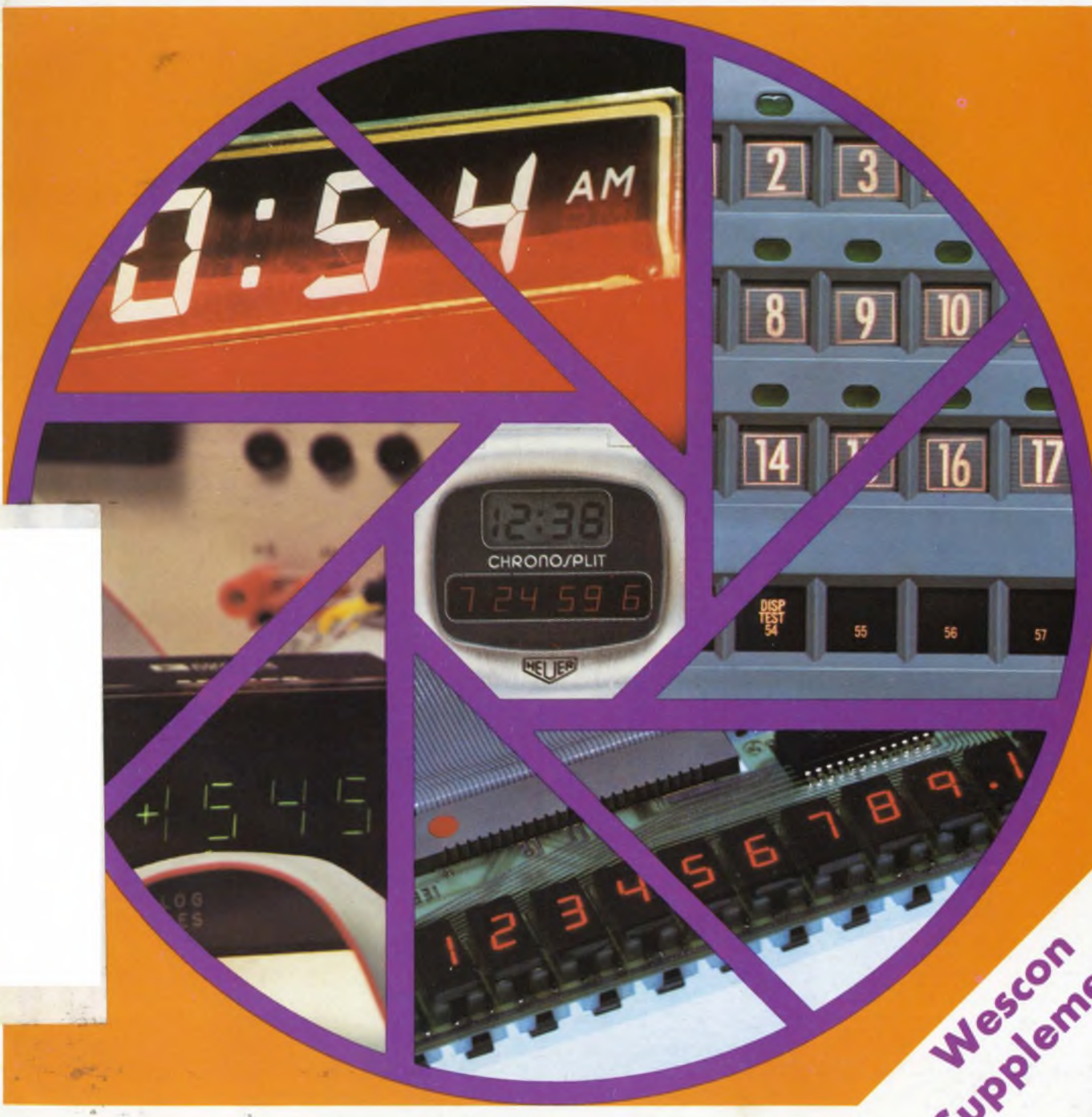
Electronic Design® 19

VOL. 23 NO. 19
FOR ENGINEERS AND ENGINEERING MANAGERS
SEPT. 13, 1975

The pervasiveness of displays has made proper selection more important than ever. But recent improvements in technology make the choice tougher. LEDs have become bigger, brighter and more pleasing to the eye, while LCDs have increased their switching speed and life expectancy. Shed light on the problems, see page 52.



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INFORMATION RETRIEVAL NUMBER 263

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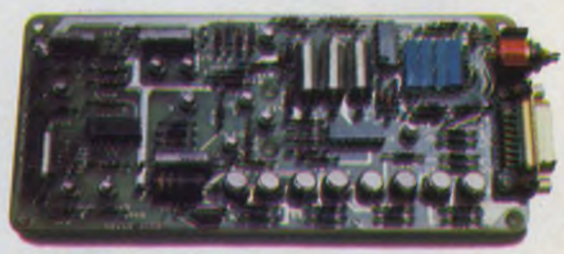

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NT 37C Torpedo
Courtesy of Northrop Corp.

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INFORMATION RETRIEVAL NUMBER 3

VOL. 23 NO.

Electronic Design 19

FOR ENGINEERS AND ENGINEERING MANAGERS

SEPT. 13, 1975

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Cover designed by Art Director, Bill Kelly, photographs courtesy of Analog Devices, Heuer, Industrial Electronic Engineers and RCA.

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INFORMATION RETRIEVAL NUMBER 4

Sr. Vice President, Publisher
Peter Coley

Editors
Editorial Offices
50 Essex St.
Rochelle Park, NJ 07662
(201) 843-0550
TWX: 710-990 5071
Cable: Haydenpubs Rochellepark

Editor-in-Chief George Rostky

Managing Editors:
Ralph Dobriner
Michael Elphick

Associate Editors:
Dave Bursky
Jules H. Gilder
Morris Grossman
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Contributing Editors:
Peter N. Budzilovich
Alberto Socolovsky
Nathan Sussman

Editorial Field Offices

East
Jim McDermott, Eastern Editor
P.O. Box 272
Easthampton, MA 01027
(413) 527-3632

West
David N. Kaye, Senior Western Editor
8939 S. Sepulveda Blvd.,
Suite 510
Los Angeles, CA 90045
(213) 641-6544
TWX: 1-910-328-7240

Editorial Production
Marjorie A. Duffy

Art
Art Director, William Kelly
Richard Luce
Anthony J. Fischetto

Production
Manager, Dollie S. Viebig
Helen De Polo
Anne Molfetas

Circulation
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Across the Desk

Further reflections on 'noble' electronics

My sensibilities were stunned by a letter from James Rieger in the May 10, 1975 issue (Parking-Meter Sensor Makes Him Blow Fuse," ED No. 10, p. 7). Here is a man who is anguished by the inhumane use of a Hall-effect device as a parking-meter sensor, and he says that "a less noble use of electronics is hardly imaginable."

If he would want to imagine a "less noble use of electronics," I suggest that he look into his own engineering files and those of his fellow engineers at the Naval Weapons Center, where some of the most fiendish weapons of mass destruction are devised with his beloved electronics.

David Wald
Staff Engineer
American Videonetics Corp.
795 Kifer Rd.
Sunnyvale, CA 94086

A kind word about the rotating UPS

Your May 10 issue concerning the multifaceted computer world was very good. I particularly enjoyed "Focus on Uninterruptible Power Supplies and Inverters," because we are developing equipment in this field. Your article seemed very comprehensive in the static inverter technique, but failed to mention other ways to do the job. Several manufacturers of rotating equipment supply UPS for the computer industry, and Precise Power Corp. is one of them.

Our system uses a new variable-speed, constant frequency generator with inherent flywheel energy storage. A simple induction motor drives the generator, whose output is crystal-controlled through low-density electronics for frequency stability of better than 0.025%. Voltage regulation is better than +5%. Energy storage times range from a few seconds to several minutes, with use of flywheels.

We can also clutch in a combustion engine to the mechanical shaft after a few seconds to provide UPS indefinitely, if required. Thus we would have an engine-generator on line within seconds, without any change in output. A well-designed static UPS requires a backup engine generator (beyond battery capability). The Precise Power system eliminates the batteries, battery charger, inverters and filters. An induction motor, a clutch and a small electronic controller replace these.

Because all of the power to the computer is derived through the shaft, the UPS is an absolute line-isolation system. The system can also be designed as a frequency converter (we have 60-to-400-Hz units) and as a phase converter, to make three-phase power output available with single-phase input while the inherent UPS requirement is supplied.

Ninety per cent of the usual power line interruptions last less than two seconds, but battery systems are designed for five minutes to an hour. They can't be designed for shorter durations, due to limitations on allowable rates of discharge. Flywheels are not rate-limited; so they can be designed for optimum energy storage. Besides eliminating batteries, the Precise Power system can be designed for three-phase output from a single machine. This means that the price can be reduced to one-

(continued on page 11)

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

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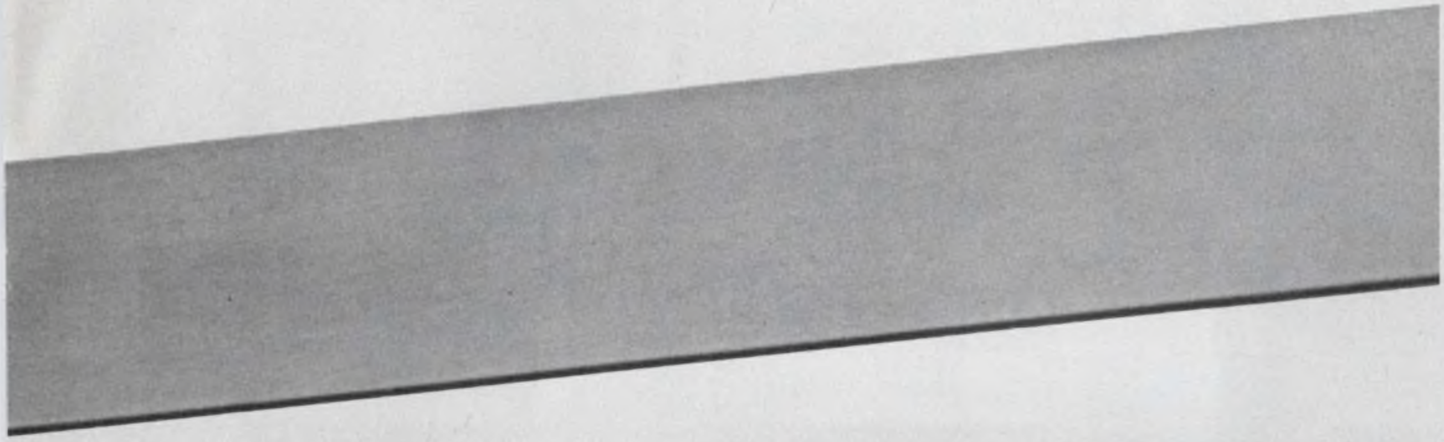

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It doesn't figure to spend your time designing a custom RF amplifier. TRW has already done it for you, and is now mass producing them with off-the-shelf delivery, applications assistance, unmatched performance and reliability. Curious? Check the specs on the three typical parts below and then send for a complete file on TRW's design time eliminators.

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Bandwidth	10-400 MHz	10-350 MHz	5-150 MHz
Gain	17 db	33 db	18 db
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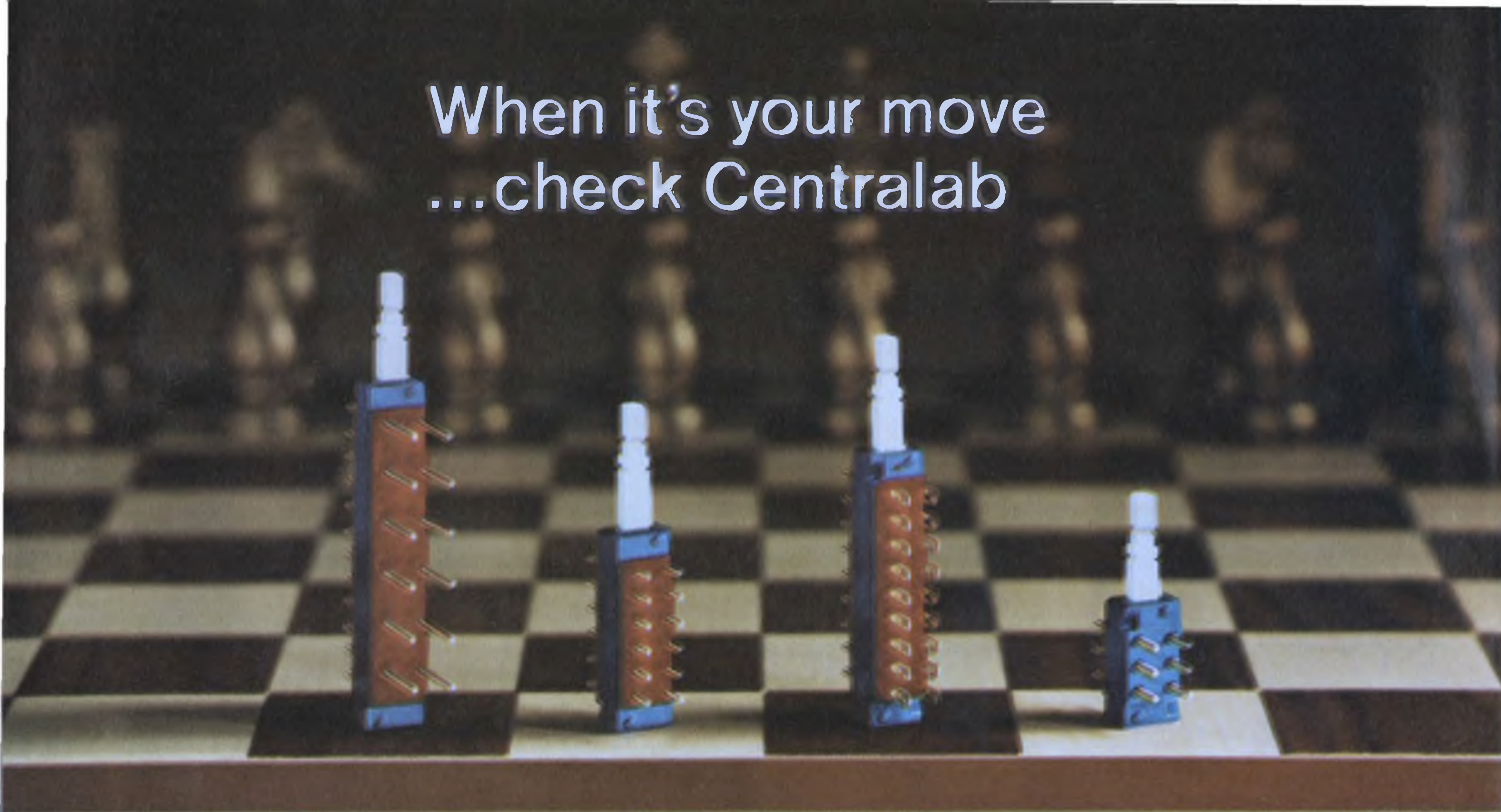
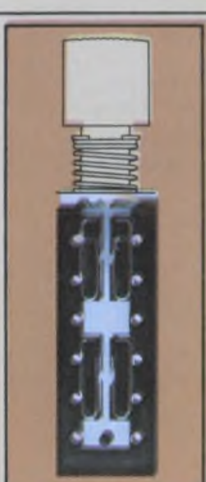


Best pushbutton switch for your board

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

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



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

Centralab pushbutton switches meet these demanding specifications:

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

Dielectric strength: 1,500 volts.

Contact resistance: .004 ohms.

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

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

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

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

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

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

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

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

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INFORMATION RETRIEVAL NUMBER 8

(continued from page 7)

half that of solid-state inverters.

Finally, the combination of rotating machinery for high-power output and solid-state controls at low-power densities provides promise of high reliability.

A kind word about rotating-machinery UPS devices would be appreciated.

R. T. Morash
Mechanical Engineer
Precise Power Corp.
P.O. Box 1905
Bradenton, FL 33506

Ed note: To keep the article within reasonable bounds, we limited discussion exclusively to solid-state UPS systems.

Misplaced Caption Dept.

"I can type and do wire bonding and die attach."

Sorry. That's Pierre-Auguste Renoir's "Young Woman Against a Blue Background," which hangs in the Henri Bernstein collection in Paris.

About that misplaced 'misplaced caption'

Some detractors say that engineers are Philistines, too wrapped up in numbers and "things" to appreciate beauty. ELECTRONIC DESIGN has proof positive that this simply is not true. A freshet of letters has cascaded into the editor's office to point out that a great work of art was mislabeled in the July 19, 1975 issue (ED No. 15, "Misplaced Caption Dept.," p. 10). The picture displayed, as many readers point out, is not Edouard Manet's "Lunch on the Grass."

One reader said that it was "The Gleaners" and suggested timidly: "Corot?" Most identified it correctly without hesitation: "The Gleaners," by Jean François Millet. It hangs in the Louvre in Paris.

The misplaced "misplaced caption" was one of those rare printer's errors in which the three lines of type were rerun after having been publishd in the May 24 issue (ED No. 11, p. 16).

It's nice to know there are so many art lovers out there.

A different language

Tom Nawalinski of Hewlett-Packard reports that recent world developments are making him consider the advisability of studying Arabic. He's concerned, though, with the numbering system which, he understands, is very complex.

VCO for music rings a bell

Idea for Design "Voltage-Controlled Music Oscillator Has Linear Properties" (ED No. 5, March 1, 1975, p. 66) will probably result in a small collection of letters saying, "There's a better way!" Mr. Berkowitz has made it easier to use an 8038—very attractive for electronic music—though some people have had trouble making it work well. However, electronic-music enthusiasts are fond of nonlinear VCOs. Bob Moog found out a long time ago that an exponential frequency-vs-voltage characteristic is more versatile. A scale factor of 1 V per octave has become a "standard."

Thus modern electronic music VCOs have no need for range switches to cover the audio range. Also, different control voltages can be summed at the VCO's inputs

(continued on page 14)

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the second of a low cost high performance microprocessor family

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WESTERN REGION—MOS Technology, Inc., 2172 DuPont Dr., Suite 221, Patio Bldg., Newport Beach, Calif., 92660 (714) 833-1600

INFORMATION RETRIEVAL NUMBER 10

(continued from page 11)
without upsetting the musical scale, which is a big advantage.

On a studio synthesizer, you can thus tune any key on the keyboard to any frequency within a range of several octaves, and the oscillator can still provide a complete musical scale. This can't be done with a linear VCO without an antilog circuit, like that in National Semi's Linear Application Note AN-30.

Nicholas Bodley
Technical Consultant
Electronic Music
300 W. 108th St.
New York, NY 10025

Sine-wave circuit 'put in perspective'

Your "International Technology" section (ED 13, June 21, 1975, p. 104) featured an interesting circuit principle for doubling an input sine wave and providing a sine wave output.

But just to put things in perspective, this circuit concept is based on the trigonometric identity (the haversine) $\sin^2 (1/2\ \omega t) = 1/2\ (1 - \cos \omega t)$. The $i_2\ I_2$ term in the article serves to cancel the offset term in the haversine identity. This same result can be achieved with an analog multiplier. If the multiplier has the transfer function XY/10, simply tie X and Y together, put $\sin (1/2\ \omega t)$ in and out comes $1/2\ (1 - \cos \omega t)$. You can ac-couple or offset and scale, as you desire.

These multipliers are available in either IC or modular form. Intronics offers a complete line that range in accuracy to 0.05% and in frequency to megahertz.

In addition we offer a module that computes $Z = \sqrt{X^2 + Y^2}$, so the equation that was implemented in the article $(i_0 \doteq \sqrt{i_2^2 - i_1^2})$ can be implemented directly by an available low-cost module.

Bucky Crowley
Senior Engineer
Intronics
57 Chapel St.
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Now You Can Record Data On 70mm Film From 4600 Line CRT With CELCO's DSC-III Photo Recorder.

Everything you need for data recording is here for you to start producing high-resolution photographs on 70mm film. Right now! Our Photo Recorder is fully integrated to accept digital and/or analogue inputs. All the necessary power supplies, electronics, and logic are included to operate this self-contained system.

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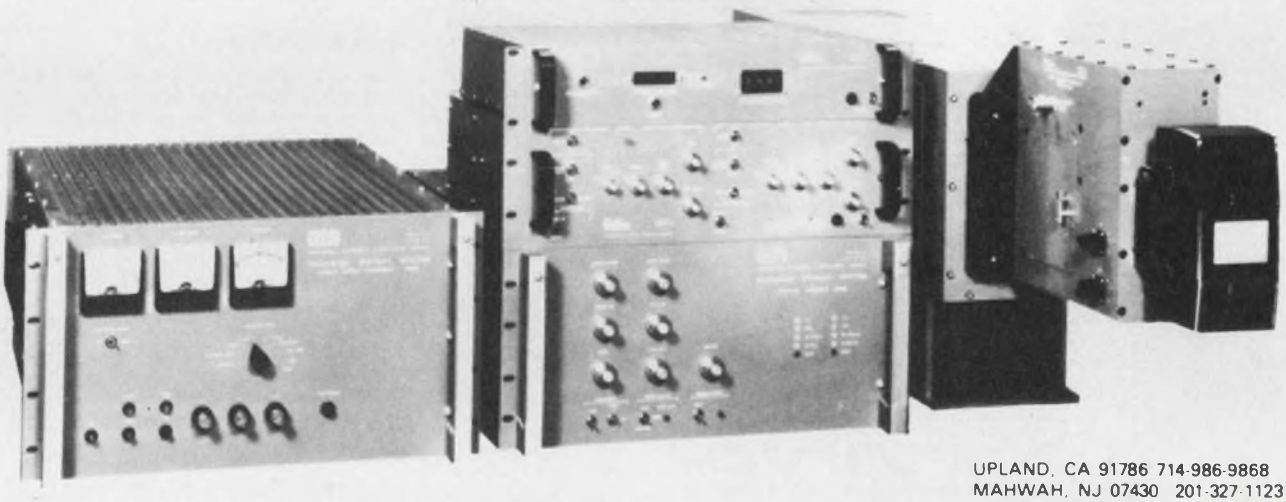

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INFORMATION RETRIEVAL NUMBER 13

SEPTEMBER 13, 1975

Electron-beam system cuts IC-mask production time

A major advance in commercializing electron beam lithography has been announced by Bell Laboratories, Murray Hill, NJ, where researchers have developed a production-oriented electron beam exposure system.

According to Donald Herriott, head of lithographic systems development for Bell Labs, the new system, known as EBES, can produce IC master pattern masks at half the cost of currently used photolithographic techniques. He also points out that the EBES masks can be made faster and with fewer defects.

Describing the system, Herriott notes that it uses an electron beam that is deflected over a field only 1/8 mm on each side. This compares with a deflection of several millimeters generally used in research electron beam machines.

Because it deflects over such a small area, the new system eliminates many problems commonly found in such devices, namely aberations, resolution, beam brightness and speed of deflection.

In addition, the Bell device uses a raster scan to write information, thus requiring the same amount of time to make any mask, regardless of its complexity. The scanning technique, combined with a moving table on which the mask blank is mounted, makes it possible to write a 128 μ-wide stripe at a rate of 2 cm/sec. This, says Herriott, makes it possible to produce a mask for a 3-in. wafer in an hour or less. When compared with the multistep process used to make an optical mask, which could take several hours, it is a significant improvement.

The electron beam system, Herriott reports, can go directly from computer-aided design to final mask. And, he continues, by eliminating the intermediate steps needed by optical techniques, the EBES system can result in greater throughput with a fourth as many people.

Unlike other electron-beam machines, which write one device at a time, the Bell unit breaks up the device to be written into an array of 1/2 μ-squares and writes one line at a time in every device on the wafer. Then the next line pattern is entered into memory and is written in every device until the entire array has been written.

Commenting on yield, Herriott points out that each of the three steps required for the optical approach result in a 50% yield, while the electron-beam approach consistently has a yield of well over 50% and more commonly 75%.

Magnetic monopole may be discovery of century

A particle described as the basic unit of magnetism has been detected that if captured and controlled could have a major impact on science and technology. "The find could rank as one of the major scientific events of the century," according to the American Institute of Physics in New York.

Responsible for the observations are research teams from the University of California in Berkeley and the University of Houston.

The reported particle—called a monopole because it consists of a single charge or pole rather than two—has a role in magnetism comparable to the electron in electricity. It is said to be much heavier than a proton and have a magnetic charge far stronger than the electrical charge of an electron.

Because of its strong magnetism the particle could respond readily to an electric field and thus could be an efficient source of energy. If enough of the particles could be captured and held in one place, the effect of the earth's magnetic field on the monopole group could propel a ship across the ocean.

Even if one of the particles were captured it could probably be used to make others.

Control of the particles could also result in more powerful particle accelerators than those that now exist. A monopole accelerator six feet long would surpass in energy a circular accelerator of the present type a half mile long. Extremely small and efficient motors and generators could be built. And new cancer therapies might result by guiding monopoles to destroy tumors in the body while doing far less damage to healthy cells than present radiation therapy.

The evidence that monopoles were, in fact, detected was a series of conical shapes, or tracks, made on a detector that consisted of plastic sheets, photographic emulsion and film that was carried on a balloon 130,000 feet above Iowa in a cosmic-ray experiment in 1973. Numerous cosmic-ray tracks, as usual, were found in the emulsion, during nearly two years of microscopic examination by the cosmic-ray group. The Berkeley group then studied the plastic sheets in their search for other particles.

One unusual track was discovered in all parts of the detector, caused, it was believed, by a magnetic monopole with a mass more than 200 times greater than the mass of a proton and traveling at roughly half the speed of light. The magnetic pole strength of the particle was found, as predicted by British physicist P. A. M. Dirac in 1931, to be so strong that the force between two monopoles would be over 18,000 times greater than the force between two electrons placed equal distances apart.

Micros future rosy for analytical instruments

"By 1982, 65% of all the analytical instruments sold in the U.S. will incorporate microprocessors," says Lynwood Eikrem, director of programs for Darling & Alsobrook, a Los Angeles-based management consulting firm.

Eikrem points out that the U.S.

market for analytical instruments in 1982 will be about $1.32-billion, up from $0.5-billion in 1975. He feels that the trend in equipment redesigns for the immediate future will be directed toward the special purpose or functional instrument. This instrument will be highly automated with microprocessors and designed to meet a heavy duty-cycle or continuous operation demand with up-time well in excess of 90%.

"For scientific instruments," he points out, "one of the microprocessor's most important functions is control of the instrument itself, replacing expensive relay logic and increasing the automation aspect and safety features. This permits the use of nontechnical personnel, while actually decreasing the probability of error. Error rate will be further decreased when the microprocessor is extended to automatic calibration and standardization, and eventually into artificial test and diagnostic troubleshooting routines."

In some applications, he predicts, using a microprocessor within the instrument to calculate and automatically apply error correction—to compensate, for example, for temperature/pressure variations or instrument drift—will be much less costly than other schemes to control those parameters.

Coherent rf energy beam easily melts ceramics

A new kind of coherent, laser-like radiation concentrates kilowatts of 13.56 MHz rf energy into a thin, pencil beam capable of easily melting high-temperature refractory materials.

Called the Energy Beam by its inventor, Thomas E. Fairbairn vice president of R&D for Energystics, Inc., Toledo, OH, its immediate use is expected in industrial heating and fabricating processes such as brazing, welding and hole drilling. But Fairbairn sees it eventually used to modulate megawatt lasers for long-range space communications and in industrial applications.

The source of the Energy Beam is a 13.56-MHz industrial rf generator, Fairbairn explains. The output of the generator is few to an output matching network where the rf energy is drawn off of a special copper-tubing tank coil at a high-voltage point.

The rf output is applied to a three-element, coaxial nozzle that is attached to the end of a section of the copper tubing. The nozzle has a central molybdenum electrode which is surrounded by a cylindrical copper sheath. The copper, in turn, is surrounded by an outside metal or ceramic cylinder. The rf is fed to the central electrode.

Gases—helium, argon, nitrogen, and even air—are pumped through the tank coil and the nozzle and a two-layer coaxial laminated flow is established.

"Some of the rf energy," says Thomas J. Sheperak, president of Energystics, "ionizes the gas that forms the coaxial sheath around the center electrode, and some energy is used to ionize a small column of gas that the rf rides on inside the ionized conduit.

"The rf energy at 13.56 MHz is conducted through this coaxial flow of gas directly to a target material," Sheperak points out.

The effect of the beam varies with both beam power and also with the target material. For example, with 1-kW input the beam melts most metals, according to Sheperak, while at higher inputs—in the order of 5 kW—it has melted ceramics with melting points between 3000 and 6500 F.

Temperatures outside the nozzle orifice are in the order of 100 to 200 F while temperatures at the target to which the beam is directed have been estimated to be as high as 35,000 F.

The effectiveness of the Energy Beam, according to inventor Fairbairn, is dependent upon the coherent rf energy reacting with nuclear magnetic resonant structure of the target material.

It creates intense molecular vibration, producing heat, much like the effect that microwave and industrial ovens have on materials irradiated by their rf energy. However, in the Energy Beam, the energy is concentrated in a tiny area, thus producing exceptionally high energy density, similar to that in lasers.

A substantial difference between the Energy Beam and the laser, Fairbairn points out, is in efficiency. While that of lasers is only a few per cent, that of the Energy Beam is 75% and higher.

YIG switch to handle high power radar pulse

A microwave switch that can successfully handle the high peak-power generated by radars has been developed by the Harry Diamond Laboratories, Adelphi, MD.

The switch operates in the J-band, and is made of yttrium iron garnet. It has a high peak-power handling capacity of 40 kW and is packaged in a waveguide 1.75 inches long.

The switch, designed to protect a mapping radar receiver during the high-power transmit pulse, incorporates the YIG in an absorption modulator waveguide configuration, according to Frank Reggia, research and electronic engineer at the Laboratories.

"The YIG was the only type of device that could handle the high power," says Reggia. "We looked at diodes, but the best power handling capability we might get, even with a development program would be about 2 kW. And ferrite materials we examined weren't satisfactory because they become nonlinear above a few kilowatts of impressed power."

YIG switches developed during the program showed an insertion loss of less than 0.5 dB and an isolation greater than 25 dB in the 15-to-17-GHz band, Reggia points out.

In addition to the small size, the Diamond Laboratories switch has other advantages, Reggia notes, including a magnetic control field of less than 50 Oe and a capability of operating at temperatures in excess of 100 C.

This high temperature operation is necessary, Reggia explains, because in the absorption mode the switch must dissipate the power that it is blocking.

Early models of the device had switching times of less than 100 μs, Reggia says. But he points out that the intrinsic response time of the YIG type material is less than 15 ns. And in the Diamond Laboratories program speeds better than 1 μs were achieved with later devices, though they did not have 40 kW power capability.

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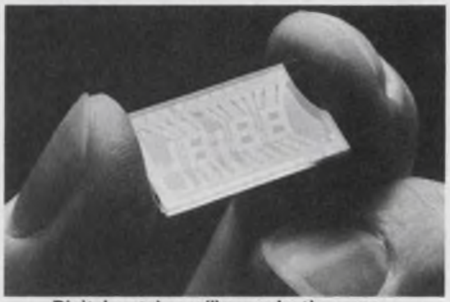

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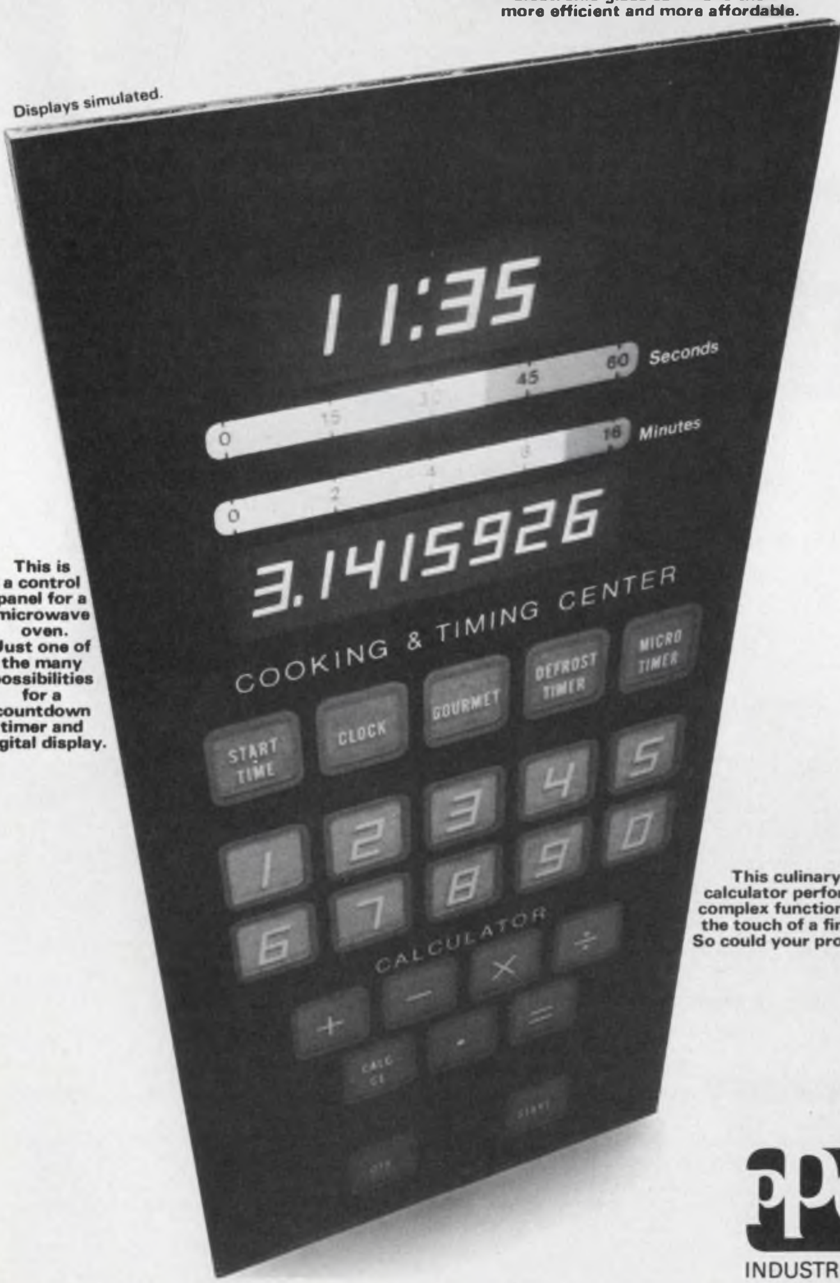

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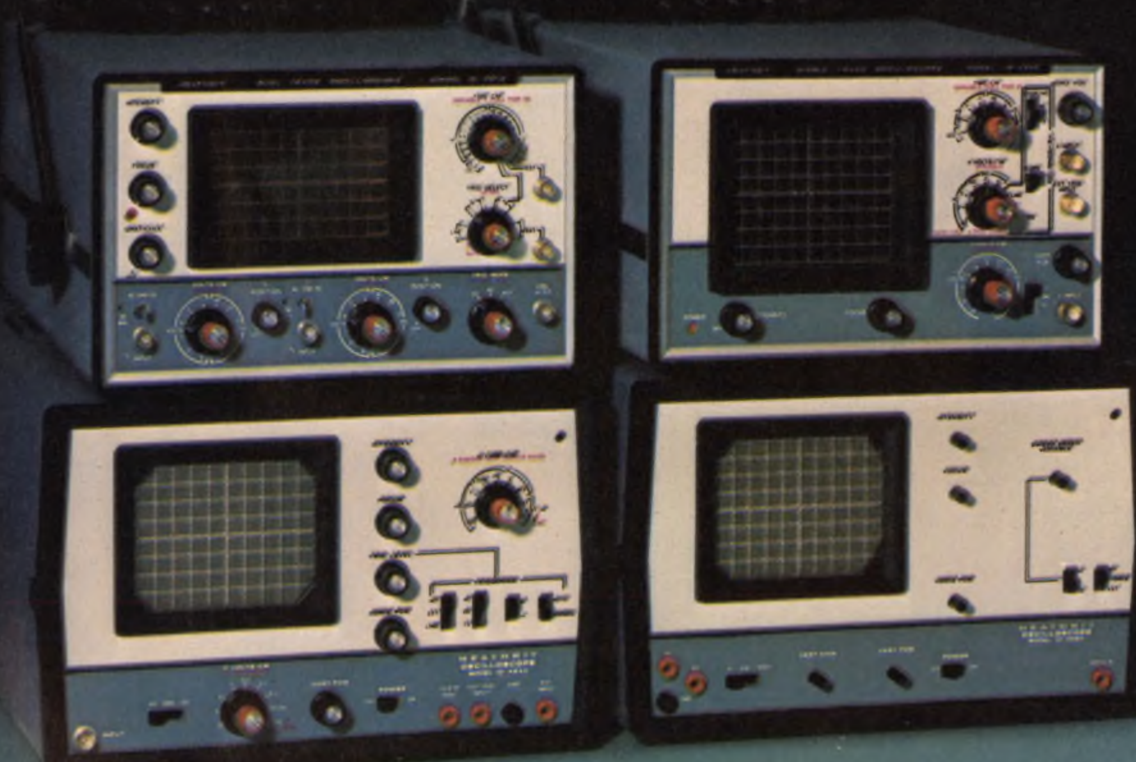

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Fig. 1

Fig. 2

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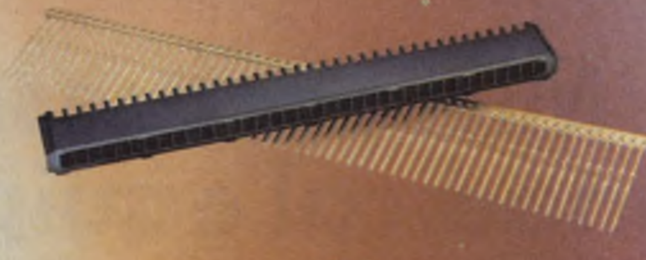

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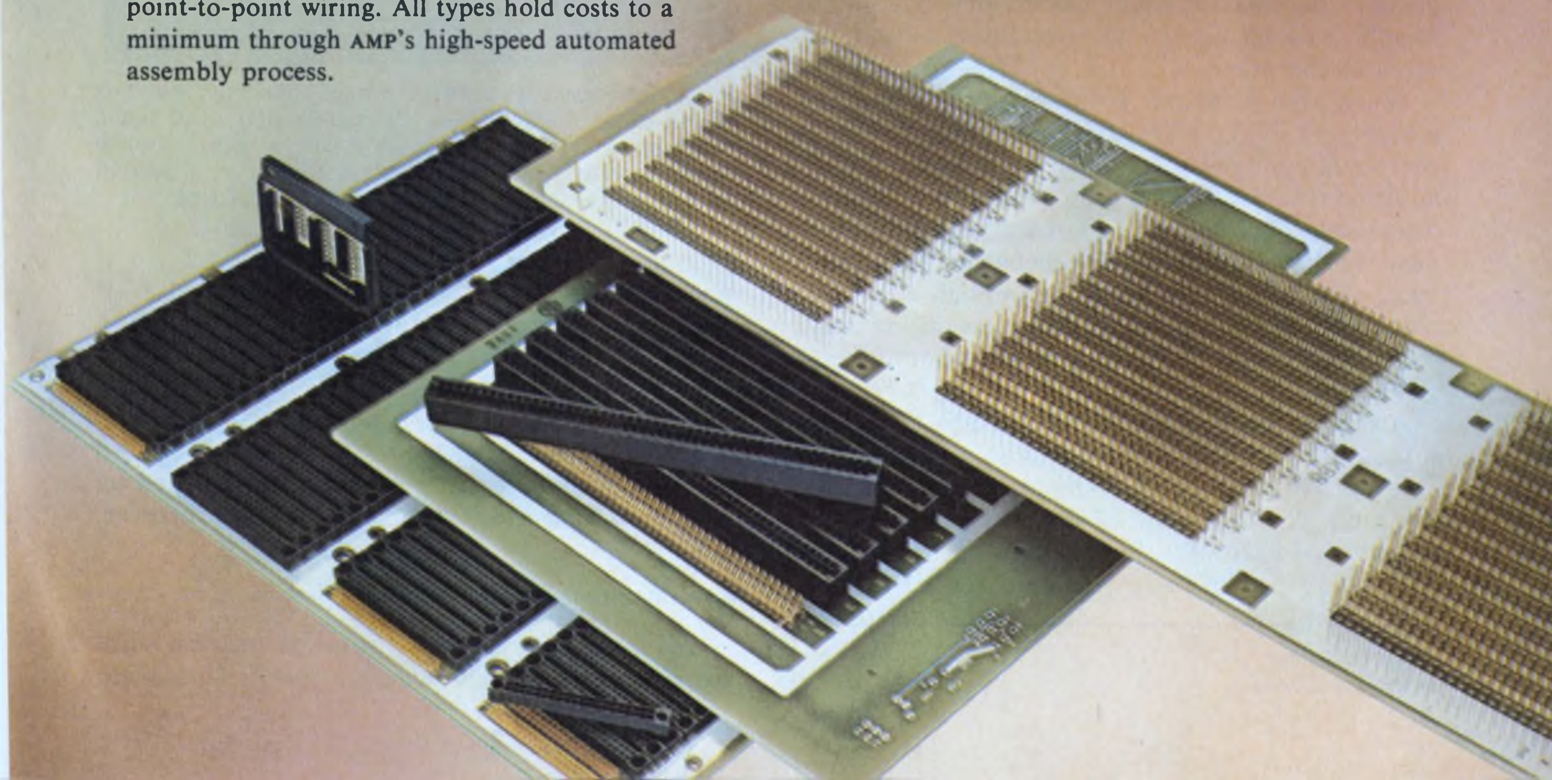


WESCON SPECIAL

Microprocessors making medical equipment 'smart'

With microprocessors invading everything from computer terminals to pinball machines it's not surprising that designers of medical electronic equipment are considering making their equipment smarter by including these computer chips.

What steps are required to incorporate micros into a piece of medical gear, how to use them and when to use them are discussed in Session 24, "Microprocessors in Medical Instrumentation," at the Western Electronic Show and Convention in San Francisco.

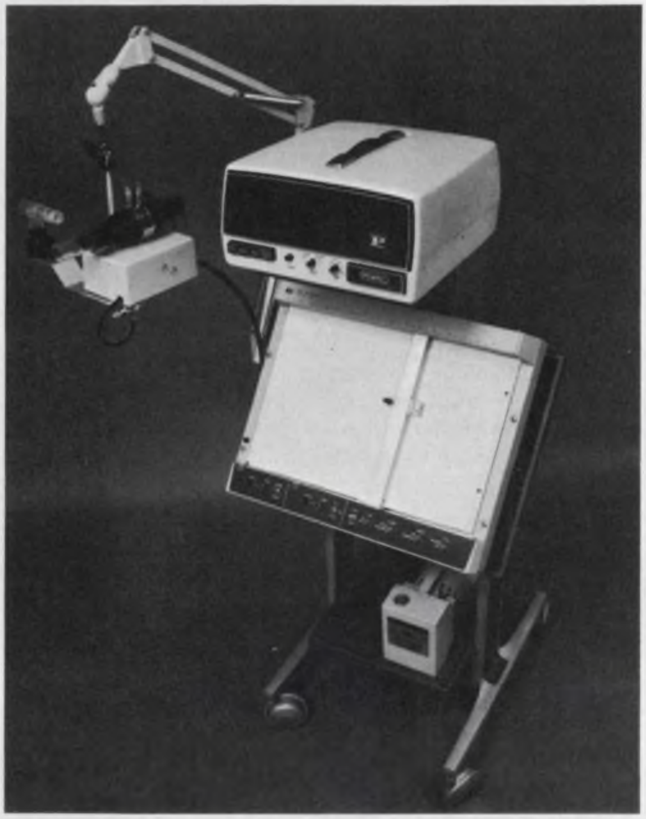
Paul Mitzen, an engineer from Beckman Instruments' Advanced Technology Operation in Anaheim, CA, points out that microprocessors are changing the design engineer's task. In the past, he notes, an engineer had to design a complete system to a spec.

But with the advent of the microprocessor, he no longer has to design hardware to take care of all the computational algorithms; that's done in software. And a lot of the mundane sequential control of the instrument is being taken over by the micro, too. Thus 90% of the actual hardware design, reports Mitzen, has been reduced to simply interfacing the various input/output devices to the processor.

