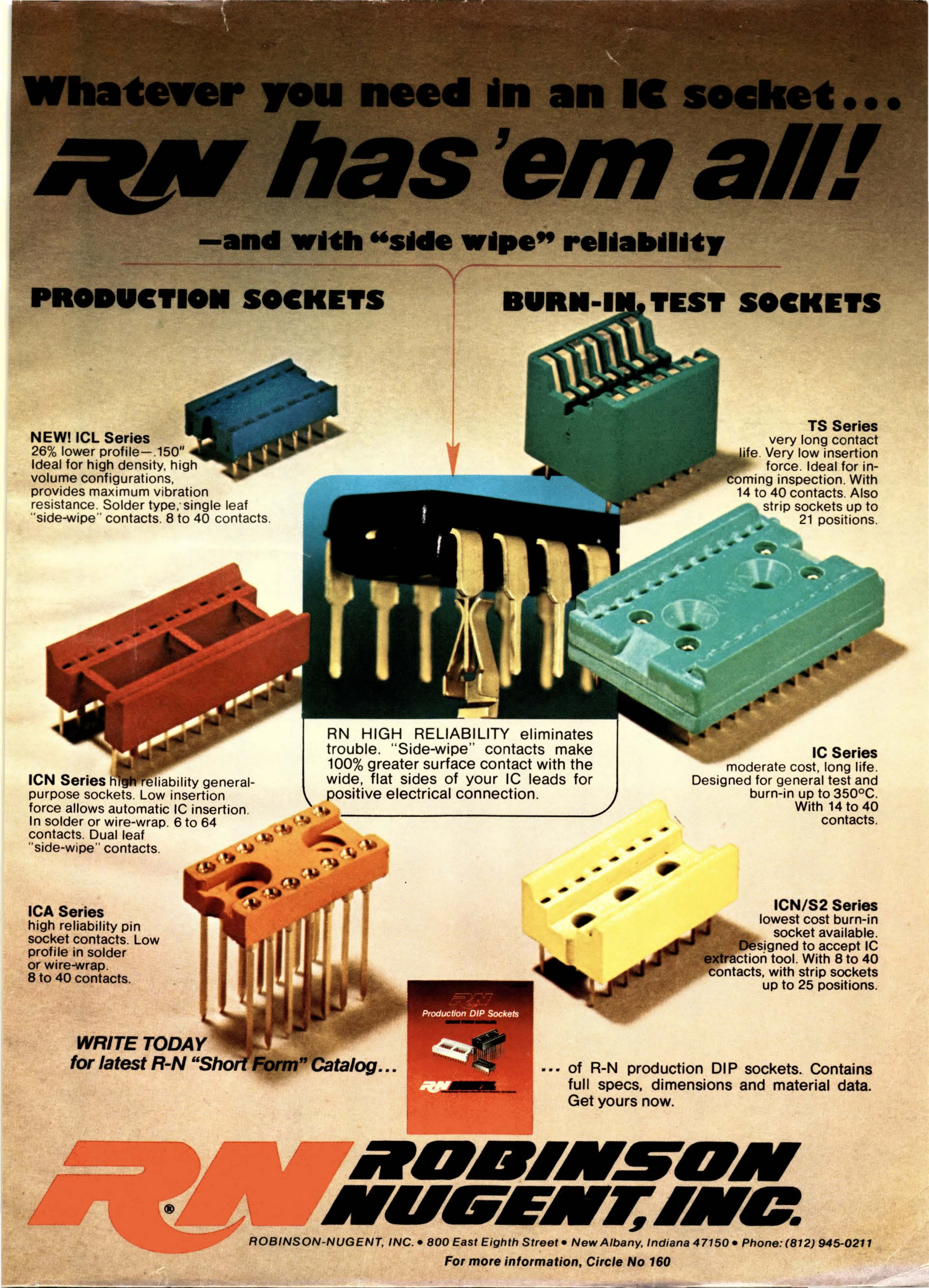
US micrographics sales to top $4.5B by 1988

US micrographics markets (both microfilm alone and data-processing linked) will grow 16% annually, topping the $4.5 billion mark by 1988, predicts Frost & Sullivan, New York.

Computer-output microfilm used for business records, along with general office micrographics, will both be fast-growth market areas, although engineering micrographics will lag, increasing 5 to 10% yearly.

Optical-microfilm storage technology will prevail over magnetic storage in mass-memory applications, Frost & Sullivan predicts. However, a customer backlash could develop against microfiche—now riding a wave of popularity—unless an engineering-system technique to store and retrieve the fiche is developed, the firm says.

Material for this page developed from *Electronic Business* magazine and other sources by Jesse Victor, Senior Copy Editor, and Joan Morrow, Production Editor.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