VOL. 23 NO. 7

Electronic Design®

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 1, 1975

Clean up your spectra: Digital averaging cuts noise and gives faster sweep rates. Store two signals in digital memory, then compare them on the display. Read center frequency on the CRT to 6 digits and amplitude in 1-dB steps. A microprocessor sets the optimum bandwidth and sweep rate automatically. P. 66.

Resistance functions ...packaged to go!

Thirty watts and 10 KVDC from a discrete thin film network? Sure! It's all in a day's work for Dale. We're specialists in tailoring the advantages of thin (metal or carbon) discrete film resistors to meet your unique and urgent needs. Dale discrete thin film network capabilities range from simple voltage dividers to complex binary D/A ladders with accuracy to 1/2 LSB.

Packaging can vary from coated or molded, single or dual in-line to custom shapes and enclosures for unusual space and/or heat dissipation requirements. Resistor pairs or sets matched for ratio, T.C. tracking and/or tolerance can also be packaged to go. When what you need isn't in the catalog, call Dale. We cater to special needs. For immediate help with special film resistors, call **402-371-0080**

DEPENDABLE DALE®

DALE ELECTRONICS, INC.
P. O. Box 74, Norfolk, Nebraska 68701
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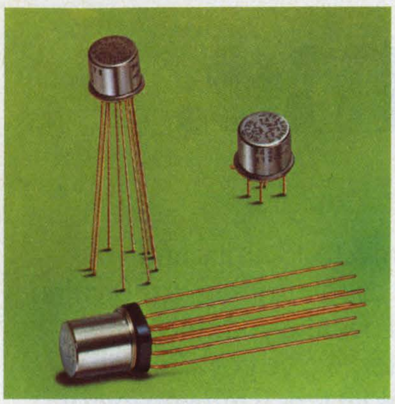
In Europe: Dale Electronics GmbH,
8 Munchen 60, Falkweg 51, West Germany
A subsidiary of The Lionel Corporation

Our complete product line can be found in Electronic Design's GOLD BOOK.

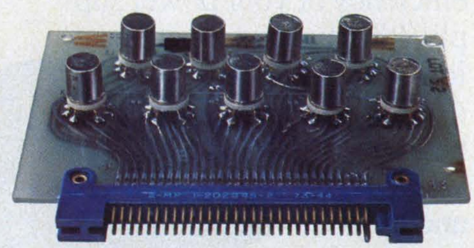
INFORMATION RETRIEVAL NUMBER 262

Total cost effectiveness. TO-5 relays from Teledyne.

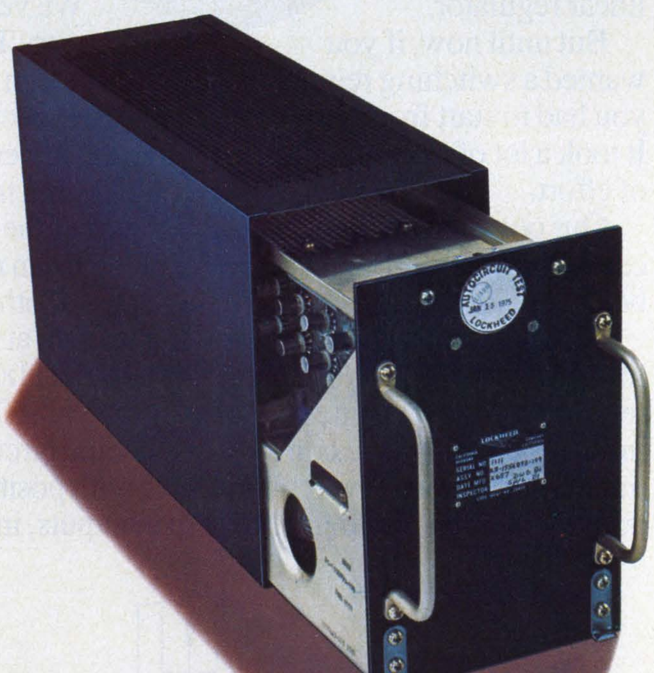


Whether you design commercial aircraft equipment, or MIL avionics, control and communications devices – the tough parameters are the same. High packing density, low power consumption and heat dissipation, utter reliability and always – cost effectiveness.

TO-5 relays from Teledyne are the unqualified answer. High density, PC board pinout, **half** the size and coil power of comparable multi-pole switching devices. And they are **more reliable** and **less expensive** than semiconductor arrays for multi-switching functions.



Teledyne has the greatest choice of TO-5 relays available to you – ultra-sensitive types, maglatches, internal surpression diodes, internal drive transistors and many contact arrangements. All – welded and hermetically sealed; all fully qualified to MIL-R 39016 B, **level "L" and "M" reliability.** Specify them for your most exacting designs. Teledyne TO-5 relays – the totally cost effective switching solution. There's an economical Commercial/Industrial line, too – and they're in stock near you. Call your nearest Teledyne Relays office for location of your local representative or distributor.



L-1011 VHF NAV Accessory Unit.
Courtesy Lockheed-California Co.

TELEDYNE RELAYS

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

Burgstrasse 6-8, 62 Wiesbaden, West Germany
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INFORMATION RETRIEVAL NUMBER 3

Electronic Design®

VOL. 23 NO. 7

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 1, 1975

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by Larry Jackson, courtesy of Tektronix, Inc., Beaverton, OR

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 50 Essex St., Rochelle Park, N. J. 07662. James S. Mulholland Jr., President. Printed at Brown Printing Co., Inc., Waseca, Minn. Controlled circulation postage paid at Waseca, Minn., and New York, N. Y., postage pending Rochelle Park, N. J.

across the desk

The Sucaba—A powerful computational tool

As much as possible ELECTRONIC DESIGN *tries to report on New Products as quickly as possible and, in most cases, a product sees the first light of print in these pages. In some cases, unfortunately, a product is bumped from one or more earlier issues because of space limitations. The story of The Sucaba is one such, so we are publishing it now, admittedly somewhat late. The technical information was furnished by Calvin R. Graf of San Antonio, Texas.*

The Sucaba, a computing device, is equipped with a number of keys to perform the four standard functions of add, subtract, multiply and divide. It can also calculate square roots and cube roots and is usually equipped with 13-digit readout. A unique "sinking" decimal point concept permits the decimal to be inserted at any location of the display and entry keys.

Unlike most recently introduced calculators, which use algebraic, arithmetic or reverse-Polish for data entry, the Sucaba uses Japanese. Entry into the keyboard is made from right to left. Entry can be made using the left or right hand, depending on operator dexterity.

The Sucaba is an all solid-state device and is usually packaged so that it can survive a drop on a concrete sidewalk. However, the digits would have to be manually reset to zero. No electrical power is consumed while calculating, though a slight amount of heat might be generated by friction during a rapid series of digit manipulations. Memory storage is infinite; the nonvolatile memory is not dumped when power is removed.

The Sucaba digits are displayed indefinitely without consumption of power, the liquid-crystal display being the nearest competitor in terms of power consumption. As with the liquid crystal, the Sucaba display operates off reflected ambient light, the display getting brighter with brighter light. Its superiority is most apparent in full sunlight where most other displays (except the liquid crystal) are completely washed out.

A moderately stable platform must be provided for the Sucaba operator, as improper orientation could destroy the display memory. The Sucaba is believed to be the only pocket calculator capable of changing each number column without disturbing adjacent entries. Any number in storage can be immediately recalled with a glance at the digit display. This device permits stored data to be observed without movement of any function or operation key and is considered unique compared with other calculators on the market or on the R&D drawing boards.