Since the software is now taking over the major part of the work that hardware used to do the equipment designer is now faced with some additional tasks that he didn't run across before. Previously, most of the design techniques he used dealt with what hardware can be put in for the least amount of money to accomplish the task. Now, says Mitzen, the designer must decide what can be done best in hardware and what in software.

An illustration of the problem, notes Mitzen, is a piece of equipment that contains a multiplexed display. The engineer now has to decide whether the multiplexing should be done by the micro, or by external hardware. Some of the considerations involved, he points out, are does the CPU have enough time to do the multiplexing? And is it going to cost more for the extra ROM required to do the multiplexing than it would for the external logic?

Jules H. Gilder
Associate Editor



A microprocessor is used in a new pulmonary function tester called REMAC from Puritan-Bennett. The micro processes input data, compares it with standard normal values stored in ROM and displays results as a percent of normal. It replaces manually operated systems.

Another result of the inclusion of a micro, Mitzen says, is that there isn't as much of a need for test circuits. Testing can be accomplished by simply writing a test program for the processor.

Several problems encountered

The actual design of a piece of medical electronic equipment and some of the problems en-

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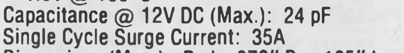

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Capacitance @ 12V DC (Max.): 15 pfd
Single Cycle Surge Current: 10A
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Leads .031" D x 1.25" L

Types: 3FF30, 3FF40 & 3FF50 *(Trr 30ns)*
PIV: 300, 400 & 500V
Reverse Current (Max.): 5μA @ 25°C
Instantaneous Forward Voltage @ 1A: 1.5V @ 25°C
Capacitance @ 12V DC: 20 pF
Single Cycle Surge Current: 25A
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Leads .040" D x 1.10" L

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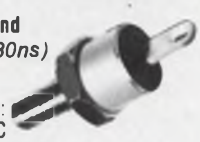

PIV: 50, 100 & 150V
Reverse Current (Max.) IR: 10 & *20μA DC @ 25°C
Instantaneous Forward Voltage:
VF @ 10A DC: 1.1V @ 25°C
*VF @ 20A DC: 1.2V @ 25°C
Single Cycle Surge Current: 125 & *250A
Dimensions (Max.): Body .424" D x .405" H

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Reverse Current (Max.): IR @ PIV: 10μA DC @ 25°C
Instantaneous Forward Voltage VF @ 10A: 1.1V @ 25°C
Single Cycle Surge Current: 125A
Dimensions (Max.): Body .424" D x .405" H

LO-V$_F$ DO-5L Stud

Types: STFF05, 10 & 15 *(Trr 40ns)*
Add "R" to type number for reverse polarity

PIV: 50, 100 & 150V
IR (Max.) @ PIV:
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@ 100°C 3mA
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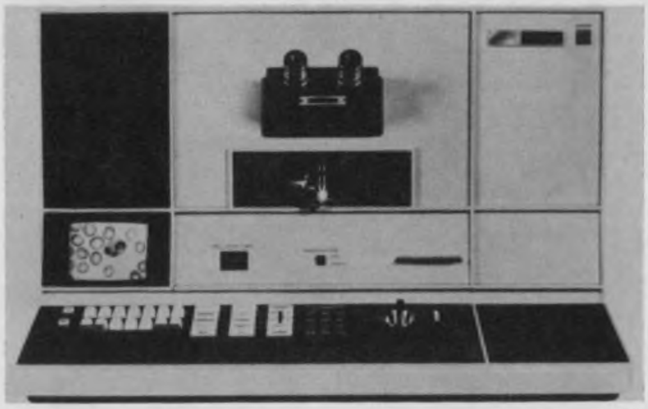

The ACS 1000 from Honeywell combines a microprocessor, color television and a microscope to produce a machine that will do differential white blood cell counts.

countered are described in the second paper, "Consideration in Designing a Microprocessor into a Commercial Medical Instrument." Randolph S. Carlson, another Beckman engineer, notes that the functional, environmental and reliability requirements applicable to medical equipment affects the way micros are used.

Medical equipment is generally calibrated a lot more than other types of equipment. For example, Carlson says, blood gas analyzers are calibrated before and after each measurement. So, he goes on, if a system that makes calibration automatic can be designed—and it can with a micro—operation of the instrument can be made a lot simpler.

One of the biggest problems in designing medical equipment is allowing for changes in line voltages and emi.. Hospitals are notorious for their poor power lines. It is best not to use the power line to derive timing signals, he points out. The reason is that the voltage looks like a sine wave only some of the time. And, it is not uncommon to find 2000 and 3000-V spikes on the line. Sure, he continues, you can stick gigantic filters across the line and extract the 60 Hz signal, but it just may wind up costing you more than putting in a crystal oscillator. Also, the time the equipment will probably be needed most is when the power fails and the emergency generator is producing a signal that varies between 47 and 63 Hz.

But, problems don't only crop up in the design of microprocessor-based medical equipment, says Carlson. Testing is also a big problem. Conventional analyzers, for example, consist of a sensor, an amplifier and a meter. So, when the machine is calibrated with a known sample, the operator in effect is checking out all of the circuitry.

With microprocessor equipment however, calibration won't always check out the whole machine. This is particularly true if part of a stored table is used in the sample mode and not in the calibration mode. All the locations of the memory must be checked. In the analyzer Beckman designed, which has yet to be announced, this is done by adding up all of the memory bits and combining it with a control word. The sum of the memory contents and the control word must be zero, or a warning light comes on. This check is made everytime the microprocessor starts to operate.

Microprocessor instruments abound

The Beckman blood gas analyzer is not the only piece of medical equipment to use micros, says Erich Pfeiffer, chief of the Biomedical Engineering Section at the VA Hospital, Sepulveda CA. In his paper, "Potential Applications of Microprocessors in Medical Instrumentation," Pfeiffer points out that there are already many pieces of equipment that use micros out on the market.

One is an automated drug detector known as Olfax from Universal Monitor Corp., Pasadena, CA. It is particularly helpful, he says, for overdose cases where physicians have to quickly determine what drug is involved. It uses a mass spectrometer and an Intel 8008 processor to check blood samples for specific drugs, according to the program card inserted. In addition to identifying the drugs, the machine prints out a confidence index which indicates the probability that its analysis is correct.

An 8008 microprocessor is also used in an automated computerized scanning system for hematological studies that was developed by Honeywell Medical Systems Center, Hopkins, MN. This system, Pfeiffer notes, does differential white blood cell counts. While there are many devices currently available that count white blood cells, he points out, none until now could break them down into subgroups and do differential counts. But by combining a microscope, color television monitor and a microprocessor, Honeywell's ACS 1000 can automatically locate a cell, focus in on it and allow the operator to push a button identifying it.

A less specialized piece of equipment, says Pfeiffer, is REMAC—a respiratory measurement and comparison system from Puritan-Bennett of Kansas City, MO. The REMAC, he continues, is used to perform a respiratory function test. A patient breaths into the device and it performs certain calculations and measurements. The results for a patient of a specific sex, age, weight and height are then compared with standard values stored in ROM. The measured values are then displayed as a percentage of normal. This unit uses a 4-bit microprocessor, says Pfeiffer. ■■

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WESCON SPECIAL

IEEE standard found weak for instrument interfacing

You want to give a test instrument the capability of operating with other instruments in an automatically controlled environment, so you consult IEEE Standard 488. Are your problems ended? They may only be starting in earnest, according to speakers at Wescon's Session 3, "Instrument Interfacing with the IEEE Standard Bus."

The problems, they say, arise not from what the spec includes but rather what is omitted. For example, Tom Coates, development engineer for Hewlett-Packard, Santa Clara, CA, points out in his paper, "Interfacing to the Interface: Practical Considerations Beyond the Scope of IEEE Standard 488," that while the standard itself details how to send information from one point to another, it doesn't tell the designer what the information is or in what format to send it.

Coates, designer of the instrument interface for the HP 5341 microwave counter, says that while Standard 488 covers the first interface—how to send an 8-bit byte from a controller to an instrument—it places no limits on how many bytes can be sent or on the order in which they are sent.

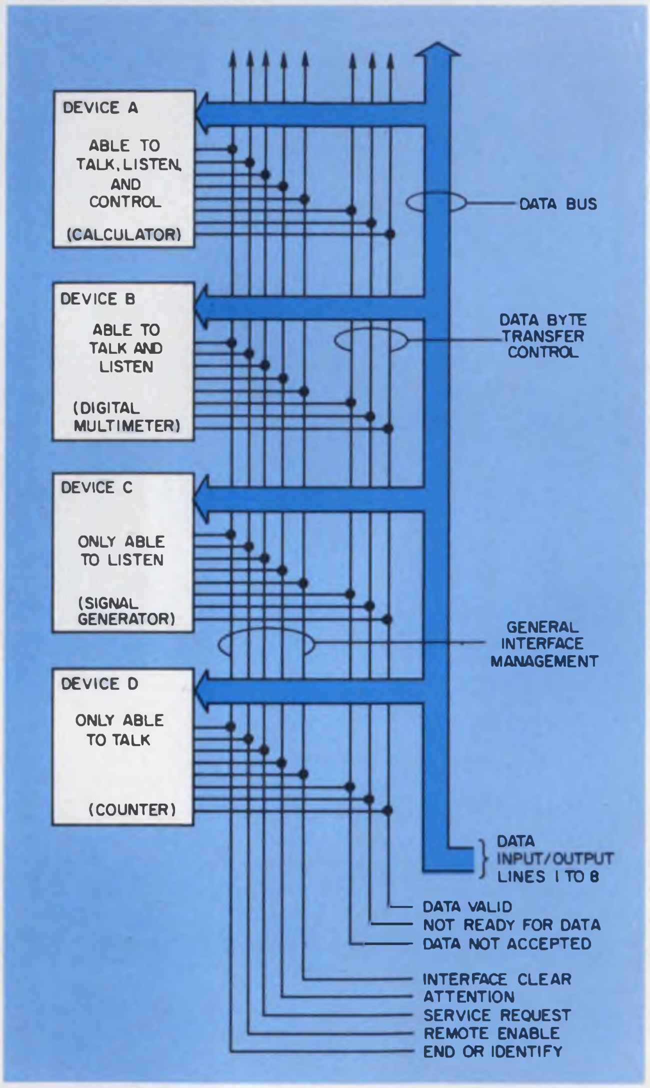
What Coates defines as a "secondary interface," unique to an instrument and placed in it, determines the organization of such data. But this secondary interface is not defined in the 488 standard, Coates points out. And the designer may not discover this until he gets deeply involved in using the standard, he notes.

Others in the industry, he says, have also pointed out the lack of such a secondary-interface standard and have indicated a need for it.

The secondary interface acts as an interpreter of the bytes coming off the IEEE 488 standard bus, Coates explains, serving to translate the incoming bits into a language that can control a particular instrument.

"For example," he says, "if the instrument interface sees an 'R 6,' it may say, 'Set the range switch to position 6.' Further, the local interface

Jim McDermott
Eastern Editor



The data bus—eight lines of the IEEE 488 interface— carries data between the instruments and controller. Data transfer control requires three lines and the general interface management uses five more.

serves to translate the answer or output of the instrument—it may be in BCD from a display—into characters of 8-bit bytes that can be sent back out over the bus to other instruments or a controller.

"Hopefully, this is done in a format that a lot

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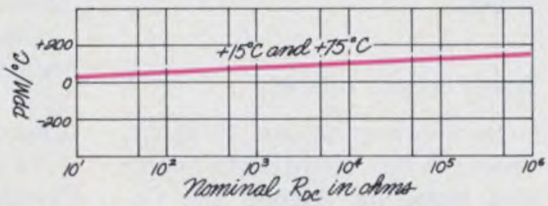
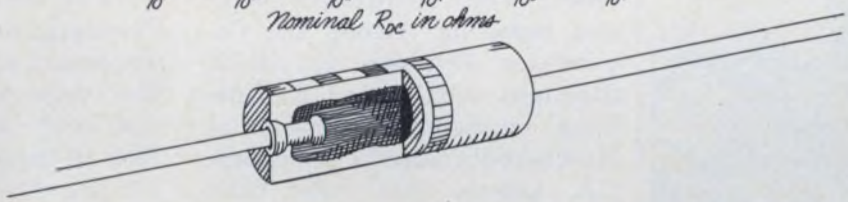
The Resistance Temperature Coefficient of Allen-Bradley hot-molded fixed resistors is typically less than 200 PPM over the entire resistor range shown in the normal equipment operating temperature of +15°C to +75°C. Excellent RTC ratings have always been an Allen-Bradley benefit. And consistency of Allen-Bradley resistors means repeatable results and tight performance patterns. Allen-Bradley resistors offer the **lowest cost—on the board**—where it counts!





Reliability is unsurpassed. Over 700 million unit test hours without a single failure.

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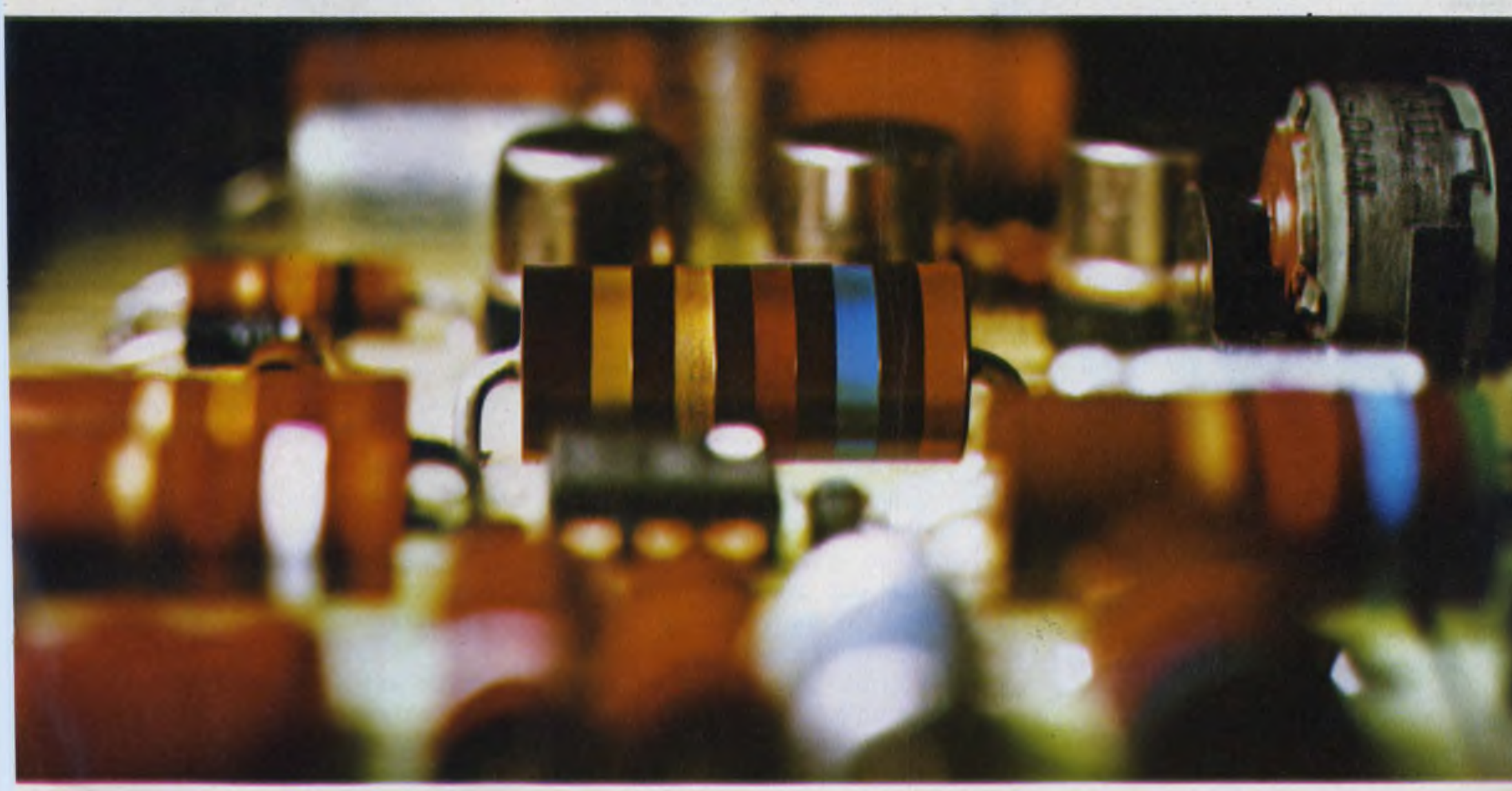

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INFORMATION RETRIEVAL NUMBER 22

of people can understand. In most cases it's an ASCII character format that follows the standard definition."

Probably the biggest decision the instrument designer has to make is how to send out his data. Coates leans toward floating-point format. But it turns out that this is the hardest to generate, he notes, usually requiring more hardware in the instrument to generate the words.

Seven options offered

In another Session 3 paper, "Identifying, Understanding and Selecting Among the Capabilities Provided by IEEE Standard 488," Daryl E. Knoblock, development engineer at Hewlett-Packard, Cupertino, CA, asserts that "the basic standard is nothing more than the connection to the cable."

"The standard defines only the interaction between the bus and the instrument rather than the logic required for it," he notes. "Some designers will use state machines, others will use random logic, and still others will use microprocessors for the interaction needed. To implement the full standard is expensive."

But Knoblock points out that the best way to minimize instrument interface design costs is to use only those features of 488—he calls them "options"—that are needed for a particular instrument function.

The controllers of most instrument systems are computers or calculators, Knoblock points out. And interaction between the controller and the instruments is, according to 488, performed through 8-bit coded commands "broadcast" by the controller through the data bus to all instruments within the system. Also, asynchronous transfer of interface commands is specified so that the bus can accommodate instruments of varying data speeds.

The instruments on the bus must contain circuitry that permits them to recognize and remember when they have been instructed to send or receive.

Thirty-one interface commands are allocated as "listen addresses," Knoblock points out, while 31 more are allocated as "talk addresses." Data transfer begins, he explains, when the controller changes the Interface Command state of the bus and allows data bytes to be sent.

Choice of the options and the logic to implement them depends upon the instrument function, Knoblock notes.

"For example," he says, "sending data is particularly important for a voltmeter. And the voltmeter designer might not need the Interrupt operation to interrupt the computer. On the other hand, receiving—not sending—is important for a printer.

"If you wish to send data, then you'd choose the Send Data option. This is a pair of interface functions, one called the talker and one called the handshake. If a microprocessor is used, then each option represents more microcode."

The problem of designing the interface for instruments that are not compatible with Standard 488 but are tied together on the standard bus is complicated by the fact that 488 omits much information needed for software interface design, says John Fluke Jr., author of a Session 3 paper on "System Considerations in Using the IEEE Digital Instrument Bus."

"While the standard is exceptionally explicit about hardware interfacing details," notes Fluke, technical director of automatic test equipment for John Fluke Manufacturing Co., Seattle, "it leaves out a lot of the details with respect to software.

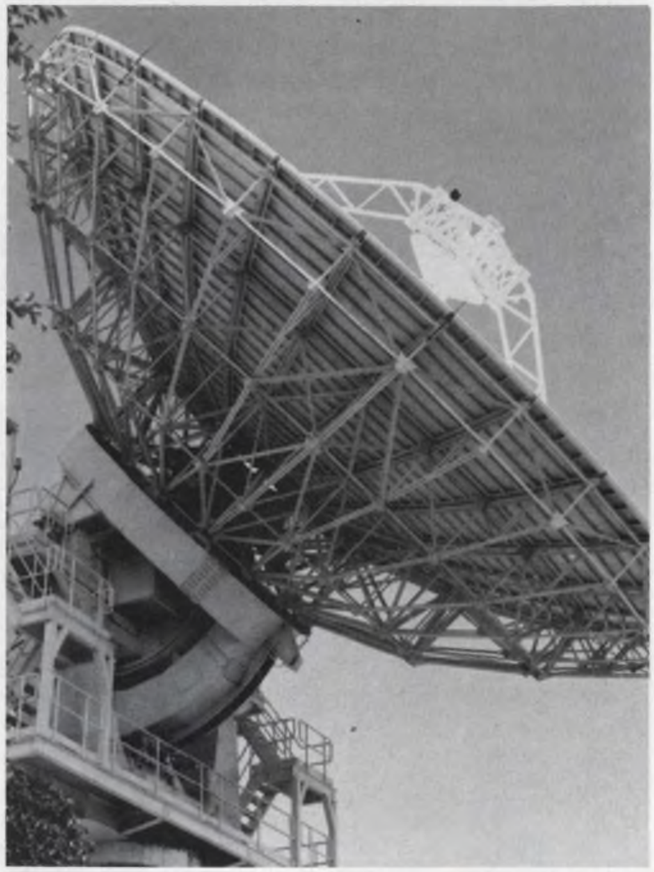
"Probably what should have happened is that there should have been some kind of a software standard and no hardware standard." ■■

Designers cramming more traffic into satellite communications net

Satellite communications has matured to the point where domestic communication satellites are now ready to carry huge volumes of traffic. But the technology doesn't stop growing. Designers are pushing toward multiple use of the same frequency, time-division multiplexing, multiple polarization and higher frequencies with larger bandwidths to increase capacity still further.

Frequencies in the mm-wave region (30 GHz and up) will be used for high-bandwidth satellite and ground links. In addition optical communications is already with us. Data links are appearing in military programs. By 1980, commercial fiber-optic links may be in use by the Bell system. Free-space optical links are improving all the time.

"Our main thrust is to provide more circuits per satellite at a lower cost per circuit," says Dr. Sydney Metzger, chief scientist at Comsat in Washington, DC. He points to several steps that could lead to increased satellite capacity. Some are already in use in a few military and civilian satellites.



Satellite communications antenna is located at Philco-Ford Corp.'s WDL Div. in Palo Alto, CA.

Stretching frequency use

"First on the agenda," he notes, "is frequency reuse. If you use the same frequency band over and over again, you multiply your capacity by the number of times you reuse the frequency band."

This is already being applied in the current generation of Intelsat satellites. The Intelsat IV-A, built by Hughes Aircraft, El Segundo, CA, has a pair of 53-in. high-gain dish antennas. These can each use the same frequency band to communicate with different installations. Intelsat IV-A contains 20 transponders, yielding 20 channels, each 36 MHz wide.

When AT&T launches its domestic Comstar I early next year, it will use another technique for frequency reuse. This satellite will use a pair of orthogonal polarizations, with each polarization having full use of the available bandwidth. The satellite will contain 24 transponders, each carrying a 40-MHz channel. The down-link frequency will be 4 GHz and the up-link 6 GHz. The satellite will also contain beacons for testing the feasibility of an 18-GHz down-link and a 30-GHz up-link.

Intelsat IV-A uses a 4-GHz down-link and a 6-GHz up-link. While only 500 MHz of bandwidth is available at 4 and 6 GHz, 2500 MHz is available at 18 and 30 GHz. RCA's 4 and 6-GHz satellite, due to be launched late this year, will also be capable of dual-polarization frequency reuse.

Another frequency band of interest—one be-

David N. Kaye
Senior Western Editor

ing used experimentally by Canada's domestic communications Telesat—is a 12-GHz down-link and 14-GHz up-link. Only 500 MHz of bandwidth is available at these frequencies.

Next, according to Metzger, will be a switch from frequency-division multiplex modulation to time-division multiplexing (also called TDMA, or time-division multiple access). Telesat and Eurosat, the European domestic communication satellite, will contain TDMA. Intelsat IV-A doesn't have it now, but might get it at a later date. TDMA results in an approximate doubling of capacity.

Metzger also points to full digital satellites. With these, digital switching can be used to switch messages from one channel to another in an attempt to keep all channels in maximum use. This technique is called digital speech interpolation.

Finally the alternative of just putting up additional satellites to increase capacity might be attractive. Metzger notes that all alternatives are being considered in the design of the next generation of Intelsats, to be known as Intelsat V.

The Hughes Intelsat IV-A satellite contains 20 transponders, permitting 20 channels, each 36 MHz wide, to operate through twin 53-in. dish antennas. It uses a 4-to-6-GHz downlink and 6-GHz uplink.

Higher and higher frequencies

AT&T's experimentation with 30 GHz as a communication frequency is but one example of the application of mm waves to communications. Bell Telephone Laboratories at Holmdel, NJ, has developed a mm-wave guided system to operate in the 40-to-110-GHz region. Through a 2.5-in. circular waveguide, Bell can transmit upward of a quarter million telephone channels. Researchers feel that there is a potential for a half million channels in the near future.

For protection, the waveguide is sustained on rollers and surrounded by a steel tubular shell. An experimental system has been installed underground and is being tested.

Kerns Powers, director of the Communications Research Laboratory at RCA Laboratories, Princeton, NJ, says: "I think that guided mm-wave links are just an interim solution that will ultimately be replaced by fiber-optic links. Fibers should ultimately be the major guided-wave communication trunk line."

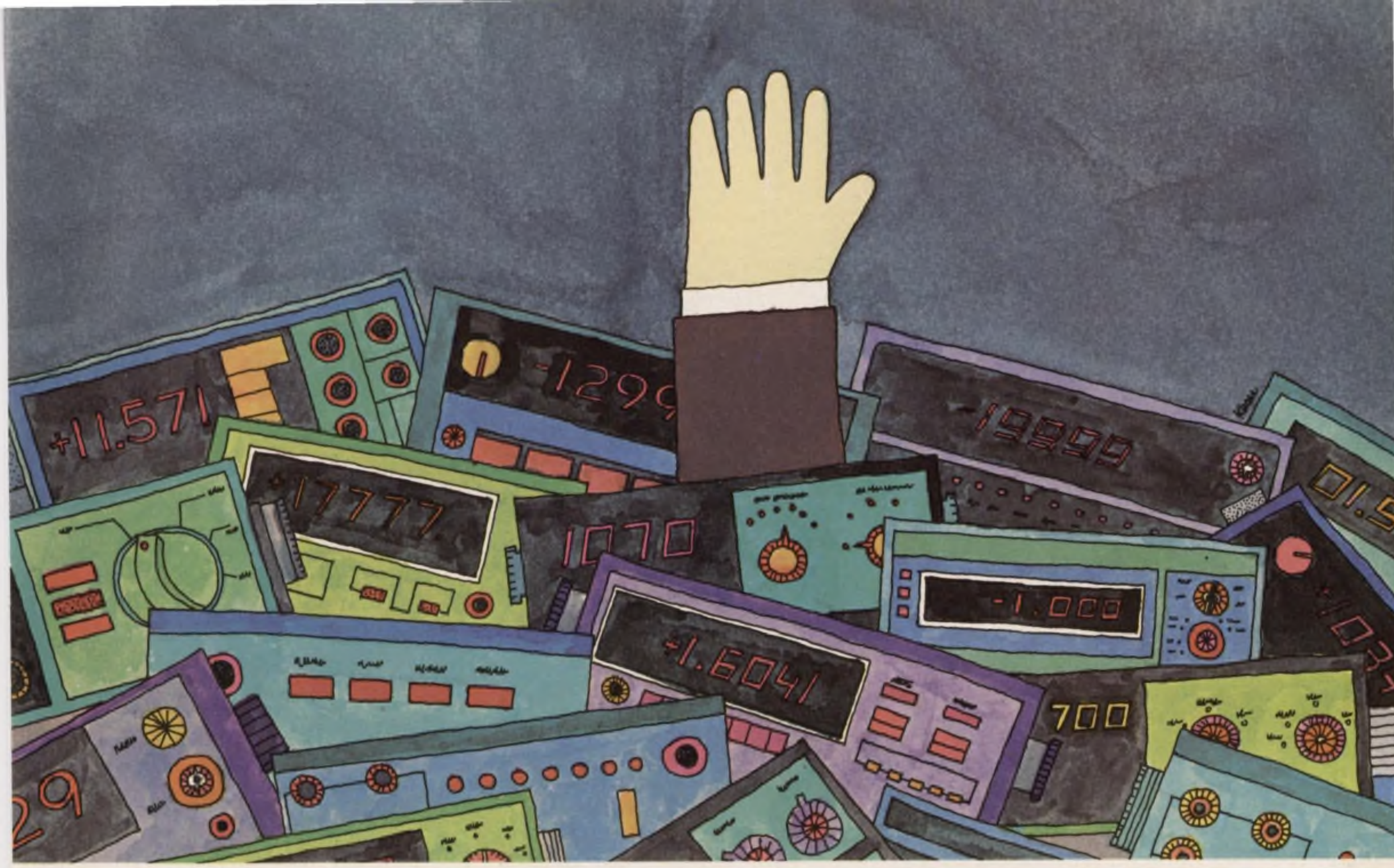
However, Dr. Powers sees free-space mm-wave communications as a useful technology for local distribution systems of up to a few miles. He says: "Initially the 31-to-35-GHz band lends itself to all-weather links of up to 1 mile. Later, when the spectrum gets too crowded at 31 to 35 GHz, systems will be developed to use the 90-GHz window in atmospheric attenuation."

The greatest promise lies in optical communications, researchers say. Optical communications will take two forms, each with two variations. The two forms are free space and fiber-optic, and the two variations are LED and laser sources.

Free-space optical communications has been around for some time. Several years ago Computer Transmission Corp., El Segundo, CA, introduced a system called Optran. This system, still on the market, uses an infrared GaAs LED as a source to transmit digital data up to 1000 ft at a data rate of up to 250 kb/s. With a GaAlAs LED, the range is extended to 4000 ft, but the data rate drops to 19.2 kb/s. The military and a few other companies also make optical free-space data links.

Meret Corp., Santa Monica, CA; American Laser Systems, Santa Barbara, CA, and Motorola Communications in Schaumberg, IL, all make LED free-space, short-distance links for video transmission. Meret has a 6-MHz bandwidth system, good to a range of 1 km. American Laser's system has a 15-MHz bandwidth and Motorola's 4 MHz. Among the main applications for these systems is the transmission of high-quality television pictures from building to building as part of a security system.

Stephen W. Harting, a member of the technical staff at Computer Transmission, notes: "We're planning a digital link that will transmit 1.544 Mb/s for better than a half mile. This would compete across rivers and highways with AT&T's T-1 carrier phone links. Our link will



When it comes to picking the right 4½ digit multimeter, are you drowning in a sea of sales claims?

Check the Fluke truth table for all the important facts.

4½ Digit Multimeter Competitors #	1	2	3	4	5	6	7	8	9	10	FLUKE 8600A
Five-range AC/DC volts to 1200V											●
Five-range AC/DC current to 2A			●						●		●
Six-range resistance to 20 megohms					●			●	●		●
Autorange through all ranges plus individual range selection manually									●		●
10,000 Hour demonstrated MTBF											●
Continuous overload specified for all ranges/functions with overload indication								●		●	●
Environmental capability specified and defined											●
Automatic zeroing	●	●				●	●				●
Full line of accessories offering HI volts to 40 KV, RF to 500 MHz, current to 600A											●
Rechargeable battery option, completely built-in and self-contained				●		●	●		●		●
7W or less power consumption for reliability								●			●
Basic DC accuracy of 0.02% for 90 days at 15° C to 35° C	●										●

Ten companies claim to offer a 4½ digit multimeter competitive to the Fluke 8600A. As you can see from the truth table, no one measures up to Fluke. Some have more features than others. None have all the fine features of the Fluke 8600A. For a modest $599 (U.S. Price), you can put the 8600A to work right away.

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American Laser's compact laser communicator transmits data at up to 1.5 Mb/s with 99.99% reliability. Its range is between one and three miles. Such equipment may find use in high-quality TV security systems.

use the same transmit diode as the lower bandwidth link, but we will go to an 8-in. lens instead of a 3-in. and use better spectral filtering and a narrower beam-width receive envelope."

While others are also working optical links that are like the T-1, Bell Laboratories has recently released information on an updated T-1 link called T-1C. It will have bandwidth capability of 3.152 Mb/s.

Powers of RCA feels that short optical links will complement short mm-wave links. He says: "Optical links are better in rain, and mm-wave links are better in fog. We might see a combination of the two at the same installation."

Free-space laser links are also being worked on. American Laser Systems sells one that uses a GaAlAs room temperature laser diode that has a 1.5 Mb/s data rate and a range of over 3 mi. The error rates are about 1 in 10^{10} during clear weather.

Many companies are working on military free-space laser projects. Typical of the hardware is a laser communicator, about the size of a large pair of binoculars, built by the Hughes Santa Barbara Research Center in CA. It uses pulse rep-rate modulation at a 5-to-6-kb/s typical rep rate. With it, says Robert J. Cinzori, project manager at Hughes, "you can usually communicate about 20% farther than you can see."

Two or three years ago 20 dB/km was considered a very-low-loss optical fiber. Now several fiber manufacturers are down below 5 dB/km. The best results have been recorded by Bell Laboratories and Corning Glass Works, Corning, NY. They both have achieved 1.1 dB/km. Close behind is the ITT Electro-Optical Products Div., Roanoke, VA, at 2 dB/km. With such low loss, long-distance fiber-optic communication links become practical.

Stuart E. Miller, director of the Guided Wave Research Laboratory at Bell Laboratories, Holmdel, says: "We hope there will be commercial fiber-optic links by 1980."

Miller expects the earliest practical systems to use multimode fibers rather than single-mode. Multimode fibers are several times larger in diameter and contain transmission in several modes. Because of their larger size, it is easier to couple energy into the fiber. In fact, if the source is to be a LED, multimode fibers must be used. Only a laser can feed a practical amount of energy into a single-mode fiber of 10 μ or less.

Although the low-loss fibers exhibit pulse dispersion of better than 1 ns/mi (allowing for theoretical data rates of 1 Gb/s or better), few researchers are looking at data rates higher than 300 Mb/s.

Miller feels that the most practical systems will use GaAlAs diode lasers as sources. Until recently, the lifetime of these devices, when operated at room temperature, has been a concern. However, in the last year or so major developments have led to diode lasers with demonstrated lifetimes of 10,000 hours and more. ■■

A few of the electronic products now being made in Puerto Rico:

Electronic precision instruments • Mini-computers • Thermostats • Electric and electronic measuring instruments • Capacitors • Monolithic electronic modules • Potentiometers • TV, Radio and Phono assemblies • Tape recorders • Two-way communications radios for cars and boats • Color TV electron gun mounts • Magnetic core memories • Radial detectors

A few of the reasons Puerto Rico has attracted so many of your competitors

Electronics is now Puerto Rico's second-largest industry.

In the past five years, shipments of electrical and electronic products from the island are up an average of more than 90%*.

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1. Unheard-of profits

Unheard of on the mainland, that is. Your competitors in Puerto Rico show an average 25.7% profit-to-sales ratio. That's 5 times better than on the U.S. mainland.**

No wonder companies like R.C.A., Digital, Technicon, Bell & Howell, G.E., Westinghouse, GTE Sylvania, Instrument Systems Inc., AMP Inc. and Motorola like the business climate in Puerto Rico.

2. No federal income tax

None at all. Puerto Rico is not subject to any federal taxes. So these companies pay no United States income tax, personal or corporate. And neither will you.

3. 100% local tax exemption up to 30 years

Companies can be exempt from local taxes of any kind. That means no corporate income tax, no real and personal property tax.

Tax exemption is granted for a minimum of ten years to a maximum of thirty years, depending on where you locate your plant on the island. And there are many excellent locations available throughout the island.

4. Workers who produce

U.S. companies report that the productivity of their Puerto Rican workers is at least equal to—and often surpasses—that of their mainland counterparts.

Over 100,000 such workers are immediately available for employment. A young, eager labor force capable of producing anything from capacitors to the most complex electronics instruments.

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5. 2-year wage incentive

Eligible companies can benefit from government reimbursements of up to 25% of production wages paid in their first two years of operations in Puerto Rico.

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6. In Puerto Rico, U.S. companies are on U.S. soil

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*Source: Puerto Rico Planning Board: *External Trade Statistics* re: shipments to the U.S., the Virgin Islands and foreign countries. 1969-1974.

**Source: Latest available profitability figures (1973). Commonwealth of Puerto Rico. Economic Development Administration. Office of Industrial Economics and Promotional Services.

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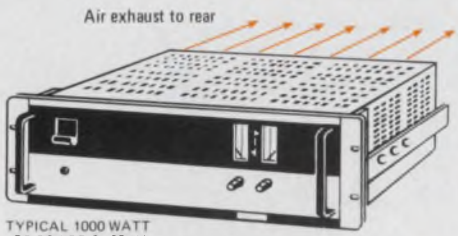

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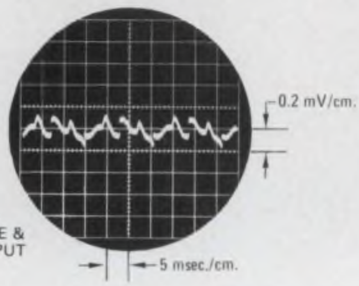

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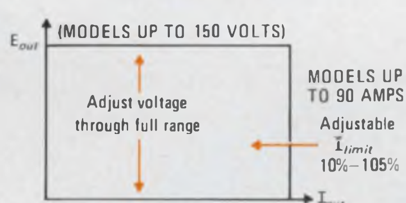

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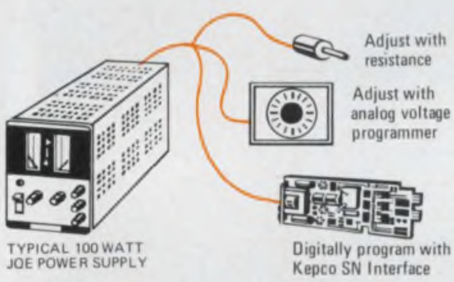

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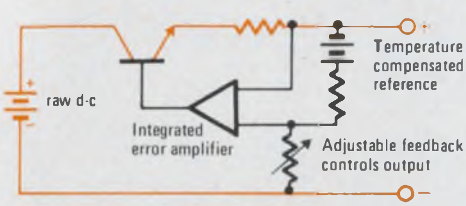

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INFORMATION RETRIEVAL NUMBER 31

Washington Report

GAO assails NASA's cost and work estimates

The General Accounting Office. after surveying 25 major unmanned satellite projects of the National Aeronautics and Space Administration, has criticized the space agency for cost and schedule estimates that "frequently have been optimistic"—possibly to the tune of a billion dollars in cost overruns and delays of up to 29 months.

The agency is particularly critical of NASA's method of allocating costs, such as not including launch-vehicle support, tracking and data acquisition, Civil Service personnel, and facilities that are directly identifiable with the projects. The GAO, noting that NASA is to provide Congress with reports on its major projects, suggests that Congress may want to discuss the problems with the space agency.

The GAO concludes that costs have grown by $1.02-billion over the original $1.79-billion initially estimated for the projects. NASA puts the overrun at $256.1-million.

Nuclear development budget appears intact

Despite some futile last-ditch Senate efforts to cut funds for nuclear weapons and nuclear energy, it appears certain that the first budget for the Energy Research and Development Administration will be approved pretty much as proposed.

Before heading home for the summer recess, the Senate passed a $6.1-billion authorization for the new agency to carry it through the 15 months that started on July 1. The House, which passed a simiiar measure on June 20, differed with the Senate by $171-million. A short conference will work out the differences.

Most of the Senate debate was on slowing development of the first liquid-metal fast-breeder reactor, which is to be located on the Clinch River in Tennessee. Soundly defeated also was a proposal to delete $232-million from the nuclear-weapons authorization and to limit the U.S. nuclear arsenal to its present size.

Electronic control of jet engines studied

Still another promising market for electronics appears on the threshold, this time to substitute digital electronics for increasingly costly and complex hydromechanical systems to operate jet-engine air inlets, afterburner and nozzle units.

Under a $7.9-million contract to the Air Force, Boeing is developing and testing the new control technique, called an Integrated Propulsion Control System. Ground tests have been reported successful, and the final proof is to come this fall in a flight test program using a modified

F-111E aircraft.

One of the two engines and its inlet, afterburner and nozzle have been modified to operate under the control of a computer installed in an insulated capsule in the aircraft's weapons bay. One expected benefit: reduced fuel consumption. If this saving is realized, commercial aviation will undoubtedly be highly interested, especially with fuel prices zooming upward.

A Bureau of Telecommunications sought

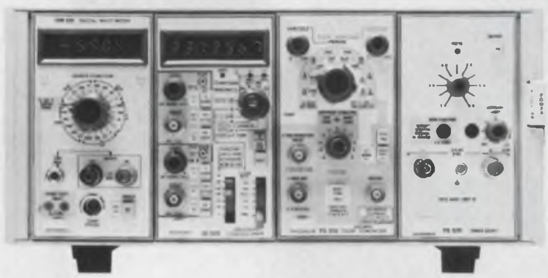
In a move to elevate the status of telecommunications in the Federal Government, Rep. Harley Staggers (D-WV), chairman of the House Commerce Committee, has introduced a bill to establish a Bureau of Telecommunications in the Dept. of Commerce.

If passed, the legislation would upgrade the present Office of Telecommunications to a bureau. The goal would be the development of a broadband communications system in the U.S. The proposal by Staggers follows a decision by Secretary of Commerce Rogers Morton not to consolidate the present office with the National Bureau of Standards.

Capital Capsules:

The Air Force has **shelved its plans to close the Rome Air Development Center at Griffis AFB, NY,** and transfer its functions to Hanscom AFB in Massachusetts. Political pressure caused the reversal. Now the Rome center will report to the Electronics System Div. at Hanscom, which accomplishes the realignment of electronic R&D, as planned, but without personnel savings. . . . **McDonnell Douglas has unveiled its YC-15 medium short-takeoff-and-landing transport,** which is to compete with the Boeing YC-14 for an order of 300 or so aircraft by the Air Force to replace the aging Lockheed C-130s. Boeing's entry is to make its maiden flight next July 4. Then the two planes will enter a flyoff to determine the winner. . . . RCA has given the Army a successful preview of EQUATE—Electronic Quality Assurance Test Equipment. Designated the AN/USM-410(V), **the system is a test bed for the Army's Automatic Test Support System. It will diagnose and fault-isolate both digital and analog equipment and circuits in depot and field environments.** A six-month test is under way at Fort Hood, TX. . . . The Federal Railroad Administration is **proposing radio standards and procedures to govern the use of radio communications in railroad operations.** The impetus comes from Federal safety officials, who cite accidents that could have been avoided through communications. . . . The Air Force has announced it will **acquire two preproduction models of a mobile air-traffic-control simulator** from Hydrosystems Inc., Farmingdale, NY. . . . NASA has the Boeing Co. **studying two potential satellite power-generating systems,** one a thermal engine converter, the other a thermionic converter. A microwave power system would transfer the energy to an earth station. Boeing has a whopper station on the drawing board, measuring 22 square miles, that would produce the electric power equivalent of the Grand Coulee Dam. Between 35 to 40 stations could handle all U.S. needs. Cost: $60-billion a copy. . . . The National Library of Medicine is **turning to electronics to halt unauthorized removal of books, journals and other materials.** The library is seeking a vendor who has a system that will give both an audible and visible signal when a theft is attempted. A key requirement is an adhesive strip that can be installed in random fashion in a book. It would be difficult to detect and remove by light-fingered readers.

If you design with ECL or TTL, You need to know about Tektronix TM 500



If You're into High Speed Logic,

the Tektronix TM 500 High Speed Logic Instrumentation plus the Tektronix 485 Oscilloscope (350 MHz) or 475 Oscilloscope (200 MHz) provide all the instrumentation you need for TTL or ECL up to 250 MHz. The four plug-ins of the TM 500 High Speed Logic system are a PG 502 Pulse Generator ($1295) with 1 ns rise time and independently variable logic 1 and 0 levels . . . a DC 505A Digital Counter ($1395) with 10 ns single shot resolution and averaging to 100 ps . . . A DM 501 Digital Multimeter ($575) with temperature measurement capability added to all its conventional functions (so you can verify operating temperatures of logic IC's and detect hot spots in tightly packed circuitry) . . . and the PS 505 Power Supply ($195) with the 3.0 to 5.5 V dc high-current (4 A) output essential for breadboarding or testing TTL and ECL devices. Also, you can expand the capabilities of the system to provide jitter-free oscilloscope triggering for viewing any segment of long pulse sequences by including the DD 501 Digital Delay ($625). The 485 Oscilloscope features dual trace, 1 ns rise time, and delayed sweep.