(continued on page 8)

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

(continued from page 7)

No rfi is generated by the Sucaba, and further, its memory and logic can withstand extremely strong irradiation by radio or other fields without suffering damage or alteration of the displayed digits.

Because of these unique features the Sucaba is attracting new attention. It is marketed, mainly, under its more popular name, the Abacus.

He questions accuracy of TV color signal

In your News Scope for Jan. 4, 1975, "Oscillator Calibrated With TV Color Signal" (ED No. 1, p. 21), you state in part that the color-burst signal is "present only in live color broadcasts." It should be pointed out that the burst signal is present in all color broadcasts (and regrettably in some black-and-white broadcasts, but that's another story). But the atomic-standard accuracy is present only in those broadcasts originating in New York that are not time-delayed for viewing in other time zones.

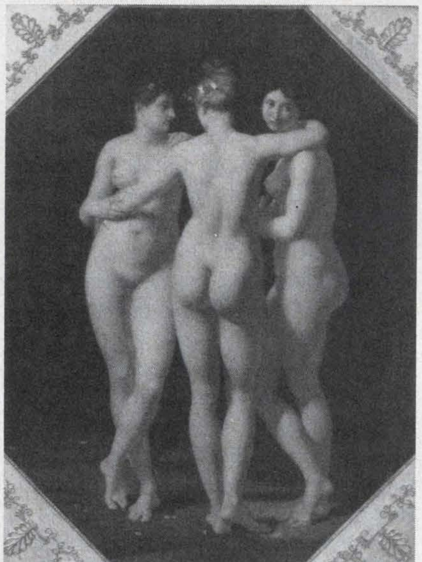
Such broadcasts may be filmed features, since the color sync is generated "live," but such apparently live programs as the Carol Burnett Show come from videotape, and although a lot of correction is provided, I doubt such an accuracy is maintained. On sports broadcasts I believe the color sync is generated at the remote site, so accuracy is not necessarily assured.

The evening newscasts are assembled in round-robin fashion and contain every kind of sync but kitchen, and local stations often insert local advertising within network programs if the network did not sell that local area to the national sponsor. Accuracy on a randomly selected color-burst frequency is between one and two parts per million, by Federal Communications Commission requirements. Locally generated cable TV color signals, live or taped, are often even less accurate.

Suffice it to say that one had better be sure of what he is measuring.

James Rieger
Electronic Engineer
Code 3735
Naval Weapons Center
China Lake, CA 93555

Misplaced Caption Dept.



"Watch it. Here comes that guy from engineering with the cold hands."

Sorry. That's Jean-Baptiste Regnault's "The Three Graces," which hangs at the Louvre Museum in Paris.

Corrections needed on optical-coupler idea

Some errors crept into my Idea for Design, "Optical Coupler Helps Transmit Data and Clock Signals on Single Wire Pair" (ED 26, Dec. 20, 1974, p. 104) during editing.

The optical couplers, OC_3 and OC_4 in the diagram, should have been designated similarly in the text instead of G_3 and G_4, respectively. Further, the polarity of the input diode OC_4 should be reversed to be opposite that of the polarity of the input diode on OC_3.

Richard Gunderson
Senior Project Engineer
ADC Telecommunications
4900 W. 78th St.
Minneapolis, MN 55435

Helping hand is viewed as investment in future

As a sales/applications engineer, I read with great interest your editorial on "Nice Young Girls and Consultants" (ED No. 25, Dec. 6, 1974, p. 51). It was excellent. I would quarrel with only one part of your conclusion. As I suspect is the case with the nice young girls and consultants, it is often difficult to tell who is an unlikely prospect. So, like those whom you met, I tend to err on the side of trying to "help" almost everyone, if I can. One never knows if that student or pesky technician will someday turn into a customer, or if they will mention to someone how they were helped by your company.

J. E. Wurtz
Senior Applications Engineer
Electro-Optical Devices
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Electron Tube Div.
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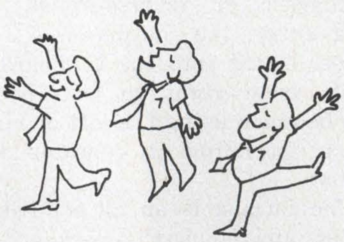
San Carlos, CA 94070

Jumping for joy . . .

is how we received the news that American Business Press has bestowed on editors of Electronic Design two of its coveted Jesse H. Neal Award Certificates for editorial achievement. The Neal awards are considered the business-press equivalent of Pulitzer Prizes.



Electronic Design's FOCUS series won the award for "Best Staff-Written Series of Feature Articles." The other award was for the "Best Series of Editorials."

In comments to the staff, Editor-in-Chief Rostky said: "We're always delighted to get one Neal Award. But two? I'm almost speechless—and you know how rare that is."

(continued on page 19)

MEASUREMENT COMPUTATION NEWS
innovations from Hewlett-Packard

APRIL, 1975

in this issue

HP-21: New powerful pocket-sized scientific calculator at a more affordable price—$125

The smallest scientific pocket calculator in our line—the HP-21 delivers extraordinary problem solving power in the Hewlett-Packard tradition.

Now you can have Hewlett-Packard quality craftsmanship in a *low-price* calculator, the HP-21.

The HP-21 has more capability than our pace-setting HP-35. There are 32 pre-programmed functions and operations, including:

- all log and trig functions, the latter in radians or degrees
- full Display formating. Allows you to choose between fixed decimal and scientific notation
- underflow feature will not allow you to confuse a smaller number with a 0. Automatically reverts to scientific notation.

(continued on third page)

BAMP on a Calculator for Microwave Circuit Design

BAMP 30 and an HP 9830A calculator gives you systematic and efficient solutions in the design or analysis of high frequency and microwave circuits.

HP introduces BAMP 30 (Basic Analysis and Mapping Program), the software package now available for designing or analyzing high frequency and microwave circuits.

Originally developed for use on a time-shared computer system, the full power of BAMP is now available on a HP 9830A Programmable Calculator.

BAMP 30 is a collection of programs for obtaining the frequency-domain response of linear electronic circuits that can be built up by interconnecting two ports. BAMP 30 is a two-port program. This means:

Elementary two-ports are used as basic building blocks.

The overall or composite circuit built up by BAMP 30 is in turn a two-port.

The first result of any analysis performed by BAMP 30 is the scattering, or s-matrix, for the overall circuit. The s-matrix is stored in the 9830A Calculator as a function of frequency and can be used to compute, print, and plot numerous additional outputs.

BAMP 30 will help you design better circuits in less time. Circuit models can now be made as complex as necessary to accurately represent physical circuits, without danger of losing control over the design process. Analysis is more comprehensive and circuits can be as optimum as physical laws will allow them to be. The greater the circuit complexity, the greater the savings through BAMP 30.

If your design problem is too troublesome for manual analysis but does not warrant the time and expense of a computer, try the HP calculator-aided design solution. The BAMP 30 software pack may be ordered under Part No. 09830-71103.

To receive an Application Summary on Basic Analysis Mapping on the 9830, check Q on the HP Reply Card.