Whatever Pursuit in Electronics You're Into, you should learn more about TM 500 instrumentation. A particular group of plug-in modules in a four-hole mainframe provides the instruments most often needed in telecommunications, another fulfills the needs of industrial instrumentation calibration and troubleshooting, another for medical instrumentation, others for education, and so on.

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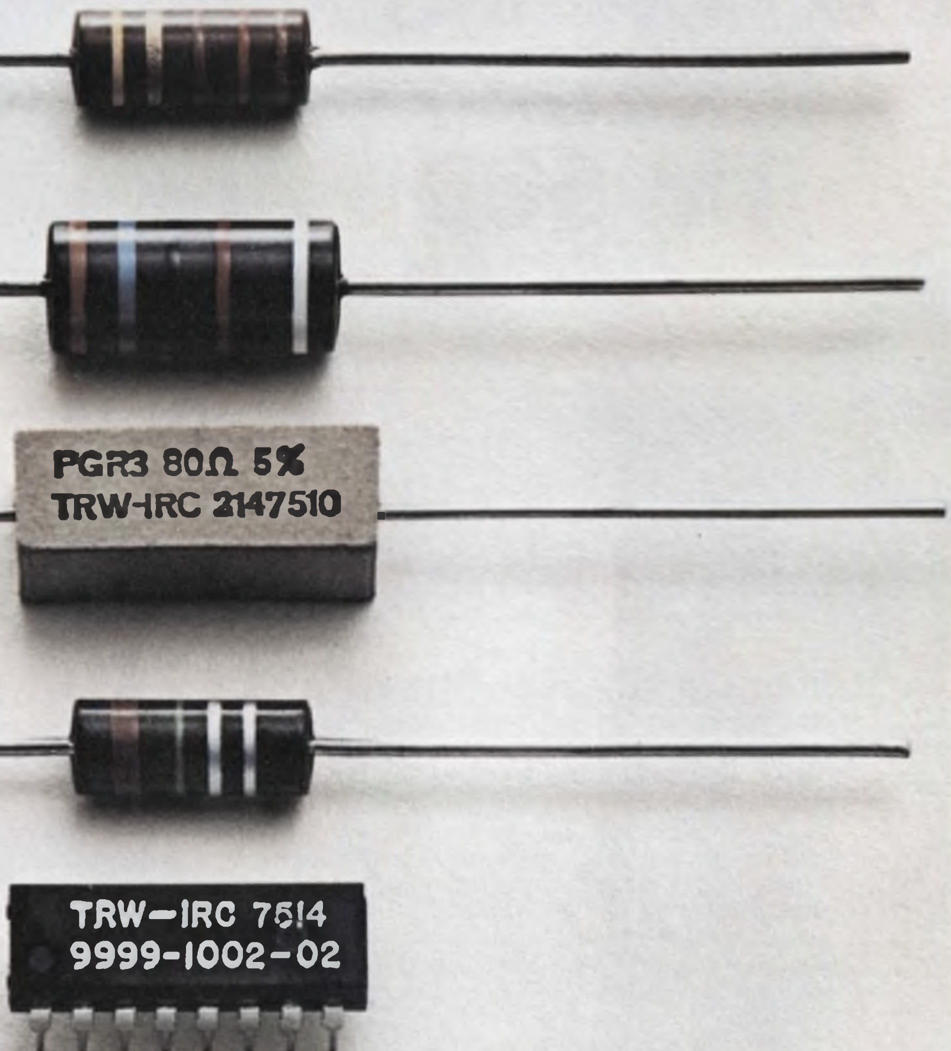

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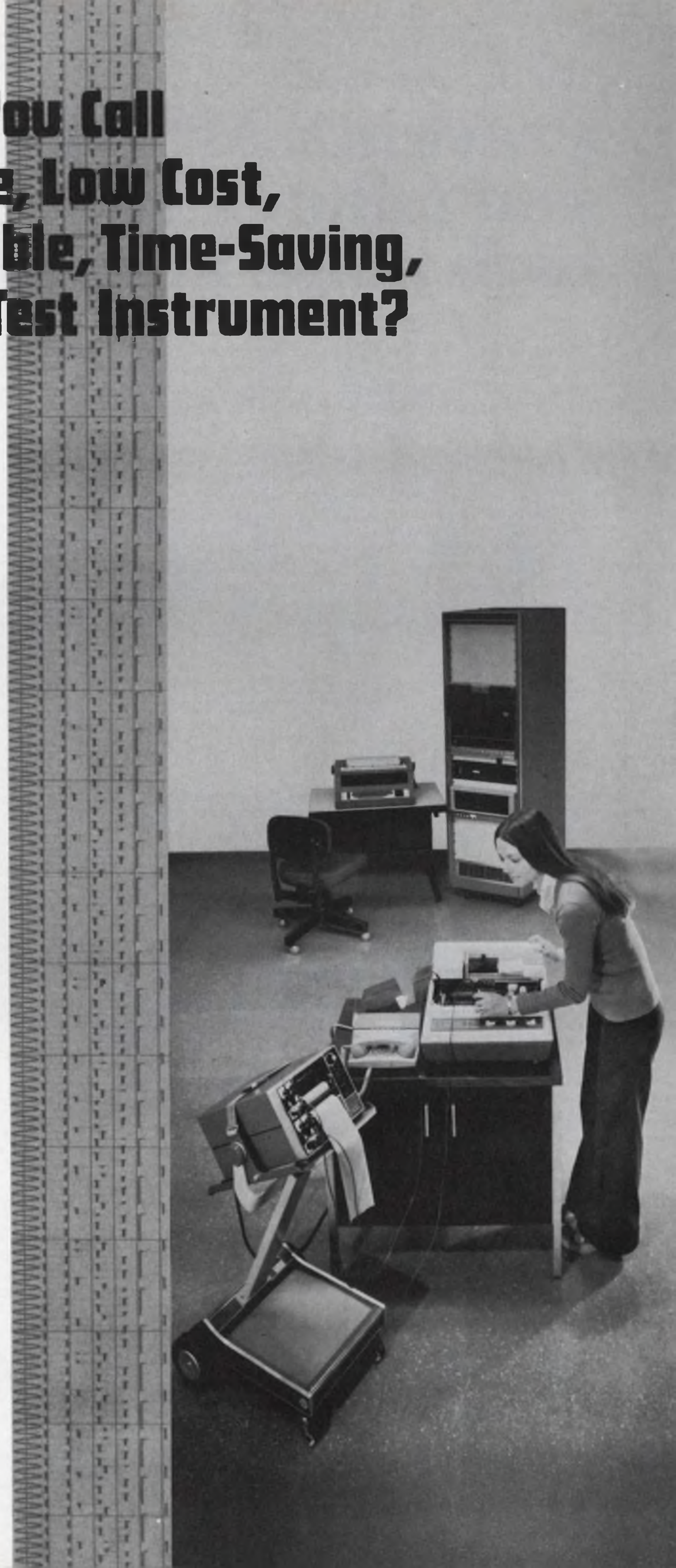

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INFORMATION RETRIEVAL NUMBER 35

HiNIL Interface

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

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

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

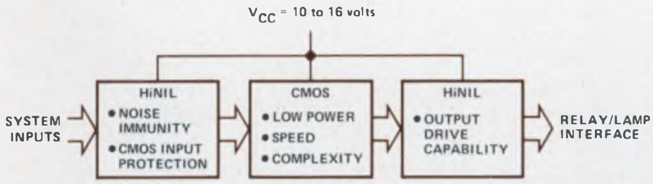

Figure 1. HiNIL input interface protects CMOS inputs while HiNIL outputs directly drive long lines and peripheral devices

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

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

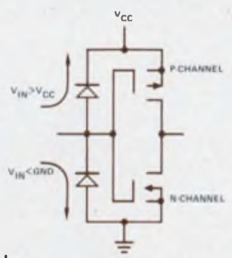

Figure 2A. CMOS latch-up causes

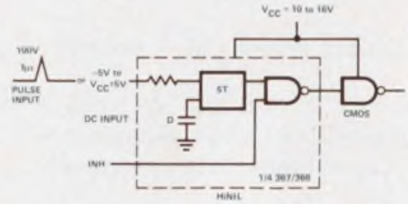

Figure 2B. HiNIL input protection

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

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

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

Examples of HiNIL Interface Devices

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

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

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INFORMATION RETRIEVAL NUMBER 37

Editorial

Remember 'pervasiveness'?

A few years ago "pervasiveness" was all-pervasive. Wherever you went you could hear somebody holding forth about the pervasiveness of electronics and, more particularly, of semiconductors. Because of their pervasiveness—in automobiles, appliances, entertainment goods, time-keeping products, data-processing equipment and other areas still undreamed of—the course of electronics would forever be onward and upward.

There could be minor dips, of course, but these would be unimportant and brief. And then, WHAM! When our industry took its plunge everybody forgot about pervasiveness. The people who had been hailing the glories of pervasiveness were wailing that the world was falling down. They were wrong—again.

But they'll be back. They'll return with new buzz words and with a renewed feeling that the present moment is the totality of history. They'll forget that society in general, and our industry in particular, move on relentlessly and pay no attention to our slogans and buzz words. They'll become so entranced with their slogans that they'll mistake them for reality.

I know one chap who often finds new catch phrases to impose on his staff as words of eternal wisdom. He expects engineers to design with these sacred verities and salesmen to sell them as if they were something real. But since the marketplace obeys its own laws, he often finds that the words that so enchant him have no effect. Unfortunately, he finds no fault with buzz words, which remain holy, but rather with inadequate attention and inept execution by his engineers and salesmen.

Unfortunately, he's not alone. Many of us fall prey to our own slogans and mistake them for reality. We invent a pretty phrase and become so enamored of it that we permit it to obscure product weaknesses that we should correct. We take solid concepts and etherealize them till they lose their concrete meanings and become mere slogans.

While slogans can be useful for summarizing the features of a product, they can be dangerous when we forget that they are mere representatives of a product—not the product itself. They can be disastrous if we see them as a substitute for the reality underlying the words.

Believing our own baloney can be a dangerous disease. How many of us are immune?

George Rostky
Editor-in-Chief

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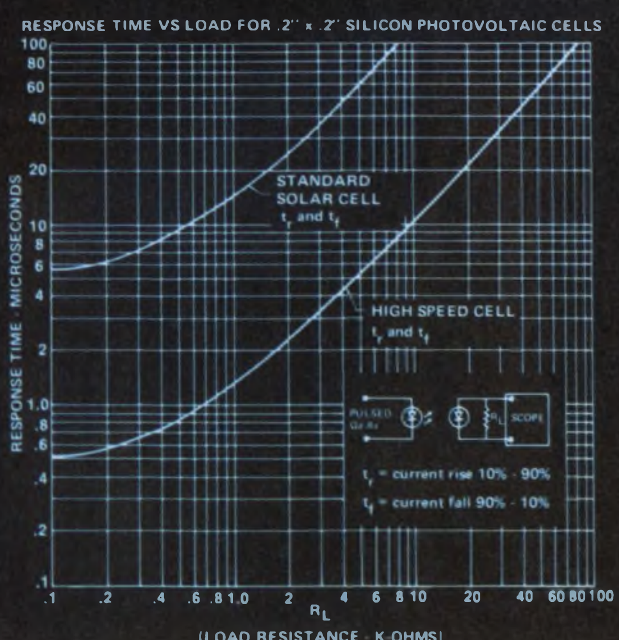

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INFORMATION RETRIEVAL NUMBER 39

FOCUS on Displays

With digital displays being designed into everything from kitchen ranges to electronic navigation equipment, choosing the right display and applying it properly is more important than ever.

The field has narrowed somewhat, making selection easier. For numeric and alphanumeric displays, the principal contenders today are light-emitting diodes, liquid crystals, incandescents, fluorescents and multi-character, planar, gas-discharge displays. The stacked-character, single-digit, gas-discharge display (like the Burroughs Nixie), which completely dominated the market a few years ago, is no longer an important contender for most applications.

One display, the liquid crystal, was formerly rejected by many engineers because of early deficiencies, some of which have since been cured or modified. Principal among these was the fact that its life expectancy was unknown or brief—3000 to 5000 hours. Improvements in processing and materials have extended the expectancy to respectable figures, sometimes approaching 100,000 hours.

Temperature sensitivity has been improved, too. Early liquid-crystal displays died after exposure to temperatures below −20 C or so. Most of today's LCDs recover after being returned to more moderate temperatures.

And the newer LCDs, those using field-effect technology, allow multiplexed operation (difficult or impossible with dynamic scattering types) to cut the cost of driving multiple digits.

Thus with all these improvements, deciding which one to use becomes a difficult task. To add to the confusion, designers using displays also have to consider the nebulous factor of aesthetics. Will the display look right in the final unit? Will the customer prefer a different color display? Or one with a different character font? All of these subjective parameters must be considered before a display is chosen.

Furthermore, the engineer who designs a display into his equipment must also wade through spec sheets that are often laden with misleading and confusing specs.

Jules H. Gilder
Associate Editor

Beware the brightness spec

Probably the most confusing and misleading parameter found on display data sheets is the brightness spec. The ambiguity that surrounds this spec stems from the complexity of brightness. It can be measured with several different methods—each having a number of variations depending on color (or mixture of colors) and the measuring equipment used.

Some manufacturers specify brightness in millicandelas; others use foot-lamberts and still others use lumens. Where a point source is the critical factor, then the luminous intensity in candelas and the flux in lumens are the meaningful measurement units. Where a broad-area source is being measured, the luminance—also known as photometric brightness—in foot-lamberts and the luminous emittance in foot candles are the appropriate units of measure.

To add to the confusion caused by the terminology, manufacturers often spec brightness according to the brightest small area that can be found on the display. This is a relatively useless way of specifying data since the human eye tends to see surfaces—not points or spots which yield better numbers. Another confusing aspect of the brightness game is that some manufacturers list the brightness with one segment lit up, while others list it with all segments lit.

Therefore, since brightness ratings are not al-

Alphanumeric characters can be displayed by 16-segment LCDs. These one-inch-high units from Hamlin can be read at 30 ft.

ways comparable, it's usually smarter to use data sheet information only as a very general guideline. Once the display technology is selected, and the size and color of the display have been determined, the engineer should ask all potential suppliers for samples that represent their respective lines.

After evaluating these samples at the electrical input levels planned for the actual application—and also under any extreme ambient conditions that will exist—one can select a supplier. Samples then should be used as correlation standards to write the final purchasing specs and to calibrate the equipment that will be used for testing incoming shipments.

If you do this, it doesn't really matter what measurement units are assigned to the brightness factor. As long as the measured value of brightness of the displays you receive is similar to the measured value of an acceptable sample, the display's appearance will be satisfactory.

One of the first 1-in. LED displays to be announced is this one from IEE. It uses two LED chips per segment and, therefore consumes twice as much power as the small half-inch displays.

Displays that do not emit light have no brightness spec. An example of this type of display is the liquid crystal readout, which either reflects or refracts light. Instead of a brightness spec, liquid crystals have a spec called contrast ratio. Contrast specs are inadequate because they can vary, depending on the light source and the exact type of measuring equipment being used.

Display life is another parameter that can confuse the unwary engineer. At what point is a display judged to be dead? You don't always know,

Incandescent displays are best for high brightness. Full color capability is another big plus for incandescents. These CM5 devices from Chicago Miniature Lamp are said to last 100,000 hours.

because the definition of end of life is omitted from most data sheets. And in those instances when it is listed, you can't always trust it.

An example of how display manufacturers can deceive the engineer on life specs pops up when the display's brightness is being investigated. Often a very high brightness will be listed for the display. But what is not pointed out is that operation at that brightness level will drastically reduce the lifetime of the unit. In such a situation, the life spec that is listed is for 1/10 of the brightness level on the data sheet.

Many factors affect the life of a display. Some of these include heat, overcurrent, vibration, shock and ac vs dc operation.

One common definition that is used to specify end of life is, "When the brightness decreases to 50% of its original value the display is dead." The problem is to find out when it has decreased to that value. It's not too difficult to make measurements in the lab, but checking a display out in the field to see if it's living up to its claim of long life can be difficult.

Another thing to consider is what a display looks like at the end of its life. Many function fairly well, but fluorescents become irregular, liquid crystals fade and darken and their response time goes up, while filaments droop on incandescent displays.

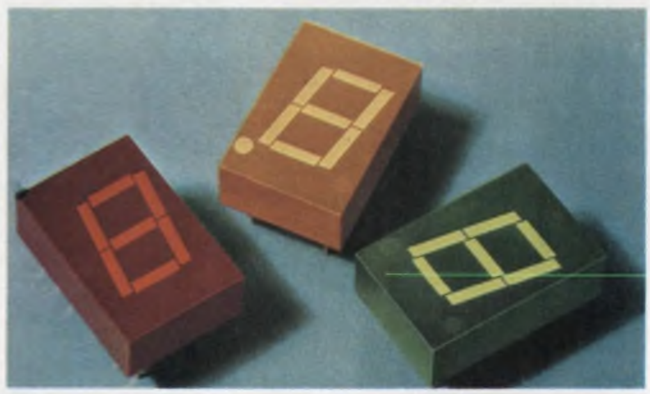
When life considerations are paramount, most display makers agree that LEDs are best. Their brightness degradation vs time is negligible—usually they stop working due to some catastrophic failure such as a bond opening up. In general, however, if a LED display lasts more than four hours, it will outlive the equipment that it's used in, note LED manufacturers. Some life-expectancy figures for LEDs indicate that they have an operating life of 1 million hours—or more than 114 years.

Optical considerations are largely ignored in display data sheets. For a piece of gear that uses displays, it is important to minimize optical problems such as those that can be caused by reflections and incident light. But alas, no information on the required filter characteristics appears in data sheets.

Similarly, spec sheets don't show how best to position the display so that it won't be washed out by high ambients. And manufacturers don't tell you that green displays, when used in direct sunlight or under fluorescent lighting, will exhibit a poor contrast ratio.

An important point to remember about green displays is that the eye is extremely sensitive to green and will detect slight differences in the intensity of two adjacent displays or display segments. That's one reason they are so difficult and expensive to manufacture.

A mixture of different message formats such as alphanumerics and fixed messages can be combined into one unit using the National Electronics Plasmac display.



High efficiency and extremely low drive currents are the key features associated with these 0.43-in. displays from Hewlett-Packard. They are part of the company's 5082-7600 Series.

LED displays from Dialight come with heights up to 0.625-in. and can be supplied with a bezel that holds up to 10 digits. It comes with or without decoders.

In many cases you can underestimate the complexity of driving circuitry. On data sheet schematics, manufacturers often make the drive circuitry seem much less complicated than it really is. They do this by drawing a block diagram and labeling a box "driver" or "control," rather than giving the complete schematic. Always insist that the vendor tell you the exact drive requirements. The cost of drivers can significantly raise the cost of what appears to be an inexpensive display.

For example, a planar gas-discharge display might cost $1.20 per digit in quantities of 10,000, while a LED for the same quantity would cost about $1.50 per digit. Although the gas-discharge display appears to be 20% cheaper, when the cost of the decoder-driver is added—$1 for gas discharge and 70¢ for LED—the cost of using the two displays is the same.

Try multiplexing for economy

If more than four digits are going to be used in the display, consider the possibility of multiplexing the devices. This can economize on drivers and PC board space. But be careful. Not all displays can be multiplexed effectively. Dynamic scattering liquid-crystal devices are generally too slow. But researchers at RCA Laboratories report that progress is being made with field-effect liquid-crystal devices.

A common deficiency in display data sheets is environmental data. It is very important to know under what temperature and humidity conditions the displays will work. Plastic packaged LEDs, for example, must work below 85 C. If the package goes above 85 C it will melt. Also some displays, such as Schiff-base liquid-crystal types, are very sensitive to moisture.

Environmental data are often omitted because of "lack of space." It's true that such data tend to require a lot of explanation and qualification to cover all possible conditions. But you can usually get the information you need by contacting the factory.

Look out for these common errors

The mistakes made most commonly by display users are related to light output. If you fail to double-check the data sheet with your own tests for things like brightness, color consistency, segment-to-segment matching and dimming capability, you risk buying displays that don't look the way you intended. This is especially true when individual display units are mounted side by side to form a multidigit array.

Another mistake, a classic one in many areas of electronic design, is to evaluate the device as a single entity and not as part of a total system. This type of oversight can force you to use extra components—perhaps even an extra power supply. All this can boost the final cost of your system. Shooting for the lowest parts cost is perhaps the major blunder of inexperienced display users. Little attention is paid to maintenance cost and to the cost of peripheral circuitry.

In battery-operated equipment, for example, a designer might choose gas discharge displays because they look good and cost less than LEDs. What he may not consider, however, is that a dc-to-dc converter is needed to supply the high voltages that these devices need.

When choosing a display, make sure it suits the ambient light conditions. If the display is to be used in high ambient light, three factors must be considered: (1) color, (2) contrast and (3) intensity. Amber, in general, is the most visible.

Display contrast can be enhanced significantly by using a dark, nonreflective background so that the unused segments of the digits don't show. This will prevent incident light from washing out the display, and will help assure unambiguous readings.

If gas-discharge displays are used, a few rules of handling will prevent a lot of unnecessary seal failures. First, don't take the display out of its shipping package until it is ready for use. If you want to check one, borrow a trick from neon-lamp users; just bring the display near the terminals of a high voltage transformer and watch it light up.

When soldering glass-packaged displays, avoid exceeding the allowable temperature differential between the glass and the pins. A handy way to lower the differential is to use an infrared lamp to heat up the entire display unit.

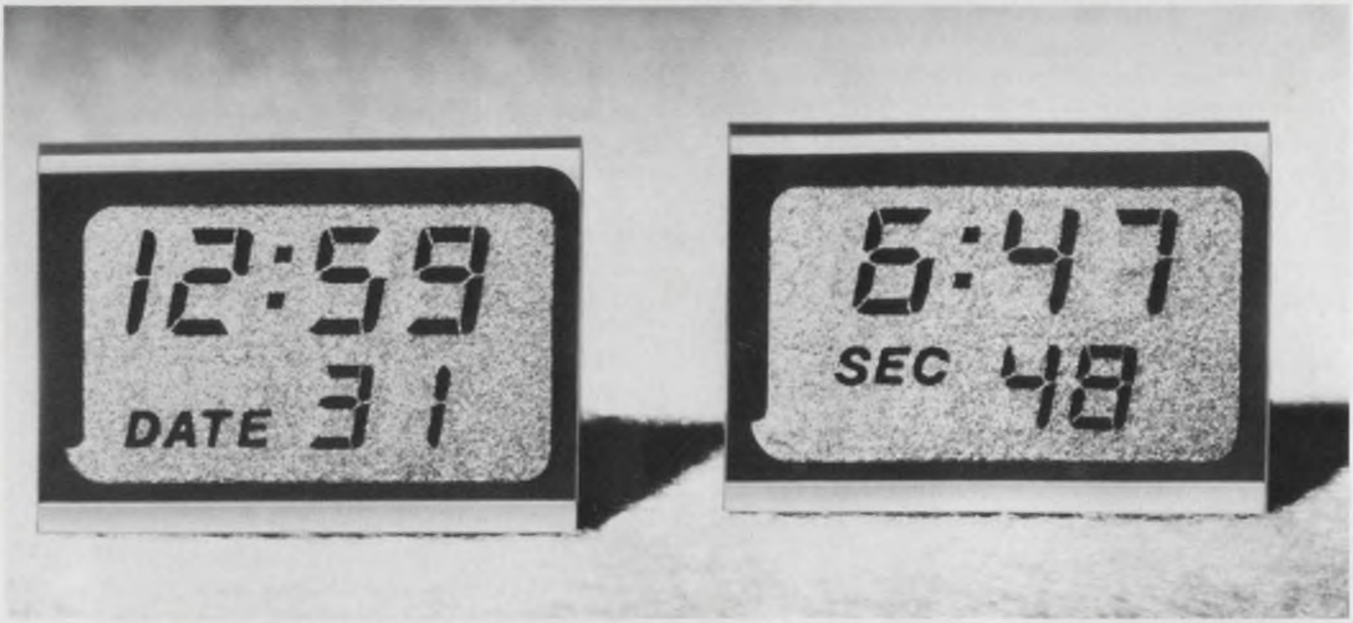
Help the vendor

If you work with potential vendors close enough, specifying displays will become a lot easier. Tell them your requirements. How many digits per assembly will be required? What is the lowest current that will be available to the display? Displays that seem well matched under normal operating conditions may look quite different when operated at low currents.

Are there any electrical restrictions? How about space requirements? Will the displays be operated continuously or multiplexed?

Temperature-range requirements should be spelled out for all applications in which the ambient will span wide extremes. Also consider how much heat the display will generate, and see if there's adequate ventilation.

Other things to discuss with vendors are character size, viewing angle, mounting dimensions and back panel depth. If individual units are going to be made into an array, make sure the



Field-effect liquid-crystal displays from Beckman can be built with as many as 5-1/2 digits and can be supplied with one of two annunciator words. They're part of the company's 705 Series of displays.

mechanical tolerances are tight enough so that there are no layout problems.

While they can be used efficiently in cold ambients, LEDs grow dim and their lifetime decreases in hot ambients. At 100 C the brightness drops to 50% of what it is at 25 C. Available colors are restricted to red, orange, yellow and green. And their small size and brightness usually limits them to applications in which they will be viewed from fairly close range. The maximum viewing distance of 0.3-in. displays is 10 ft.

But longer distance viewing will become possible as the brand new one-inch LEDs come into production and become commercially available in large quantities. At least three companies have announced the availability of the new large LEDs. The companies are Litronix, Fairchild Semiconductor and IEE. The displays from IEE —the 1720 common-anode and the 1723 common-cathode—are manufactured by Sharp in Japan. IEE however has the world marketing rights. Like the other one-inch displays just introduced, the IEE devices use two LED chips to illuminate each segment. This means that the devices will consume twice the power of half-inch devices. Each segment of the one-inch displays requires 3.3 V at 20 mA.

The one-inch displays also look slightly different from the smaller units because the aspect ratio has been changed. Customers in the past had complained that 7-segment LEDs were too fat. So the one-inch display is twice as high as it is wide.

Texas Instruments has also developed a one-inch LED display, but it doesn't plan to introduce it until some time next year. The feeling at TI is that one-inch displays are larger than needed for volume applications, and that most engineers will continue to design with the smaller displays.

A new trend is developing in LED packaging. Semi makers are extending the assembly techniques they originally developed for pocket calculators to the larger digits. It is now possible to get arrays of up to seven half-inch-digit displays in a single package.

As far as costs go, an instrument maker who uses different types of displays says that even at the 10,000 to 20,000 piece level, LEDs are 10 to 20 percent more expensive to use than gas-discharge displays. Semi makers dispute this.

In the competition between LEDs and liquid crystals, results from a survey of the only U.S. market—digital watches—that uses both types extensively shows that LED watches outsell LCD versions by 10 to 1. Reasons for this include the bad reputation LCDs have had for reliability and their poor visibility at low light levels.

While liquid crystals are improving, so are LEDs. The drive-current requirements have decreased from several milliamps per segment to a few tenths of a milliamp. Efficiencies continue to improve, and soon it will be possible to drive LEDs directly from improved MOS circuits—without using special lamp drivers.

Some LEDs, such as those in the Hewlett-Packard 7650 series and the Monsanto MAN4000 series, feature a high luminous intensity that results from improved packaging and material efficiency. While the Monsanto devices are available in red, orange, yellow and green, HP offers only red, yellow and green.

Calculator displays are finding increasing use in a variety of noncalculator applications such as tape-footage indicators, elapsed-time meters, event counters, blood-pressure monitors and stop watches. The reason for this widespread usage is that calculator arrays are built by the millions and designers can take advantage of these low cost standard parts.

Planar gas discharge getting bigger

Like the LEDs, planar gas-discharge displays have grown in size and one-inch-high digits are now commonly available. Gas discharge displays offer very good readability—even with bright ambient light—and are relatively inexpensive. And the cost is still coming down, due mainly to new fabrication techniques.

Unlike LEDs, gas-discharge displays are limited in color to orange and colors, like red, that can be filtered from orange.

Another disadvantage of gas-discharge devices is that they require relatively high voltages—usually from 135 to 200 V. This leads to two other problems: (1) more expensive decoder drivers, and (2) a special high-voltage supply—which may require Underwriters' Laboratory approval.

But the high-voltage requirement can become an asset if the equipment is to be line operated. Supply design is then very simple and inexpensive. And though they require higher voltages, gas-discharge displays always consume less power than LEDs. Also, dc-to-dc converters that are barely larger than ICs are now available. These can be mounted adjacent to the display to eliminate high voltage wiring.

Like the LEDs used in most calculator applications, some planar gas discharge displays are internally connected for multiplex operation so that the number of pins required is reduced. Displays such as the Panaplex II from Burroughs and the Plasma-Lux from Cherry Electric can easily be multiplexed, even in arrays containing up to 16 digits. Other display devices such as liquid crystal and fluorescent ones, become limited by response time, the complexity of the multiplexing circuitry and the magnitude of the peak currents.

Another form of gas-discharge technology is used for matrix display panels—like the Burroughs Self-Scan. These are used primarily to display large amounts of alphanumeric data.

The original Self-Scan panels from Burroughs are good for applications requiring between 10 and 600 characters. The latest development, the Self-Scan II, consists of a basic 20-character display that can be butted horizontally and stacked vertically to produce extra large display systems that have capacities of 2000 or more characters.

In addition to its expandability, the Self-Scan II differs markedly from the original Self-Scan in that the characters are formed by a fixed 5-by-7 dot-matrix format. In the earlier panels, character format was variable and if a 4-by-6 or a 7-by-9 format was desired, it could be used.

The world's largest LCD system can display more than 600 alphanumeric characters. Produced by Hitachi, it may one day compete with plasma panels and CRTs for computer-terminal applications.

The Self-Scan II has a light output that exceeds 300 microcandelas per glowing dot. This makes the display visible at up to 50 ft. Production quantities will be available in the fourth quarter of this year. The price, with drive electronics, is $99.50 each in 1000-unit quantities.

IEE is also offering some new plasma panels. It is coming out with 64, 128 and 256 character models—in either red or green. The green is produced by using the glowing neon gas to excite a phosphor. The panels also come with either "mini" 0.2-in. characters or "maxi" 0.3-in. characters. There is no price differential for the different sized characters, but there is a minor additional charge for the green color. IEE is also offering a new 4-line, 88-character, scrolling display. Data in this display are inserted, by the line, left to right from the bottom, with the overflow disappearing at the top. And, in the near future, IEE will be introducing a 2-line, 32-character, scratch-pad display.

Unlike the dc plasma panels offered by Burroughs and IEE, National Electronics has an ac capacitively coupled gas-discharge device—known as Plasmac—that incorporates several display functions into a single panel. Mixtures of alphanumerics and fixed messages can be easily accommodated. Panels can be as small as 1 × 3-in. or as large as 8 × 15-in. Fixed messages employ backlighted film.

With several display functions in one panel, significant cost savings can be realized for the total display subsystem—including logic and driver-interface electronics.

Owens-Illinois also has an ac plasma panel called the Digivue. It can show up to 4000 characters.

Low power is liquid crystal's forte

Liquid crystals have extremely low power consumption when compared with other display devices. For battery-powered instruments that must operate for long periods before the battery is to be replaced, they are a logical choice.

Since their introduction, liquid crystals have been plagued with technical problems. But things are getting better. Reliability and contrast are increasing and improvements are being made in operating voltage and power consumption.

During the last few years, power consumption for LCDs has dropped from 15 μW to 300 nW for a 200-mil high 3-1/2 digit display. A large part of this decrease can be attributed to a switch from dynamic scattering devices to field-effect ones. The rest of the improvement results from better materials and fabrication techniques.

Today's LCDs operate from 12 V or, for a higher price, 6 V. And manufacturers are beginning to talk about an LCD that will need only a 3-V peak-to-peak voltage, making direct operation from a single battery with no voltage conversion possible.

At low light levels or in the dark they need an external light source. Some new LCD watches, for example, have a switched incandescent bulb to backlight the display. While this at first may appear to negate the low-power advantage of LCDs, studies show that watches are read only a small fraction of the time in the dark.

Because they contain liquid, LCDs are restricted to a narrower temperature range than other displays, typically 0 to 50 C. They also have shorter lifetimes—generally about 50,000 hours—though progress has been made in extending them to as much as 100,000 hours. Finally, they have a noticeably slower switching time. This affects the ability to multiplex them.

Contrary to popular belief, LCDs can be multiplexed. This has been demonstrated on field effect LCDs. But the resulting display usually has a strong angular dependence and slower transient response times. Also multiplexing requires higher peak power, though the over-all power can be reduced.

Probably the largest LCD digits available are the Series LD, 8 × 10 in. units from Transparent Conductors. These are dynamic scattering types and can be used in either transmissive or reflective modes.

For alphanumeric data, Hamlin offers one-inch-high, 16-segment, dynamic-scattering displays that provide good readability at up to 30 feet. They are available in either reflective silver or transmissive versions. Films are available that will make the segments appear colored on a black background.

In watch displays, Beckman offers a new 5-1/2 digit unit, its model 705, which includes the annunciator words "Date" and "Sec."

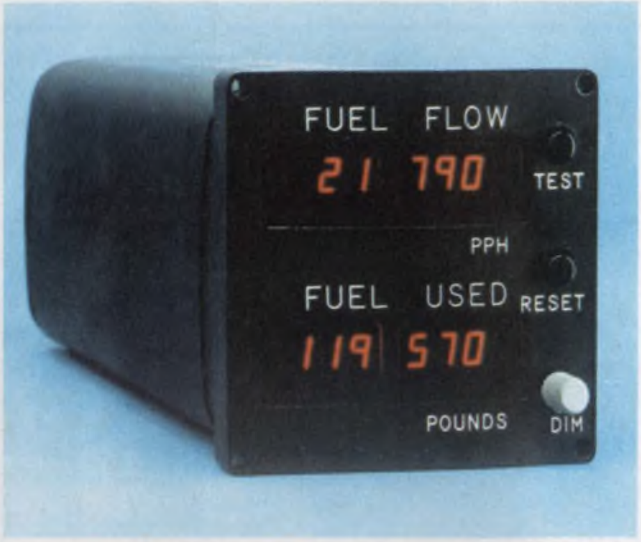
In another development, Hitachi Ltd. of Japan is thinking of using an LCD to compete with plasma panels and CRTs. The company recently announced the development of a system capable of displaying more than 600 alphanumeric symbols. This would make them attractive for computer-terminal applications.

Until now, the fabrication of large area LCDs has been unsuccessful because of the long time lag between the application of voltage and the change in transparency of the liquid-crystal material. But this has been overcome by improving the material used in dynamic-scattering displays.

Incandescents are brightest

For brightness, incandescent displays are unequalled. They offer more light output than any other type of display and are readable even with high ambient light levels. For example, the CM5 Series from Chicago Miniature Lamp are seven-segment displays that feature a typical brightness of 8000 foot lamberts, the highest output

Dc plasma panel from Burroughs comes with all decoding, driving and scanning circuitry.



Gas discharge displays, like these from Beckman, feature high visibility even in bright ambients.

available from any miniature display.

Contrary to popular opinion, multifilament incandescents can have fairly good shock and vibration characteristics. This is demonstrated by the fact that they meet MIL-STD-202C shock and vibration requirements and can be used in airplane cockpits. Unlike many other types of displays, incandescents can work at temperatures ranging from −55 C to +125 C. But they also generate a lot of heat. So if many displays are being used, some sort of ventilation or cooling may be required.

Although incandescents require more power than LEDs—250 mW to 1 W versus 10 mW to 140 mW—like LEDs they can directly interface with TTL or DTL logic. While the character height of these displays is seldom larger than a half inch, their good brightness eliminates many visibility problems.

Incandescent displays, such as those from Chicago Miniature, Dialight, Pinlites and RCA, are the only ones that can provide an output in any color. This is done by simply adding a filter of the correct color.

Also, incandescent displays are not as short lived as many think. In fact, typical life ratings are 100,000 hours. A disadvantage to incandescents, however, is that they may require additional drive circuitry. But the parts are readily available.

A display that is finding increasing popularity because of its pleasing blue-green color is the vacuum fluorescent. The dominant manufacturers are Japanese companies that include Ise Electronics Corp., Futaba Electronic Industries and Nippon Electric Corp. They are also made in the U.S. by LFE Corp. in Massachusetts.

Fluorescent displays have a few disadvantages. They require between 20 and 50 V for operation

Fluorescent displays produce a **pleasing green glow** when lighted. They require low power and low voltage, but are susceptible to shock because of their glass package.

and come in a glass package that is susceptible to damage from shock. Also they contain filaments which continuously drain power. And filament breakage can make it necessary to discard a multidigit display.

Nevertheless many users feel that the attractiveness of the display outweighs its disadvantages.

Try magnetic discs for size

If large size is a prime requirement for your display, electromagnetic discs that are painted in fluorescent colors and arranged in dot matrices are a good choice.

Like the liquid-crystal display, this type is reflective and looks better as the ambient light level increases. The absence of lamps or other active elements in the display results in an operating life in excess of 20 million hours. And the display has inherent memory. This means it requires only a single current pulse to change the data and no power to maintain it. Thus, this type of display can be easily multiplexed without refresh circuits and consumes very little power.

The electromagnetic display is also available in segmented character configurations. Ferranti-Packard is the major vendor. ■■

(continued on page 60)

(continued from page 59)

Need more information?

We wish to thank the companies that provided information for this report. The products cited in here have been selected for their illustrative, or in some cases, unique qualities. However, manufacturers not mentioned in the report may offer similar products. Readers may wish to consult manufacturers listed here and ELECTRONIC DESIGN's GOLD BOOK for further details.

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DuMont's color CRTs provide the exceptionally high performance and high resolution that are demanded by cockpit displays in Digital Avionics Integrated Systems. Display precision is completely unaffected by airframe vibration. Line widths as fine as 4 mils are available on most standard designs.

DuMont's proprietary multicolor penetration screen permits the display of data in up to four colors by varying the voltage of a single electron beam. It eliminates the complicated convergence circuitry required by conventional multi-gun color CRTs.

Two typical display formats that are enhanced by multicolor penetration screens are shown below. The EADI mode clearly presents information needed for take off, cruise, approach and final flight control bearings. A simplified moving map display showing distance to stations, course, relative station position, station identification and selcted course outbound is at the bottom, right.

All DuMont color CRTs will withstand vibrations exceeding 60Gs and up to 90Gs with state-of-the-art vibration isolation.

DuMont head down displays also provide superior brilliance and contrast, and perform beautifully in raster-scan and dot-matrix applications, as well as in random-address, stroke-writing systems. There is a wide choice of available CRT models with dimensions ranging from 1.9 x 3.4 to 7.6 x 7.6 inches.

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EADI Display

Moving Map Display

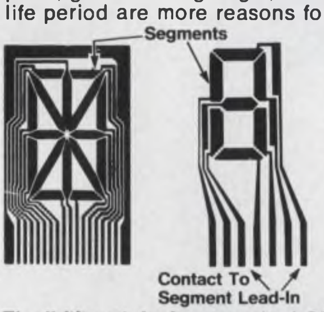
For complete specs and information on the most advanced color cockpit CRTs in the world, contact us at: 750 Bloomfield Avenue, Clifton, N.J. 07016 (201) 773-2000.

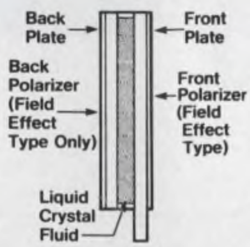
INFORMATION RETRIEVAL NUMBER 41

Liquid Crystal Displays: An Application Report

Design and function of liquid crystal displays are stimulating increased interest and expanding application of this versatile, digital readout. Although the LCD is a late comer in the display field, it is presenting a strong challenge to the other types, principally the light emitting diode — LED.

LCD advantages are greatly responsible for the fast development and lower cost of exciting new products. And for improved design of conventional equipment and machines. For example, simple sandwich construction of Hamlin's LCD fits limited space. Alphanumeric displays (transmissive and reflective) provide side-by-side mounting versatility. Light control film offers a choice of colored displays. There's no washout in high ambient light levels. Microwatt power requirements, few parts, good viewing angle, exceptional reliability over extended life period are more reasons for the switch to LCDs.

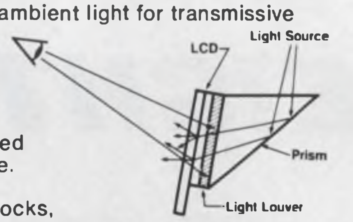




Flexibility of design permits LCDs to be scaled up or down to meet product needs. For example, Hamlin makes a display used in a ladies watch that measures only .450″ x .575″ (11.25 x 41.375 mm), but production facilities permitting, a display could be almost any size. Type of artwork used for creating the display design also provides an inexpensive way to customize with a logo, product illustration, etc.

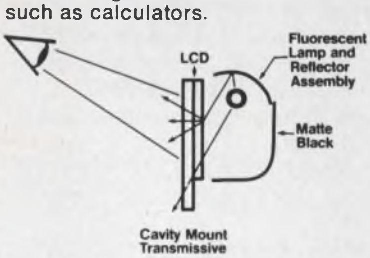
A choice of lighting methods permits LCDs to match a wide range of applications. Because liquid crystal displays are not self-illuminating, ambient light must be used to best advantage, or the light source must be placed to cast light through or on the display. To meet viewing needs in relation to product design, Hamlin suggests a variety of lighting techniques:

Louver backlighting with ambient light for transmissive displays utilizes a plastic film at the back of the displays which permits the angle, depth and color to be varied. It provides a dark background while the activated display appears a frosty white. It is suitable for battery powered calculators, desk clocks, portable instrumentation, etc.

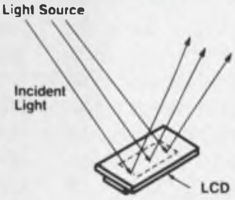


Louver Backlight-Ambient Light Transmissive

Cavity mount, employing a light source and reflector, achieves a high contrast white-on-dark display. Designed for transmissive displays, the light is hidden from the viewer. This arrangement is ideal for line cord operated instruments such as calculators.



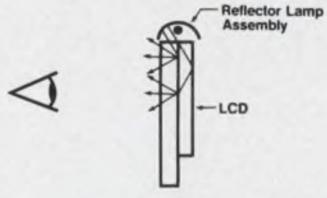
Cavity Mount Transmissive



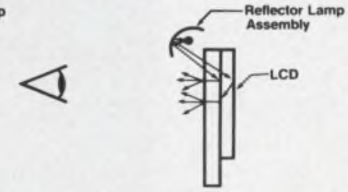
Ambient Light Reflective

Ambient lighting (reflective displays) is the simplest of all arrangements, but the display should be mounted as closely as possible to the panel with minimum recess to receive maximum illumination. For good contrast, a dark background such as a matte black surface on the back plate should be used.

Edge lighting offers a low power, compact method for reflective displays. Flat pack arrangement permits the display to be viewed by ambient light by day, and edge lighting by night.



Edge Lighting Reflective

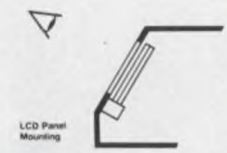


Front Lighting Reflective

Front lighting (reflective design) uses incandescent lamps or a fluorescent (typically 3-watt). It provides the advantage of viewing with ambient light by day and artificial light at night.

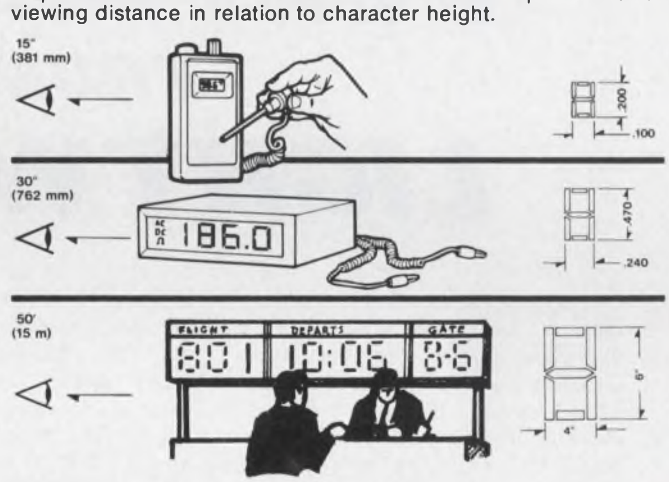
Mounting techniques with large LCDs are applicable to most equipment designs. Two most common types are:

Panel Mounting requires a special bracket to hold the display in the panel. The panel can be sloped to place the display viewing surface perpendicular to the operator's line of sight, or a bezel can be used to attain the same effect. Type of display and lighting will, of course, determine the mounting.