Calculator based system monitors complex variables; boosts productivity

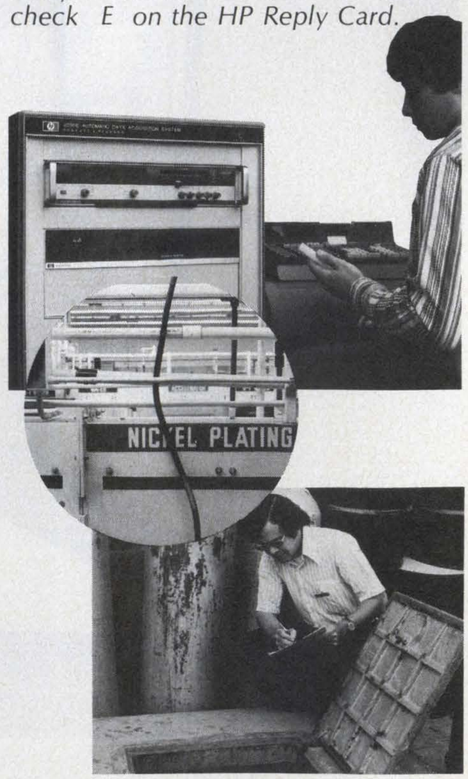
Monitoring the pH and precisely controlling the amount of caustic that should be used to neutralize the acid in order to prevent damage to the bacteria in a municipal sewage plant is shown below as HP helps control the effluents from the manufacturing plant in Loveland, Colorado.

The new HP 3050B Data Acquisition System is coupled with a programmable calculator providing a system that replaced multiple recorders previously required throughout the facility.

The system is programmed for precise pH levels. It continuously monitors pH and indicates an alarm condition when the limits are not in specification.

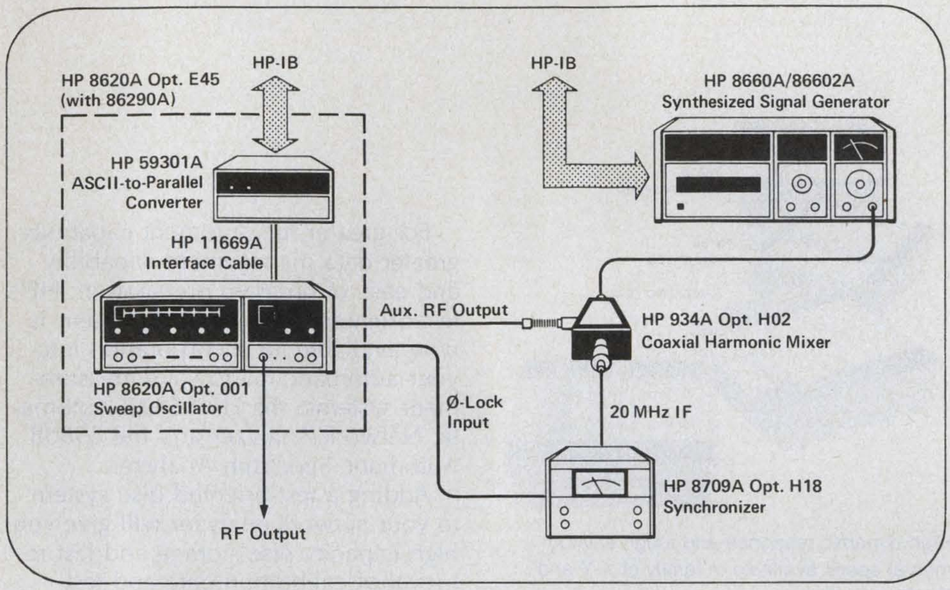
Measuring multipoint physical parameters to monitor or analyze phenomena and control devices will provide many varied applications of the HP 3050B System. Transmission of the data may be possible over thousands of miles using the HP-IB Common Carrier Interface and an optional modem.

For more information and other ideas on applications where data acquisition, analysis and control are critical, check E on the HP Reply Card.



On-site data acquisition with remote control and analysis.

Interface Bus compatible Solid State Sweeper has new options



Synthesizer accuracy to 18 GHz is easily obtained via the HP-IB.

Now the HP Interface Bus can be used with HP 8620 sweepers to achieve calculator control of frequencies from 3 MHz to 18 GHz. The 8620A Opt E45 sweeper with appropriate RF plug-in becomes a source with 1000 points per band programmability. The HP 86290A, our new 2 to 18 GHz plug-in, is ideal for HP-IB systems because of its flexibility, excellent frequency accuracy and linearity. The bus-controlled 8620A/86290A can quickly step through as many as 3000 frequencies—typically with ±5 MHz accuracy. For higher accuracy, add the HP 5340A counter plus D/A converter to automatically correct frequency to within 100 kHz. Even greater precision (to 25 Hz) can be obtained by phase-locking the sweeper to the HP 8660 synthesized signal generator and programming both the sweeper and 8660 via the HP-IB. Precision power level control of the sweeper is also possible using the new 436A digital power meter. (See sixth page)

These plus other practical microwave signal sources are described in our data sheet.

For more information on the HP Interface Bus controlled sweeper mainframe, check O on the HP Reply Card.

(continued from page one)

NEW Scientific Calculator–

- 10-digit display and 2-digit exponent
- 4-register arithmetic. Allows you to add, subtract, multiply and divide in the storage registers.
- performs basic data manipulations: $1/x$, y^x, $\sqrt{x}$, $x \gtrless y$, π, e^x
- converts polar to rectangular coordinates and back again
- calculates a common antilog (10^x) with a single keystroke
- RPN logic system
  - continuous and immediate display
  - all operations are sequential—backtrack if you make an error
  - re-use numbers without re-entering them
- completes pre-programmed functions in 1 sec. or less
- error display if you key in an impossible instruction
- five total memory registers

The HP-21 solves long and complex equations. Challenge it with your numerical problems—personal or professional.

The HP-21—a quality calculator. $125.

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

Mini DataCenter now gives computer power directly to the users

Hewlett-Packard now makes it possible to distribute computer power directly to the people who need it, when they need it.

The HP 3000CX Mini DataCenters are designed to meet the needs of stand alone and distributed computer networks with cost-saving efficiencies. You now can have distributed power for your department, region or division—serving the needs of manufacturing, administration, science, engineering, and real time applications.

The four 3000CX models (50CX, 100CX, 200CX, 300CX) implement timesharing, multiprogramming, and virtual memory operations. This is accomplished by separating programs into code and data modules, processing segmented programs into several modules, and stacking data to meet the needs of executing programs.

Several users can run their own programs concurrently using BASIC, RPG, COBOL, FORTRAN, or HP's SPL.

Input-output spooling capability is permitted at terminal or batch devices. Mini DataCenters offer a communications subsystem to link CX Series systems to each other and to larger computers as well.

A 32-bit LSI ROM microprocessor is at the heart of every Mini DataCenter. This microprocessor implements 182 instructions, has a cycle time of 179 nano-seconds, utilizing overlapped microinstructions to provide as many as 5.27 million operations per second.

Choose from the four 3000CX models to fit your job, your site, and your budget.

For details to help you choose the model best for you, circle D on the HP Reply Card.

For extra capability, the next logical step in automatic testing

HP's distributed systems capability has been expanded by the addition of a new, complete interface package to link Automatic Test Systems to a distributed system network.

The package includes both software and hardware for automatic microwave network analysis, spectrum analysis, and general purpose stimulus response measurement systems.

Linking the HP 9500 and 8500 systems to a central computer system (HP 9600E series) gives you the advantages of stand-alone intelligent systems functioning as a distributed system satellite.

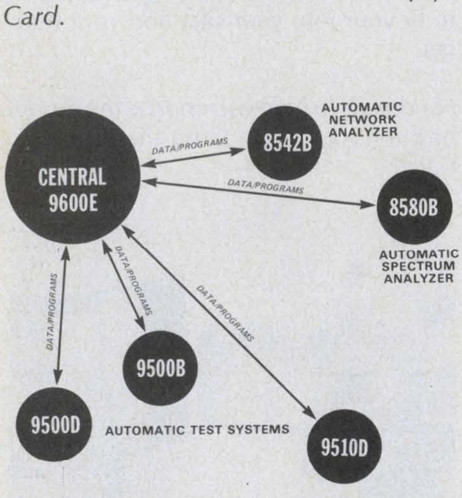
The satellites can each request off-line data manipulation and report generation at the central.