Connector Mounting is made with an edge board connector to hold the display and for making electrical hook up.

Determining viewing distance vs character size is a critical factor in adapting liquid crystal displays. Character height, width, spacing; segment width, separation between each and slope of characters are all to be considered. Examples illustrate viewing distance in relation to character height.



In application, liquid crystal displays meet the needs of an almost unlimited number of products — from watches to office equipment, flight instruments to appliances. In fact, where MOS and C/MOS compatibility, flexibility of design, low power requirements are factors, LCDs provide an efficient and practical solution.

Hamlin stocks several standard LCDs in both dynamic scattering and field effect types (transmissive and reflective) for immediate delivery. Special displays with virtually any image can be produced to order with surprisingly low preparation costs. And LCD's simplicity means lead time of just a few weeks. For detailed specifications and application data, write Hamlin, Inc., Dept. #614 Lake Mills, WI 53551, 414/648-2361
Evaluation samples are available at moderate cost.

HAMLIN
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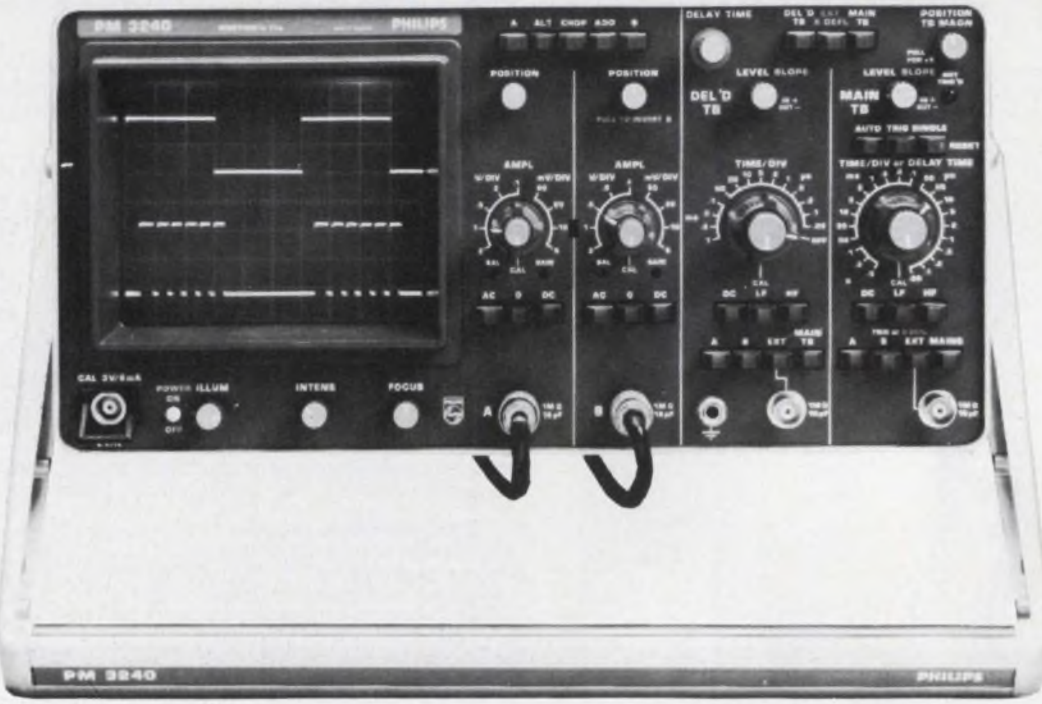

HEAVYWEIGHT PERFORMANCE FROM A LIGHTWEIGHT

Lugging excess weight around on service calls under all kinds of environmental circumstances doesn't improve the efficiency or enthusiasm of servicemen. That's why more and more of the purchasing decisions are being influenced by weight besides the price and performance of a portable oscilloscope.

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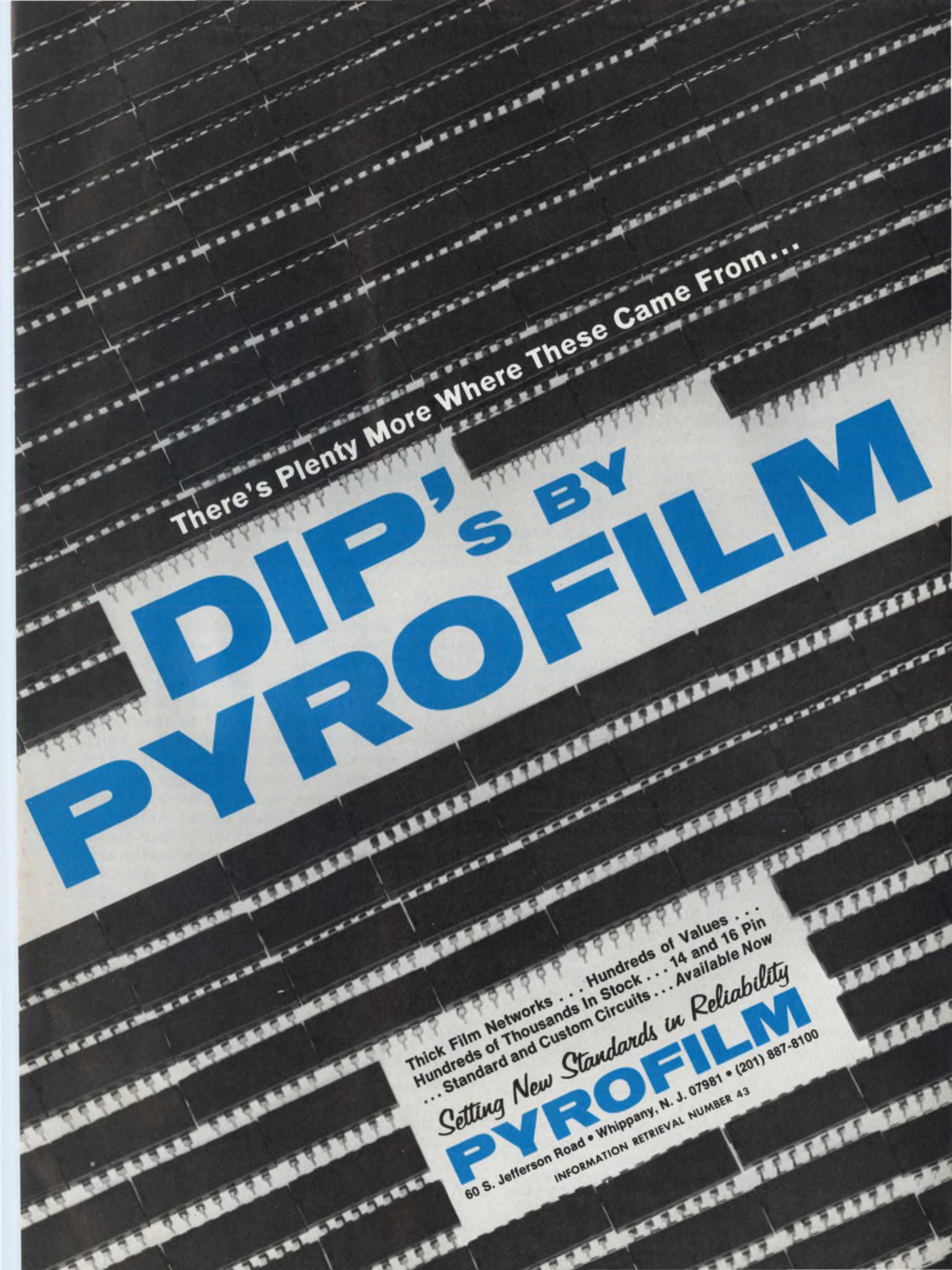
FOR DEMONSTRATION CIRCLE 48

INFORMATION RETRIEVAL NUMBER 49



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INFORMATION RETRIEVAL NUMBER 43

Consider LCDs for your next design.

Liquid-crystal displays need little power. They can show complex images, and present them clearly.

Probably you've already considered liquid-crystal displays for use in your system. If so, you made a decision for or against LCDs—versus, say, light-emitting-diode displays. But now improved LCDs have come along. And they make a new appraisal a must.

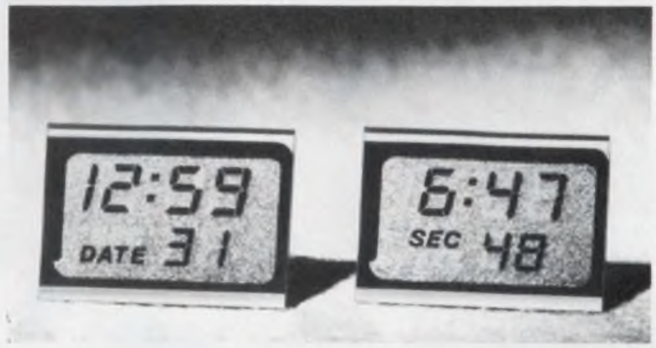
Perhaps you already selected earlier LCDs simply because of their low-power requirements. That's still a major advantage. However, today's LCDs also offer the following benefits:

- They can mix alphanumeric characters of any font style, pictures and symbols in a single package (Fig. 1). In essence, any image that can be photographed can be presented as an LCD.
- Various color combinations of images and backgrounds can be obtained. Images can be presented in black or even blue against sharply contrasting backgrounds.
- LCDs combine readily with CMOS (complementary-MOS) circuits to produce compact, portable equipment that has long operating life. In line-powered systems, the combination of LCD and CMOS simplifies drive and supply circuitry and reduces cooling requirements. Thus system costs can be decreased.

LCDs dissipate microwatts

The low-power benefits of LCDs extend to both field-effect (also called twisted-nematic) and dynamic-scatter displays—the two types of LCDs. As part of a digital watch, a field-effect display typically requires a mere microwatt to energize all segments. A dynamic-scatter display, operating at 12-to-20-V levels, dissipates about 40 to 50 μW. By comparison, a four-digit LED-watch display typically uses 60 mW when operated at 3 V.

Both types of LCDs sandwich the liquid-crystal material between two glass plates, separated by about one-half mil, or 12 μ. The plates are sealed around their perimeter. The image appears between two layers of conductive material—one etched on the surface of each glass plate.



1. **Liquid-crystal displays for clocks** can combine hours and minutes with seconds or dates. These units are the 705-series from Beckman Instruments, Helipot Div.

In operation, voltages applied to the display change the molecular orientation of the liquid-crystal material, thereby modifying the light passing through.[1] Dynamic-scattering displays present white images on a clear or reflective background. Field-effect displays usually have black or dark images on a clear or lighter-colored background. However, the color combination may be reversed by rotating one of the polarizers (needed to orient light correctly in field-effect LCDs) by 90 degrees.

Various color combinations of digits and backgrounds can be obtained by varying the tint, or percent transmission, of the polarizers used. For example, a black digit is usually obtained with a 42%-transmission polarizer. At the higher transmission of 55%, the digits appear blue. Typically 42 to 45%-transmission polarizers are used, because of their wide availability. Black digits are most popular, because they present a sharp contrast against light backgrounds.

LCDs emit no light. Thus, they require no power for this purpose. Both field-effect and dynamic-scattering displays can be used in either a reflective or transmissive mode. In the reflective mode, ambient light passes through the cell

Daniel J. Renn, Chief Engineer for Display Devices, **Lyle F. Pittroff,** Product Manager Hybrid Microcircuits, Beckman Instruments, 2500 Harbor Blvd., Fullerton, CA 92634, and **John D. Dunn,** Display Systems Manager, American Microsystems, 3800 Homestead Rd., Santa Clara, CA 95051.

and reflects back through the cell toward the viewer. However the absence of emitted light renders reflective-mode LCDs less readable in very low light levels.

A transmissive-mode display, properly backlighted by an external source, provides low-light-level performance equivalent to a gas-discharge or LED display. The trade-off, however, is increased power consumption of the light source. This partially neutralizes the LCD low-power advantage. Of course, the light source need not be operated continuously; it may be switched on only during low-ambient conditions.

Both reflective and transmissive-mode displays show increased readability in high ambient light. Newer digital LCD watches employ a transmissive-mode display and a light source that can be turned on and off by the watch wearer. This is the only display technique today that allows a watch to have excellent readability in high ambient light levels and provision for nighttime viewing.

But LCDs also have disadvantages. These include slow turn-on and turn-off times and somewhat limited operational temperature ranges. However, there have been recent advances in materials, packaging, and the understanding of failure modes. These advances have led to improved display parameters and heightened display-life projections.

LCDs: nonlinear circuits

The equivalent LCD circuit consists of temperature-sensitive nonlinear capacitors and nonlinear resistors in parallel. The resistance and capacitance values also depend on display threshold. At 25 C, the capacitance below the threshold level is about 40% of the capacitance above the level, while the resistance below threshold is about one-half of the resistance above threshold (Fig. 2).

Typical drive requirements are 12 to 20 V ac for dynamic-scattering devices, and 2 to 8 V ac for field-effect units; capacitance above threshold typically ranges from 5 to 35 pF per segment. Resistance above threshold is typically 1 to 10 MΩ for dynamic-scattering, and over 400 MΩ for field-effect units.

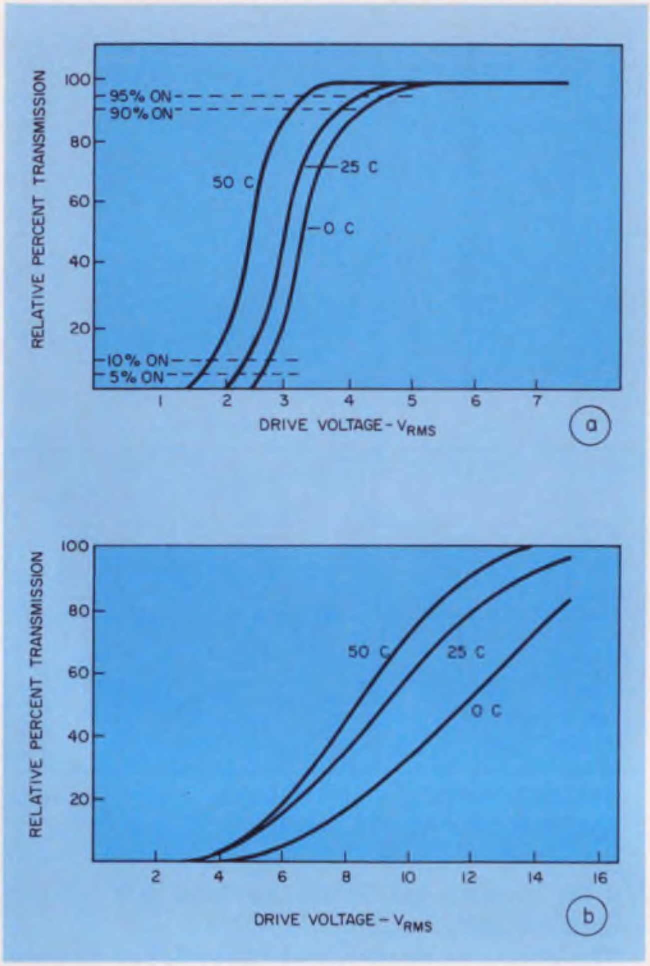
LCD type	Dynamic scatter	Field effect	
Operating voltage—V		3	6
On	> 12	> 2.5	> 5
Off	< 5	< 0.5	< 1
Dc current drain per cm^2—mA	12	0.1	
Ac power per cm^2—μW	150	3	
Capacitance per cm^2—pF	300	600	
Turn-on delay (@25 C)—ms	100	150	
Turn-off delay (@25 C)—ms	100	200	

2. **Typical specifications for LCDs** show power consumption to be in the microwatt region.

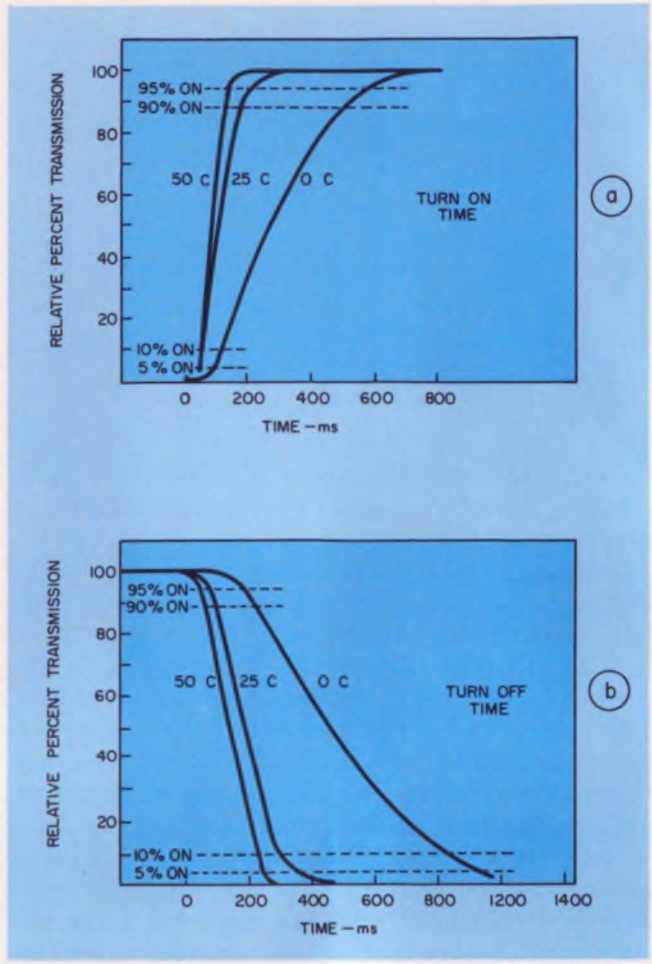
The effects of temperature changes can be seen from an examination of threshold-transmission curves (Fig. 3). With both LCD types, an increase of temperature within the 0-to-50 C operating range reduces drive requirements. The difference is more significant for field-effect devices, since their drive requirement is lower. Below −15 C LCDs lose their liquid-crystal characteristics. However the devices aren't damaged by the low temperatures; they will again function properly when returned to higher temperatures. Similarly, above the operating temperature range, LCDs lose their liquid-crystal characteristics. But again this loss is reversible.

Switching times (Fig. 4) depend on several factors: temperature, drive levels, the liquid-crystal material, and the distance separating the front and back plates of the display cell. Reduced plate spacings result in faster switching times. But manufacturing tolerances then become more difficult to maintain. And the problem worsens when display cells become larger, as they do for some instrumentation displays. Generally large-area displays require a special blending of liquid-crystal materials.

It's important to know that different manufacturers define switching, or response, times in different ways. Some vendors specify switching time as the period between 10% and 90% of complete turn on. This approach hides an initial delay time that often adds an extra 50 to 100 ms.



3. **Temperature variations affect LCD transmission** of light. The change is greater for field-effect units (a) than for dynamic-scatter (b), because field-effect LCDs have lower thresholds.



4. **Switching times for a 3-V field-effect LCD** also depend on temperature. At 25 C, turn-on time (a) from trigger signal to 90% on is 200 ms. Turn-off time (b) at the same temperature is 350 ms.

A better approach defines response time as the period beginning with the application of the trigger signal and ending when the device is 90% on. Actually LCDs have fast switching times above 25 C, but they become slower as temperatures decrease to 0 C. Recent and continuing advancements in materials technology are gradually improving switching characteristics.

Ac drive signals are necessary

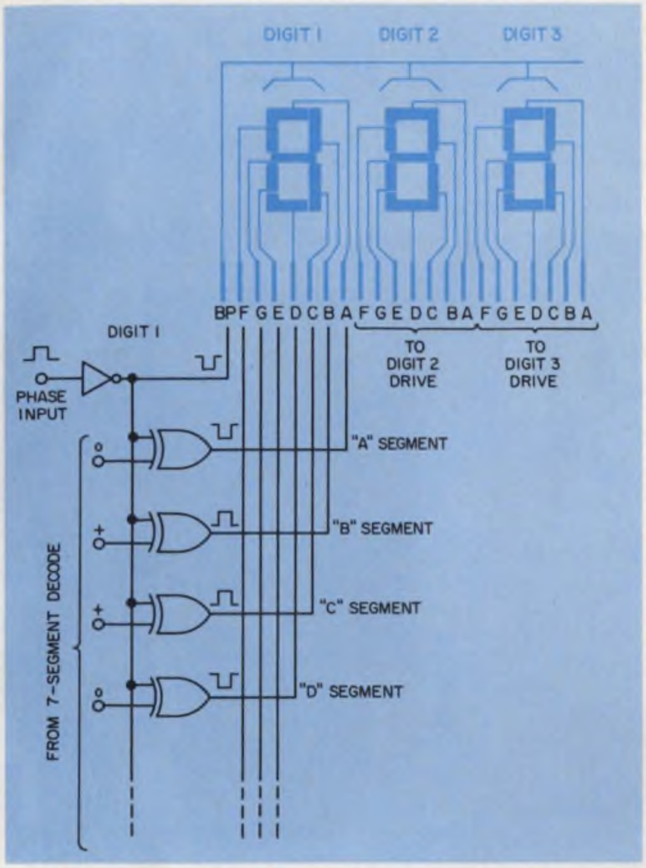
LCDs require an ac drive signal that may range from 25 Hz to 1 kHz. Watches typically use a frequency of 32 Hz, while 50 to 60 Hz is the standard for line-powered instruments. A completely symmetrical ac signal is ideal, though small dc offsets—below 25 mV—appear to have no degrading effect.

Several single-digit, seven-segment, decoder-drivers are available in standard CMOS logic families. An Exclusive-OR circuit—like the RCA CD4055 and CD4056, or Motorola MC14511 and MC14543—can be used to drive a display (Fig. 5). However, costs can be reduced by the use of a dedicated CMOS LSI circuit. The LSI chip replaces several less-complex circuits that primarily provide the display's parallel-drive signals. Several suitable LSI chips have been introduced, and more are expected.

The multiplexing of LCDs would seem to be the next advance. A simple three-digit, seven-segment, display with a common backplane requires only 22 pins, and each output has its own drive circuit. With more digits, the pinouts and associated drive circuits become more complex. Hence a multiplexed subsystem should result in lowered equipment cost.

However multiplexing has thus far been achieved only with dynamic-scattering displays, and for groups of four digits. These displays employ multiple-voltage and multiple-frequency addressing techniques. As for field-effect displays, the industry has yet to introduce a display that can be multiplexed over a reasonable temperature range.

Most LCDs use either screening or photolithographic techniques. Thus the term "price-per-digit" doesn't really apply. All digits are batch



5. **LCD uses CMOS Exclusive-OR gate** to obtain parallel-drive signals and achieve low over-all power consumption.

fabricated, so it's the price per cell that counts. And that depends on display area, image complexity, materials, quantity, and yields.

How it's made affects the price

For example, a 4-digit watch display that sells for $5.00 in 100,000-piece quantities has a price per digit of $1.25. But the same sized cell with six smaller digits to display hours, minutes and seconds might be built for the same price assuming screening or photo tolerances permit the same yields.

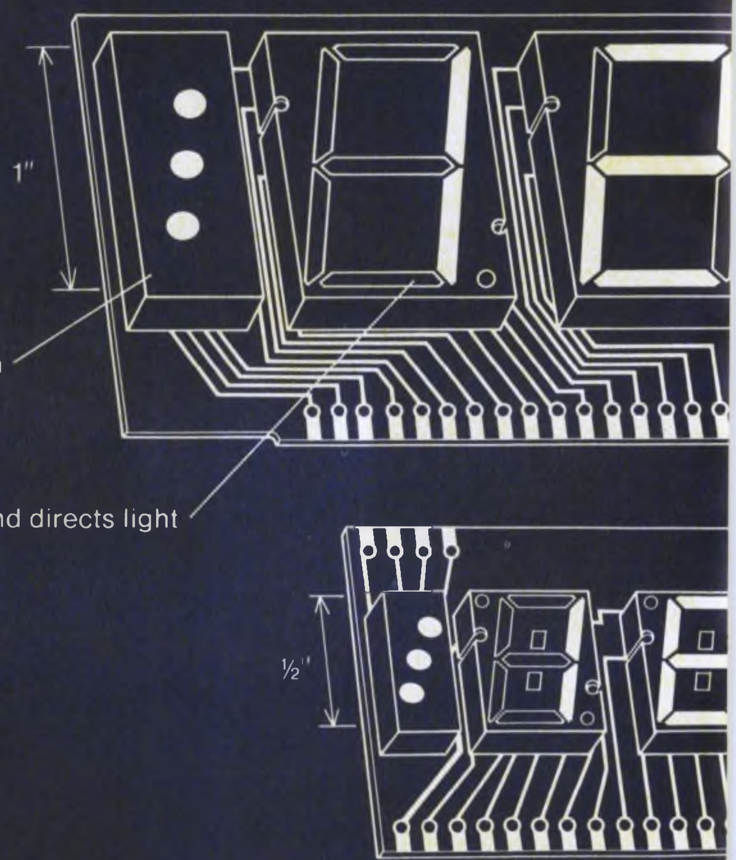
With small displays, the major constraint on yield is line resolution. Current screening techniques limit resolution to 6-mil lines and spaces. Photo techniques allow much tighter lines and spaces—about 2 to 3 mils—with good yields.

Large-area LCDs have poorer yields—and hence, higher costs—than do small displays. The increased area heightens the chance that bubbles, specks, or lesions will develop. For example, a speck only seven mils in diameter is visible. Depending on location, this speck might cause the cell to be discarded. ■■

Reference

1. Tannas, Larry E., Jr., "Liquid Crystal Displays Are Great—but . . . ," *Electronic Design* No. 14, July 5, 1974, pp. 76-80.

Let's hear it for 1" high LEDs!



The first ever.

See?

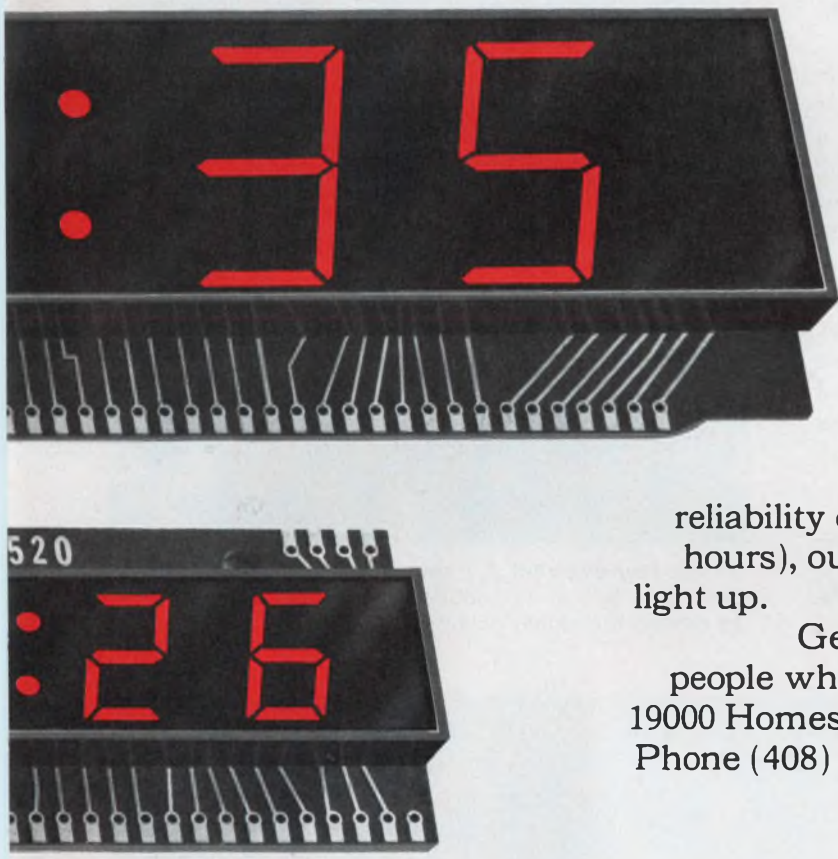
Good things are worth waiting for.

Litronix (who else?) is pleased to announce the industry's first 1-inch high LEDs—big, beautiful, and bright. You can easily read them from 60 feet away without squinting.

That's nice news for manufacturers of digital clocks and panel meters.

But that's not all the news.

These 1-inch digits (as well as our new ½-inch digits) use a new technology to reduce costs. This means a price saving to you of more than 10%. For example, our ½-inch reflective model costs less than 90¢ per digit vs. about $1.00 per digit for our ½-inch light-pipe model. Nice?



Here's the clincher. You can get an entire array of 2 to 8 digits already mounted on a single PC board—with colon, AM/PM sign, or ± sign, and over-range "1" as required. All this reduces your assembly costs. Makes the production easier. And simplifies testing and inventory.

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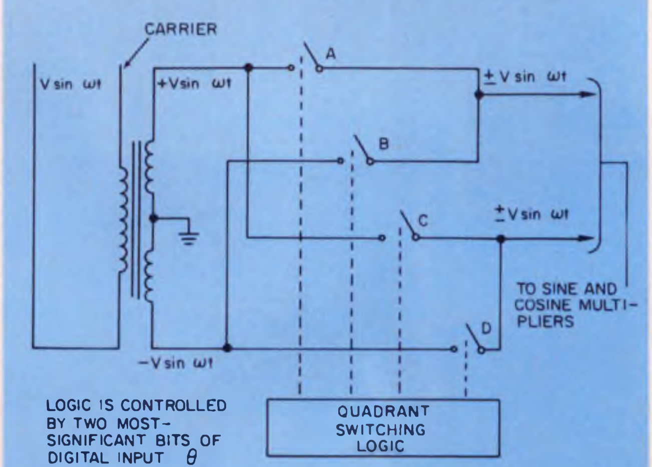
INFORMATION RETRIEVAL NUMBER 45

Mate synchros with computers by using solid-state conversion modules. S/d and d/s converters can minimize mechanical interfacing while boosting reliability.

Eliminating the moving parts in any computer-controlled measuring system can increase the over-all reliability. You can do this in mechanical synchro and resolver based systems by replacing the gear trains and mechanical shaft encoders with solid-state synchro-to-digital and digital-to-synchro converters.

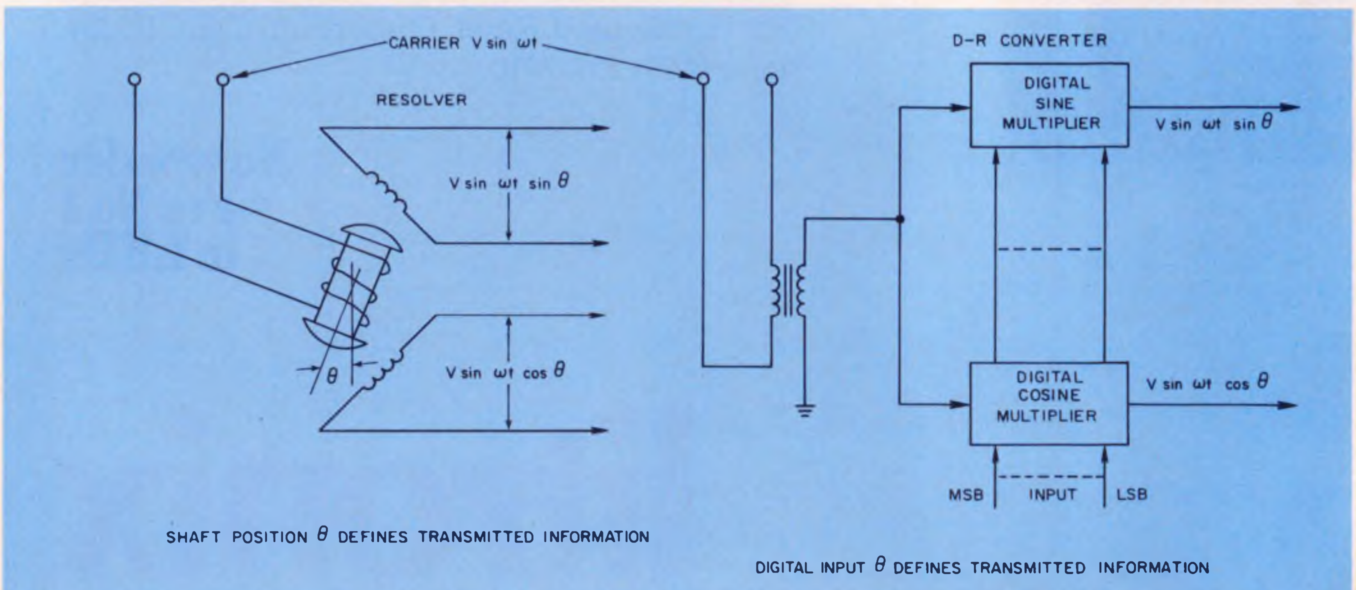
Synchros, though more widely known than resolvers, require more circuitry to handle their outputs. The synchro transmitters provide a three-wire, three-phase modulated-carrier signal, where each phase is shifted by 120°. This type of signal cannot be easily handled by digital controllers or processors. The resolver transmitters, on the other hand, provide a four-wire, two-phase modulated-carrier signal that is shifted by only 90°—much easier for digital processing equipment to work with. (For more resolver and synchro basics, see the article "Consider Using Resolvers and Synchros," ED No. 17, Aug. 16, 1975, pp. 70-72.)

Richard Ferrero, Product Manager, Synchro Converters, Analog Devices, Rte. 1 Industrial Park, Norwood, MA 02021

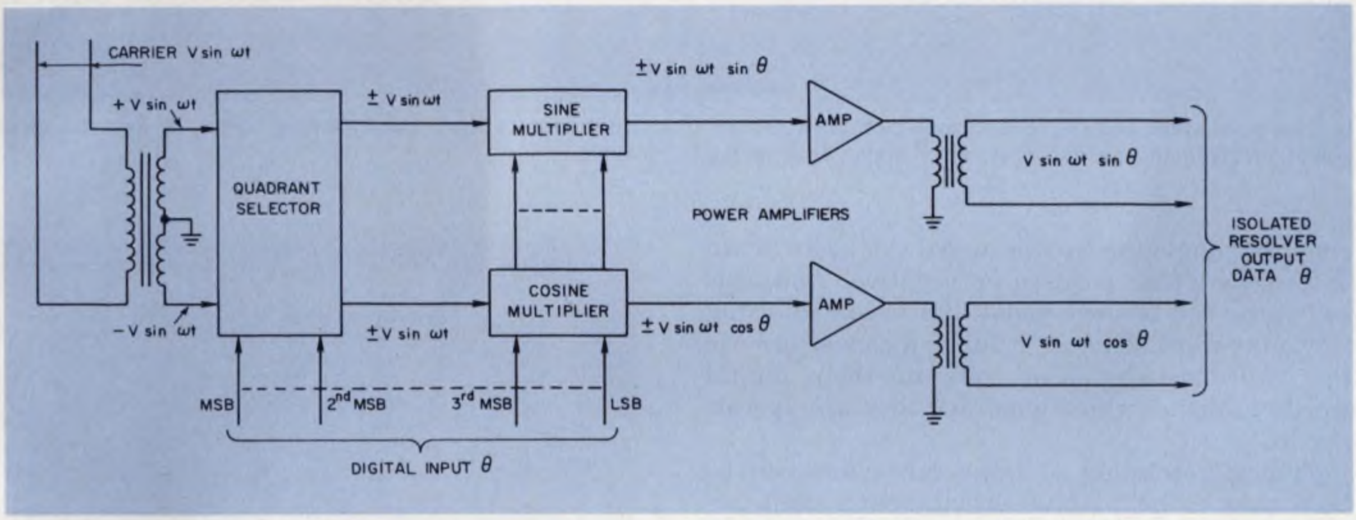


QUADRANT	sin θ	cos θ	SWITCH CLOSURES	BINARY INPUT
FIRST	+	+	A , C	0 0
SECOND	+	−	A , D	0 1
THIRD	−	−	B , D	1 0
FOURTH	−	+	B , C	1 1

2. **The four-quadrant d/r converter** uses switching logic, controlled by the two MSBs of the digital input word, to change the signal polarity.



1. **The digital-to-resolver converter** simulates the modulated-carrier resolver signals under digital command.



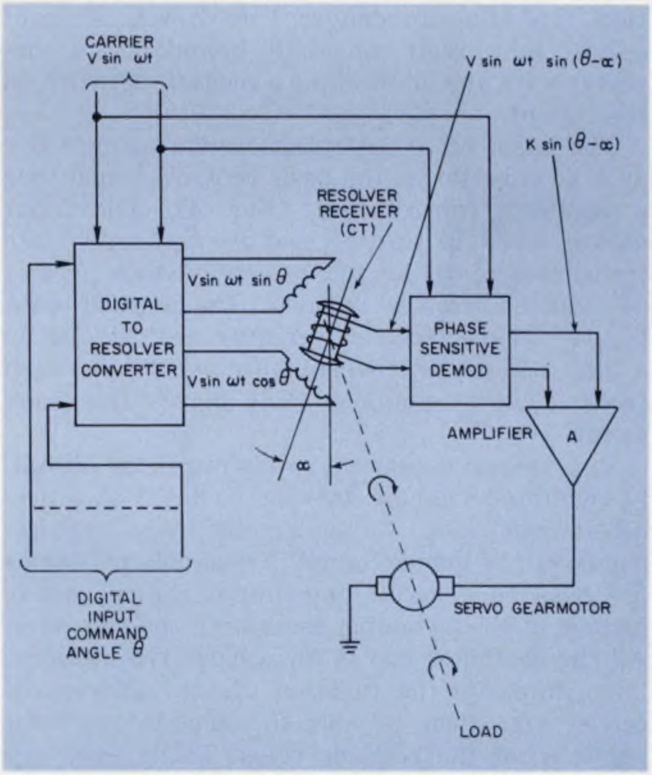
3. **Power amplifiers can be added** to the d/r converter to better drive the resolver receivers. Transformers can be added to the converter to isolate the output and prevent short circuit damage.

To simplify the conversion and signal-processing circuitry, synchro signals must first be converted into resolver-type signals by the use of Scott-T transformers on the input lines. In fact, most commercial s/d or d/s modules are really resolver-to-digital or digital-to-resolver (r/d and d/r) modules with built-in Scott-T networks.

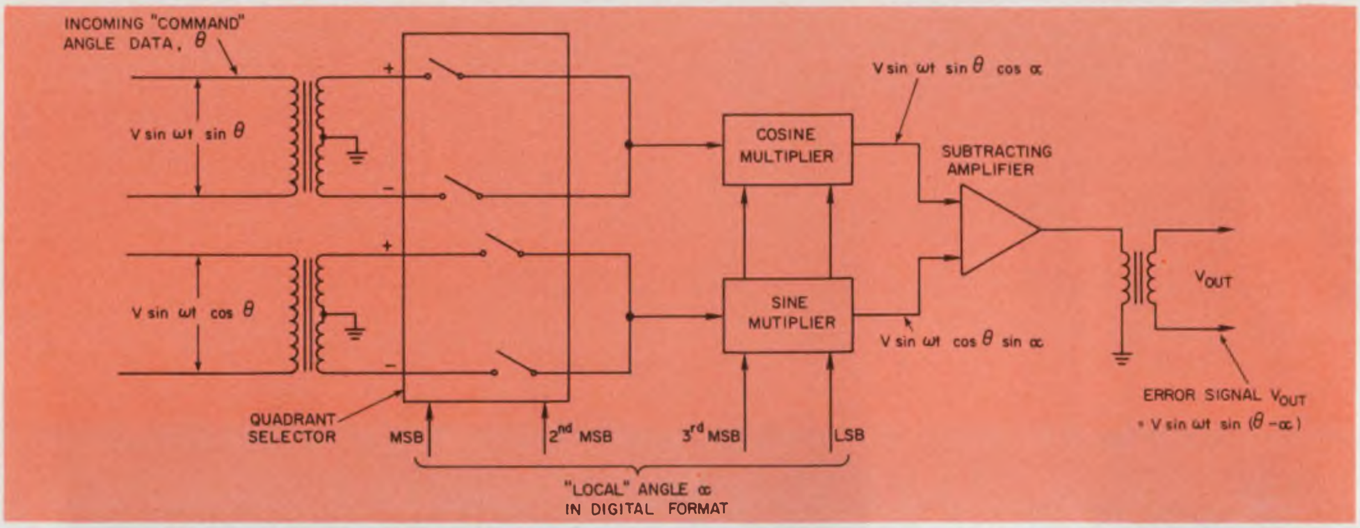
Inside the solid-state resolver

To simulate the electromechanical action of the resolver transmitters, the solid-state units use sine and cosine digital multipliers. These multipliers duplicate the variable coupling of the actual moving stator (Fig. 1). The two multipliers produce modulated-carrier outputs that are 90° out of phase with each other. They develop outputs of $V(\sin \omega t)\sin \theta$ and $V(\sin \omega t)\cos \theta$ in response to a digitally coded input signal that corresponds to angle θ. In most d/r or r/d converters, the digital multiplier is a variable reference digital-to-analog converter.

The circuit shown in Fig. 1 is good only if the amount of rotation to be simulated is less than 90°. For larger angles, the sign of the output voltage must correspond to the graphical quadrant of the angle θ (Fig. 2). To simulate this



4. **A basic closed-loop servo system** puts the output of the resolver rotor through a phase-sensitive demodulator to control a gearmotor.



5. **The solid-state control transformer** simulates the resolver receiver and produces an error signal that is the difference between the incoming angle, θ, and the local angle α.

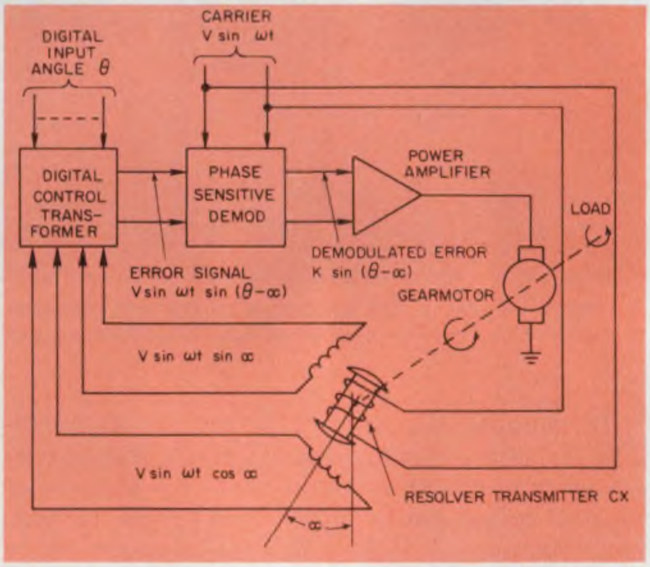
changing angle the carrier signal can be switched to become either positive or negative. And, this switching can be done under digital control using a two-bit word. Thus, d/r and r/d converters use the two most-significant bits of their digital words to define which quadrant they are operating in.

Typical resolution of these converters can be then said to be 14 bits—even though their accuracy is usually limited to 12 bits. The full four-quadrant d/r converter shown in Fig. 3 comes complete with reference, output isolation, quadrant selection circuitry and power output stages that typically can deliver 1 to 2 VA. And, of course, the circuit can easily become a d/s converter with the addition of a Scott-T network on the output.

The basic servo controlled system using a d/r or d/s converter as the basic control element has a feedback control loop (Fig. 4). The input digital word is transformed by the solid state transmitter into angular signals which feed a mechanical resolver receiver. The angular data induced in the receiver armature are decoded by a phase-sensitive demodulator which in turn feeds a power amplifier that drives the gearmotor.

This system becomes a rate servo if the digitally generated angular data get updated at a predetermined rate. Computer software requirements can be kept minimal if read-only memories are used to generate the digital control words instead of the computer generating the raw data. All the computer has to do is clock the memory.

To duplicate the function of the resolver receiver, you must be able to simulate the local angle, α, of the resolver rotor. To do this, you can use a circuit similar to the circuit of Fig. 3, except that there are two input transformers (Fig. 5).