The central system supports the automatic test system satellites by providing mass storage, greater efficiency in program preparation, and shared peripherals.

The distributed system satellites provide specific automatic testing capabilities including precision microwave phase and amplitude measurements, computer controlled spectrum analysis, and computer controlled testing of a wide range of modules from DC to 18 GHz.

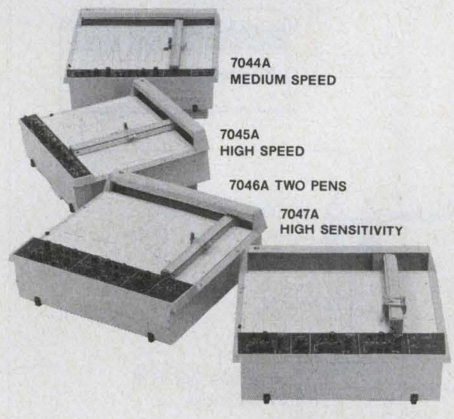
If you have automated your testing already and have stand-alone 8500 or 9500 series systems in your operation, investigate the expanded capability you can have with this new distributed systems package.

For details, check M on the HP Reply Card.



Link your automatic test systems to a distributed system network.

New more sensitive X-Y recorder expands choice to meet your needs precisely



High dynamic response and tough environmental specs available in family of X-Y and X-Y/Y recorders.

The new 7047A recorder, with high sensitivity and unique input circuits, is the newest addition to our family of 11 × 17" X-Y recorders. Starting with the 7044A medium speed, the 7045A general purpose, and the two pen 7046A, you now have a wide choice if you want high quality recordings without sacrificing ruggedness or reliability.

A wide range of quick-changing signals can be reproduced accurately and dependably. If you need speed, the 7045A and 7047A offer Y-axis acceleration exceeding 7620 cm/sec² (3000 in/sec²).

Abritrary full scale voltage ranges may be established with the vernier control in conjunction with the calibrated dc ranges.

These recorders are equipped with front panel polarity switches to reverse pen direction, eliminating the need for reversing the input leads.

The trouble-free Autogrip electrostatic holdown platen solidly grips any size paper up to 11 × 17" (28 × 41.9 cm) including European DIN A3. Disposable pens are available in four colors.

Options available include the Time Base (standard on the 7047A), Event Marker and Metric Scaling.

For detailed specifications, check K on the HP Reply Card.

Now, disc capability enhances microwave measurement systems

For greater measurement capability, greater data management capability and ease of program preparation, HP's test-oriented disc operating system is now available for incorporation into your automatic microwave measurement systems: the HP 8542B Automatic Network Analyzer and the 8580B Automatic Spectrum Analyzer.

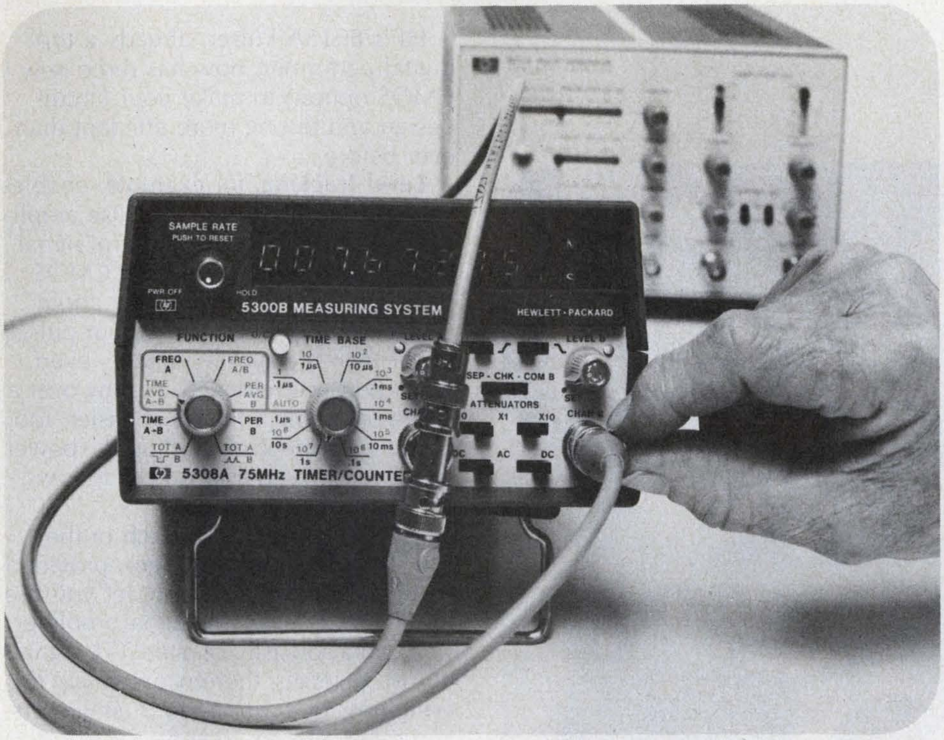
Adding a test-oriented disc system to your network analyzer will give you high capacity disc storage and fast retrieval of calibration data and test procedures by means of single statements.

Or, adding a test-oriented disc system to your spectrum analyzer will enhance your capability to generate application programs. In applications such as spectrum management, a disc will provide storage for the large amounts of needed data.

For more information on the test-oriented Disc System for the 8542B Network Analyzer and for the 8580B Spectrum Analyzer, check N on the HP Reply Card.

Increase measurement thruput with easy storage and fast retrieval of both programs and stored data.

Counter sets new mark for capability and compactness with economy



Measuring the electrical length of a coaxial cable using Time Interval Averaging on the 5308A Counter.

For the most electronic counter/timer capability available in such a small package and at such a low price—see the new 5308A 75 MHz Counter/Timer module. Not only does this instrument offer the frequency, frequency ratio, period, period average, time interval, scaling and totalizing capability of full rack width universal counter/timers, it also offers sub nanosecond time interval averaging plus unique HP features in the area of automatic ranging, totalizing, and trigger level setting.

AUTO RANGING: Now, you can auto range time interval averaging and frequency ratio measurements in addition to frequency, and period average. Furthermore, the Time Base selector can be left at Auto most of the time, even for the non-auto ranged functions. This is because in Auto these functions go to their highest resolution range, wherein the eight-digit display can totalize up to 10^8 counts or measure periods or intervals to 10 sec.

TOTALIZING: The stop and start signals for totalizing are conditioned by the same versatile slope, level and attenuator controls that apply to time interval measurements. Also, events on Channel A can be totalized while Channel B is low, or between events on Channel B, as needed in bit-error-rate counting, for example. Use it as an electronic stopwatch, too with ranges from 100 sec (1 μsec resolution) to 10^{10} sec.

TRIGGER LEVEL SETTING: LEDs indicate triggering and are pulse stretched so even a nanosecond input pulse gives a visible blink, as in a logic probe with pulse stretching. Trigger levels are switch-presettable around 0 volts or TTL or ECL levels for convenient measurement and troubleshooting of digital circuits. Also there's access to trigger level circuits for precise setting via external voltmeter, and a gate signal for scope Z-axis modulation.

Since the 5308A is part of HP's snap-together 5300 Series measurement system, you can snap on any of the other seven modules to convert to other instruments, including a 1100 MHz counter and digital multimeter. Or, add to any combination: a battery pack, D/A converter and/or HP Interface Bus module.

For detailed specifications, check I on the HP Reply Card.

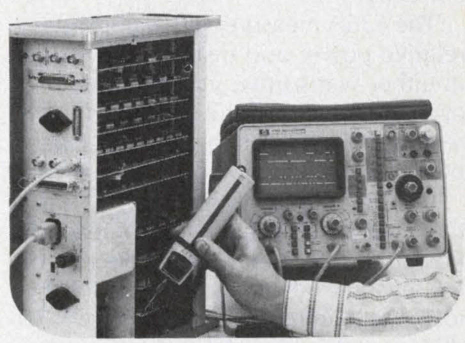
Two new HP scopes offer dual-delayed sweep

The dual-delayed sweep technique exclusively available in the new HP 1722A microprocessor and 1712A oscilloscopes give you improved accuracy for precise interval measurements in digital circuits. Now you can have improved accuracy and repeatability for such time measurements as rise times, propagation delay, clock phasing, and other high-speed applications with resolution to 100 picoseconds.

The 1712A displays two intensified markers which are two delayed sweeps displayed alternately. The first delayed sweep is controlled by the TIME INTERVAL START pot. The time between markers is scaled according to the main sweep, and delivered as an analog voltage to outputs at front and rear. Thus, the 1712A can be used with any DVM for direct readout of time intervals.

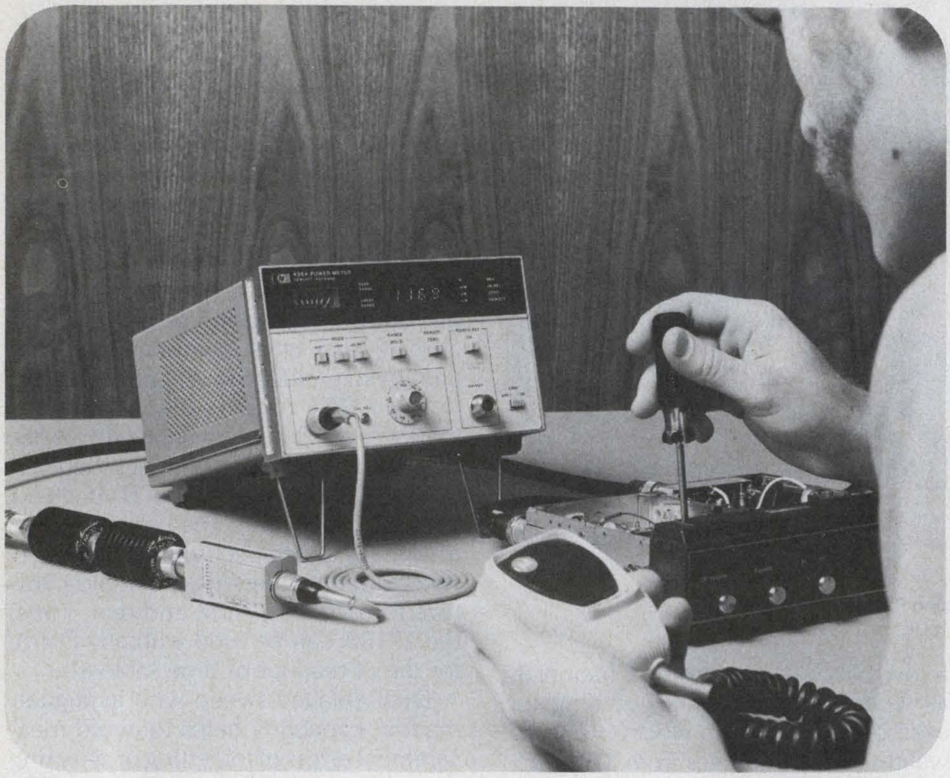
Dual-delayed sweep with its digital readout capability helps to avoid measurement errors of forgetting or selecting the wrong graticule line, reduces the chance of misreading a dial, and calculation errors. Dual-delayed sweep is also auto-zeroing, making calculations or manual zeroing unnecessary.

For details on this dual-delayed scope, check C on the HP Reply Card.



With dual-delayed sweep, two markers select time period to be measured and a proportional voltage output is provided for DVM readout.

New programmable autoranging power meter offers new level of accuracy and ease of operation



A new digital microwave power meter, the HP 436A, has built-in firmware 'intelligence' to switch automatically among its five power ranges, to translate its reading into watts, dBm or dB Relative, to recognize which of several possible sensors is connected and calibrate its display accordingly, and to locate the displayed decimal correctly.

The 436A measures either absolute or relative power and displays the results in either watts (mw, μw, and nw) or dBm. Relative power is displayed in dB relative to a reference value set by push-button.

Instrumentation uncertainty is less than $\pm 0.5\%$ (1% in range 5) of reading. Power and frequency range depend on the sensor used; it may be from 100 kHz to 18 GHz in a power range from -30 dBm to $+35$ dBm. All thermocouple sensors of the 8480 series are compatible.

Readings are indicated on a large 4-digit LED display. Autoranging makes operation "hands off" but may be disabled with a push-button to "hold" a given power range. In addition to the digital display, an analog meter indicates fast-changing power levels and permits tuning and adjustment of power output.

The 436A is fully programmable (except CAL FACTOR). Interface for control and readout may be via the HP Interface Bus or BCD. With these capabilities, the 436A power meter will be a powerful addition to most mini-systems used in microwave production test applications.

This completely new instrument is designed to stay out of the user's way while doing his job. It is an ideal general purpose power meter for the RF and Microwave engineer.

For details, check B on the HP Reply Card.

New CMOS options extend versatility of high voltage pulser

HP's 8015A Pulser, already a top digital performer, now has three new CMOS options to make your circuit design and testing more efficient than ever before.

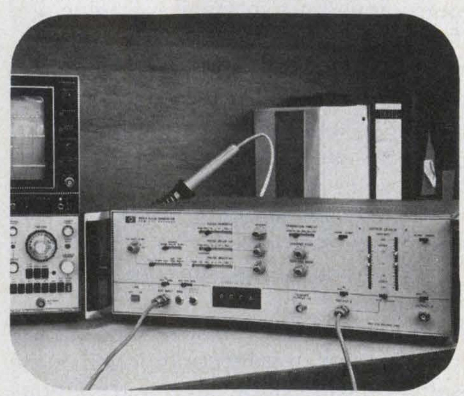
Level tracking, for example, enables you to control the 8015's pulse amplitude with an external DC control signal. With the 8015A tracking the CMOS power supply, you can forget about circuit damage caused by input pulses larger than the supply voltage, even when power is removed. Testing over a range of supply voltages is easier, too, because you need only adjust the power supply and the pulser output follows automatically.

Direct access inputs to **each** of the 8015A's linear **output stages**, provided by the second new option, let you use the 8015A as an analog signal amplifier. You can also easily convert TTL signals to CMOS levels, thereby extending the usefulness of existing word generators and other TTL equipment.

The **TTL output** option is especially useful whenever CMOS and TTL IC's are used together. The option gives you an extra pulse output with preset levels set for TTL compatibility.

The 8015A itself is a 50 MHz, 16 volt pulser with transition times fully variable down to 6 ns. Its two independent output channels may be delayed with respect to one another to make setup time measurements or to generate two-phase clocks. They may even be added to provide 30V test pulses.

For details, check L on the HP Reply Card.



Pulse burst is generated upon receipt of trigger pulse. Length is determined by thumbwheel switches.