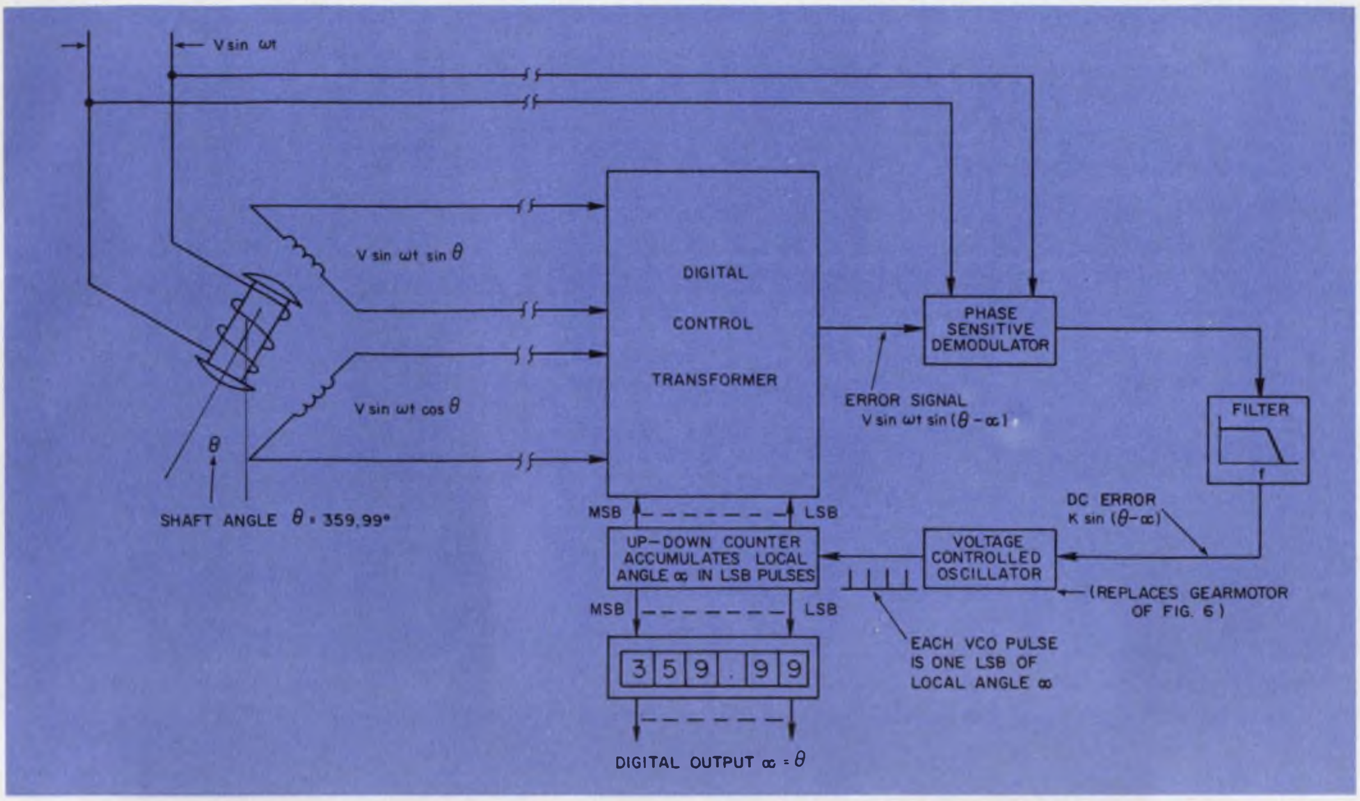


6. **This digitally driven servo system** can replace the system shown in Fig. 4. It doesn't need the power amplifiers used in the earlier circuit to drive the resolver receiver since just logic signals are needed.

The local angle can thus be fed into the digital inputs of the solid-state resolver receiver (sometimes known as a control transformer). The resulting output of the receiver circuit is a difference signal that can be used for servo control.

By using a control transformer instead of the d/r converter, you can again build a circuit that functions similarily to that of Fig. 4. Both Fig. 6 and Fig. 4 do the same job, but accomplish it by different methods.

From an applications point of view, the circuit of Fig. 4 is optimized if the d/r transmitter is located close to the computer, with the target angle transmitted to a distant servo in analog format. The high-voltage, low-impedance, resolver signals provide fairly good noise immunity and thus can be transmitted over long dis-



7. **A solid-state control transformer** can make the circuit needed for a digitally displayed shaft angle very simple. The circuit needs no power amplifiers and no complex mechanical linkages.

tances with negligible error.

The circuit of Fig. 6 works better if the control transformer is located close to the servo, rather than to the computer, to avoid long distance transmission of low-level signals. In this case, data are transmitted digitally from computer to a solid-state control transformer. Serial or parallel data transmission is possible, although the circuit shown uses parallel. To get serial transmission all you have to do is use a parallel input register—such as is included in the Analog Devices SERDEX data transmission module.

The electrical design of the two similar systems is also radically different. For instance, in Fig. 4 a d/r converter is used instead of a resolver transmitter. Thus angular data being transmitted must have sufficient power (several VA) to energize the resolver receiver's stator coils. Thus the d/r will need some outboard power amplifiers.

On the other hand, the circuit of Fig. 6 has solid-state circuits that must handle only computer level data—no power amplifiers are needed and thus the circuit could be made smaller. And, the lower power requirements also tend to place less stress on the components, thus increasing reliability.

If you need a digital display to indicate the angle of the shaft, don't despair. You can easily add a display by including a string of up/down counters, a voltage-controlled oscillator and a low-pass filter, as shown in Fig. 7. The entire circuit, aside from the resolver, can be built on a single circuit card and mounted in the computer.

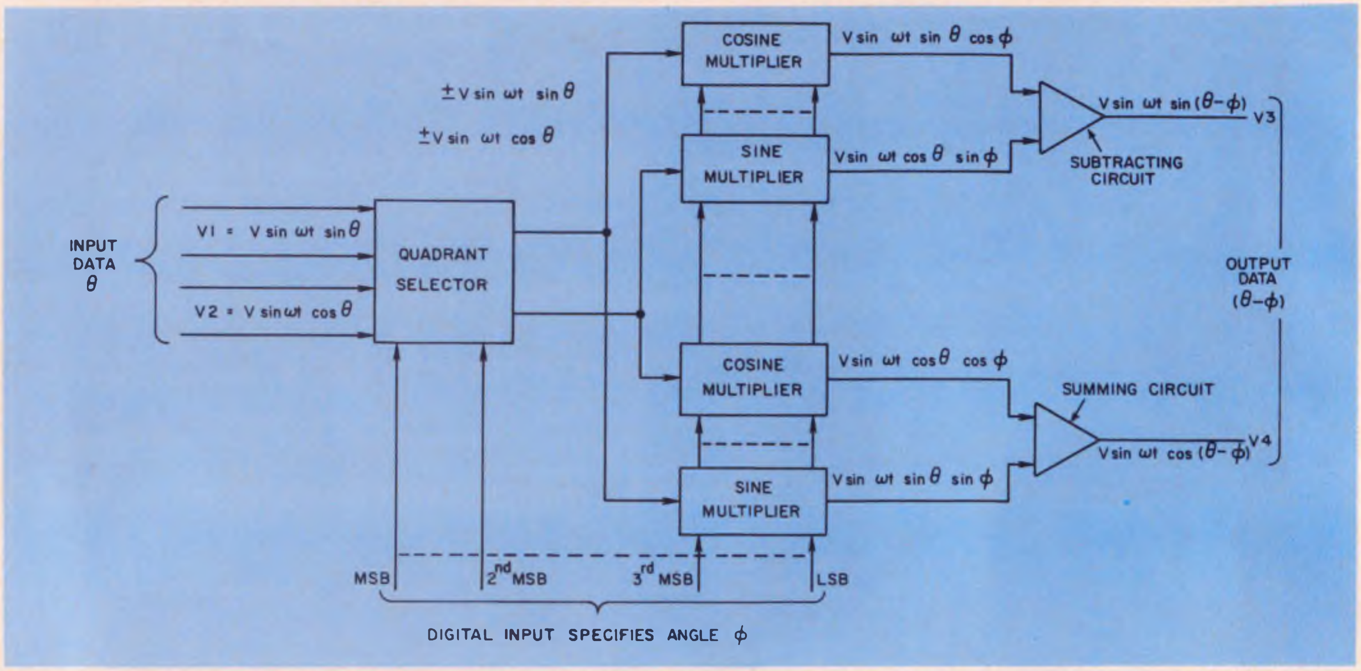
A comparable electromechanical system would require motors, gears, mechanical readouts and a digital shaft-angle encoder to re-transmit the digital data. The system in Fig. 7 contains only one integrator—the combination of the VCO and counter—so in classical servo theory, the system can be classified as a Type I servo.

Watch out for error sources

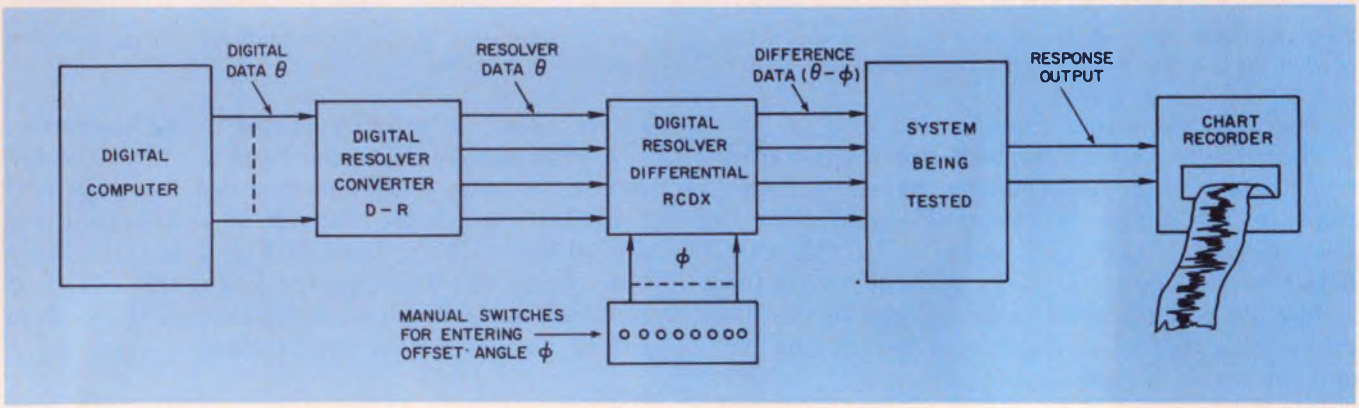
Rarely will the resolver conversion circuits be required to digitize data from stationary rotors. In numerical-control machine-tool applications the converter must keep the processor informed of cutting-tool position throughout the cutting cycle. Thus errors associated with the rotating shafts—usually referred to as rate and acceleration errors—must be specified.

The VCO used in the tracking converter system shown in Fig. 7 must have a finite input voltage to sustain the train of LSB input pulses to the count chain. And, to produce this VCO drive voltage, there is an inevitable lag, known as velocity lag, between the input angle θ and the digitally generated local angle α. Also, the faster the input data change, the higher the VCO voltage must become to keep the counter updated.

This dynamic lag is known as velocity error and is expressed in terms of the hardware's basic velocity constant, K_v, and the actual input angular rate, $d\theta/dt$:



8. **The differential control transmitter** has dual sine and cosine multipliers that provide a difference voltage which corresponds to the angle between θ and ϕ. This voltage is also modulated by the carrier.



9. **A simple computerized test system** uses the differential transmitter to manually enter any offsets that can compensate for variations in the system being tested and thus customize every unit.

$$\text{Velocity error} = (d\theta/dt)/K_v.$$

For a converter designed for a $K_v = 20{,}000$ and $d\theta/dt = 1200°/s$ (about 180 rpm), the lag between digitized output and angular input becomes 0.06°. A short table compares angular accuracies for different levels of converter performance.

You can reduce the dynamic lag by introducing a second stage of integration within the servo loop. However, if you reduce the lag error, you must pay the price with a more sluggish system—increased acceleration error. In some applications, though, this increased error may not be important—such as in constant-velocity N/C machine-tool operations.

Locate the second integrator just before the VCO of the circuit of Fig. 7 so that the VCO responds to the time-integral of the demodulator output. This system is classically categorized as a Type II servo.

The phase-sensitive demodulator used in the system also helps to keep errors down. It minimizes any errors caused by random noise, harmonics and quadrature. The demodulator also develops an output of the correct polarity so that the servo loop appropriately counts up or down. And, since the error voltage is averaged over several carrier cycles, instantaneous errors from large, short-duration spikes are minimized.

Differential transmitters are needed, too

The last solid-state equivalent to the electromechanical resolvers is the differential control transmitter. This device provides a pair of output signals that represent the difference between the input angle θ and the digital input angle ϕ (Fig. 8). Inside the transmitter are two resolver

Digital resolution vs digitizing error

Number of bits (n) in system	Digitizing Error (2^{-n})* as a fraction	as a decimal	as percent	as angle in degrees
6	1/64	0.0156	1.56%	5.6°
7	1/128	0.0078	0.78%	2.8°
8	1/256	0.004	0.4%	1.4°
9	1/512	0.002	0.2%	0.70°
10	1/1024	0.001	0.1%	0.35°
11	1/2048	0.0005	0.05%	0.176°
12	1/4096	0.00025	0.025%	0.088°
13	1/8192	0.000 125	0.0125%	0.044°
14	1/16, 384	0.000 161	0.0061%	0.0221°
15	1/32, 768	0.000 031	0.0031%	0.011°
16	1/65, 536	0.000 015	0.0015%	0.005°

* Where the total number of bits represents one revolution of the system (360°)

control transformers that process the resolver voltages $V(\sin \omega t)\sin \theta$ and $V(\sin \omega t)\cos \theta$ to create the equivalent of a differential transformer's induced voltage components. These components are fed into a subtractor circuit which develops the output $V(\sin \omega t)\sin(\theta - \phi)$, and $V(\sin \omega t)\cos(\theta - \phi)$.

A simple application of this type of circuit occurs in the computer controlled test system shown in Fig. 9. In this system the computer puts the electromechanical device through its paces by feeding it digitally generated resolver command angles. The differential transmitter permits you to introduce manual offsets in the angular data reaching the item under test.

There are many other ways that solid-state resolver modules can be used to modify mechanically generated resolver data. For instance, by using digital divider circuits between two sets of multiplier circuits you can simulate a rough and fine control adjustment of the servo system. The divider circuit replaces the gear ratio that would be found in the mechanical servo system.

Another modular system that uses the solid-state converters is found in pulse-position indicating radar systems. Here, the resolver input data feed into an r/d converter that in turn feeds two d/a converters that reconstruct sine and cosine waveforms from the digitized signals. ■■

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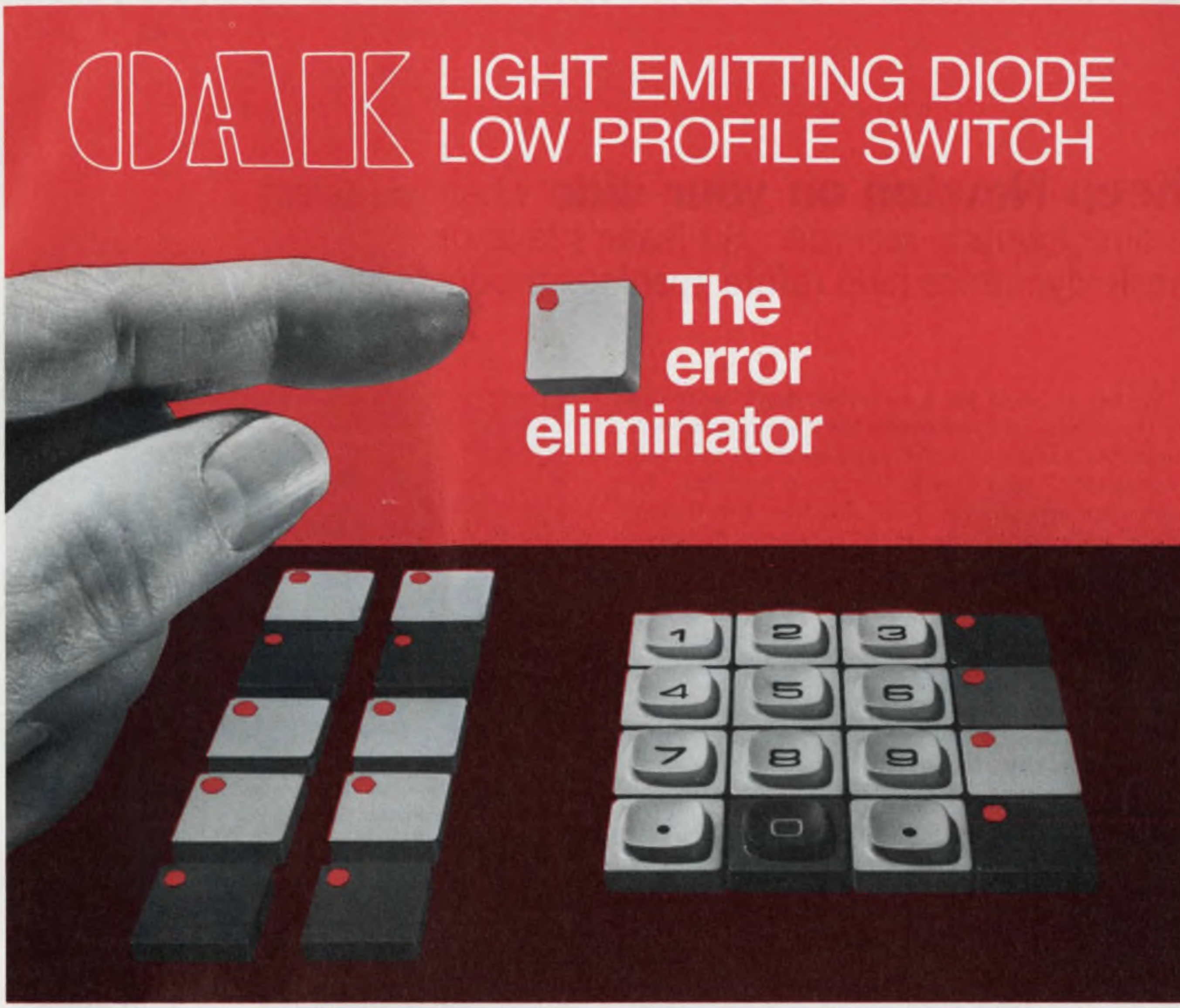

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INFORMATION RETRIEVAL NUMBER 50

Keep Newton on your side when you select a direct-writing recorder. Sir Isaac's laws of basic dynamics help refute specious product claims.

When you look for a recorder, don't be fooled by the claims and counterclaims for superior performance parameters. All galvanometers are electromagnetic second-order dynamic systems. As such, performance is determined by the inertia of the rotor stylus, the spring constant (mechanical or simulated with a position detector) and the damping (obtained from back-EMF, tachometer feedback or derived).

Arguments abound for the advantages of strengthening one parameter or another. Many manufacturers claim equivalent performances for their recording systems—at least when they leave the factory. But in some cases only an expert can make the system perform as stated. The buyer, left to his own judgment, should keep in mind a few rules:

- The relative cost of recorders generally is a function of weight and power consumption.
- From basic dynamics, it follows that smaller and lighter devices are faster. Heavier systems, even when their performance is equivalent to lighter ones, are not necessarily more rugged, as they need proportionally higher forces and hence more power.
- The looks of the recorded trace traditionally exert a strong influence on system choice. Numerous factors come into effect: writing medium and method, dynamic and electrical performances, etc. Actual fidelity of reproduction often places second to tradition.
- Instruments using recent technology and materials, such as samarium-cobalt magnets, titanium-clad metals, LSI circuitry, and gelled-electrolyte batteries, are likely to give more for the money.
- Numbers alone should not serve as the basis for selection of a strip-chart recorder.

Three ways to drive stylus

At present 75,000 recording channels a year are manufactured in the U.S., mostly for biological function measurements. Equipment manufacturers competing in this market offer three basic galvanometer-stylus drives. In each, reliability, weight and cost are crucial factors—along with performance, of course. The methods are (1) Open-loop galvanometers with back-EMF damping; (2) Galvanometers with active velocity feedback; and (3) Galvanometers with position and velocity feedback.

Each method has been promoted at one time or another as the most desirable. But new materials,

Jean Montagu, President, General Scanning, Inc., 150 Coolidge Ave., Watertown, MA 02172.

Velocity-feedback galvanometers of equivalent performance: The two larger units are intended for EKG recording with heated stylii, while the smaller unit uses ink for recording EEGs.

Table 1. Characteristics of open-loop recording galvanometers with back-EMF damping

Manufacturer	GSI Z-139	MFE R-154
Rated torque (g-cm)	950	750
Natural frequency with stylus (Hz)	68	62
Power supply required (VA)	4.2	7.5
Weight (oz)	16	16

use of ICs and new designs have blurred the lines between the various types.

As a rule, practically all direct-writing recorders attempt to meet the American Heart Association's (AHA) guidelines for frequency response and amplitude. Roughly, these are:

1. Chart span = 50 mm pk-pk.
2. Frequency response (dc to 50 Hz) = ±1/2 dB and (dc to 100 Hz) = −3 dB. Both at 10 mm pk-pk.
3. Maximum overshoot = 1/2 dB pk-pk for a 10-mm square wave.

Galvanometers with position servos: The center unit uses pressurized ink while the two others write with indirectly-heated stylii. The thermal units, though, usually require the use of heat sensitive chart paper.

Table 2. Characteristics of recording galvanometers with active velocity damping (velocity servo)

Manufacturer	GSI GR-760	Technirite TM-215	Sanborn 607
Rated torque (g-cm)	600	300	245
Natural frequency with stylus (Hz)	50	30	45
Power supply required (VA)	2.5	7.0	N.A.
Weight (oz)	16	32	100

In all recorder methods, high torque is continually stressed as desirable. But equivalent performance is available in galvanometers with peak torques ranging from 250 g-cm to 2000 g-cm. It's easy to see why. The minimum torque to meet a required frequency response is obtained from Newton's Law.

$$T = I\frac{d^2\theta}{dt^2},$$

where I is the combined inertia of the rotor and stylus and θ is the sinusoidal angular motion with a frequency ω. Therefore the maximum torque required is:

$$T = \omega^2\theta I.$$

This equation explains why a machine with a 100-Hz response at 10 mm, pk-pk, will have a 45-Hz response at 50 mm, pk-pk. Both displacements require the same torque.

Conversely, to move a 25 g-cm² stylus rotor at 100 Hz over 0.105 radian, pk-pk (equivalent to 10 mm, pk-pk), approximately 400 g-cm of torque is required.

The overshoot requirement indicates that the frequency response must be monotonically decreasing. For a spring/mass-damped, second-order system, overshoot also defines the minimum resonant frequency of 82 Hz to meet AHA requirements.

Tradeoffs in the open-loop approach

Though the open-loop design with back-EMF damping is the most direct approach, it calls for a very strong magnetic coupling. Only moving-iron galvanometers are now built to operate in this fashion. These are fixed-coil devices, but at small excursions they behave much like the moving-coil design. Open-loop performance is quite successful when the rotor stylus inertia is kept below 25 g-cm². As inertia increases, the damping and gain become sensitive to the temperature of the galvanometer coil, and temperature control may be necessary to compensate for dc drift.

Table 1 shows the performances of commercial open-loop devices. These achieve their frequency response through a high resonant frequency, which brings much higher demands on torque and damping than those determined by Newton's Law. In practice, RC networks and low-pass and high-pass filters are used to improve the frequency response.

Moving-iron galvanometers with open-loop driving meet the demands of cardiac measurements (EKG) but don't quite do for electroencephalograms (EEG), where the stylus inertia typically is 45 g-cm² and the angle of motion 7-1/2 degrees.

Adaption of an EKG galvanometer for an EEG recorder yields about the same resonance, but the damping requirement is doubled. Since EEGs call for physically narrower galvanometers, the damping ratio deteriorates even more, and frequency response cannot be controlled. And since torque and inductance vary with angular position, the frequency response of the system varies with the position of the base line. Consequently these devices aren't suitable for applications that demand uniform frequency response across the entire chart width. Typically, a system set for 5% overshoot on a square wave in the center of

Table 3. Characteristics of galvanometers with position servos

Manufacturer	HP	Gould	G.S.I.	Parke-Davis	Cambridge Inst.
Inertia of rotor stylus (g-cm^2)	40	85	25	40	25
Torque available (g-cm)	900	2000	1000	900	500
Power (VA)	10	18	2.5	10	13
Spring constant (gm-cm/radian)	2800	small	500	2800	0
Position detector	Capacitor	Inductive	Capacitor	Capacitor	Potentiometer
Velocity	Derived	Pick-off	Derived	Derived	Back EMF
Writing	Rectilinear and edge writing	Rectilinear and edge writing	edge writing Rectilinear and	Edge writing	Tip writing
Patents	Detector	Detector and stylus	Galvanometer and detector	Stylus	Stylus

the chart, will have 20% overshoot three-quarters up the chart.

In the velocity servo—the second type of galvanometer—a secord-order system is heavily damped (a ratio of about 5) to make its frequency response similar to that of a first-order system. Then, by addition of a first-order lead network, a stable system is realized, with flat frequency response, good damping and case of control. Frequency and phase response are much superior to an equivalent second-order system, so it is possible to use only the torque constraint of Newton's Law to meet AHA performance.

Coupling is a problem

One difficulty with this type of pen motor is the need to generate a velocity signal free of any coupling with the drive current. The signal must then be amplified to give the needed damping. Moving-coil galvanometers, which cannot be built with torque-to-inertia ratios comparable to those of moving-iron, traditionally are constructed with an auxiliary velocity pick-off winding on the drive coil. But inductance effects—which increase with the second power of frequency—limit performance, especially at resonance where induced drive currents change phase relative to the velocity.

Moving-iron galvanometers can't be built this way because the mutual inductance of two coils on a common magnetic core is enormous—just as it is in a transformer.

The classic solution is to install a velocity pick-off that rides piggyback on the galvanometer and is sufficiently remote to be free of coupling. The Gould motor, for example, has an auxiliary, independent d'Arsonval movement that serves as a tachometer; it is located approximately one inch away from the drive coil. Table 2 shows the performance of such commercial devices.

At present the cost of a recorder using a velocity servo is lower than that of a recorder of equivalent performance but using open-loop or position servos. This is especially true for battery-operated recorders.

The position servo—the third galvanometer type—separates the three functions of a classic second-order system so each can be controlled independently. The functions are: a torque generator, a position detector and a tachometer. Often the velocity signal, used for damping and stability, is derived from the position signal to ensure the accurate reproduction of the information.

Position devices have all the problems of velocity servos plus a few of their own. All signals must be added in adequate proportion and proper phase relationship. And corrections must be made for all detector and processor quirks.

Like the velocity servo, the torque requirement is defined only by Newton's Law. The major difficulty, however, is stability. If damping isn't introduced, the system destroys itself. Stylus motions and internal vibrations—which are detected by the position pick-off and amplified—tend to make the system "whistle" at various conditions. This is not only disturbing but can also cause fatigue failure of either the stylus or contact detectors, such as potentiometers.

Stability is achieved by various methods, such as the conventional spring return coupled with a very rugged, heavy stylus or use of a self-damped stylus. Or an additional velocity detector is sometimes used. Table 3 shows the performance of typical devices. ■■

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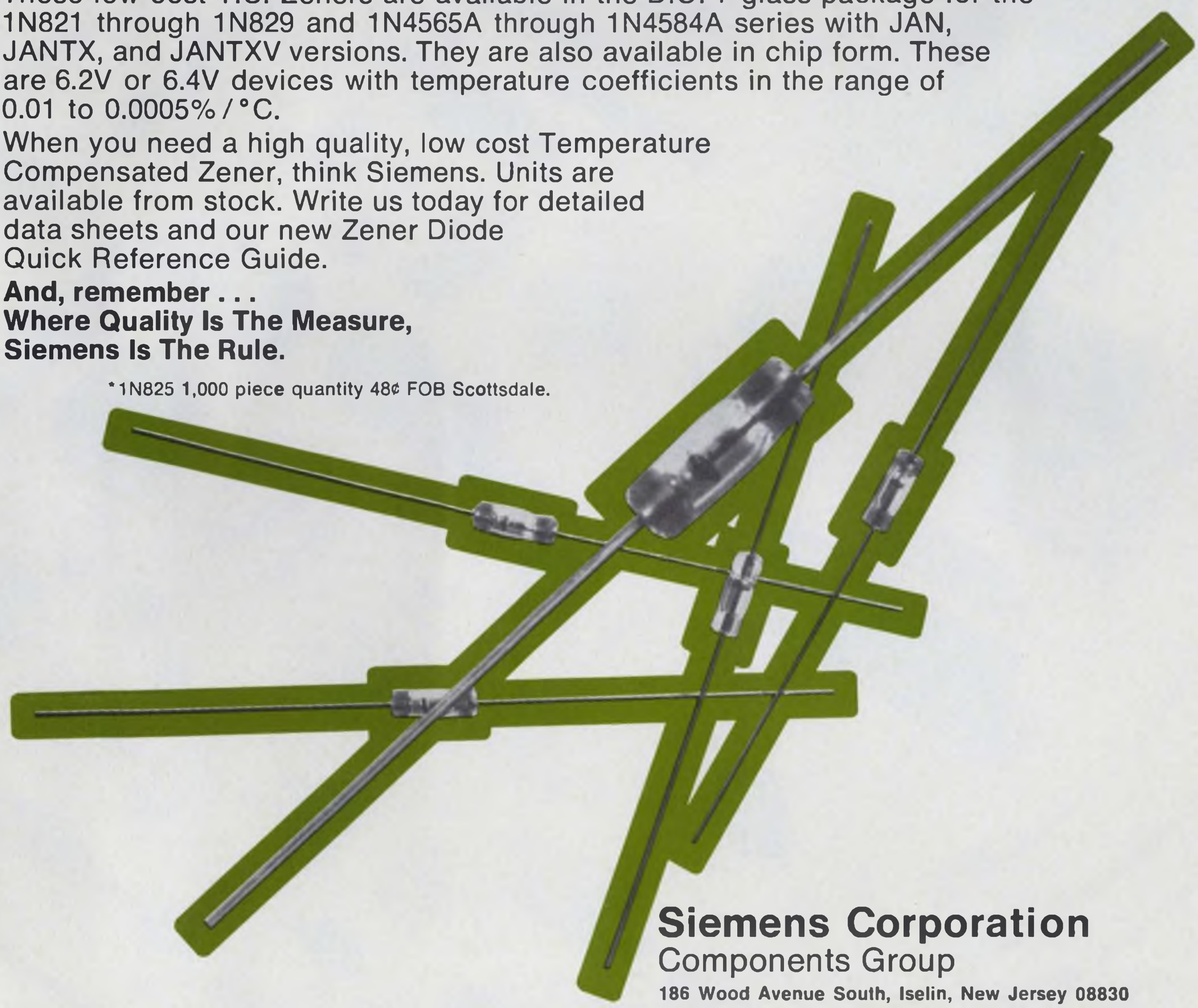

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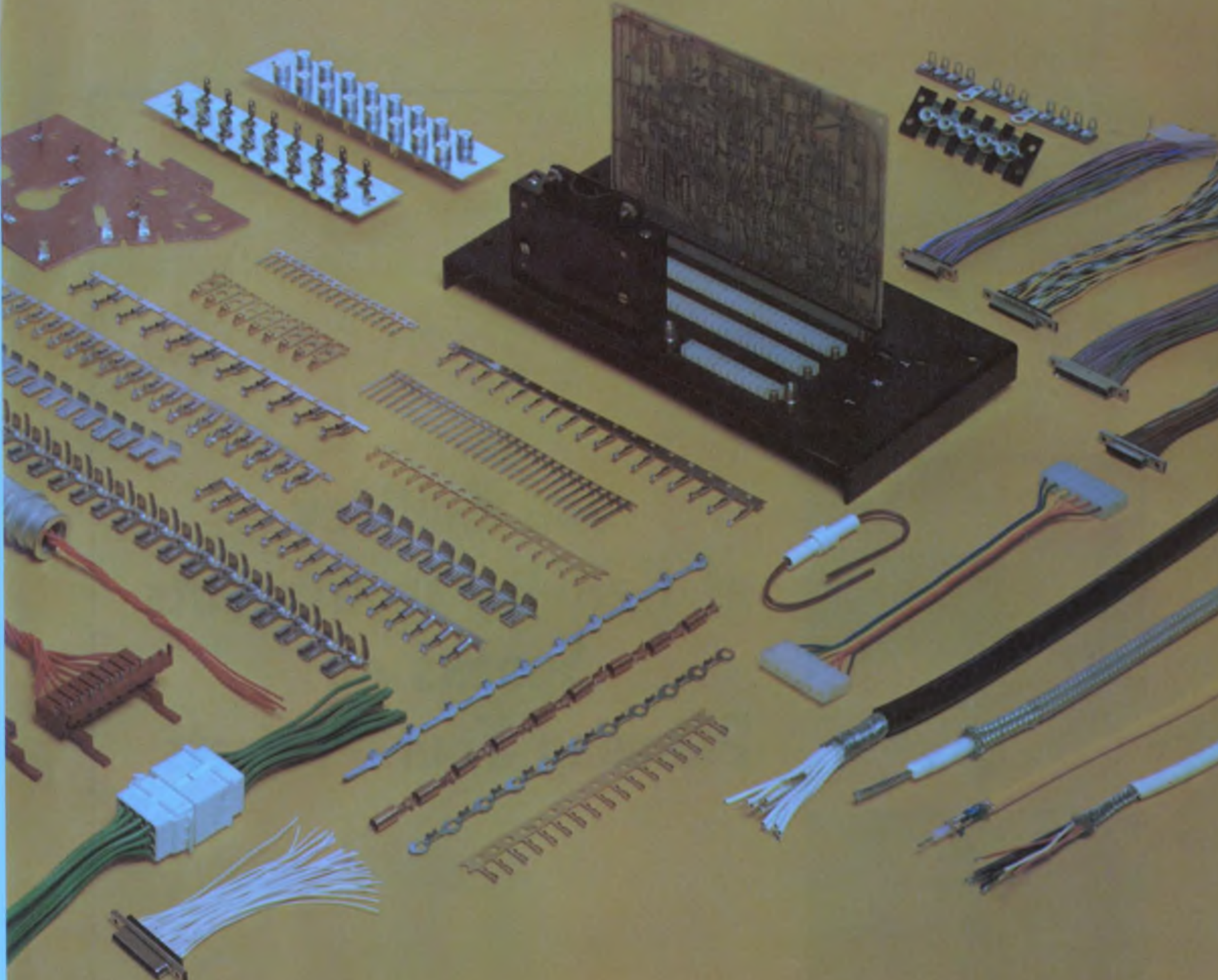

Joe Keithley of Keithley Instruments Speaks on Planning Your Projects

Take a project to an engineer and he'll tell you it's, say, a four-month job. Maybe it is. But maybe it isn't. It might well take twice that long. And therein lies a problem.

Time can mean the difference between success and failure, profit and loss.

What you need, of course, are realistic estimates. But how do you get them? For starters, you get accurate, historical records describing work accomplished and the time each element took—the engineering man-hours. Of course, a sticky element comes in here—time cards. A dirty word to the free-spirited engineer. But how else can you calculate engineering costs?

Almost any experienced engineer can look at an instrument and determine the materials cost. And you can probably make a close stab at the manufacturing cost. But the engineering cost—which, of course, is a very significant part of the over-all cost—is more difficult.

Time cards are a big help in determining the cost of engineering. When an engineer with time cards tells you he can do a project in four months and you ask him how come it took him 18 months on a previous project, he might be able to tell you. Using his time cards to measure the number of engineering man-hours the entire project took, he might be able to remember what portion of the time each individual element requires.

There are probably things he can steal from earlier designs. So he subtracts this design time from the new project. Lots of circuits don't have to be designed twice. He might be able to swipe the display module from an earlier design and simply add another digit. If he designed a good attenuator on his last job, he can use it on this one.

Records alone, of course, aren't enough. You've got to use judgment. And that's what engineering managers are for. You still have to judge the person. You have to know which engineer tends to be optimistic and which is a pessimist. You have to know, for example, that the young engineer, when left to himself, may overlook certain time-consuming obstacles.

The young engineer—I'm speaking from personal experience—is terribly optimistic. He thinks he can do anything.

The young fellow out of school thinks he can do anything in no time at all.

He realizes that he can tweak some circuits to get a decent response. But tweaking can be costly when it's necessary to make many instruments on a production line. The more experienced engineer, even without making a worst-case analysis, knows what's necessary. He knows where he's been burned over the years.

Even the mature engineer can be over-optimistic on his time estimates, unless he is experienced in keeping track of time. If he's had that discipline, however, he'll be pretty good.

As a matter of policy, we try to encourage our engineers to think in terms of the time it takes to get things done. We're not always completely successful. Some guys think it's poppycock to spend so much time doing "book work." And there are engineers who feel that time-consciousness is too commercial and beneath their dignity. They want to deal with theory and equations, not with dollars. But these are the guys who get a year behind on their projects if you don't keep an eye on their progress.

But most of our people do a splendid planning job. They get their projects done when they promised, and their promises are realistic. They don't estimate "four years"; anybody can do things in four years. They establish good reasonable schedules, and they meet them. They are systematic, methodical engineers.

Of course, problems peculiar to a particular project often crop up. We know from time cards how long it takes to create an instrument, but we can't tell from these records how long it takes to build part of an instrument—a particular circuit this project calls for. Here's where engineering management comes in. A manager might recall that an identical circuit was designed for another project he supervised. He finds out how much that engineering job cost and then subtracts the time and the cost from the project at hand.

A good manager can look back and know where to swipe an idea from an old project. But he also sees the pitfalls.

On the bright side, I remember using the same package for several different instruments. They were plastic housings. We saved money.

Then there was the power transformer designed for a popular instrument that we also used for several low-volume instruments. This was fine until the popular instrument was redesigned and a different transformer put in. What happened? The low-volume instruments that were getting a bargain ride with the high-volume transformer were left high and dry. The high-volume transformer became low-volume, and its price shot up.

Moral? Someone should be told when changes like this occur. Maybe the power transformer shouldn't have been changed, or maybe it should have been but the new transformer should also have been used in the low-volume instruments.

There were probably several good solutions, all better than letting the bill for the transformers come as a surprise.

This is one way an experienced engineer differs from a beginner. He thinks of the implications of everything he does.

Your managers should value money.

If you hire a technical genius who considers money beneath him, you have a problem. He'll be too lofty to measure time. But he may learn. People like to see their projects run smoothly and mesh. It's a good feeling when things happen on schedule and fit in with the schedules of other departments. You can push these advantages and help him to see the light.

Schools, incidentally, are not much help here. They don't teach us how long things take or how much they cost.

Even when people do start thinking about costs, it's amazing how many engineers will figure out the cost of a project and leave out their own time and salary. Sometimes I tell one of these fellows: "Hey, that's very nice. You're going to work for us free for the next few months?" This usually gets the point across.

Frankly, I had an advantage because I went to a school that stressed costs. Towards the end of our sophomore year we had to list all the equipment we used in the lab and go out and find out how much it cost. This was a real shocker. I remember my surprise that the decade-resistor box cost $100. And those were the days when a year's tuition was $500.

So here we make engineers conscious of time and money. After an engineer has designed an instrument, he prepares a parts list, which may include 300 parts.

We've had some problems in procedure to iron out. A fellow lists just the electronic components and ignores the housing or the switches, knobs or connectors—all of which cost money. We've had engineers who don't count things like resistors because "they're cheap." Or they feel they'll get tremendous quantity discounts on ICs but forget they're only going to build seven instruments a month.

Again, here's where a good engineering manager pays off. He trains his engineers to count dollars—even the small ones. Only then can he help make plans.

Once a fellow has a firm background in understanding the cost of things and the time it takes to build them, he can participate in planning.

The planning process starts when someone comes along and says: "Let's build a meter like . . ." Or somebody asks what kind of instruments you need to make a viable product line. You may get suggestions from the engineering department or the marketing department, or from friends on the outside—or, of course, from customers. Customers contribute some of your most important ideas.

A potential buyer may say about a product: "If only it had . . ." You have to be careful about acting on every suggestion. Your salesman may lose a sale because a customer wanted purple knobs. The salesman might then run in wanting you to redesign your whole line with purple knobs.

Ideas are easy. But at some stage you have to translate them into a proposal and then invest money. "Let's spend X dollars and investigate this"—that's when the thing gets serious.

Now, how do you turn a suggestion into a formal proposal?

Someone usually comes up with an idea that he is willing to carry through. "If we had a

Who is Joe Keithley?

Listening to him play the clarinet, Joe Keithley's mother decided that he was not cut out to be a musician. Instead, she noted, when he was 12 years old, the number of radios he had built by using cigar boxes, Boy Scout knives and galena crystals. She decided, then and there that Joe would study electrical engineering at MIT. And that settled that.

After he got his master's in EE from MIT in 1938, he went to work for Bell Telephone Laboratories in New York City. That was very good experience, he points out, because it taught him how to be methodical and how to design for a 30-year service lifetime. It also showed him how to work in a professional engineering organization.

He learned some practical things that he didn't quite master in school—like how to get oscillators to oscillate and bridges to balance. Using some of what he had learned from three of his MIT profs—Dr. Harold Edgerton, Dr. Kenneth Germeshausen and Dr. Herbert Grier, experts in stop-motion photography and later founders of EG&G, Inc.—Keithley used his spare time working with a photographer, Gion Mili. Together they used stop-motion photography to cover theater and sporting events.

In this activity, as the customer of his own designs, he learned the importance of making equipment that works when the customer wants it to work. He learned that it's not good

Joe Keithley, right, holds frequent meeting with company president Thomas G. Brick.

enough merely to hope that the customer isn't bitten too badly.

In 1940, working for the Naval Ordnance Laboratory on equipment related to mine detection, Keithley was able to follow some of his designs from conception to implementation in war theaters. So he developed a further sensitivity to the reality of design. Most engineers, he points out, are too distant from the users of their designs.

When he came home from the war in 1945, Keithley bought an HP oscillator, a DuMont scope, a Ballantine voltmeter, a General Radio impedance bridge and decade resistor boxes, an RCA Voltohmyst, a Simpson 260 VOM, a soldering iron, a drill press and some surplus work benches. He moved into an $8.50-a-month shop with a leaky roof and started to build high-input-impedance isolation amplifiers.

He sold these to friends in Washington and elsewhere on the East Coast and did consulting work for General Electric in Nela Park (Cleveland).

1948 was a turning point, personally and in business. He got married, set up an office—in his bedroom, and acquired a secretary—his wife, Nancy.

Keithley's original high-impedance amplifier gave birth, in time, to electrometers, microvoltmeters, digital multimeters and, more recently, data-acquisition systems—all of which contribute to an annual sales volume of some $8-million for Keithley Instruments.

When not engaged in his duties as chairman of the board of Keithley Instruments (Thomas G. Brick is president), Keithley enjoys photography and collecting art. He has an extensive collection of lithographs. He likes sports cars, is a linguist (fluent French and German) and a patron of the Cleveland Symphony.

$500 voltmeter with these particular features," he might say, "we could sell 50 a month for five years." If he's right, he's talking about a gross of $1.5-million.

You then ask what it takes to get one of the boxes built. Looking back from the vantage point of a semi-scarred veteran, you recall that it took so many engineering dollars to build Model X, so many for Model Y and so many for Model Z. So you use your good judgment to decide how much the engineering for this one is likely to cost. Later you go to marketing and ask how many they can sell, then to manufacturing to find out what it will cost to tool up.

This we call preliminary screening. After this you're ready to move into the serious study phase. You do some real market research to find out if enough people out there really want the beautiful product you've dreamed up. And perhaps you design some prototype circuits.

So by the time you get to the study phase, you already have something written on strategy and a fair idea on what it's going to cost for engineering, marketing and manufacturing. In addition, you have a fair idea of how many per month you're likely to sell and what the product's market lifetime will be.

Also, you'll have a decent idea of your costs for materials, labor and overhead. And you will decide pretty quickly that if your expenditures are close to your selling price, you're in trouble. Your selling price should cover all your costs over the life of the product, then leave something for the development of the next instrument plus something for the shareholders. That, in essence, is the plan for a new instrument.

By now you know how serious you should be about the project. You think, for example, that an investment of $100,000 can get you a before-tax profit of $300,000 over the product's lifetime. That sounds attractive enough. So you move on into the evaluation phase.

Here you check things more carefully, and you begin to catalog unknowns. Can you really build the product for so many dollars? Will the zero drift really be so many nanovolts? And will you need terribly expensive input components to get low drift and low noise? Will a $100 transistor be needed in the front end or will a 25-cent component do?

You decide to spend, say, $5000 or $10,000 to find out. Meanwhile marketing is trying to get a better fix on how many of these instruments are likely to be sold, to whom and whether they would fit into your regular distribution channels. If they don't, you want to know about that pretty quickly.

When your serious study phase is over, you are ready to define your project more precisely. By this time you've studied the competitive situation carefully and you know what features you want to include and what features you don't. You know your selling price and the number of instruments you're likely to sell. Manufacturing has told you it can build the instrument without having to build a whole new factory. And your engineers have done some testing and breadboarding. "Yes," they'll tell you, "it looks like a pretty good shot." That's when you're ready to spend money to build engineering samples. So you begin converting rat's-nest wiring to printed circuits and ICs. And you're in the engineering development phase.

You manufacture a few engineering samples and call them demonstration units, and you show them to a few key customers who can give you some good advice on modifications. But watch out! Don't let a few customers "modify" you into a completely new design—unless your old design was really bad. And don't let one or two customers alter your design so that you won't be able to sell it to anybody else.

Finally, if you've done everything right, you can move smoothly into manufacturing and distribution. An important key to your success will be the carefulness of your planning and the accuracy of your time and cost records. But you need some flexibility, too. And here's where something we call short-step iteration comes into the picture. It allows you to step back from one phase to an earlier one when you see the need for modification. You don't want to adhere slavishly to a plan if it will lead to disaster—even if you get there on time. So if you think during engineering development, for example, that you have omitted a feature that could substantially increase the market for an instrument, then go back to the serious study phase and check into it more carefully.

These iterations take time and money. But if you plan for them and keep them short, their benefits will far outweigh their penalties. The road to success is paved with careful planning. ■■


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H-3-4

Ideas for Design

Floating regulator gives 0.1% regulation over 0-to-100-V-dc, 200-mA range

For a continuously variable, high-voltage, floating regulator, you can't use most monolithic voltage regulators. They can handle output voltages to only 30 or 40 V. The regulator in the figure, however, can provide 0 to 100 V at load currents to 300 mA. Short-circuit protection is also included.

The circuit is powered by an auxiliary supply of 15 to 20 V at 40 mA. This supply must be isolated from the high-voltage input, V_{IN}. Pin 5 of an MC1723 is floated by zener Z_1 at a voltage of $V_{OUT} - V_{Z1}$ with respect to ground. This ensures an adequate common-mode range for the MC1723's internal error amplifier, A_1.

The reference-voltage source, pin 4 of the MC1723, is used to derive a reference current, I_{REF}. The value of I_{REF} is given by

$$I_{REF} = \frac{V_{REF} - V_{BEQ1}}{R_6} \simeq 1 \text{ mA}.$$

Transistors Q_2 and Q_3 form a "current mirror" whose output is equal to I_{REF}. This current flows through adjustable resistor R_1 to establish the output voltage, V_{OUT}. The output voltage is

$$V_{OUT} = I_{REF} \times R_1 \simeq 1 \text{ mA} \times R_1.$$

Resistor R_1 can be set for any output voltage from 0 to 100 V.

Resistors R_2 and R_3 form a voltage divider to provide a voltage at pin 2 that compensates for offset voltage at the input of A_1. This offset voltage is

$$V_{R3} = (V_{REF} - V_{Z1}) \frac{R_3}{R_2 + R_3} \simeq 18 \text{ mV},$$

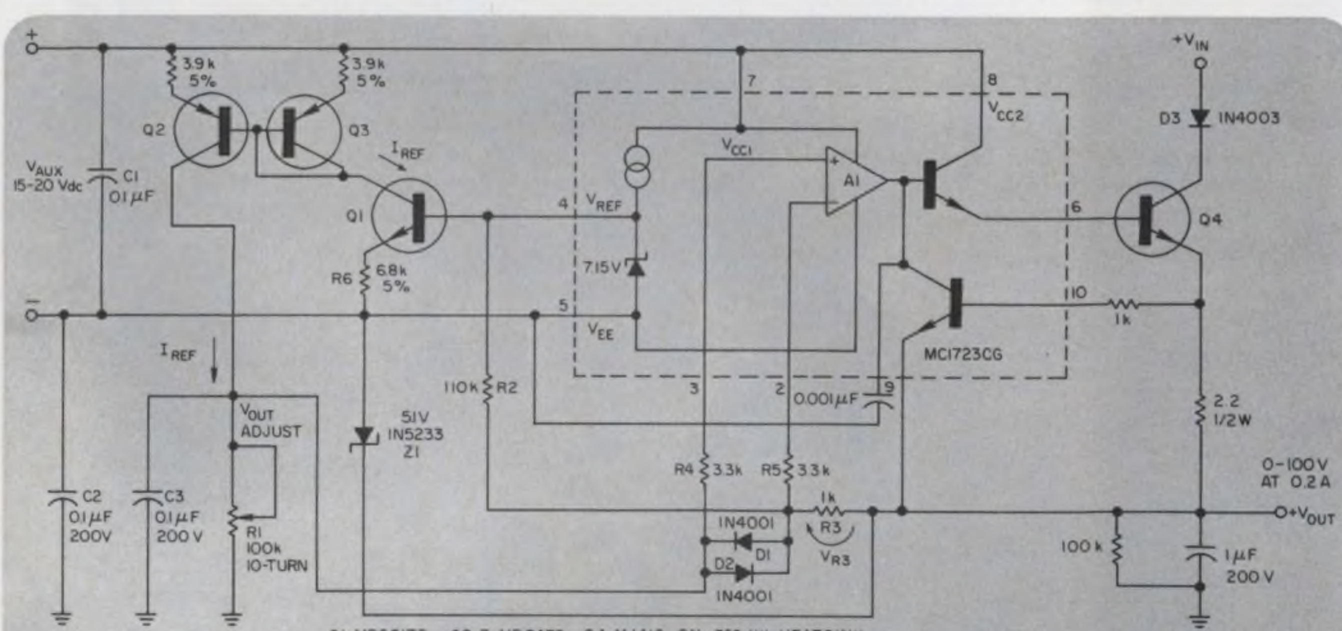
and it allows adjustment of the output voltage to zero.

The short-circuit current limit is set at 300 mA and can be safely drawn continuously. Diodes D_1 through D_3, capacitors C_1 through C_3 and resistors R_4 and R_5 provide transient protection for the MC1723.

Load regulation of the circuit was found to be 0.1% for output currents from 0 to 200 mA. Better than 0.1% line regulation was obtained for V_{AUX} = 15 to 20 V and V_{IN} = 105 to 115 V. All measurements were taken at 20 C and V_{OUT} = 100 V.

Henry Wurzburg, Applications Engineering, Motorola Semiconductor Products, Inc., 5005 E. McDowell Rd., Phoenix, AZ 85008.

CIRCLE NO. 311



The 0-to-100-V range of this floating regulator is adjusted by the 10-turn potentiometer, R_1.

Match antenna over 1.5-to-30-MHz range with only two adjustable elements

The antenna matching circuit in Fig. 1 provides both the huge transformation range and the adjustment simplicity needed for short antennas, as in manpack transceivers. The circuit's impedance-matching range covers several decades. The worst-case antenna impedance is a combination of a highly capacitive load with extremely low ground loss—about 5000-Ω capacitive and 6-Ω resistive. At the other extreme, the load is slightly inductive and about 40-Ω resistive.

In addition, because manpack units are often used by people with little training, the circuit has only two variable elements, unlike conventional arrangements, such as Collins filters.

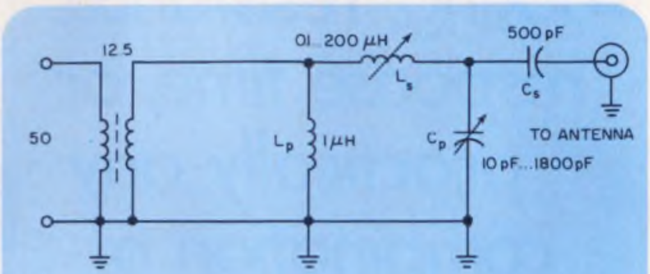
Impedance is transformed down in a 4:1 transformer from 50 to 12.5 Ω. The transformer consists of two parallel 50-Ω lines wound through a ferrite toroid. The ferrite should have a cut-off frequency of 10 MHz and an A_L factor of at least 80 to achieve the Q necessary for wideband performance. The matching circuit that follows consists of a low-pass L-section filter paralleled with an inductance of 1 µH and a 500-pF capacitor in series with the antenna.

The Smith diagram (Fig. 2) shows how the 1-µH parallel inductance enables the circuit, at low frequencies, to transform impedances as low as 6-Ω resistive. At high frequencies, this inductor has little influence.

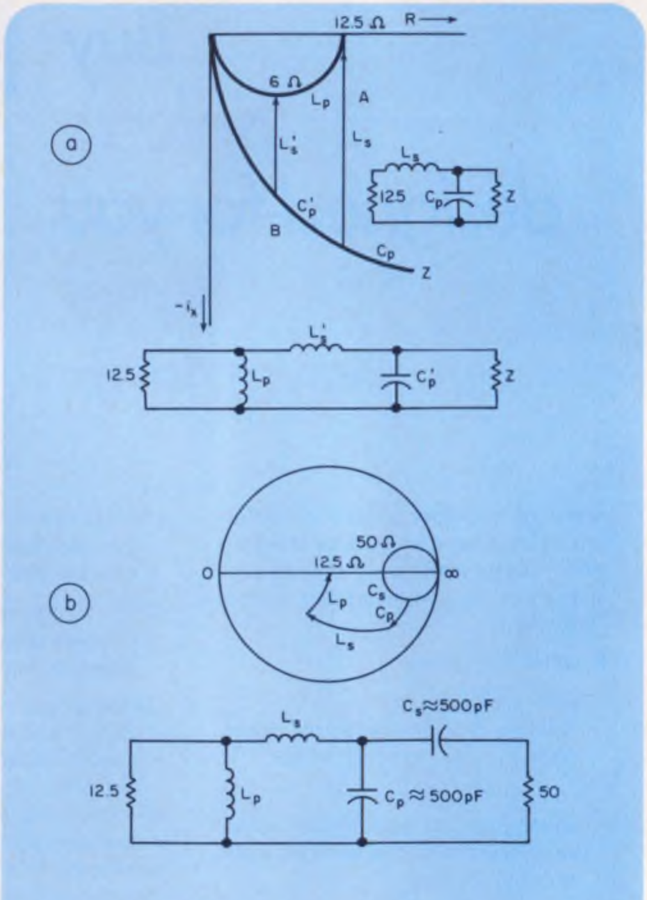
The 500 pF series capacitor allows use in the filter of a small variable shunt capacitor. Without the series capacitor, a shunt capacitor with a maximum value as high as 4000 pF would be required to cover the impedance range. In the circuit, less than half this value does the job.

A whip antenna has a capacitance of approximately 8 pF/m; a popular military 7-m whip has only about 56-pF capacitance. Thus the series 500-pF capacitor of the circuit doesn't appreciably affect such an antenna's capacitive impedance component. The effect of the capacitive or inductive component of long antennas and wideband dipoles is reduced, however, by this series capacitor.

Ulrich L. Rohde, President, Rohde & Schwarz Sales Co., Inc., 14 Gloria Lane, Fairfield, NJ 07006. CIRCLE NO. 312



1. **A wide-range of antenna impedances can be converted** to 12.5 Ω with only two adjustable components L_s and C_p.



2. **Impedance Chart A** shows the transformation of an impedance, Z, to 12.5 Ω. And with the help of parallel inductance L_p, Z can be as low as 6-Ω resistive. In Smith Chart B, Z = 50 Ω is transformed to 12.5 Ω. The presence of C_s = 500 pF allows C_p to be a low-valued capacitor.

400-Hz power supply for servos delivers up to 0.5 A at 11.8-V rms

Very frequently the electronics engineer needs a power source to test his small servo-system designs. A common standard operating voltage for servo components is 11.8 V rms at 400 Hz. This peak-to-peak level of more than 35 V is too large a swing for electronic circuits built with standard monolithic op amps; these usually operate on only ±15 V. But a high-voltage LM343H op-amp oscillator circuit with a discrete transistor output stage can easily deliver up to 0.5 A of 11.8-V-rms, 400-Hz power. The circuit operates conservatively on ±24 V, since the op-amp's maximum is ±40 V.

For amplitude control, two 1N4454 diodes provide the needed nonlinear action in the oscillator. The diodes are off-the-shelf and generally are more easily obtained than special light bulbs or thermistors. The 47-kΩ resistor, in series with the diodes, limits their clipping action, so only a small amount of distortion results.

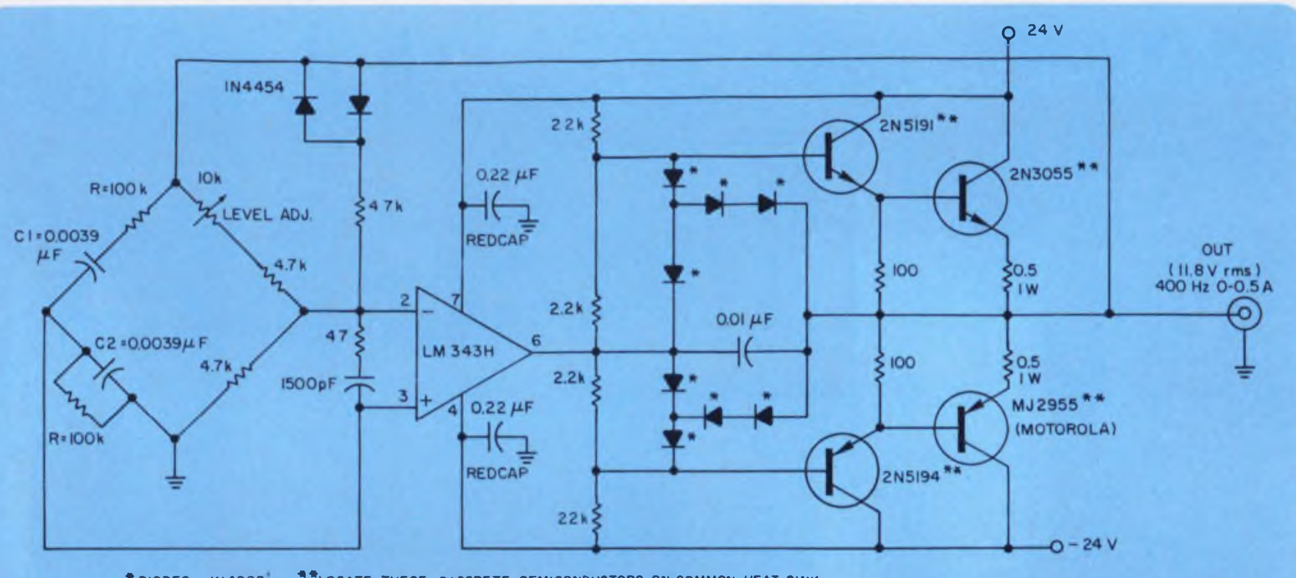
The frequency of the oscillator can easily be changed to 800 Hz if the values of the two 100-kΩ bridge resistors, R, are halved. The frequency is given by

$$f = \frac{1}{2\pi RC}.$$

And the circuit can provide higher outputs by operating with a ±38-V supply.

Henry Olson, Stanford Research Institute, 333 Ravenswood Ave., Menlo Park, CA 94025.

CIRCLE NO. 313



400-Hz, 11.8-V power supply can be made to operate at 800 Hz with halved bridge resistors, R.

IFD Winner of May 10, 1975

Jim Wyland, Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. His idea "Power Op Amp Provides ±100-mA Output and Up To 100-V/μs Slew Rate" has been voted the Most Valuable of Issue Award.

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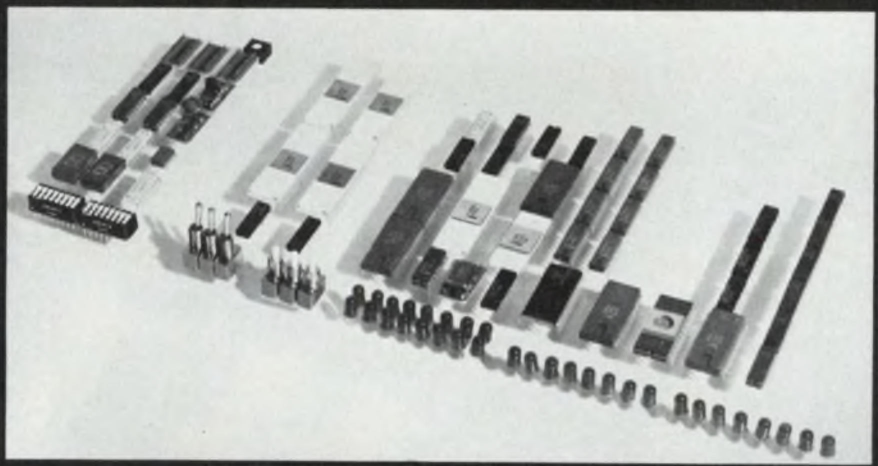

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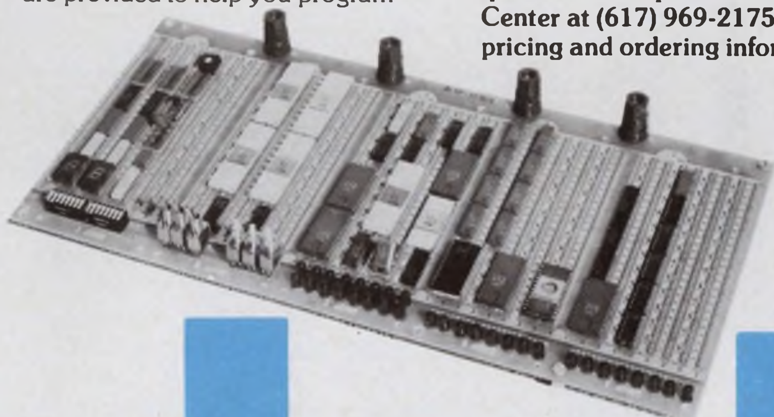

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INFORMATION RETRIEVAL NUMBER 59

Avalanche circuit gives fast-rise pulses

High-power, fast-rise pulses have been produced by a circuit designed at the Institut fur Elektronik of the Ruhr University, West Germany. Developed in collaboration with Dornier System GmbH in Friedrichshafen, the circuit gives pulses with a rise time of 150 ps and a fall time of 200 ps. The pulse duration can be varied between 0.3 and 120 ns, while maximum amplitude is maintained at 15 V.

Use of avalanche transistors—epitaxial silicon planar transistors working in the avalanche-breakdown mode—provides the high speeds. In a conventional avalanche-transistor circuit (Fig. 1), with a delay-line pulse shaper (Z), the triggering pulse, V_{tr}, causes the transistor to discharge the delay line through R_L. The pulse is terminated by the reflected pulse turning the transistor off.

The new German circuit (Fig. 2) uses a second transistor (T_2) to provide the turn-off pulse. The delay line between X_1 and X_2 decouples the two transistors. Duration of the pulses is determined by the time difference between trigger pulses at the bases of T_1 and T_2, which can be varied by monostable multivibrator MM_2. Additional circuit elements—R_1 and L plus C and the 50-Ω resistor—further improve pulse shape. A clean 0.3 to 120-ns pulse results.

Fig. 2

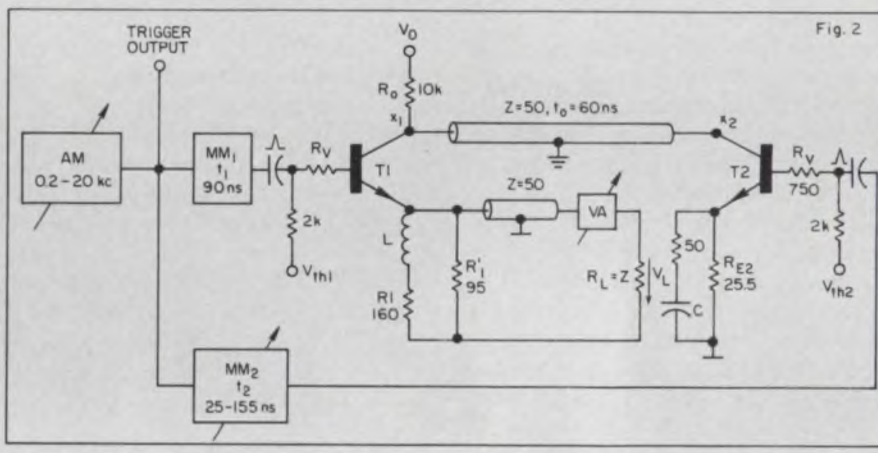
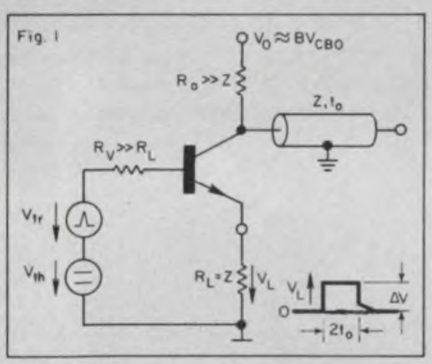


Fig. 1



Bubble memory needs only one mask per chip

An experimental bubble memory requiring only one mask per chip instead of the usual three or more has been produced at Philips Research Laboratories, Eindhoven, the Netherlands. Writing, reading and erasure are achieved by temporary changes of the sense of rotation of the drive field. Bubbles are propagated in the new memory by means of the well-known Permalloy T-bar structures, while special transfer switches have been incorporated to perform writing, erasure and transfer between the major and the minor loops.

Bubbles originating from the generator can be passed selectively into the major loop and can circulate inside the loop. Storage can take place in a parallel manner in various sub-loops, and the bubbles can be switched to these loops by activation of the input switches, which control the sense of rotation. Reading is a reverse operation in which the bubbles are switched from the storage loops to the main loop.

Compared with a conventional current-controlled bubble memory, the Philips prototype has a somewhat longer access time for writing and erasure, and the bit density is less.

Monolithic inductors operate up to 6 MHz

Monolithic IC inductors that operate at 4.43 and 6 MHz have been developed at the Mullard Research Laboratories in England. Gyrator circuits were used in combination with integrated junction capacitors.

The new circuits are reported to provide resonators with Qs up to 30 and trap circuits with rejection of better than 40 dB. Each resonator employs 15 transistors and occupies a 1-mm² chip.

The experimental circuits combine five resonators to make a single-chip TV filter that is able to separate luminance, chrominance and sound i-f signals. The filter is tuned by variations in the bias voltage on the junction capacitors.

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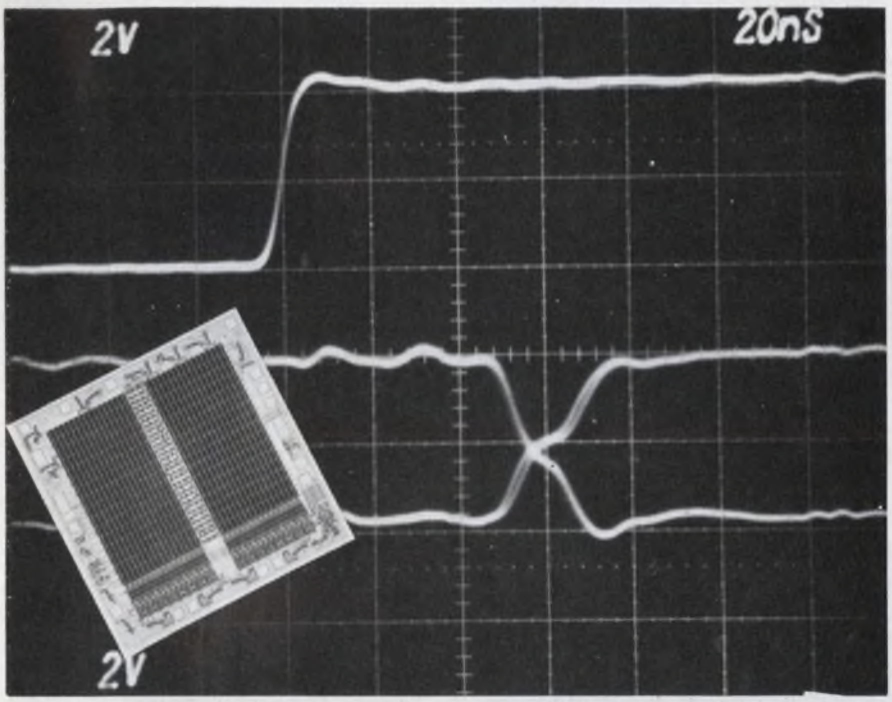
INFORMATION RETRIEVAL NUMBER 61

1024-bit NMOS RAM offers bipolar speed at low power



Intel, 3065 Bowers Ave., Santa Clara, CA 95050. (408) 246-7501 P&A: See text.

A new RAM, with MOS density and low-power operation, competes with bipolar memories for many high-speed cache applications. The MOS alternative provides an access time of less than 100 ns with dissipation of less than 600 mW.

Intel now offers the 2115-2, an NMOS 1024-bit random-access memory with worst-case access time of 70 ns and dissipation of 525 mW, max. The memory is fully static and works off a single 5-V power supply. It comes in a standard 16-pin ceramic package (with a plastic version to follow soon).

At present the cache-memory field is dominated by the 93415 Isoplanar bipolar memory from Fairchild, Mountain View, CA. Intel's new memory is pin-compatible with the 93415, which has the advantage of many thousands of units in the field and strong product acceptance, but the disadvantage of 815-mW, maximum dissipation.

Other bipolar alternate sources for the 93415 include the IM5508 from Intersil, Cupertino, CA, and the 82S110 from Signetics, Sunnyvale, CA. While the Signetics memory is identical to the Fairchild in power dissipation, the Intersil dissipates 630 mW.

About to enter the fray is the bipolar AM93415 from Advanced Micro Devices, Sunnyvale, CA. This will be similar to the Fairchild memory, but details on it are as yet unreleased.

A pair of CMOS memories—the IM6508A-1 from Intersil and the TA6780 from RCA, Somerville, NJ —are also challenging the 93415. However, both require more than 5 V to get anywhere near speeds of the Intel unit and the competing bipolar memories.

Intersil's CMOS chip requires 11 V to get down to 90-ns access time. But it dissipates only about 10 mW. In addition it has a standby mode, where it dissipates only a few μW. The RCA TA6780 only gets down to 120 ns at 10 V. It dissipates 20 mW. RCA says this memory will be down under 100 ns in a few months. Both of these CMOS devices are pin-compatible with the 93415.

There are a whole flock of quasi-static MOS chips on the market. Some are as fast as or faster than the 93415, but all require more than one power supply, and they are not pin-compatible with the 93415 and are somewhat more difficult to use.

Versions of the 2115 are available with max access times of 70 ns, 90 ns and 120 ns. These have open collector outputs and sell, in 100-999 quantities, for $28.00, $17.95 and $16.95, respectively. Three-state output versions are also available at each speed.

The 93415 sells for $28 in the same quantities. Up in the 100,000-quantity range, where prices are negotiable, both the 93415 and the Intel memories will sell in the vicinity of $7 to $8.

All devices are specified to operate a 0-to-70-C range.

The outputs on the 93415 and Intel chip can both handle up to 10-TTL loads.

Intel	CIRCLE NO. 306
Advanced Micro Devices	CIRCLE NO. 307
Fairchild	CIRCLE NO. 308
Intersil	CIRCLE NO. 309
RCA	CIRCLE NO. 310
Signetics	CIRCLE NO. 320

Keyboard encoder creates custom codes

Electronic Arrays, Inc., 550 E. Middlefield Rd., Mountain View, CA 94043. (415) 964-4321. $9.90 (100); stock.

The EA2030, a 99-key four-mode encoder, simplifies the customer-encoding of keyboards. The IC identifies each key and mode with a simple binary number. With that binary input, a PROM may be programmed within a few hours. The IC features a 10-bit code output, an on-chip clock generator, built-in keybounce suppression, complete N-key rollover, electronic shift lock, error detection for simultaneous key depressions, complete compatibility with TTL logic signals and operation with standard +5 and −12-V supplies.

CIRCLE NO. 326

μP costs plunge while versatility increases

MOS Technology, Valley Forge Corporate Center, Norristown, PA 19401. (215) 666-7950. P&A: See text.

A full 8-bit microprocessor for under $20 in unit quantities? That's right. MOS Technology has developed the MCS6501—a microprocessor chip that is pin compatible with the MC6800 microprocessor developed by Motorola.

The pin compatibility of the MCS6501 permits the use of existing parts which are not available from MOS Technology yet, but a complete range or RAMs, ROMs and I/O devices is under development. Programming, though, is not interchangeable between the Motorola unit and the MCS6501.

Addressing features of the MCS-6501 include true indexing, two types of indirect addressing and two index registers. These features are claimed by MOS Technology to make the MCS6501 outperform all other 8-bit microprocessors on standard industry benchmarks.

The unit operates from a single 5 V supply and is fully TTL compatible. This permits simplification of much supportive circuitry. The MCS6501 is built by use of n-channel, silicon-gate, ion-implanted, depletion-load processing.

A cross assembler and a Fortran-like emulator will be available shortly for user purchase or rental on time sharing networks. The microprocessor is available from stock.

Booth No. 1010 *Circle No. 327*

12-bit CMOS register simplifies ADC

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. $7.45 (100); stock.

A 12-bit successive-approximation register contains all of the digital control and storage needed for a 12-bit ADC. The MM74C905 operates over a supply range of from 3 to 15 V, and has a guaranteed noise margin of 1.0 V. The register can be expanded or truncated, and it functions in either a start/stop mode or in a continuous-conversion mode.

CIRCLE NO. 328

8-bit DAC ensures monotonicity

Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. $5.95 to $8.55 (100 up); stock.

A monolithic 8-bit d/a converter, the AD559, uses thin-film resistors to provide 2 ppm of FSR/°C differential nonlinearity tempco. Hence, monotonicity can be guaranteed over the full operating temperature range. Also the unit has a maximum initial accuracy of ±(1/2) LSB, and a maximum zero error of 200 nA. Internal compensation is provided. The AD559 can replace Motorola's Model 1408/1508 DAC.

CIRCLE NO. 483

Encoder provides 10^7 programmable codes

TMX, Inc., 250 Park Ave., New York, NY 10017. (212) 661-9400.

The TMX 2141, an IC pulse-width encoder housed in a 14-pin DIP, can supply over 10-million discrete codes, each a unique combination of five pulses. The width and sequence of each pulse are programmed with external RC networks. The encoder includes a clock-pulse generator and a binary counter that provides the following: seven counts for "clear," starting times for the five pulses and "steps." Also contained are five one-shot delay circuits and an intergroup delay generator.

CIRCLE NO. 484

4-MHz CMOS clock IC uses single supply

Intersil, Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $4.40 (100-999).

The ICM7049 CMOS quartz-clock circuit operates at 4 MHz and uses a single 1.5-V battery instead of the standard two-battery supply. Thus power consumption, size and cost of quartz clock modules are reduced. Using a 4-MHz quartz crystal, the ICM7049 consumes approximately 25 μA of current from a 1.5-V power source. Operation is guaranteed to 1.2 V over the temperature range of −20 to +70 C. The new clock circuit pulses a unipolar stepper motor once a second.

CIRCLE NO. 485

INTEGRATED CIRCUITS

1-k static RAM accesses in 70 ns

EMM Semi, 3883 N. 28th Ave., Phoenix, AZ 85017. (602) 263-0202. $6 (1000).

Two 1024-bit static RAMs have access times of 70 and 90 ns—the 1802 and 1801, respectively. The 1801 features TTL-compatible inputs and outputs, and the 1802 features two complementary data-out signals that can be used to drive a differential amplifier. Both memories are organized as 1024 words by one bit, and they come in standard 18-pin DIPs.

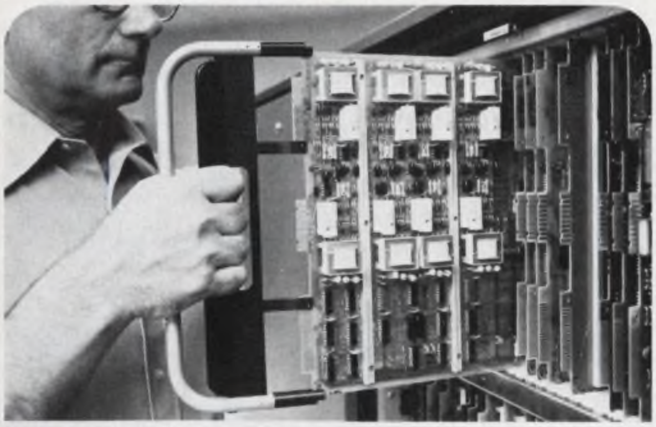
CIRCLE NO. 329

LSI circuits extend Isoplanar CMOS line

Fairchild Integrated Circuits Group, 464 Ellis St., Mountain View, CA 94042. (415) 962-3816.

The company's 34000 series of Isoplanar CMOS circuits now includes four LSI chips: the 34702 programmable bit-rate generator, 34720 256-bit RAM, 34710 16 × 4-bit clocked RAM, and the 34731 quad 64-bit shift register. The 34702 generates all 13 commonly used bit rates with an on-chip oscillator and an external crystal. One 34702 can control up to eight output channels. The 34710, a static read/write memory, feeds a clocked output register and provides bus-oriented, three-state outputs. The 34720 RAM operates over a voltage-supply range of 3 to 15 V, and it has a typical access time of 80 ns at 10 V. Each of four independent static 64-bit shift registers in the 34731 operates from dc to 4 MHz, and each has separate clock, input and output, and direct TTL-logic drive.

CIRCLE NO. 330



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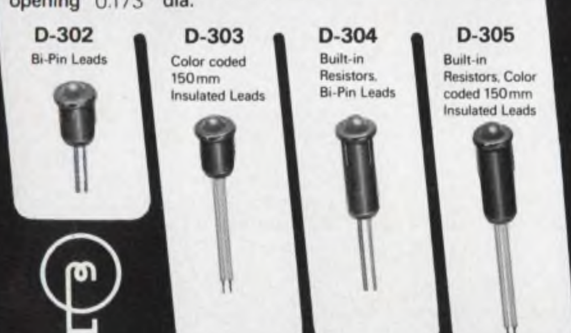

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TOKYO, JAPAN

INFORMATION RETRIEVAL NUMBER 66

Complete 12 Bit D/A

$49.00*

Actual Size

Micro Networks MN3200 Series of thin film hybrid converters are the industry's first low cost family of "complete" 12 bit D/A's.

*100 pc. quantity

These converters incorporate the internal reference and output amplifiers—and are totally adjustment free. The converters guarantee ±1/2 LSB linearity from 0 to 70C as well as monotonic performance because of the laser trimmed ultrastable nichrome resistor networks employed.

Other salient features of the MN3200 are:

- User Selectable Output Ranges.
- Hermetic Sealed Dip.
- Unipolar (MN3200), Bipolar (MN3201) and BCD (MN3202).

The MN3200 Series are available for immediate delivery.

For complete data write or call— Jerry Flynn: Tel. 617 852-5400.

MICRO NETWORKS CORPORATION

324 Clark Street • Worcester, Mass. 01606

INFORMATION RETRIEVAL NUMBER 67

Commercial connector is flame retardant

Bunker Ramo Corp., Amphenol Industrial Div., 1830 S. 54th Ave., Chicago, IL 60625. (312) 242-1000. $0.12 pair; 94V-0, 9 contact (10,000 up); $0.07 per contact (100,000); stock.

Low-cost electronic connectors, the 32 Series, are the first available with housings of a flame-retardant material classified 94V-0 by UL, according to Amphenol. They are designed for high-volume applications that require from 2 to 15 contacts operating up to 250 V and 12 A per contact. The connectors are also CSA listed. Connectors molded of the 94V-0 material are designated Fire-Plug, while those of a standard nylon 94V-2 material are called Econo-Plug. The nylon units come in six colors.

The Amphenol 32 Series connectors are interchangeable with similar types of other vendors. Housings fit into existing panel cut-outs, contacts fit into competitive housings and competitive contacts fit into Amphenol's 32 Series housings.

Only fingertip pressure is required to push and lock the housing into a panel. And the connector's mounting latches and wings self-adjust automatically so the housing fits snugly in panels 0.031 to 0.093-in. thick. Fingertip pressure on the latches releases the connector from either side of the panel. Connector housings mate only one way to eliminate incorrect connections in assembly or testing.

Three wire-barrel sizes accept 14-to-30-AWG wire and carry 1 to 12 A. When wire of 24 AWG or heavier is used, contacts can be inserted into the housing without a tool. For lighter-gauge wire, an inexpensive tool provides easy insertion. The same tool is also used to remove all sizes of contacts from housings.

A range of available termination equipment includes hand-operated, semi-automatic and automatic terminating equipment for production rates up to 9000 crimps per hour.

CIRCLE NO. 333

Assemble custom pots from prototype kit

Allen-Bradley, 1201 S. Second St., Milwaukee, WI 53204. (414) 671-2000. $97.50 (unit qty).

MPIP, or Mod Pot Instant Prototype, is a kit assortment of modules and hardware, sufficient for the design engineer to assemble 10-single, eight-dual, six-triple or four-quadruple-section potentiometer controls, or combinations of these multisection controls. Each assortment is packaged in a carrying case with an assembly fixture, tools, manual and other materials. The 5/8-in. square Mod-Pot family offers a large variety of switch, shaft, bushing and terminal configurations. MPIP is available only through Allen-Bradley distributors.

CIRCLE NO. 334

Proximity sensor works on Hall-effect principle

Micro Switch, 11 W. Spring St., Freeport, IL 61032. (815) 232-1123. $2.50 (OEM qty).

The 400SR solid-state proximity sensor operates at speeds to 100,000 times per second and weighs just 1/4 oz. Hall-effect actuated, the sensor operates on a 6-to-16-V-dc power supply, withstands temperatures from 40 to 150 C and is provided with solder or quick-connect terminals. This no bounce, no-touch, sensor provides either current sourcing or current sinking outputs that interface directly with nearly all logic families. And there is no need for signal amplification in most applications. Output current is 40-mA maximum.

CIRCLE NO. 335

Chip capacitors allow fine and course adjust

Vitramon, Inc., P.O. Box 544, Bridgeport, CT 06601. (203) 268-6261. $99.50 (unit qty); stock.

Vee Cal adjustable/fixed chip capacitors in two kit packages enable engineers to design and fabricate preproduction circuits for quick evaluation. Kit VC-1 contains 60 parts—five chips in each of 12 base values ranging from 10 through 130 pF; kit VC-2 contains 48 parts—four chips in each of a dozen base values ranging from 160 through 680 pF. Each kit includes epoxy for making permanent connections and a 9H pencil and eraser for making and removing connections. An instruction book and technical bulletin illustrate how to add or subtract capacitance. A maximum of six adjustments provides coarse adjustment on one side and fine adjustment on the opposite side of each chip. The chips have a standard tolerance of ±10% prior to adjustment, and they can be adjusted only upward.

CIRCLE NO. 336

Gates introduces the future in energy cells.

There's now a new energy source that's a superb alternative: Rechargeable, sealed lead-acid batteries from Gates.

We call these batteries the future in energy cells. And for good reason.

They have all the product advantages you need plus economic advantages that may well give a new dimension to your product pricing.

Advantages: Gates Energy Cells are as compact as nickel cadmium or gelled type cells. And they are completely sealed, so that no acid vapor can leak out (they also include a self-sealing vent for extra safety). Gates Energy Cells provide low internal impedance for high discharge rates (more than 100 amps from the D cell and 200 amps from our X cell for short periods of time). And can be operated or stored in any position.

Gates Energy Cells offer great packaging flexibility. In fact, our individual cell availability allows you to choose your own specific voltage (in 2-volt increments) and current, as well as configuration.

Just as important as what Gates Energy Cells have to offer is what they don't have to offer. Like outgassing problems. Or cell reversal. Or "memory" problems.

Because Gates Energy Cells are made from low-cost materials that are readily available, they're very high in watt-hr. per dollar value. Which means that if you specify them, you'll probably save your company more than a few dollars. And make yourself into something of a hero in the bargain.

To find out more about the future in energy cells, circle our reader service number or write us. We'll send you *free* literature containing features, application information, ratings and specifications. George Sahl, Gates Energy Products, Inc., 1050 S. Broadway, Denver, CO 80217.

Gates®
Energy Products

Where the energy future is now

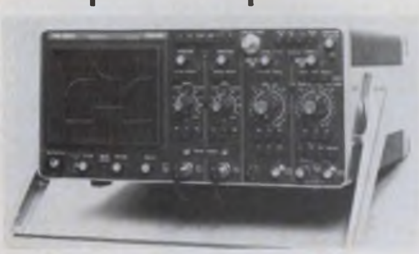
OEM panel meter sells for $139

Newport Laboratories, 630 E. Young St., Santa Ana, CA 92705. (714) 540-4914. $139 (100); 30 days.

Model 2003 4-1/2-digit DPM features an extra bright 1/2-in-high LED display rated for 11 years of continuous operation. Standard features include 1000-MΩ input impedance, automatic polarity and a third-wire ratio input. An automatic-zero circuit precludes the need for manual zero adjustment. BCD data outputs are standard in the Model 2003, which is housed in a high-impact, fire-retardant case and fits the standard 1.68 × 3.92-in. (42.7 × 99.6 mm) panel cutout.

CIRCLE NO. 337

150-MHz scope multiplies 2 inputs

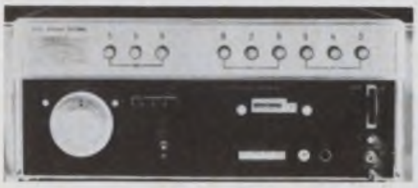


Philips Test & Measuring Instruments, 400 Crossways Park Dr., Woodbury, NY 11797. (516) 921-8880. $2550.

A new 150-MHz, dual-trace portable scope offers a 100-MHz analog multiplication facility. Designated the PM3265, the unit is useful for dynamic power measurements, servo analysis or where the product of two signals must be measured or calculated. Electric output of mechanical transducers can be multiplied in real time to show, for example, horsepower as a result of rpm and torque. The unit has a 5 mV/div sensitivity and a fastest sweep rate of 2 ns/div.

CIRCLE NO. 338

Plug-in extends range of synthesizer



Adret Corp., 1887 Lititz Pike, Lancaster, PA 17601. (717) 569-7059. $7500; stock.

Model 6315 is a frequency synthesizer plug-in module that extends the frequency range of the company's 6100 and 6101 mainframes. The 6315 covers 400 kHz to 600 MHz with 1-Hz resolution (0.01 Hz optional). Programming is accomplished by BCD TTL levels with a switching speed of 500 μs. Phase noise in a 1-Hz band is down over 115 dB at 25 kHz from the carrier, and 130 dB at 1 MHz. The output level of the 6315 is adjustable from +10 to −110 dBm, and is displayed on a panel meter in V rms and dBm. In the remote programming mode, the level is programmable from +13 to −139.9 dBm in steps of 0.1 or 1 dB. Cw, AM, FM, and phase-modulation operating modes are selectable by panel pushbuttons.

CIRCLE NO. 339

Convert X-Y recorder to roll-chart unit

Houston Instrument, One Houston Sq., Austin, TX 78753. (512) 837-2820. $765; stock.

Model SCA-1 strip-chart adapter converts the company's OMNIGRAPHIC Model 2000 X-Y recorder to continuous roll chart operation, yet retains all X-Y recorder capabilities. In addition, the SCA-1 provides single frame (11 × 17-in. chart) advance or reverse on command at the recorder or from a remote station. Chart speeds are 1, 2, 5, 10, 20, 50 and 100 s/in. All controls can be driven with TTL or switch closure.

CIRCLE NO. 340

INSTRUMENTATION

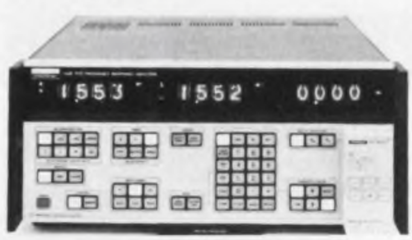
Sweep/function gen gives 50-Ω output

Dana Exact, 455 S.E. 2nd Ave., Hillsboro, OR 97123. (503) 648-6661. $350; stock.