A new 5V, 100A switching supply stays cool under stress

HP's new 500-watt modular supply, the 62605M, combines the high efficiency and small size of an advanced 20-kHz switching regulator with an integral forced-air cooling system that eliminates conventional heat sinks.

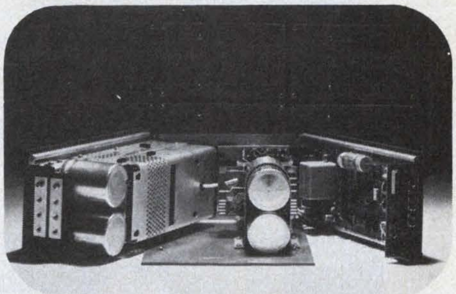
The result is an efficient, compact and trouble-free power supply. The supply is regulated to 0.1% with ripple and noise of 15 mV rms, 50 mV p-p (20 Hz to 20 MHz). It will output 5 volts at 100 amps continuous from 0 to 40°C, with linear derating to 60 amps at 70°C. All of this is packaged in a 5" × 8" ×11½" case weighing only 14 pounds (6.4 kg).

Operating costs are reduced due to the supply's higher efficiency. Additional savings may be realized from the reduction in supplementary in-cabinet cooling and the power it uses.

For reliability, "cool-operation", small size *and* lasting value consider the HP 62605M.

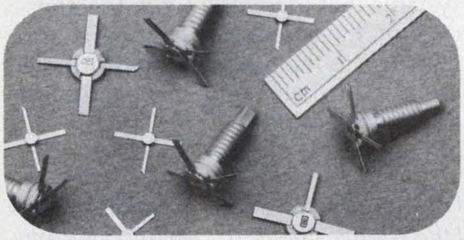
For full details about this new power supply's many advantages, check J on the HP Reply Card.

Modular power supply with overvoltage, overcurrent, overtemperature and reverse voltage protection.



HEWLETT-PACKARD COMPONENT NEWS

New transistor for high reliability applications



New transistors offer guaranteed tuned gain and meet military standards for environmental and test.

HP offers two new general purpose microwave transistors. Model 35828E, a small signal NPN bipolar transistor with guaranteed tuned gain at 2 GHz, is available in the H Pac 70 GT, a rugged metal-ceramic hermetic package.

The Model 35829E, optimized for high gain at 2 GHz, utilizes a co-fired alumina package. For both transistors, the tuned gain is guaranteed under fixed optimum source and load conditions simplifying the designer's job in extracting the maximum performance from the devices.

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

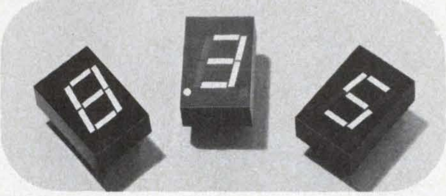
High intensity displays in three colors

The new HP 5082-7650 series LED displays, available in high efficiency red, yellow and green, are five times brighter than our previous .43" displays at the same operating current. High brightness means they can be read easily in outdoor applications. The new high efficiency red (635 nm) has been shifted towards the orange to enhance readability.

At an operating current of 20 mA per segment, luminous intensity per segment is 1720 microcandelas.

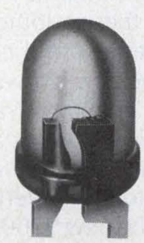
For improved readability, the bodies of the displays are color-coordinated to hide the unlighted segments.

For more information on these displays: 5082-7650 High efficiency Red, 5082-7660 Yellow, 5082-7670 Green. check H on the HP Reply Card.



High-brightness, low-power displays, readable up to 20 feet.

Sharp on/off transition in new voltage sensing LED



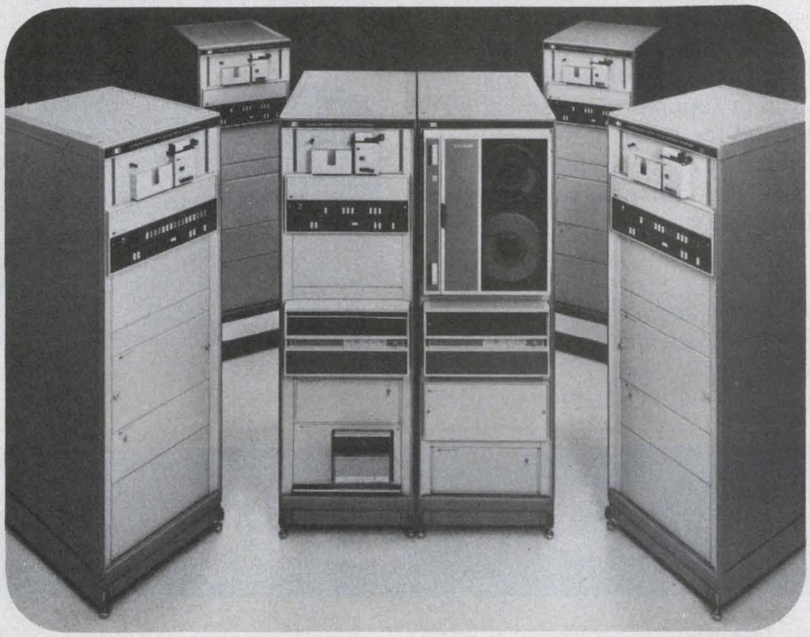
Designed for use as a built-in push-to-test battery voltage tester for cameras, radios, test instruments and other appliances.

With very high sensitivity to the threshold voltage, the new HP 5082-4732 VSLED is ideal for applications where precise voltage level indication is required, including V-U meters, logic level indicators, and other voltage indicating arrays.

This solid state lamp combines an IC and a red GaAsP LED in a standard red diffused T-1 LED package that snaps on sharply at a nominal 2.5 volts, ±10 millivolts. The effective threshold voltage can be increased to any desired level with the use of a resistor, diode or zener in series.

For rating and characteristic information, check G on the HP Reply Card.

New satellites and new central computer expand HP Distributed System capabilities



Five new minicomputer satellite systems and a new system specially configured to function as the central can now be incorporated in HP distributed systems. With these additions, 9600MX series measurement and control systems, 8500 series microwave network and spectrum analyzer system, and 9500B and 9500D series automatic test systems can all serve as distributed systems satellites. Interface between satellites and the new 9700A distributed systems central system is via high-speed data communications hardware and distributed systems software. The central supports the working-level operations of the satellites with disc-based storage for programs and data, and data processing assistance.

HP distributed systems make it practical and economical to automate large-scale operations in science and industry with minicomputers, with implementation accomplished in easy stages, satellite-by-satellite. Because each satellite can function on its own, unaffected by the failure of another, the distributed systems network provides better reliability and faster response to local needs than a big computer. At the same time, interconnection gives big-computer advantages—disc-based program development that doesn't interrupt productive operations at the satellites, central program storage, sharing of data processing workloads, and multi-satellite access to a large common data base.

The 9700A central can communicate with IBM 360/370 systems at EDP centers, tapping the tremendous processing power and extensive library of data processing and report generating programs there.

Today, over 50 companies use HP distributed systems for computer-aided manufacturing, lab automation, materials handling, product testing, and process control. You can, too. For many applications, distributed minicomputer systems that think and work together offer many advantages including faster response to the needs of the distributed application, better reliability, and easier implementation.

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

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(continued from pg. 8)

Pnp circuits available for driving LEDs

In the article "Should You Use LCD or LED Displays?" (ED No. 23, Nov. 8, 1974, pp. 88-94), the authors, David Laws and Roger Ady, say on p. 92: "In the absence of low-cost monolithic pnp arrays, later designs have turned generally to a high-gain npn emitter-follower configuration."