Model 196A is a low-cost sweep/function generator with 50-Ω output. The unit offers sine, triangle, square, pulse and sweep waveforms over a frequency range of 0.1 Hz to 1 MHz. Signal amplitudes of 20-V pk-pk open circuit or 10 V pk-pk into a 50-Ω load are available from a 50-Ω output. 70 dB of attenuation is provided in 20-dB fixed steps and 30-dB variable. The Model 196A has an internal generator to sweep the frequency of the main generator with a variable sweep width up to three decades (1000:1). The sweep rate is adjustable from 1 ms to 10 s.

CIRCLE NO. 341

Unit analyzes servo systems



EMR/Schlumberger, P.O. Box 3041, Sarasota, FL 33578. (813) 371-0811. $10,990 to $16,790; 2 wk.

This frequency-response analyzer determines the dynamic behaviour of feedback controlled servo systems. The 1170 Series is a dual-channel, point-to-point, incrementally swept analyzer featuring sweep up/down; logarithmic/linear, as well as sweep and hold conditions. It covers the range 0.0001 Hz to 9.999 kHz with fully floating and isolated inputs and outputs and displays the systems response in terms of (1) in-phase and quadrature components (a+jb), (2) amplitude and phase shift (R, θ) and (3) gain and phase shift (Log R, θ).

CIRCLE NO. 342

Word generator offers memory expansion

Tau-Tron, 11 Esquire Rd., North Billerica, MA 01862. (617) 667-3874. $4000; 8-10 wks.

Model MG-3 programmable word generator module provides operational speeds up to 50 MHz. The unit contains 1024 bits of random access semiconductor memory programmable from front-panel controls via an optional remote bus. The 1024 bits are arranged in a matrix of 128 words by 8 bits. An auxiliary ninth channel is also standard. Data outputs may be in either 8-bit parallel format or serial format, RZ or NRZ selectable. The output word length or bit length in either serial or parallel modes is controllable in integer steps.

CIRCLE NO. 343

X-Y scope features dual 12-in. display

Wavetek Indiana, 66 N. 1st Ave., Beech Grove, IN 46107. (317) 783-3221. $595; 30 days.

A 15-kHz bw and a 12-in. dual display describe the Model 1910 scope. Vertical amplifiers offer sensitivities from 1 mV per division. The dual-trace presentation alternately sweeps from channel 1 to 2 but incorporates a P-1 phosphor CRT, which eliminates the blinking sometimes found in other magnetic deflection dual-trace scopes. Protection circuits automatically blank off both traces in the event of loss of horizontal input to prevent burnout of the CRT phosphor.

CIRCLE NO. 344

DISCRETE SEMICONDUCTORS

High-voltage/current diode has 3-kV PIV

Electronic Devices, 21 Gray Oaks Ave., Yonkers, NY 10710. (914) 965-4400. $2.90 (1000-up); stock.

The 3W3 high voltage and high current silicon rectifier diode has a surge capacity of 300 A. The diode has a 3000 V PIV rating at 2-A forward current. Two other similar designs are available with PIVs of 2000 and 2500 V. Fast recovery types are also available. The 3W3 diodes are housed in axial lead packages that have diameters of 0.22 in. and lengths of 0.38 in.

CIRCLE NO. 345

Magnetic flux sensing diodes have V_R of 50 V

Shigma, P.O. Box 71, 1550 Northwest Highway, Park Ridge, IL 60068. (312) 298-6160. 10,000 up prices: $2.30 (130C), $6 (230A): stock.

The MD130C and MD230A magneto-sensitive diodes are available either as a single unit (130C) or a matched pair (230A). The diodes can handle surge currents of 10 mA and have reverse voltages of of 50 V. When subjected to a magnetic flux of +1000 Oersteads the 130C produces a voltage change of +0.7 V while the 230A produces a change of 0.8 V, minimum. For a flux of −1000 Oe the minimum voltage change is 0.4 or 0.8 V, respectively. At zero flux, the bias voltage across the 130C is typically 4.2 V and the center potential for the matched pair (230A) is typically 3 V.

Booth No. 1650-52 Circle No. 346

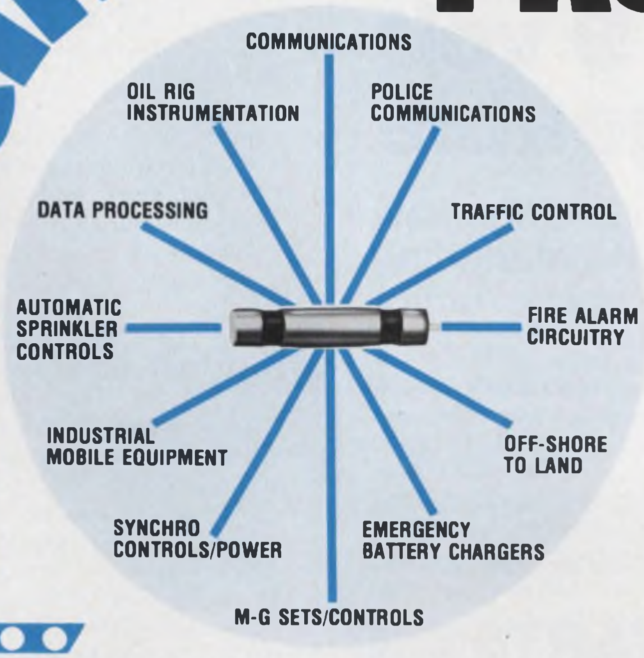
High output LEDs come in four colors

Chicago Miniature, 4433 N. Ravenswood Ave., Chicago, IL 60640. (312) 784-1020. $0.63 (1000-up); stock.

A line of 12 high-intensity LED lamps in yellow, orange, green and red offers a choice of wide-angle or forward-view light patterns. For each color, there are three combinations of luminous intensity and viewing angle. A clear-lens unit provides a "spot" light pattern for backlighting, and two diffused-lens units provide either a 24° pattern for directional applications or a 65° pattern for general applications. In yellow (CM4-580B Series) the clear-lens unit has a typical intensity of 45 mcd, the diffused-lens, narrow-angle unit, 10 mcd and the wide-angle unit 6 mcd. In the orange/amber (CM4-480B Series), the green series (CM4-380B) and the red (CM4-280B) the light output is slightly lower. All lamps have cylindrical T-1-3/4 cases that are colored to match the color of light output. Typical peak wavelengths, important for color-consistency matching in all nonred LEDs, are 635 nm for orange, 585 nm for yellow and 565 nm for green.

CIRCLE NO. 347

FULL CIRCLE SURGE PROTECTION



Protect your solid state equipment from junction damage caused by high-current surges due to power switching and lightning transient induction. Ordinary protective devices ground only one wire, allowing currents to reach your equipment through the "other" wire. TII 3-Electrode Gas Tube Surge Arresters simultaneously ground both wires of a signal or power pair. TII protection can end unnecessary service calls and customer complaints. To learn more about surge and how to protect against it, write for your free copy of "Surge Protection for Solid State Circuitry" or circle the appropriate reader reply number.

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UL Listed and REA Accepted Models Available

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TII TELECOMMUNICATIONS INDUSTRIES, INC.
® *More than 2,000,000 TII Gas Tube Surge Arresters in Service.*

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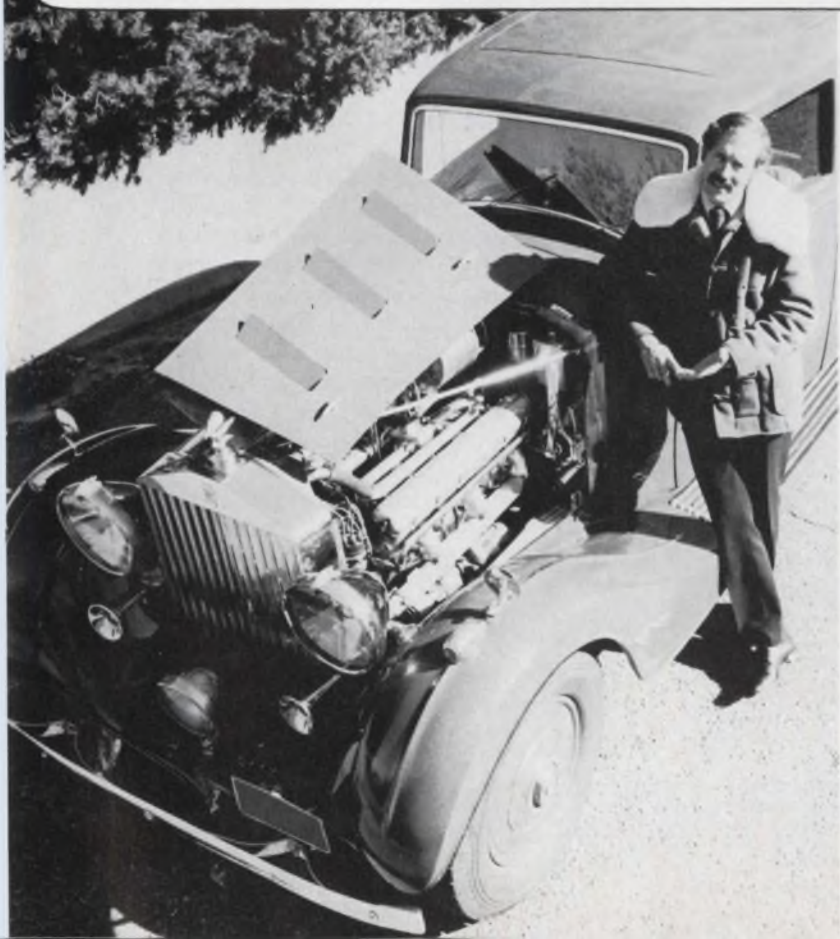
INFORMATION RETRIEVAL NUMBER 74

"You don't have to buy a new car to get an electronic ignition."



Let's face it. After 37 years, even a Phantom III can use a lift. That's why I put a Delta Mark Ten B Capacitive Discharge Ignition on my Phantom . . . to give her a spark I'd pit against any '75 model car. I went to Delta because they aren't Johnny-come-latelys. Delta's been making electronic ignition systems for over a decade.

Whatever kind of car you drive, you can give it the same great Delta performance I gave mine.

- Mark Ten B Capacitive Discharge Ignition Systems are manufactured by Delta Products, Inc., a company with a conscience, and with a proven record of reliability both in product and in customer relations.
- The Mark Ten B really does save money by eliminating the need for 2 out of 3 tune-ups. Figure it out for yourself. The first tune-up or two saved pays for the unit, the rest is money in your pocket. No bunk!
- Because the Mark Ten B keeps your car in better tune, you actually can save on expensive gasoline.
- With a Mark Ten B, spark plugs stay clean and last longer . . . fouling is virtually eliminated.

I want to know more about Mark Ten B CDI's. Send me complete no-nonsense information on how they can improve the performance of my car.

Name________________

Address________________

City________ State________ Zip________

DELTA PRODUCTS, INC.
P.O. Box 1147, Dept. ED, Grand Junction, Colo. 81501
303-242-9000

Mark Ten B, assembled	$64.95 ppd	Standard Mark Ten, assembled	$49.95 ppd
Mark Ten B, kit	$49.95 ppd	Deltakit®	$34.95 ppd

INFORMATION RETRIEVAL NUMBER 75

Laser diode arrays operate at room temp

RCA Electronic Components, 415 South Fifth St., Harrison, NJ 07029. (201) 485-3900. From $87; 30 to 60 day.

Eight GaAs laser arrays are designed for use in illuminators, target designation, gated viewing and intrusion alarm systems. These devices, designated C30002 through C30009, have minimum power outputs ranging from 25 to 300 W at a drive current of 25 A and room temperature. The peak wavelength of spectral radiant intensity at 27 C is 904 nm. The C30002 through C30009 may also be operated at cryogenic temperatures (−196 C) if desired. The individual arrays consist of one, two, or four strips of series-connected laser diodes and, depending on the type, from 10 to 15 diodes are typically used in a strip. All of the arrays are packaged in an OP-4A case.

CIRCLE NO. 348

Numeric LED displays available in four colors

Monsanto, 3400 Hillview Ave., Palo Alto, CA 94304. (415) 493-3300. $2.65 (1000-up); stock.

A 0.4-in.-high LED display comes in a choice of four colors and has a high readability font. There are three standard configurations in the new series, each available in red, yellow, orange and green. The orange unit has a typical intensity of 2000 microcandelas at 20 mA and 500 microcandelas at 5 mA per segment. The models available are a common-anode, right-hand decimal digit; a common-cathode, right-hand decimal digit; and a common anode, overflow (±1) digit wth right-hand decimal. The units in the series feature very high brightness segments in all colors: green, 500 microcandelas at 565 nanometers; orange, 2000 microcandelas at 630 nanometers; red, 300 microcandelas at 660 nanometers; and yellow, 1200 microcandelas at 586 nanometers, all measured at 20 mA dc.

CIRCLE NO. 349

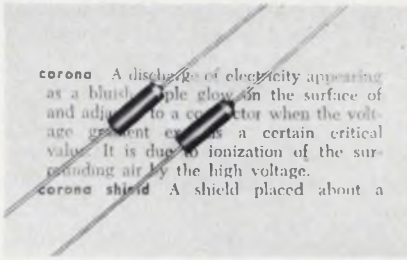
Power transistors made for switching high loads

Motorola Semiconductor, P.O. Box 20912, Phoenix, AZ 85036. (602) 244-6900. From $2.25 (250-up); stock.

The Switchmode series of power transistors is designed for high-voltage power switching applications. The first devices in this series are the 2N6542 through 2N6547 npn, triple-diffused, silicon transistors. The transistors have a V_{CEO} that ranges from 300 to 400 V, $V_{CE(SAT)}$ from 2 to 2.5 V, I_c (peak) from 10 to 30 A and P_D from 100 to 175 W. All ratings are specified for inductive loads and 100-C operation.

CIRCLE NO. 350

High voltage diodes rated up to 25 kV



Microsemiconductor Corp., 2830 S. Fairview St., Santa Ana, CA 92704. (714) 979-8220. From $8; 4 to 8 wk.

A line of corona-free switching and nonswitching rectifiers is available with PIVs ranging from 2 to 25 kV. The diodes have an average reverse current of 500 mA to 50 mA, respectively. Reverse recovery times range from 0.3 μs for switching devices to 5 μs for nonswitching units. The devices exhibit less than 50 picocoulombs of corona. One or more diode chips are sealed in a DO-7 size voidless glass package and potted. Dual-tungsten studs ensure rapid heat dissipation.

CIRCLE NO. 351

Small-signal uhf devices operate up to 6 GHz

Amperex, Solid State and Active Devices Div., Slatersville, RI 02876. (701) 762-9000. From $2 (1000-up).

Ten small-signal uhf transistors have gain-bandwidth products from 2 to 6 GHz at collector currents between 100 μA and 150 mA. The transistors offer low intermodulation distortion and low cross-modulation distortion. Noise figures as low as 1.9 dB at 500 MHz are also available. The 10 types bring the number of small-signal GHz transistor types available from Amperex to 23. Included are all conventional package types: plastic Micro-T, ceramic Micro-T, JEDEC TO-39 and TO-72 metal cans, and stud-mounted strip-line types.

CIRCLE NO. 352

Marking pencils handle light or dark ceramics

Electro Materials Corp. of America, 605 Center Ave., Mamaroneck, NY 10543. (914) 698-8434. $15/dozen; stock.

Special marking pencils are made specifically for marking ceramic substrates. The markings will remain visible and stable in air or nitrogen up to 1200 C even after prolonged temperature exposure. Above 1200 C, the markings will gradually begin to lose their color with the color completely burning off at 1550 C. Markings are not affected by chlorinated hydrocarbons, alcohols or other commonly used cleaning agents. To meet industry requirements for white and dark ceramics, pencils are available with either brown or white marking colors.

CIRCLE NO. 353

Molded plastic knobs available in many styles

Buckeye Stamping, 555 Marion Rd., Columbus, OH 43207. (614) 445-8433. From $0.55 (1 to 99); stock.

The line of Imperial knobs is functionally designed to enhance the appearance of instruments and control panels. The knobs are precision molded of ABS in a tapered design with recessed fluting. Features include all popular sizes in standard, concentric and bar types that can be modified by skirts and a variety of markings. Aluminum bushings with Allen-Head screws are precisely set into each knob to assure concentricity. Stocked colors include: black with white ring, dark grey with white ring, red with white ring and light grey with black ring. Other combinations are available.

Booth No. 1513, 1515 Circle No. 354

Plastic mat removes dirt from shoes easily

Dycem Plastics Ltd., 26 Strawberry Hill, Stamford, CT 06902. (203) 324-7536. From $116.

A plastic mat can collect footborne contamination as personnel enter a clean room. The mat requires only washing for maintenance. Its permanently tacky surface not only holds dust and dirt but also shows when it is in need of cleaning. The Protect-a-Mat is made of a translucent substance whose surface has a very high coefficient of friction. Dust and dirt on shoes clings to the mat from which it is easily removed by a mild soap and water solution. On drying, the original tackiness returns. The nonslip material is highly durable—with a minimum life of one year—and is neither damaged nor tracked by carts. The mat measures 4 × 2 ft.

CIRCLE NO. 355

DATA PROCESSING

Learning aid teaches power of microprocessor

Technitrol, Inc., 1952 E. Allegheny Ave., Philadelphia, PA 19134. (215) 426-9105. $2000 (unit qty); 4 to 6 wks.

The Primer 4/8 is a learning aid to help hardware-oriented engineers master microprocessors. The unit for any 4 and 8-bit microprocessor on the market allows: entry of memory address and instructions in machine language; display of memory address and data by front-panel LEDs, increment, decrement or force-load of program memory address; display of results of CPU operation; and single-step operation to facilitate learning and program debugging. The primer can execute all instructions in the CPU manufacturers instruction set and give the operator an immediate feel for the power of the set and the advantage of software solutions to hardware problems.

CIRCLE NO. 356

Dispatcher's display identifies vehicle

Coded Communications Corp., 1620 Linda Vista Dr., San Marcos, CA 92069. (714) 744-3710. $1600; 45 days.

A digital identification display, Model MB/D/1U, for use in mobile radio vehicles, provides the radio dispatcher with instantaneous vehicle identification and emergency alert notification. Display has a four-digit LED readout for numbers from 0001 to 2047 and a built-in decoder for two messages —a vehicle-identity message and a functional or emergency message. The unit can be desk-top or console mounted. It can be powered from either 13.8 V dc or 117 V ac and it measures 3 H × 8 W × 9-1/2 D in.

CIRCLE NO. 357

CCD memory circuits start with 16 k bits

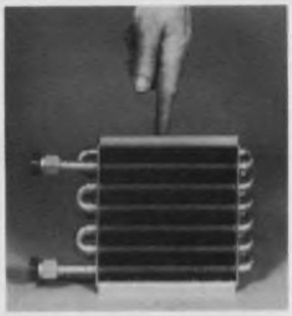
Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. (408) 246-7501. See text.

The first 16 kbit CCD (charge-coupled device) memory is now a commercial product. The Model 2416, a single-chip 18-pin package, contains an array of 64 shift registers, each 256 bits long. Access to data is a fast 200 μs and transfer rate is 6 Mbit/s. Thus speed and access rate vastly exceeds that of normal disc storage. Access to the memory is similar to that for disc: an address code selects the register and one or a succession of registers is accessible between shift cycles. A megabit demonstration card provides access to any location in a time frame of 100 to 200 μs and consumes less than 4 W. Available as 18-pin plastic dips or 22-pin ceramic packages, the 18-pin version costs $85.50 (single) to $55.50 (100 to 999); the 22-pin prices range from $89 to $58 for similar quantities.

CIRCLE NO. 358

Heat exchangers that fit where others won't.

Compact Lytron heat exchangers fit tight spaces... pump heat out, efficiently.



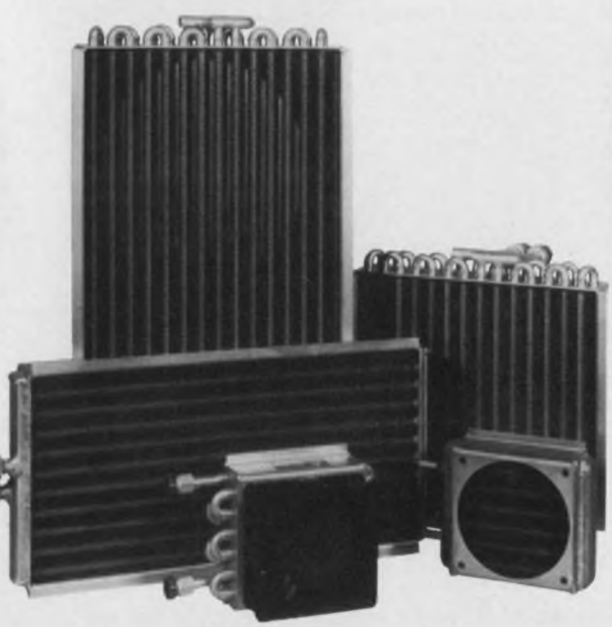
Solve heat buildup problems with these compact, space-saving Lytron heat exchangers. Choose from 24 standard models, aluminum or copper. Exclusive INNER-FIN® construction increases internal cooling surface and saves up to 50% of ordinary coil space.

Ideal for cooling electronic cabinets, lasers, machine tools, computer systems, X-ray machines, space vehicles, airborne and mobile equipment... and a variety of electronic or mechanical equipment where unwanted heat builds up in tight quarters.

Compact Lytron heat exchangers—they fit where others won't. Special designs for special problems also available. As well as applications engineering assistance.

For compact size, minimum weight, proven reliability, prompt service and delivery at low cost, contact Lytron Incorporated, 2 Dragon Court, Woburn, Massachusetts 01801. Phone: (617) 933-7300.

LYTRON INCORPORATED



INFORMATION RETRIEVAL NUMBER 82

Rogan knobs look better and are built better,

and we'll prove it with a free sample.

After you receive our catalog, send us a note outlining your specific requirement and the quantity involved.

Or furnish us with our competitor's part number and we will cross-reference it.

Our samples and quotation will be returned promptly.

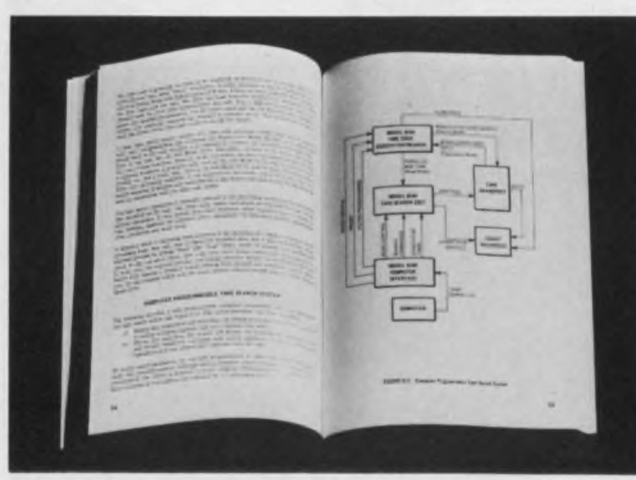
ROGAN CORPORATION

3455 Woodhead Drive, Northbrook, Illinois 60062 (312) 498-2300

INFORMATION RETRIEVAL NUMBER 83

New 121-page handbook for those who have time (code) on their hands... only $3.50.

Here's a valuable reference prepared by Systron-Donner's team of time code specialists. The handbook covers such subjects as accuracy and synchronization of standards; time codes and formats; and systems and instruments for time code generation, reading and tape search.



For your copy of "Precision Timekeeping and Tape Search," send your check payable to Systron-Donner Corporation, Data Products Division, 935 Detroit Avenue, Concord, CA 94518.

SYSTRON DONNER

INFORMATION RETRIEVAL NUMBER 84

DATA PROCESSING

Plotter features built-in microprocessor

Glaser Data Co., 225 Forest Ave., Palo Alto, CA 94301. (415) 321-1348. $14,000; 60 to 90 days.

Glaser's DP-1600 plotter can handle 22 × 34-in. drawings at plotting speeds to 800 increments per second. The device attains an accuracy of 0.004 in., and a built-in microprocessor simplifies the drawing of straight lines. Its slope generator requires the specification of only the two end points of the line. In addition, an internal 55-character symbol generator reduces software and data-transmission needs.

CIRCLE NO. 359

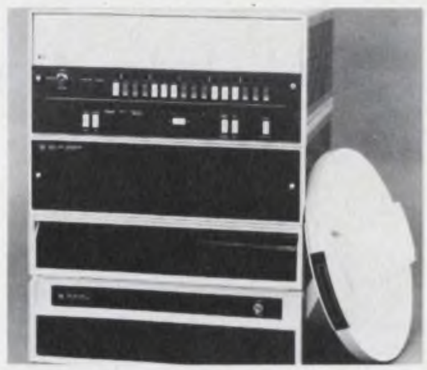
Analog I/O systems compatible with μP

Burr-Brown Research, International Airport Industrial Park, Tucson, AZ 85734. (602) 294-1431. See text.

To an Intellec microcomputer, the new Burr-Brown 4-to-16-channel acquisition units look like memory locations. But one simple instruction enters a 12-bit data word from the system or to the outside world. Any of the three systems —MP8104, 8208 or 8216—plugs into any memory or I/O slot of the microcomputer. The 8104 output system includes four 12-bit DACs and buffer registers. The MP8208 and 8216, both complete acquisition units, contain analog multiplexers, instrumentation amplifiers, sample-hold and 12-bit converter and all interface logic. During conversion (20 μs) these systems send a wait request to the CPU until ready. The input ranges are ±10 V, 0 to 10 V, 25 V and 0 to 5 V, with specified accuracy of ±0.025%. The 8104 sells for $695 in single quantity; the 8208 and 8216 single price is $795.

CIRCLE NO. 360

Minicomputer plus disc includes smart interface



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. See text; 60 to 120 days.

A 64 k-word 21MX minicomputer and fast cartridge disc provide extensive software capability. The disc, HP's new 7905A, adds 15 Mbytes memory with 25-ms average access time and a transfer rate of 936 Mbytes a second. Pre-wired and checked out as a package, the MX/65 system sells for less than the sum of its parts. It consists of a 21MX minicomputer, a 7905A disc, and a microprocessor-equipped control unit. The minicomputer is microprogrammable. Direct memory access through the processor's dual-channel port controller makes programs assignable to any I/O channel; the port controller also provides independent word count and address registers. The disc subsystem is expandable to 120 Mbytes with additional discs and allows access by up to eight CPUs. Quantity prices start at $15,675 with 16-k CPUs, with a 128 kbyte CPU (the largest) the price is $23,946.

CIRCLE NO. 361

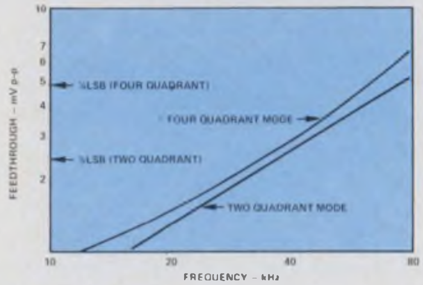
Microcomputer memory and cassette offered

Micromation, 11339-K Sorrento Valley Rd., San Diego, CA 92121. (714) 452-0101. See text.

Users of Intel's 8080 μP or Model 80 computer can replace paper tape with the MM2000, a dual-cassette storage device. Selling for $950 (qty 1), the unit's interface board plugs into the host and interfaces with Intel software via a PROM program. Also offered are plug compatible memories, Model MM1000, of 8 k × 8 bits for $895 (1-9 qty).

CIRCLE NO. 362

Lowered feedthrough lets d/a performance shine through



Analog Devices, Route 1 Industrial Park, Norwood, MA 02021. (617) 329-4700. P & A: See text.

Feedthrough in multiplying digital-to-analog converters prevents them from maintaining their accuracy when the analog reference signal increases in amplitude or frequency. Analog Devices has changed that with the introduction of its Model 1125.

The DAC1125 has a four-quadrant feedthrough of only 0.5 LSB maximum at a maximum frequency of 40 kHz. The DAC accepts 12-bit data words and settles to within 0.03% accuracy in under 10 μs (3 μs typical).

Input lines of the DAC are complementary-binary coded in the two-quadrant mode and can be programmed for offset-binary or two's complement coding in the four-quadrant mode.

Differential nonlinearity and gain temperature coefficients are kept to a low 3 ppm/°C. Monotonicity over a 0-to-50-C range is guaranteed in the four-quadrant mode; in the two-quadrant mode it's guaranteed from 0 to 70 C. Rejection of ripple from the power supply is better than 80 dB.

The reference input can handle signals that vary over a ±10-V range, and has a 450-kHz, −3-dB bandwidth. Slew rate of the reference input is a high 20 V/μs, while the phase shift, input-to-output, is less than −0.5° at 5 kHz.

Some units that compete with the DAC1125 include the Model 869 from Beckman (Fullerton, CA), the CY2219 from Cycon (Sunnyvale, CA), the DAC-MV12B from Datel (Canton, MA), the 412-BIN from Function Modules (Costa Mesa, CA), the DAC316-12 from Hybrid Systems (Burlington, MA) and the 4072 from Teledyne Philbrick (Dedham, MA).

Compared with these multiplying DACs, the DAC1125 from Analog Devices is one of the more expensive units—it costs $295 in unit quantity, compared with a low of $135 for the Hybrid Systems DAC-316-12 and a high of $315 for the Philbrick 4072.

Of course, the lower priced units sacrifice performance. For example, the Hybrid Systems unit has a feedthrough of 2 LSB at 20 kHz and has only a 100-kHz bandwidth. Its tempco is also higher—at 30 ppm/°C. Most of the other units have tempcos ranging from 5 to 30 ppm/°C and bandwidths that range up to 200 kHz.

The Analog Devices DAC1125 is housed in a 2 × 2 × 0.4 in. (51 × 51 × 10 mm) module and requires a positive supply that ranges from 13 to 17 V at 17 mA max, and a negative supply that provides −12 to −18 V at 10 mA. It is available from stock.

Analog Devices	CIRCLE NO. 303
Beckman	CIRCLE NO. 304
Cycon	CIRCLE NO. 305
Datel	CIRCLE NO. 486
Function Modules	CIRCLE NO. 487
Hybrid Systems	CIRCLE NO. 488
Teledyne Philbrick	CIRCLE NO. 489

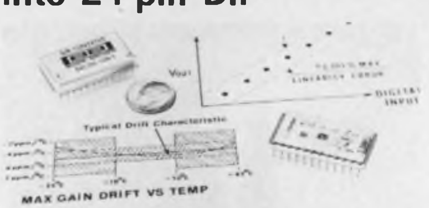
INFORMATION RETRIEVAL NUMBER 86

Broadband amplifiers span 5 to 500 MHz

Aydin-Vector, P.O. Box 328, Newtown, PA 18940. (215) 968-4271. $120 (1 to 9); stock to 2 wk.

Two hybrid circuit broadband transistor amplifiers, Models MHD-151 and MHD-152, are available in four-pin DIPs. Both units cover the 5-to-500-MHz frequency range. The MHD-151 has a gain of 21 dB and the MHD-152 has 31 dB. The noise figure is 5 dB and the power output +9 dBm, for both units. Power required by the amplifiers is +12 V dc at 65 mA for the 152 and 45 mA for the 151. These units are electrically and mechanically interchangeable with the discontinued Fairchild FMA-131 and FMA-135. **CIRCLE NO. 363**

16-bit DAC squeezes into 24-pin DIP



Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734. (602) 294-1431 From $119 (1 to 9).

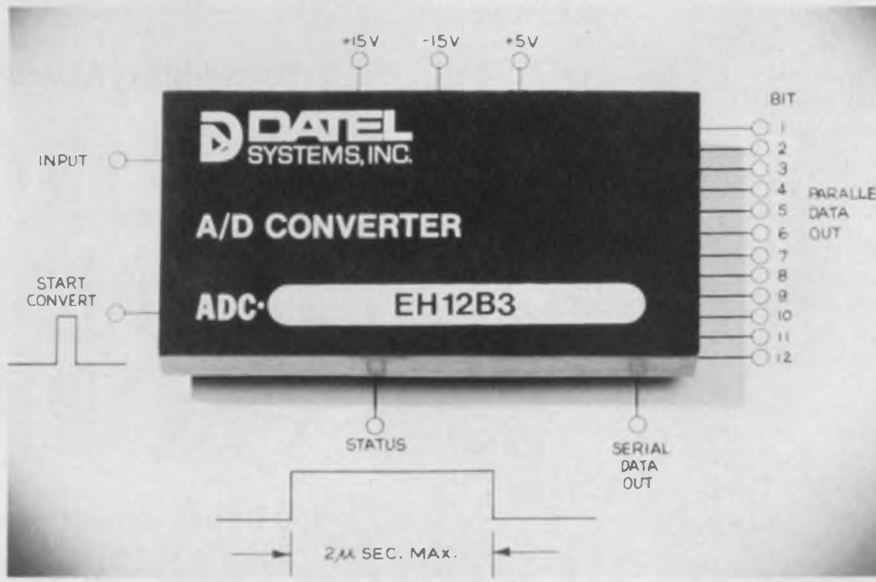
The DAC-70 d/a converter provides 16-bit resolution and 14-bit accuracy. The converter is housed in a 24-pin metal DIP. The unit comes complete with internal reference and scaling resistors for driving an external amplifier. The internal thin-film ladder network is trimmed to ±0.003%. Nonlinearity and drift match the IC current switches and zener reference to keep the maximum gain drift to ±7 ppm/°C over −25 to +85 C. DAC-70 versions are available with either 16-bit binary or four-digit BCD input coding. Outputs are in the form of current with ranges of ±1 mA and 0 to −2 mA. Settling time to ±0.003% of full scale range is 50 μs for a full scale output current change. Input power requirements are ±15 V at ±30 mA and +5 V at +25 mA. The 24-pin DIP measures 1.4 × 0.8 × 0.2 in. and is hermetically sealed.

CIRCLE NO. 364

INFORMATION RETRIEVAL NUMBER 87

INFORMATION RETRIEVAL NUMBER 88

Speedy a/d converts input signals in less than 2 μs



Datel Systems, 1020 Turnpike St., Canton, MA 02021. (617) 828-8000. P & A: See text.

Fast a/d converters, with conversion times of 2-μs or better, have tended to be very expensive. Now Datel, with its ADC-EH12B3, has slashed the cost by several hundred dollars. The Datel EH12-B3, successive-approximation a/d converter provides a 12-bit word only 2 μs after the convert command is given, and it costs just $299 in unit quantities.

The converter handles inputs of 0 to 10 V when connected for unipolar operation and ±5 V for bipolar. The input impedance for either operating mode is 1.5 kΩ.

At 25 C, accuracy and linearity errors are ±0.5 LSB. The differential linearity is also 0.5 LSB and has a tempco of 3 ppm/°C max, which ensures monotonicity over the operating temperature range of 0 to 70 C. The gain tempco for the EH12B3 is ±30 ppm/°C.

The a/d converter consumes only 2.3 W, maximum, and is housed in a 2 × 4 × 0.4-in. module. An internal clock provides all the timing necessary, so only a start command is needed.

Of course, there are plenty of other 12-bit a/d converters. But at conversion speeds near 2 μs, the range of available units shrinks drastically. Available units include the ADC-1103 from Analog Devices (Norwood, MA), the MP-2712 from Analogic (Wakefield, MA), the ADC-591-12A from Hybrid Systems, (Burlington, MA) and the 4133 from Teledyne-Philbrick (Dedham, MA).

Conversion times for these units start at 2.5 μs for the 4133 from Philbrick, rise to 3.5 μs for the Analog Devices and Hybrid Systems units and increase to 4 μs for the Analogic converter. Costs, though, start at $229 for the Analogic converter, jump to $425 for the Hybrid Systems converter, to $495 for the Analog Devices unit and to $585 for the Philbrick.

Physically these converters, except for the Philbrick, are almost double the volume of the Datel unit, measuring 2 × 4 × 0.75 in. The Philbrick units are slightly smaller—2 × 4 × 0.375 in.

The Datel ADC-EH12B3 is available from stock to 4 weeks.

Datel	CIRCLE NO. 301
Analog Devices	CIRCLE NO. 302
Analogic	CIRCLE NO. 490
Hybrid Systems	CIRCLE NO. 491
Teledyne-Philbrick	CIRCLE NO. 492

Synchro-to-dc converters accurate to ±6 minutes

Computer Conversions, 6 Dunton Ct., East Northport, NY 11731. (516) 261-3300. $350 (prod. qty.); 4 wk.

The SLD214 series of synchro-to-linear-dc converter modules can track at input rates up to 1440°/s. The modules measure 2.6 × 3.1 × 0.82 in. and have standard accuracies of ±6, ±15 or ±30 minutes of arc. They convert synchro or resolver inputs of 11.8 or 90 V, 400 Hz; or 90 V, 60 Hz into a linear dc voltage proportional to the shaft angle. Dc outputs of ±10 V representing ±180°, 0 to +10 V representing 0 to 360° or ±10 V representing ±90° are available. This series of converters is insensitive to ±10% amplitude and frequency variations and ±5% power-supply variations. The converters have transformer isolated reference and synchro inputs, and units that maintain ±6 minutes of arc accuracy over military temperature ranges are available.

CIRCLE NO. 365

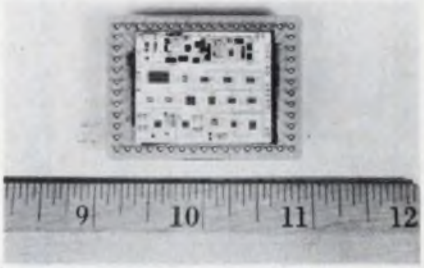
Watt transducers work over 50 Hz to 10 kHz

F. W. Bell, 4949 Freeway Drive East, Columbus, OH 43229. (614) 888-7501. $39 (100-up).

Two watt transducers are designed to measure one and three phase electrical power at various frequencies from 50 Hz through 10 kHz. The output is a power-proportional dc voltage. Fast response and wide bandpass operation enable the PX-2000 and the PX-4000 series to accurately measure power from distorted waveforms. The low frequency PX-2000 series features models with fundamental frequencies of 60, 180 and 360 Hz. High frequency PX-4000 models center at 1 and 3 kHz. Each model consists of a potential transformer, a Hall-effect multiplier and corrective circuitry that reduces the influence of low power factor and of ambient temperature variations. Each transducer is epoxied in a small nylon case with through mounting holes and wire leads. The case measures 3-5/16 × 1-13/16 × 1-5/16 in.

CIRCLE NO. 366

Hybrid a/d converter includes s/h amplifier

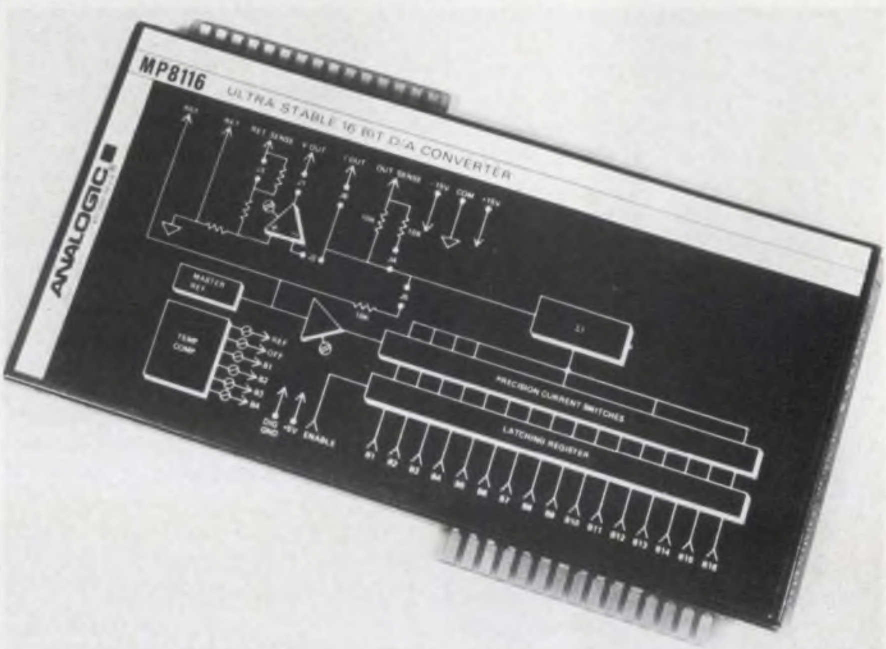


Aydin Vector, P.O. Box 328, Newton, PA 18940. (215) 968-4271. $400.

The ADH-10 series analog-to-digital converter uses thick-film multilayer technology and CMOS logic. The unit is a completely self-contained 10-bit converter, with internal sample-and-hold and clock. It is available in a hermetic package that measures 1.8 × 1.3 in. and weighs less than 1 oz. The circuit is built to meet the environmental requirements of MIL-STD-883 and has a conversion time of 25 μs for 10 bits. The internal s/h circuit has a decay of 100 μV/μs and can acquire a signal in 5 μs to 0.1% accuracy.

CIRCLE NO. 367

16-bit d/a converter claims highest accuracy, lowest drift



Analogic, Audubon Rd., Wakefield, MA 01880. (617) 246-0300. P&A: See text.

True 16-bit accuracy for d/a converters is here. So says Analogic with its MP8116 converter. The d/a provides accuracy to within 4 ppm and has a 2-ppm uncertainty traceable to the National Bureau of Standards.

Not only is the unit accurate, but it holds its accuracy with changes in temperature. The temperature coefficient of gain is given as only ±0.4 ppm/°C, max, and the tempco of offset only 0.3 ppm/°C. The differential linearity is held to 0.24 bit, max, while its tempco is 0.25 ppm/°C, max.

For worst-case conditions, the tempcos total to less than 1 ppm/°C, and thus, over a ±10 C range, the stability of the converter is 10 ppm, maximum—which, in turn, causes a drift less than one bit.

The converter has a built-in amplifier and can provide either a voltage or current output. The specs given, so far, are for the voltage output, and they get even better for the current output, since the tempcos of the output amplifier are eliminated.

Noise inside the converter is only 1.5 ppm, while the converter settling times are 25 μs for the voltage output and about 10 μs, max, for the current output. The converter can deliver a current of 2 mA; it requires 1.4 W for operation.

The output can be connected for four-wire balanced sense operation to ensure effective correction of losses between the d/a output and the load. A completely shielded 3.5 × 7-in. case protects the unit and can be opened to permit total recalibration when necessary.

Prices for the MP8116 start at $1500 for 1 to 9 pieces. Substantial discounts are available for 10 or more pieces. The converters are available from stock to 4 weeks.

Several other companies offer 16-bit converters, but none come close to the tempcos that are available in the Analogic MP8116. For instance, Analog Devices (Norwood, MA) has the DAC-16QG, which lists drifts that are about 10 times worse and settling times that are 10 times longer. There

(continued on page 129)

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Conference Program

TUESDAY, NOVEMBER 11

9:00 AM - 12:00 PM

TECHNICAL SESSION I
"OPTICAL COMPUTING I — EXTENDING THE FLEXIBILITY OF COHERENT OPTICAL PROCESSING"
Chairman: Joseph W. Goodman, Stanford University

TECHNICAL SESSION II
"WIDEBAND LASER RECORDING I — ADVANCES IN COMPONENT DEVELOPMENT"
Chairman: A. J. Jamberdino, Rome Air Development Center

TECHNICAL SESSION III
"OPTICS IN THE SOLAR ENERGY FIELD"
Chairman: Eric M. Wormser, Wormser Scientific Corp.

TECHNICAL SESSION IV
"ELECTRO-OPTICS IN ATMOSPHERIC MEASUREMENTS — I"
Chairman: John R. Yoder, Beckman Instruments

TECHNICAL SESSION V (LIA)
"LASER ISOTOPE SEPARATION"
Chairman: Jack P. Aldridge, Los Alamos Scientific Lab.

TECHNICAL SESSION VI
"INTEGRATED AND FIBER OPTIC COMPONENTS — I"
Chairman: Prof. Chen Tsai, Carnegie-Mellon Univ.

1:30 PM - 4:00 PM

LASER WORKSHOP (LIA)
"LASERS IN THE PRESENT ECONOMY — AN INVESTMENT POTENTIAL"
Chairman: Carl Bailey, Laser Investments Inc.

WEDNESDAY, NOVEMBER 12

9:00 AM - 12:00 PM

TECHNICAL SESSION VII
"OPTICAL COMPUTING II — HYBRID OPTICAL/DIGITAL PROCESSORS"
Chairman: David Casasent, Carnegie-Mellon University

TECHNICAL SESSION VIII
"WIDEBAND LASER RECORDING II — STATE-OF-THE-ART AND FUTURE TRENDS IN LASER RECORDING AND DATA HANDLING SYSTEMS"
Chairman: A. J. Jamberdino, Rome Air Development Center

TECHNICAL SESSION IX
"IMAGING DEVICES AND SYSTEMS — I"
Chairman: Herbert Lavin, General Electric Co.

TECHNICAL SESSION X
"ELECTRO-OPTICS IN ATMOSPHERIC MEASUREMENTS — II"
Chairman: John R. Yoder, Beckman Instruments

TECHNICAL SESSION XI
"ACOUSTO-OPTICS DATA PROCESSING"
Chairman: Prof. Glen Wade, University of California

TECHNICAL SESSION XII
"INTEGRATED AND FIBER OPTIC SYSTEMS — II"
Chairman: Professor Chen Tsai, Carnegie-Mellon Univ.

1:30 PM - 4:00 PM

LASER WORKSHOP (LIA)
"LASER DAMAGE SYMPOSIUM UPDATE"
Chairman: Dr. Arthur Guenther, AFWL, Kirtland AFB and Alex Glass, Lawrence Livermore Lab.

THURSDAY, NOVEMBER 13

9:00 AM - 12:00 PM

TECHNICAL SESSION XIII
"OPTICAL COMPUTING III — COHERENT OPTICAL DEVICES"
Chairman: Dr. H. J. Caulfield, Block Engineering, Inc.

TECHNICAL SESSION XIV (LIA)
"LASERS IN GRAPHICS"
Chairman: Stephen Johnson, Spectra-Physics

TECHNICAL SESSION XV
"IMAGING DEVICES AND SYSTEMS — II"
Chairman: Herbert Lavin, General Electric Co.

TECHNICAL SESSION XVI (LIA)
"LASER RANGING, TRACKING AND GUIDANCE"
Chairman: Dr. David Flinchbaugh, International Laser Systems

TECHNICAL SESSION XVII
"GLASS FIBER WAVEGUIDES"
Chairman: Madhu A. Acharekar, Galileo Electro-Optics Corp.

TECHNICAL SESSION XVIII (LIA)
"POWER SUPPLIES AND ENERGY STORAGE SYSTEMS FOR ELECTRO-OPTICS AND LASERS"
Chairman: R. Stapleton, Los Alamos Scientific Laboratory

LASER APPLICATIONS SYMPOSIUM (LIA)

COMMERCIAL I
Tuesday, November 11 — 5:00 PM - 6:10 PM
Chairman: Dr. Ralph Wuerker, TRW Systems

COMMERCIAL II
Tuesday, November 11 — 6:30 PM - 8:00 PM
Chairman: Dr. Ralph Wuerker, TRW Systems

INSTRUMENT
Wednesday, November 12 — 5:00 PM - 6:10 PM
Chairman: Jose Cruz, Cummins Engine Co.

COMMUNICATIONS
Wednesday, November 12 — 6:30 PM - 8:00 PM
Chairman: Jose Cruz, Cummins Engine Co.

MATERIAL PROCESSING I
Thursday, November 13 — 1:30 PM - 2:40 PM
Chairman: David Belforte, Belforte Associates

MATERIAL PROCESSING II
Thursday, November 13 — 3:00 PM - 4:30 PM
Chairman: David Belforte, Belforte Associates

PROFESSIONAL ADVANCEMENT COURSES

PAC I
"INTRODUCTORY COURSE ON APPLICATION OF SOLAR ENERGY IN THE HEATING AND COOLING OF BUILDINGS"
Monday, November 10 — 9:00 AM - 12:00 PM and 1:30 PM - 4:00 PM
Course Leader: Eric M. Wormser, President, Wormser Scientific Corp.

PAC II
"INTRODUCTION TO ELECTRO-OPTICS"
Tuesday, Wednesday, Thursday, November 11, 12, 13 — 1:30 PM - 4:00 PM
Course Leader: Prof. J. Gaskill, Optical Sciences Center, University of Arizona

PAC III (LIA)
"SHORT COURSE ON EFFECTS OF LASER RADIATION, RE TISSUE SAFETY, RADIOMETRY, ETC."
Monday, November 10 — 9:00 AM - 12:00 PM and 1:30 PM - 4:00 PM
Course Directors:
R. James Rockwell, Jr., University of Cincinnati
James F. Smith, IBM Corp.
David H. Sliney, U.S. Army Environmental Hygiene Agency

PAC IV (LIA)
"LASER MEASUREMENTS"
Tuesday, November 11 — 1:30 PM - 4:00 PM
Course Leader: Dr. W. Tiffany, Molectron Corp.

PAC V (LIA)
"ENVIRONMENTAL AND NON-DESTRUCTIVE TESTING BY LASERS"
Thursday, November 13 — 1:30 PM - 4:00 PM
Organized by LIA

SPSE SEMINARS

SEMINAR I
"MICRODENSITOMETRIC READOUT OF PHOTOGRAPHIC INFORMATION"
Tuesday, November 11 — 1:30 PM - 4:00 PM
Chairman: Prof. Fawwaz T. Ulaby, University of Kansas

SEMINAR II
"LASER RECORDING MATERIALS — TECHNICAL ADVANCES AND PANEL WORKSHOP"
Wednesday, November 12 — 1:30 PM - 4:00 PM
Chairman: Dr. Arthur Diamond, Diamond Research Corp.

LIA ANNUAL MEETING & LUNCHEON

Wednesday, November 12, 11:30 AM
Anaheim Convention Center
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- 25 ☐ Modulators/Beam Deflectors/Beam Splitters/Scanners, etc.
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- 32 ☐ TV Systems/LLLTV
- 33 ☐ Chemicals/Solvents/Materials
- 34 ☐ Grinding & Polishing Equipment/Supplies
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☐ PAC II: Introduction to Electro-Optics	$90.00

NOTE: PAC III, IV and V include text materials and complimentary admission to exhibits for all three days.

☐ PAC III: Short Course on Effects of Laser Radiation, Re Tissue Safety, Radiometry, Etc. (LIA) LIA Member: $50.00 Non-Member: $65.00	$______
☐ PAC IV: Laser Measurements (LIA) LIA Member: $30.00 Non-Member: $45.00	$______
☐ PAC V: Environmental and Non-Destructive Testing by Lasers (LIA) LIA Member: $20.00 Non-Member: $35.00	$______

NOTE: SPSE Seminars include complimentary admission to exhibits for all three days.

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☐ SPSE SEMINARS I and II	$15.00
☐ LIA ANNUAL MEETING AND LUNCHEON LIA Member: $5.50 Non-Member: $7.00 (Reservations must be received by Oct. 28)	$______
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Rooms have been set aside for Electro-Optic/Int'l Laser '75 in these hotel/motels:

ROYAL INN (Headquarters)
QUALITY INN
DISNEYLAND HOTEL
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Nan Parsons
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Anaheim, Calif. 92802 / Phone (714) 533-5536

In order to qualify for special rates, you must mention Electro-Optic/Int'l Laser '75 when telephoning for reservations or information!

MODULES & SUBASSEMBLIES

(con't from p. 128)

are, though, many different options for the DAC-16, with prices starting at less than $800 for the basic converter.

Burr-Brown (Tucson, AZ) has the DAC-70, Datel (Canton, MA) the DAC-HR16B and Function Modules (Irvine, CA) the 416—all of which have higher drifts than the MP8116 but cost between $119 and $500. Many of these units, though, don't include all the features of the Analogic MP8116. For instance most don't have internal storage registers, voltage outputs, four-wire outputs or trimming adjustments.

Analogic	CIRCLE NO. 321
Analog Devices	CIRCLE NO. 322
Burr-Brown	CIRCLE NO. 323
Datel	CIRCLE NO. 324
Function Modules	CIRCLE NO. 325

Synchro-to-sin/cos conv. is accurate to 12 min.

ILC Data Device, Airport International Plaza, 105 Wilbur Pl., Bohemia, NY 11716. (516) 567-5600. $585 (1 to 9).

The Model STDC converter accepts three-wire synchro or four-wire resolver data and delivers ±10-V-dc at ±5-mA sine and cosine data accurate to ±12 minutes (ratio sin/cos). It can do this even in the presence of ±3% input power variations and ±10% swings in input signal amplitude and frequency. The STDC accepts synchro inputs (line-to-line) of 90 V at 60 Hz, 90 V at 400 Hz or 11.8 V at 400 Hz. Other voltages and frequencies are available. Synchro input angle rates are 0 to ±360°/s for 400-Hz units and 0 to ±60°/s for 60-Hz units. Initial acquisition time is less than 25 ms. Under worst-case conditions, the sin/cos dc output will be smoothly varying and free of spikes, with rms noise below 2 mV and peak noise less than 5 mV. Two operating temperature ranges are available: 0 to +70 and −55 to +85 C. The converter requires: 15 V dc, ±3% at less than 50 mA and measures 2.625 × 3.125 × 0.82 in.

CIRCLE NO. 368

Bulletin Board

Enhancements to the **Xerox 1200 computer printing system** increase performance, expand compatibility and simplify control functions of the system.

CIRCLE NO. 369

Ex-Cell-O, Remex, has introduced **software** which permits users of PDP-11 minicomputers with limited software capabilities to put a flexible disc system online to replace or enhance paper tape I/O devices.

CIRCLE NO. 370

Control Data offers two new services—**SYSCAP II** (System of Circuit Analysis Programs) and **CC-TEGAS3** (Test Generation and Simulation System)—for circuit design and testing.

CIRCLE NO. 371

Training centers with **programs specializing in the use of microprocessors and microcomputers** have been established by **National Semiconductor.**

CIRCLE NO. 372

Doubled memory capacity, cardless computing and a program providing remote job entry support to operate under OS/VS1 or OS/VS2 have been added to the capabilities of **IBM's System/3 Model 15.**

CIRCLE NO. 373

Sprague's Filter Div. engineering laboratories can perform **rf interference measurements and suppression measurements** in accordance with foreign and international specifications.

CIRCLE NO. 374

Teledyne Semiconductor's Series 74C CMOS ICs now have an extended temperature range of −40 to +85 C.

CIRCLE NO. 375

Electronic Instrument & Specialty is offering its re-designed **MINI-INCH reed relay series** at a cost savings of 20 to 30%.

CIRCLE NO. 376

Application Notes

Pair cable fault locator

Application of the Anritsu Electric Model MW32B pulse echo tester and its use in locating faults in the event of water absorption, wire breakdown, short-circuit and erroneous connection of plastic communication cables are discussed in a 10-page catalog. Tau-Tron, North Billerica, MA

CIRCLE NO. 377

Signal analysis

"A New Modular System for Noisy Low-Level Signal Processing" points out analogies between devices supplied with two correlated channels: lock-in amplifier, boxcar averager and Fourier analyzer. Tekelec Airtronic, 92310 Sevres, France

CIRCLE NO. 378

Load cell instrumentation

Acquisition of remote load cell data often requires involved instrumentation and transmission circuitry. A new approach using a v/f converter is covered in a four-page bulletin. Dynamic Measurements, Winchester, MA

CIRCLE NO. 379

Conductive paints, inks

Ten basic ways by which scientists and engineers use conductive paints and inks are listed in a brochure. It contains a selector chart, description of the coatings and an offer to purchase a full range of paints at discounts up to 20%. Micro-Circuits, New Buffalo, MI

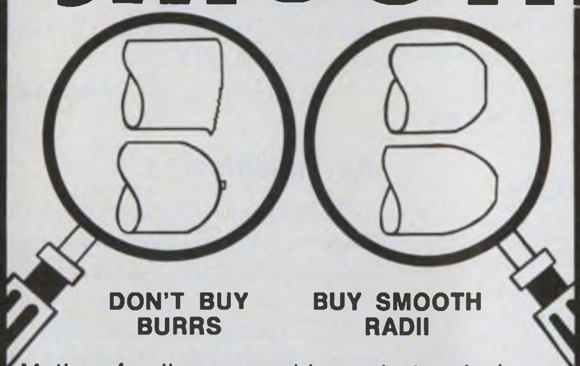
CIRCLE NO. 380

Low-pass filters

"Filter Characteristics" provides amplitude response, group delay and equivalent noise bandwidth figures for the most commonly used low-pass filters for telemetry and communication applications. EMR Telemetry, Sarasota, FL

CIRCLE NO. 381

ROLL'EM SMOOTH



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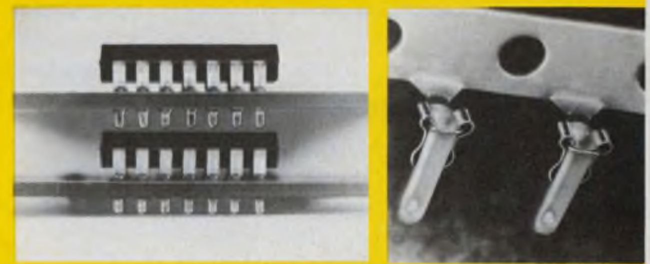
726 River Road, Shelton, Conn. 06484. Tel. (203) 929-1401

INFORMATION RETRIEVAL NUMBER 104

Minisert™ Low-Profile P.C. Socket... provides repeated pluggability for I.C.'s, DIP's, etc.



For use where space is restricted . . . extends just .030" above and .088" below board . . . allows .400" board-to-board spacing. One size Minisert* socket fits wide range of hole sizes . . . .050" to .058" in diameter . . . and accepts round or flat leads of DIP's, LED's and LSI's. Elastromeric seal keeps foreign matter out of socket. Free standing design can be used in any socket pattern. Semi-automatic machine inserts at rates up to 2000 per hour. Write for Bulletin 120 or call.

*Sockets sell for $20.00 to $30.00 per thousand in volume quantities.

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BERG ELECTRONICS
Division E. I. du Pont de Nemours & Co. (Inc.)

New Cumberland, Pa. 17070 Phone: (717) 938-6711

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INFORMATION RETRIEVAL NUMBER 105

BergStik™ Straight and Right-Angle Headers... for production line or prototype.

Here's an inexpensive method of inserting .025" square pins in boards for wire-wrapping or input/output usage. Header consists of **drawn wire pins** (¾-hard phosphor bronze) **molded in position** in glass-filled nylon carriers. Result: A stronger pin with no rough edges. Headers are available on .100", .125" and .150" centers. Carriers are notched to allow the user to break to length for any desired number of pins. BergStik Headers also have tongue-and-groove design to facilitate side-by-side stacking. Headers can be loaded like components and do not interrupt flow on the assembly line. Just plug 'em in! (Write for Bulletin 140)

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BERG ELECTRONICS
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INFORMATION RETRIEVAL NUMBER 142

New Literature

Electronic components

Color-coded indexing and pages make it easier to locate product groups in a components catalog. The catalog describes glass, glass-ceramic, ceramic and microminiature solid tantalum capacitors and metal-film resistors. Corning, Corning, NY

CIRCLE NO. 389

Photomultiplier tubes

In addition to picturing and detailing photomultiplier tubes, a 20-page volume discusses related subjects such as environmental limitations, voltage dividers, the anode circuit, considerations in tube selection and other applications. EMI Gencom, Plainview, NY

CIRCLE NO. 384

Information systems

"The Information Connection" is dedicated to building an understanding of three cornerstones in information systems technology: program management, data base management and applications for management. Computer Sciences Corp., Los Angeles, CA

CIRCLE NO. 387

Motors and gearmotors

Two brochures contain information on the K-2 line of industrial instrument and servo motors and their companion gearmotors. The two eight-page bulletins detail performance data as well as typical performance curves. Bodine Electric, Chicago, IL

CIRCLE NO. 388

Miniature accelerometers

Specifications and typical uses of single axis, biaxial and triaxial miniature accelerometers are covered in a 16-page brochure. Entran Devices, Little Falls, NJ

CIRCLE NO. 385

Delay lines

Precision delay lines, laboratory decade delay lines, fixed attenuators and video equalizers are presented in a 24-page catalog. A discussion on "how to specify delay lines" is included. Allen Avionics, Mineola, NY

CIRCLE NO. 390

Air conditioners

"Electronic Cabinet Air Conditioners: Application/Selection/Operation" contains a six-page discussion of the subject, together with a time-saving selection nomogram. Kooltronic, Princeton, NJ

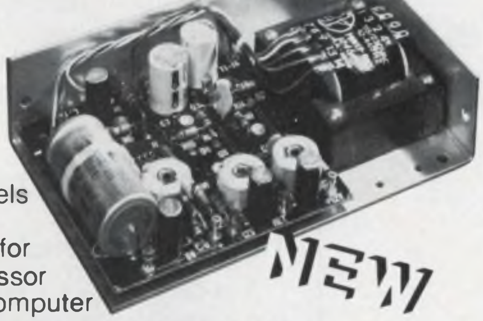
CIRCLE NO. 391

Temp indicating paints

Temperature indicating paints and crayons which change color at specific temperature levels are described in a four-page brochure. Specifications and color photographs are included. Telatemp, Fullerton, CA

CIRCLE NO. 386

MICROPROCESSOR POWER



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MODELS

DUAL:	HAA512, 5V @ 2A W/OVP 9 to 15V @ 0.5A	$44.95 Single Quantities
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INFORMATION RETRIEVAL NUMBER 109

NEW

THE BIG RED "1"

AN INDUSTRY FIRST, IEE introduces its HERCULES Series ***1720/1723R 1",*** "light-pipe", LED Digital Display. Designed to meet applications which require ***extended*** viewing distances or which smaller, more conventional readouts cannot satisfy, this ***big beauty*** can be easily read at up to ***60',*** and through angles of ***>160°.*** Slimline configuration embodies 14-pin, DIP connections on .600" spacing, and ***"KING-SIZE"*** (1.00"/26mm high), dual chip per segment, ruby-red digits which are molded into a nonconductive, plastic-compound base. High contrast brightness is 250μcd at 20mA/3.3V_F, peaking at 655nm in the visible red spectrum. Be the ***first one*** to add the ***"eye-easing BIG RED 1"*** to your system design today.

INFORMATION RETRIEVAL NUMBER 210

IEE
the Olympus of displays

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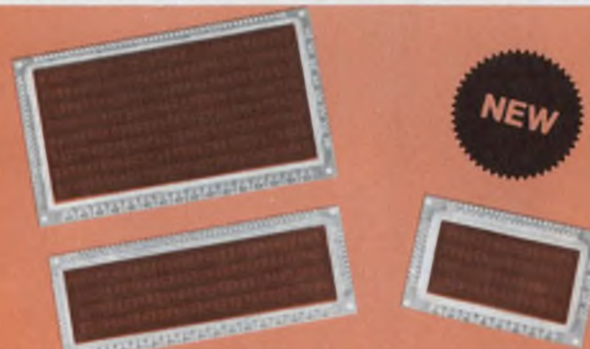
TWX 910-495-1707

European Office: 6707 Schifferstadt, Eichendorff-Allee 19, Germany.



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NOW, IEE OFFERS A CHOICE! You can select the Message Panel ***best suited*** to your needs, rather than accept just what's available. IEE's new ARGUS Dot Matrix Message Panels are ***NOW AVAILABLE*** in your choice of ***twelve*** or more configurations: ***64, 128*** or ***256*** character capacity; ***red*** or ***green;*** and ***"mini"*** (.2") or ***"maxi"*** (.25" - .33") characters . . . not to mention soon-to-be-announced 4-line/88-character ***"scrolling",*** and 2-line/32-character ***"scratch pad"*** models. Designed with human factors considerations in mind, these slimline ***"space-misers"*** are ideal for either input or output displays and terminals, and require minimal panel depth and area. Why not find out ***"WHAT'S NEW"*** in Message Display Panels, and then pick the ***ARGUS*** model that really meets your system's requirements?

INFORMATION RETRIEVAL NUMBER 211

Noise analysis equipment

Instruments and systems for analyzing vibration, noise and shock in machinery, vehicles and structures are illustrated in a 16-page catalog. Spectral Dynamics, San Diego, CA

CIRCLE NO. 392

Thick-film materials

A catalog details a line of thick-film materials. Plessey EMD, Melville, NY

CIRCLE NO. 393

Measuring instruments

280 pages present electrical and mechanical specifications, as well as application information, curves and charts on measuring instruments. Rohde & Schwarz, Fairfield, NJ

CIRCLE NO. 394

Electron beams

Illustrated with drawings, photos and tables, a 20-page booklet describes six models of the HP Febetron pulsed radiation sources. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 395

Connectors and cables

Mass-terminating connectors and cables are described in a 55-page catalog. Charts, drawings and design specifications in both English and metric dimensions are provided. 3M, St. Paul, MN

CIRCLE NO. 396

Mounts, clamps and cable ties

Cable ties, mounts and clamps are featured in a six-page, two-color brochure. Hoffman Electronics, Industrial Products Div., Farmingdale, NY

CIRCLE NO. 397

Capacitors

A quick guide to MIL-style CQR09, CQR12 and CQR13 hermetically sealed capacitors abstracts all important data from MIL-C-19978 in an easy-to-use format. Sprague Electric, North Adams, MA

CIRCLE NO. 398

Magnetic tape transport

A buffered magnetic tape transport system is highlighted in an eight-page brochure. Tables aid the user in determining proper transport speed and buffer size. Pertec, Peripheral Equipment Div., Chatsworth, CA

CIRCLE NO. 399

Rental equipment

Descriptions, pricing and an index by manufacturer and model number of over 8000 rental instruments are included in a short-form catalog. Rental Electronics, Lexington, MA

CIRCLE NO. 400

Optical components

Glass and metal components are featured in a 24-page catalog. The user can locate, at a glance, the wavelength in which he is interested and find relevant information on lenses, mirrors, filters, prisms, etc. Special Optics, Little Falls, NJ

CIRCLE NO. 479

Instrumentation

Over 2000 sizes and types of analog, digital and AnaLed panel meters, chart recorders, meter relays, pyrometers, controllers, digital and analog test equipment and a variety of portable instrumentation are detailed in a 60-page catalog. Simpson Electric, Elgin, IL

CIRCLE NO. 480

Decapsulation service

A 12-page brochure describes a decapsulation service, which safely and selectively removes potting, molding and encapsulating materials from components or assemblies. Amphenol Cadre Div., Endicott, NY

CIRCLE NO. 481

Indicator lights

Designed to help the user select the indicator light best suited for his application, a six-page product guide contains information on cartridge lamps and lampholders, subminiature and miniature lampholders, and snap-mount plastic lites. Littelfuse, Des Plaines, IL

CIRCLE NO. 482

Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card

(Advertisement)

"THE HOW AND WHY OF REAL-TIME SPECTRUM ANALYSIS OF NOISE AND VIBRATION"

New 16-page brochure on latest Ubiquitous® 500-line Real-Time Spectrum Analyzer/Calculator UA-500A-1 contains complete application data & a "how to" section. The "why" explains the need for resolution, real time, & averaging. The "how to" section solves typical analysis problems: "how to be sure correct data is being analyzed," "how to analyze transients," "how to interface to a computer," "how to cancel background noise," "how to analyze rotating machinery."

Model UA-500A-1 is specifically designed to simplify machine diagnosis, rotating machine analysis, noise source identification, mechanical signature comparisons, underwater signal analysis, & noise reduction. Includes such features as automatic harmonic identification, direct digital readout in RPM, & the ability to make relative amplitude & frequency measurements digitally.

Demo, circle 171
Lit., circle 172

Nicolet Scientific Corp. (formerly Federal Scientific)
245 Livingston Street, Northvale, New Jersey 07647
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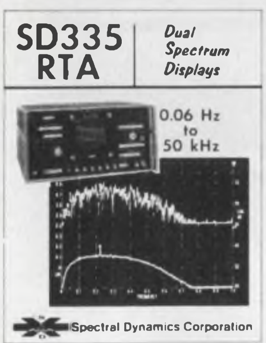
Real Time Spectrum Analyzer Provides Simultaneous On-Line and Averaged Displays



The new SD335's built-in scope and dual memory display instantaneous (on-line) frequency spectra with averaged spectra (up to 1024 ensembles) from 0.06 Hz to 50 kHz, while overall RMS level of input data appears at right of screen. Its 500-line resolution, 10 analysis ranges, greater than 60 dB dynamic range, and 5-digit readout of frequency and amplitude (linear or log) provide instant identification for even the smallest signals hidden in noise. Unique harmonic cursor automatically places an intensified dot on each integer harmonic of a selected fundamental component. SIMULPLOT feature allows simultaneous viewing and X-Y plotting under complete analyzer control. **Instrument is specially designed for noise, vibration and communication systems analysis.**

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CIRCLE NO. 173

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Advertising Sales Staff
Tom W. Carr, Sales Director

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Robert W. Gascoigne
Daniel J. Rowland
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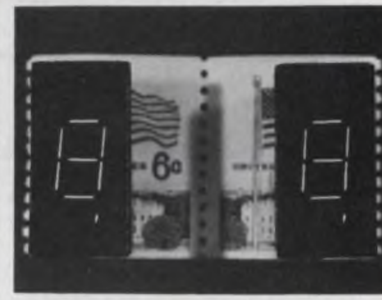
ENCLOSURES, CASES 604



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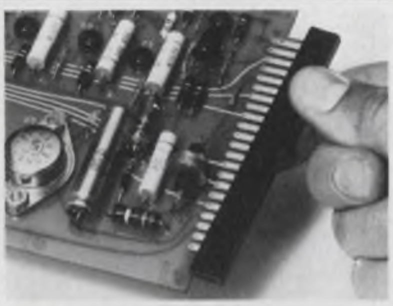
DISPLAY 607



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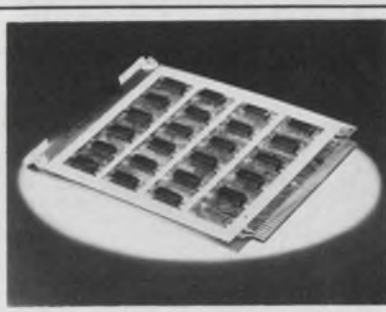

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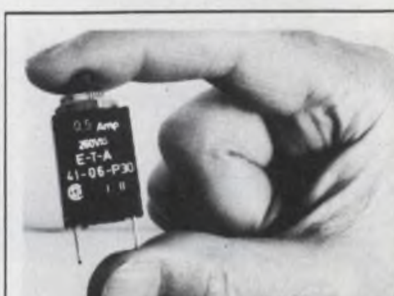
Free catalog of 34,500 power supplies from the worlds largest manufacturer of quality Power Supplies. New '74 catalog covers over 34,500 D.C. Power Supplies for every application. All units are UL approved, and meet most military and commercial specs for industrial and computer uses. Power Mate Corp. (201) 343-6294.

POWER SUPPLY 606

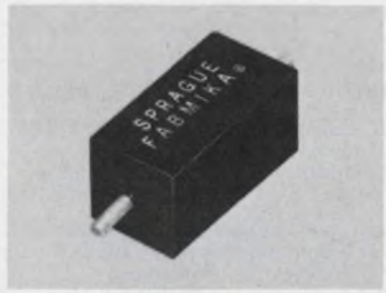


Overcurrent Protector, manual reset eliminates fuse replacement. Convenient panel mounting. 15 fractional ratings from 0.1 to 3 amp. Other models up to 400 amp. Trip-free and fool-proof, UL and CSA approved. High quality, low cost $1.29 ea. in 1000 lots. E-T-A Products Co. of America, 7400 N. Croname Rd., Chicago, Ill. 60648. Tel: (312) 647-8303. Telex: 253780.

CIRCUIT BREAKER 609

Model 5035A-easy, solderless breadboarding tool for complex TTL circuits. Has 6 bounceless HI-LO data switches, two clocks, & 4 LED indicators, allows easy design and checkout for circuits containing 16 DIPS on one removable breadboard. 1-amp supply can power several breadboards. Hewlett-Packard; 1501 Page Mill Rd.; Palo Alto, CA 94304

BREADBOARDING TOOL 610

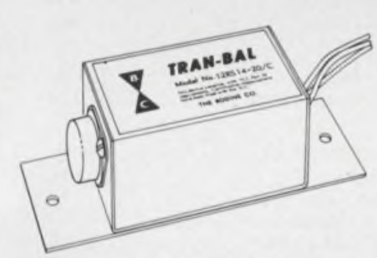


High-Voltage Epoxy/Fiberglass-Encased Type 305M Fabmika® Capacitors. Reconstituted mica dielectric, offering uniformity of performance and quality impractical with sheet mica. Impregnated with epoxy resin, forming solid capacitor section . . . no oil leak. Sprague Electric Co., 347 Marshall St., No. Adams, MA. 01247. (413) 664-4411.

HIGH-VOLTAGE CAPACITORS 613

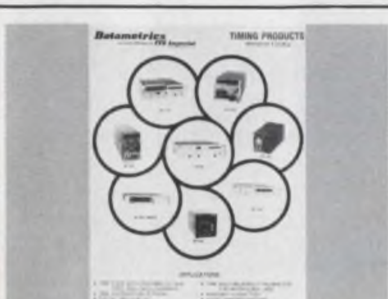
SYSTEMS MANUAL describes a complete line of microelectronic packaging systems and hardware. Mechanical and electrical specifications of wire wrap* panels, panel rack assemblies, connectors, cable assemblies and related accessories are included. Use card or write Mupac Corporation, 646 Summer St., Brockton, MA 02402. *G-D tm

WIRE WRAP* PANELS 611



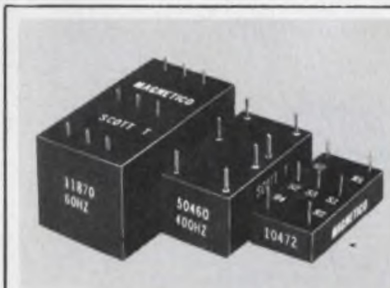
TRAN-BAL, INVERTER BALLAST; allows designer to utilize fluorescent lamp for long photo-electric light source by eliminating flicker associated with 60 H, Operation. Models available for all lamps through 40 watts. Input voltage 12 to 48 v.d.c. The Bodine Co., 236 Mt. Pleasant Rd., Collierville, TN (901) 853-7211

INVERTER BALLAST 614



"Timing Products Shortform Catalog" provides complete listing of standard Datametrics digital clocks, time code generators and readers, remote time display products. Includes operation theory of clocks and generators, application of time code for synchronization, calibration, indexing, distribution. Datametrics, 340 Fordham Rd., Wilmington, MA 01887

TIMING CATALOG 612



Scott T Transformer. 11870: 60HZ, 90v, L-L in. 1.1x2.1x1.1. 50460: 400HZ, 90v, L-L in. 7/8x1-5/8 x11/16. 50642: 400HZ, 11.8v, L-L in. 7/8x1-5/8-11/16. 10472: 400-HZ, 11.8v, L-L in. 3/4x1-1/2x3/8. All with 6v RMS sine & cosine output. MAGNETICO, INC., 182 Morris Ave, Holtsville, N.Y. 11742 516-654-1166.

TRANSFORMER 615

Advertisers wishing to reserve Quick Ad units should note the following mechanical requirements: Specs—Supply glossy photo of product and approximately 40 words which will set no more than 10 lines of 34 characters each. AFTER SUBMISSION NO COPY CHANGES CAN BE ACCEPTED. Quick Ads cost only $325 per insertion, less for frequency advertisers.

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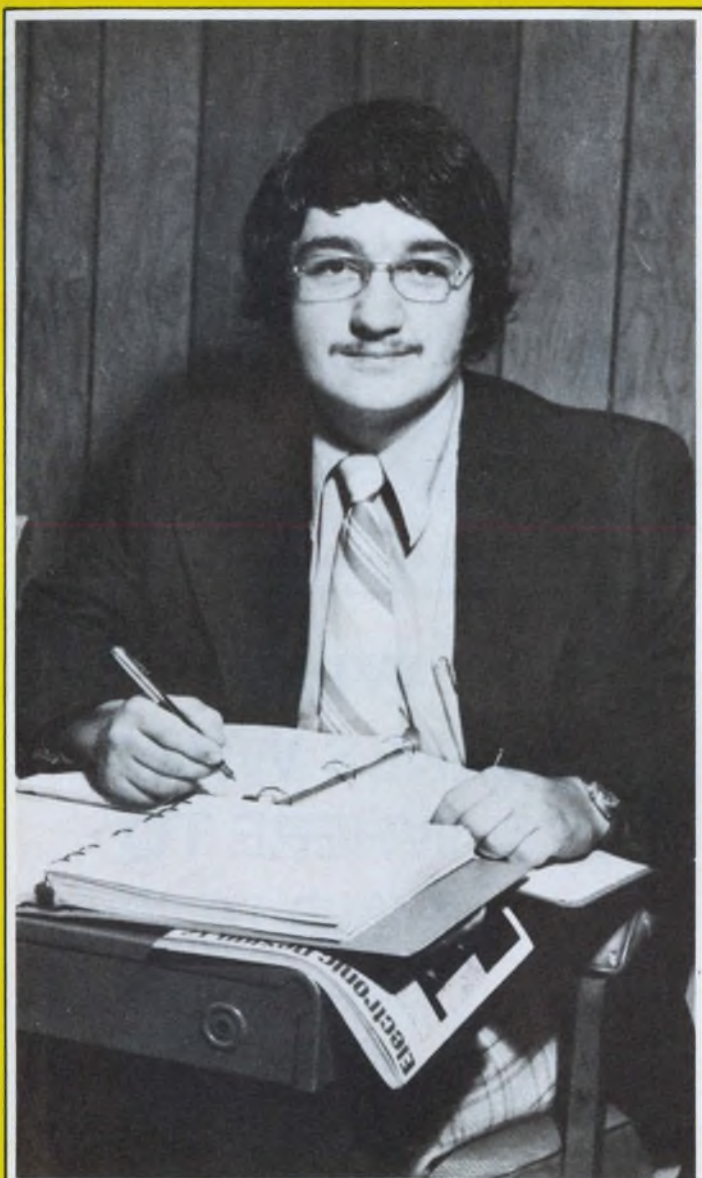
Advertiser's Index

*Advertisers in non-U.S. edition

Product Index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

Electronic Design's GOLD BOOK IS WORKING FOR ME



I USE IT

Martin A. Sala is Chief Design Engineer, Precision Systems, Cheektowaga, New York. He heads the research division at Precision and is primarily concerned with artificial intelligence and cybernetics. Accustomed to purchasing $80,000 worth of equipment annually, Sala reports that he has referred to *Electronic Design's* GOLD BOOK frequently and finds it useful in his work. "I keep it on my library shelf and use it quite often as a major source for information. In fact it's the only industry directory I use. Advertisements in the GOLD BOOK recently helped us to place orders for both memory and arithmetic circuits."

ELECTRONIC DESIGN'S GOLD BOOK IS WORKING — ALL DAY, EVERY DAY — THROUGHOUT THE U.S. AND OVERSEAS

Electronic Design / GOLD BOOK

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INFORMATION RETRIEVAL NUMBER 120

ELECTRONIC COMPONENTS EXHIBITION

U.S. Trade Center
Paris, France
December 8 to 12, 1975

Announcing A Unique Sales Opportunity

The French market for electronic components is estimated at $310 million and is expected to increase to $412 million in 1977. France's imports of electronic components amounted to $128.6 million accounting for about 45% of the total market. U.S. manufacturers were the source of more than one-third of France's annual imports in recent years and are expected to maintain that percentage of the market in the next several years. U.S. exporters can anticipate sales to France in excess of $50 million in 1977.

This Exhibition is intended to provide you with a direct route into the market so that you can take full advantage of outstanding sales opportunities available. Professional Trade Center staff will help identify and attract to your booth the revelant decision-makers and buyers of the companies most interested in your products.

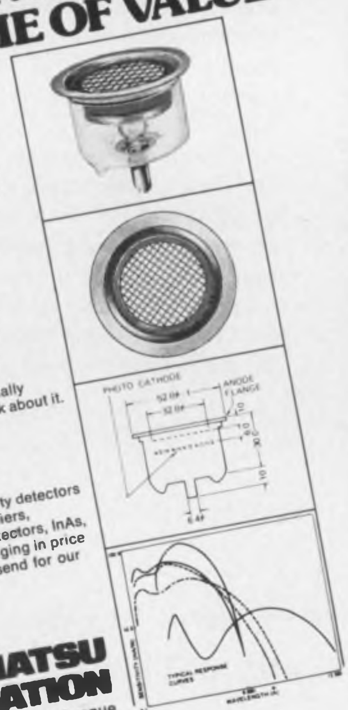
Whether your objective is to test that market, make immediate sales, cultivate customer relations or locate suitable representation; this event is designed to help you accomplish it.

All manufacturers of electronic components who wish to participate or who desire further information, please contact:

MYRA L. TRIPLETT
Project Officer, France Section.
United States Department of Commerce
Washington, D.C. 20234
phone: (202) 967-5373

INFORMATION RETRIEVAL NUMBER 122

IS A DETECTOR WITH SUB NANOSECOND RISE-TIME OF VALUE TO YOU?



IF YES-
Can you live with an S-1, S-5, S-13, S-20, or S-25 cathode?

IF YES-
Will you pay $190 for it? Or $520 in a housing?

IF YES-
Write, or call me personally (Ralph Eno) and let's talk about it.

IF NO-
But you do need quality detectors such as Photomultipliers, Vidicons, Silicon Detectors, InAs, InSb, and others ranging in price from $1 to $6,000, send for our full catalog.

HAMAMATSU CORPORATION
120 Wood Avenue
Middlesex, New Jersey 08846
(201) 469-6640

INFORMATION RETRIEVAL NUMBER 121

WHO MAKES WHAT & WHERE TO FIND IT

Volume 1 of **Electronic Design's** GOLD BOOK tells all. And, when you look up an item in its PRODUCT DIRECTORY you'll find each manufacturer listed COMPLETE WITH STREET ADDRESS, CITY, STATE, ZIP AND PHONE. Save time. There's no need to refer elsewhere to find missing information.

IT'S ALL THERE
in
Electronic Design GOLD BOOK

Amphenol Scot Pot.™ Amphenol trimmers. Two bargains your competitors may not know about . . YET.

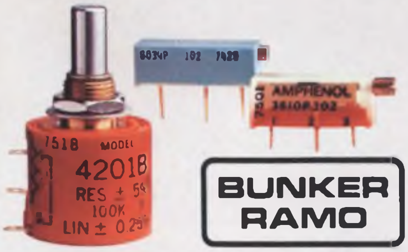
The word is out — Amphenol offers a big selection of quality precision pots and trimmers. They can replace what you're using now — in form, fit, and function — and save you money in the bargain.

Our Scot Pot is as good as (or better than) any other 10-turn wirewound miniature precision pot on the market. It has improved electrical, mechanical, and environmental characteristics. Yet Scot Pots cost as much as 25% less than other equivalent pots.

And that's news that won't stay secret for very long.

Our ¾" rectangular trimmers come in a full range of resistances and in all popular pin spacings. They're sealed to withstand automatic board cleaning. And they're highly stable — no drift. Two series to choose from: 3810 wirewound (available with Vista-Trim for fast, approximate visual settings). And 6034 cermet trimmers. Both series save you plenty. Ask for a quote and see how much you can beat the competition by.

For off-the-shelf delivery, call your local Amphenol Industrial Distributor. Your competitors may have already discovered his great service — so should you. Give him a call. Or for more information (and spec sheets on our pots and trimmers) contact: George Boyd, Amphenol Connector Division, Controls Operation, 2801 South 25th Avenue, Broadview, Illinois 60153. Phone: (312) 261-2000.



When you can connect it and forget it... that's quality.

BUNKER RAMO **AMPHENOL**

INFORMATION RETRIEVAL NUMBER 264

What's new in solid state...

RCA expands the COS/MOS universe three ways.

Now RCA offers 3 galaxies of COS/MOS integrated circuits, all with these new performance features: 100% testing to limit max. quiescent current at 15 V (A types), 20 V (B types). 1 V noise margin for better protection than TTL. Low max. input leakage of 1 μA at rated voltages.

More standard "A" types

Rated at 3-15 volts, 92 of these "industry standard" types are available in quantity, off-the-shelf. October introductions will include important new MSI functions. By January 1976 we'll offer a total of 112 "A" types.

New high-voltage "B" types

Rated at 3-20 volts, "B" types feature standardized symmetrical outputs for ease in design. Future additions will include new multiplexers, demultiplexers and arithmetic circuits. By January 1976 we'll offer 76 "B" types.

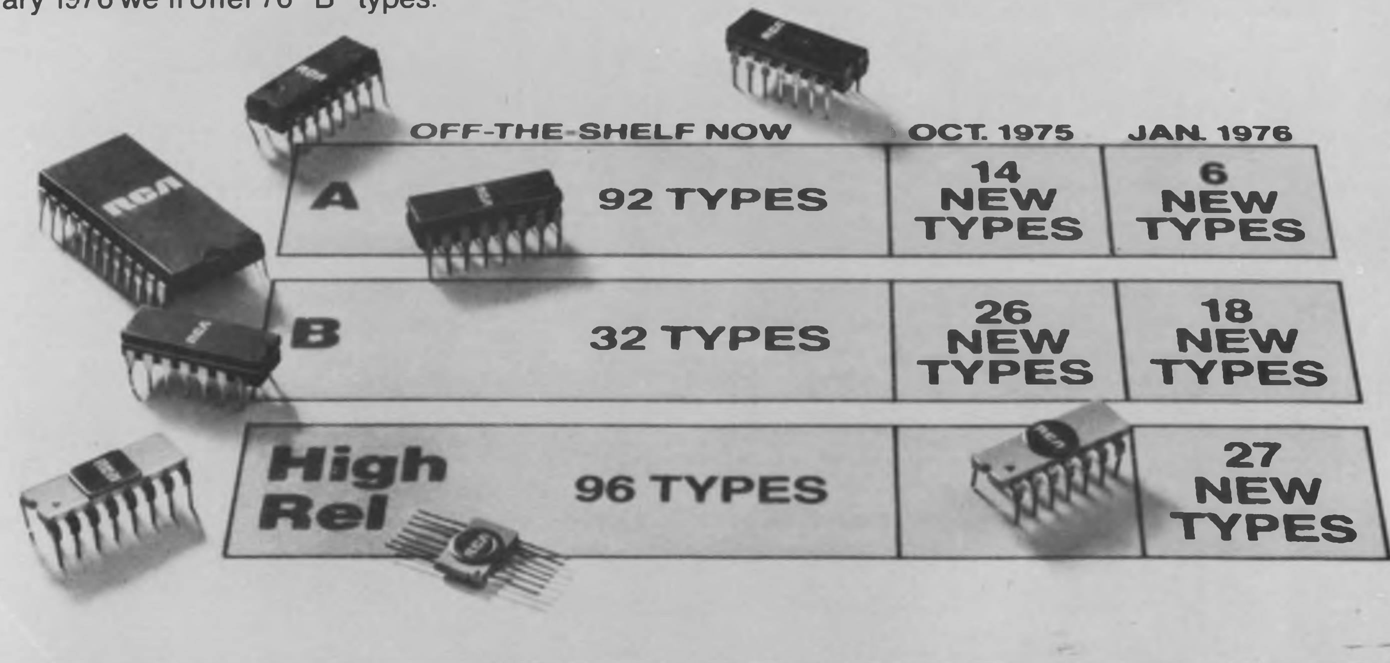
Expanded High Rel program

COS/MOS types screened to MIL-M-38510 or MIL-STD-883 requirements already total 96 types. New additions by January 1976 will bring the High Rel total to 123 types.

Send for a complete designer's planning package including reliability data and information on our Extra Value Program. Contact your local RCA Solid State distributor. Or RCA.

Write: RCA Solid State. Box 3200, Somerville, New Jersey 08876; Ste. Anne de Bellevue 810, Canada; Sunbury-on-Thames, U.K.; Fuji Bldg., Tokyo, Japan.

RCA



RCA. First house in CMOS.

INFORMATION RETRIEVAL NUMBER 265