I am afraid this statement has given an erroneous impression to your readers, in that monolithic pnp circuits designed for driving LED displays have been available for some time on the open market. Dionics Inc. is one company producing such circuits. They are being used in production quantities by a half dozen LED wristwatch manufacturers.

George R. Seaton
Marketing Manager

Dionics Inc.
65 Rushmore St.
Westbury, NY 11590

He'd rather fight than switch

While I agree with William Adams' sentiments regarding IEEE's value to the practicing EE ("Join the IEEE? He Asks, 'Why'?" ED No. 1, Jan. 4, 1975, p. 7), I am disappointed that he dropped out of the organization. IEEE claims to speak for 160,000 EEs, it controls the engineering schools, and it distributes career propaganda that is detrimental to the establishment of engineering as a profession.

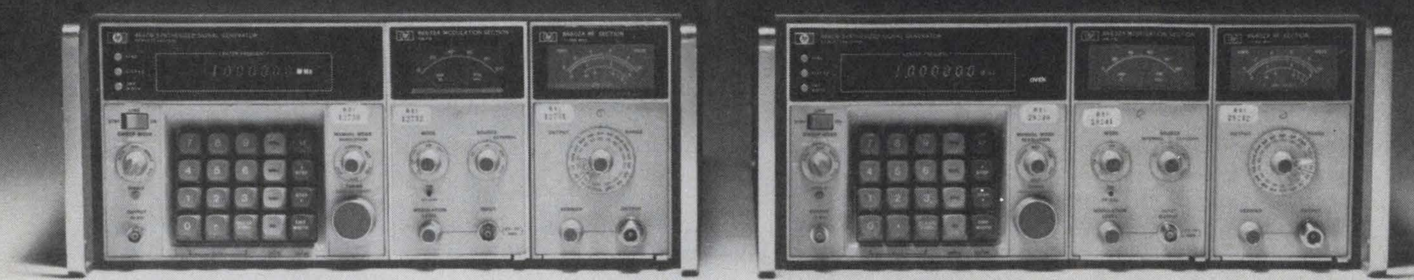
Every practicing engineer who drops out of IEEE increases the proportion of nonpracticing IEEE members who dominate the organization today.

I believe that the way to establish engineering as a profession is by widespread PE licensing and through reform of IEEE.

Philip G. Dragonetti
13864-106th Ave. N.
Largo, FL 33540

You can buy this signal generator for a 3-month job, and then let it gather dust.

You can rent this signal generator for a 3-month job, and return it when you're done.



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INFORMATION RETRIEVAL NUMBER 8

Display show sees a future for electrochromic readouts

Electrochromic displays, which industry pundits predict will start replacing liquid crystals in two or three years, will be discussed in detail April 22-24 at the Society for Information Display's 1975 International Symposium and Exhibition in Washington, DC.

According to Dr. Ifay Chang, chairman of a panel session and a research staff member at IBM's center in Yorktown Heights, NY, electrochromic displays offer the advantages of good appearance and low power.

An electrochromic display is a reflective passive device with a very wide viewing angle, Chang notes. Another interesting feature is that, by choice of proper materials, it is possible to select background and display colors.

As if this weren't enough, Chang points out that electrochromic displays can be designed to have memory. What this means is that power is needed only to produce a change in the display. This can lead to significant reductions in power consumption.

Research work in progress includes the development of displays small enough for electronic wristwatches and large enough for television applications.

Some stumbling blocks must be overcome, however, before electrochromic displays become viable. One is packaging. Electrochromic materials can be liquid, semi-liquid or solid, and experience is needed to develop the best package.

Another problem is that, like liquid crystals, electrochromic displays are slow. While this is not a major problem for such applications as electronic watches, it can be serious for TV or terminal uses. This problem, Chang reports, can be overcome by use of a beam-addressing approach. With this technique, a fast photoconductive material is serially addressed by a beam, and it subsequently turns on the electrochromic display in parallel.

Another way of using electrochromic displays in a panel application, Chang notes, is in conjunction with thin-film transistors. These can be deposited on the same substrate as the display.

Although development work must still be done before the displays become commercially feasible, Chang believes that electrochromic watch displays can come as early as 1977.

In papers to be presented at another session on electrochromic displays, researchers from American Cyanamid and Zenith Radio will discuss the development of a display that uses solid inorganic films and another one that uses a reversible chemical reaction to produce a display with memory.

Refinements reported in ultrasonic imaging

For several years, medical researchers have used ultrasonic imaging to observe body tissues that can't be seen with conventional optical and X-ray equipment. But they have had no way of knowing precisely the intensity or pattern of the ultrasonic waves being used.

An ultrasonic measuring system from RCA is reported to overcome these problems. In addition the new system is said to make it possible for researchers to determine the effect that increasing or decreasing the frequency or intensity of the sonic waves has in detecting malignancies and other tissue malformations.

The system consists of an ultrasonic transducer in a water tank that contains a gold-plated membrane. The membrane is 15 cm in diameter and just a few millionths of meter thick, and it functions like the diaphram in a telephone, vibrating in proportion to the intensity of the sound waves that hit it.

The vibrations are detected by a scanning laser beam that is phase-modulated by the reflected light. An interforometer then compares the modulated beam with an unmodulated reference beam and produces corresponding electrical signals. These signals, which can be measured by meters or displayed on a cathode-ray tube, indicate the amount of sound that is being transmitted through the object.

According to Dr. Reuben S. Mezrich, a member of the RCA team that developed the equipment, use of a 15-mW laser with the system gives a potentially high sensitivity of about 5 nW per square centimeter. The dynamic range extends from several nanowatts to several watts per square centimeter.

The frequency response of the system ranges from 0.5 MHz to about 10 MHz, Mezrich says, and it can be used in a transmissive or reflective mode.

2 large computers join Univac line

Sperry Univac has unveiled two general-purpose, large-scale computers in its 1100 series, the 1100/20 and 1100/40. The machines have abandoned core memory for IC semiconductory memory, They provide new mass-storage capacity, new communications capability, better security and remote maintenance, according to the Roseville, NM, company.

The internal logic cycle time of the 1100/20 is 125 ns, allowing the semiconductor storage to be used at 875 ns per instruction. The 1100/40, the larger of the two machines, can execute one instruction every 300 ns.

The basic 1100/20 configuration can be expanded from a unit processor with 131,072 words of storage to one with 524,288 words.

A new mass-storage family for both the 1100/20 and 1100/40 consists of three disc subsystems that can be configured to a customer's requirements. A fixed-head disc storage unit is available in two models, one providing 1.37 million words of storage and the other 680,000. Two removable pack discs provide 17 million and 34 million words of storage.

The communications system for the 1100/40 plugs into a terminal controller that is already in use with earlier 1100 series models. Requiring about half the floor space of the controller and using less power, the communication accommodates, via multiplexing, up to 32 half or full duplex lines. It can communicate concurrently with almost any mix of low, medium and high-speed data lines at from 45,000 to 50,000 bits per sec.

To protect against accidental data destruction, the 1100/20 features extensive control functions. And an identification/password combination protects against unauthorized access to data.

For remote maintenance, the user can connect his 1100/20 to the company's Total Remote Assistance Center in Roseville, where specialists can diagnose the problem and come up with solutions.

First customer deliveries of the 1100/20 are planned in July, and the 1100/40 in August.

Stepping motor curbs unwanted shaft motion

A serious drawback of stepping motors—uncontrollable, random motion of the motor shaft when operated in the region of system resonance, usually between 100 and 150 cycles—has been eliminated in a stepper unit that has optical, instead of salient-pole, steps.

In addition the new device, called Synstep by Dahmen Burnett Electronics, Londonderry, NH, can run either in a stepping mode or as a free-running slewing motor.

The key to the device, says James Burnett, its inventor, is the integration of an optical encoder with the rotor of a high-performance servo motor. When operating in the stepping mode, it is a true servo, with the output of the encoder driving the motor.

This combination greatly improves the damping ratio, Burnett points out, without sacrifice in high-speed performance or settling time. The latter is on the order of 3 to 5 ms.

Another advantage, Burnett notes, is small power drain when the unit is standing still. Most other steppers, he says, draw from 20 to 200 W of full rated power when idle.

The Synstep design is also TTL-compatible, Burnett reports, using 0-to-5-V, 10-μs pulses to run at more than 2000 steps per-second. The present encoder, which uses two phototransistors and two LEDs looks at two edges of encoder slots. The encoder has 200 elements, each 1.8° apart. Changes in the encoder design can vary the number of stepping increments, Burnett points out.

'Inside-out' generator mounts in plane's wing

An ac generator with four-and-one-half-inch hole through its center, to permit waveguide and signal and power cabling to pass through, has an "inside-out" design.

As developed by the Bendix Electric and Fluid Power Div., Eatentown, NJ, the relative positions of the alternator's rotor and stator are inverted. Whereas the rotor usually turns inside the stator, the Bendix rotor is secured to a fixed, large-diameter shaft whose center is hollow. The stator rotates around the outside of this assembly.

The generator is designed for mounting in the wing of a military aircraft. Rated at 20 KVA at 400 Hz, the moving portion rotates at 6000 rpm, according to Ralph Adams, engineering director at Bendix. The unit is about 5 in. long and has a diameter of 9 in.

Custom tests offered for logic diagrams

Give Bendix Test Systems Div. just the logic diagram of your circuit, and they will furnish you with test patterns and fault-isolation lists almost to the gate level. Proprietary software, not a circuit designer, does the job.

The program provides the following:

- A sequence of digital test inputs and corresponding outputs that certify with 90% confidence that the circuit operates.
- A list of faults should the output pattern deviate from the calculated pattern.

This service is performed at Teterboro, NJ, on a 16-k mini called the BDX 6200. The output, furnished on cards and printer in Atlas language, can be used on your own in-house testing system. Atlas is very easy to read by a nonprogrammer and is standard with the airline industry.

A main advantage of the system is that it tends to generate rather short test sequences, compared with patterns that might be suggested by a designer. It also is less prone to error.

The system can handle circuits up to the equivalent of 1000 gates. CAFIG, as the system is called (Circuit Analyzer and Fault Isolation Generator), is already in use on the Air Force F-15 Repair Depot Program.

The cost of the service is $1000 to $3000 for a 100-gate board.

CIRCLE NO. 319

Study doubts wide use of multilayer PCs

Multilayer printed-circuit boards account for only 12.6% of the world's use of printed circuits, according to researchers at Darling & Alsobrook, Los Angeles-based management consultants. The finding is far short of the 25 to 30% penetration being indicated by some industry observers.

A study by the researchers notes a rapid rise in the popularity of multilayer boards in recent months, however.

Although multilayers are used at the high annual rate of 19.8%, our study shows that the consumption of both two-sided boards and flexibles will grow even faster through 1980," says Dr. John Salzer, vice president of Darling & Alsobrook. "While flexible circuits will only account for about 5% of the $7.86-billion worldwide total PC consumption in 1980, they will have grown at an annual average of 29% to reach that level."

Other studies, Dr. Salzer believes, have projected the growth rate for multilayer boards too high because of their recent spectacular rise in acceptance.

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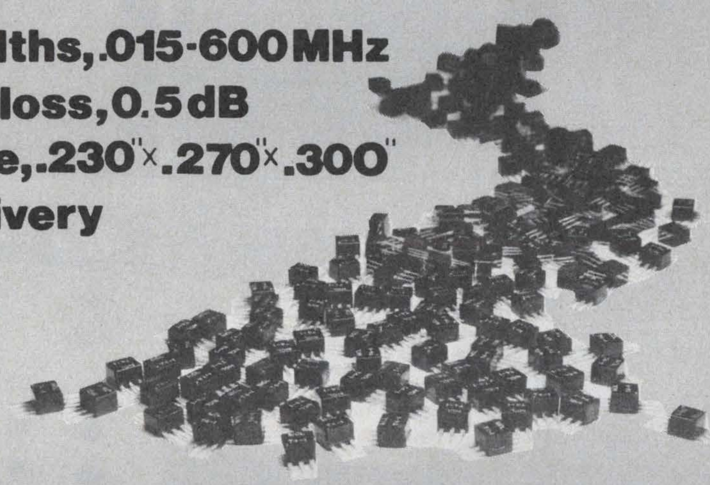

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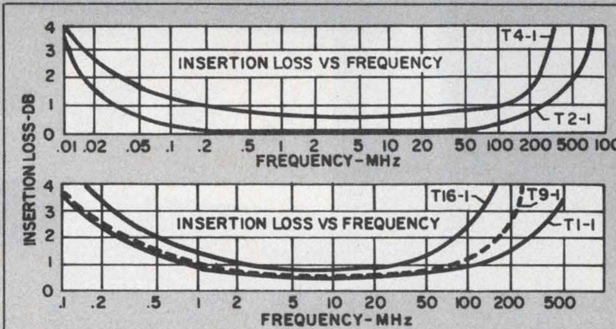
Price	(10-49)	$2.95	$3.45	$2.95	$2.95	$3.45



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NORLAND INSTRUMENTS
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Military turning to CMOS/SOS for radiation-hardened circuitry

While commercial ventures into SOS (silicon on sapphire) technology have been marked more by failure than success, military-sponsored research is in hot pursuit of CMOS/SOS because of its inherent resistance to radiation.

Tests have shown that conventional MOS and bipolar circuits are apt to be damaged by the X-rays and gamma rays of nuclear explosions but that SOS can take considerable punishment.

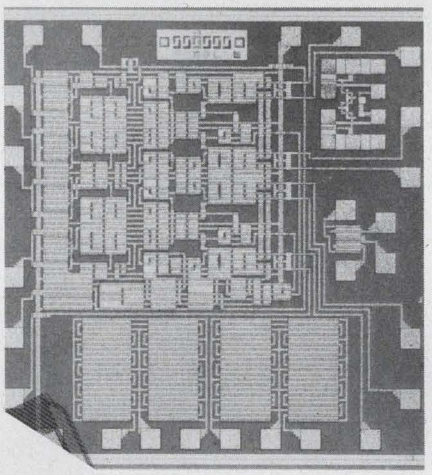
Some commercial attempts at developing SOS circuitry have fizzled after much ballyhoo—a microcomputer that Rockwell International was to build for General Automation, for example. Inselek in Princeton, NJ, has filed for bankruptcy after a big investment in commercial SOS. And RCA has been slow getting off the mark with commercial SOS, though its first products employing the technology have finally reached the market.

The Air Force Space and Missile Systems Organization at Norton AFB, San Bernardino, CA, has just let two contracts, each for two years, to Rockwell International and the Northrop Research and Technology Center, Hawthorne, CA, for the study of radiation-hardened circuits for the MX advanced computer. Although the Air Force doesn't require it, both companies have indicated that they plan to use CMOS/SOS for the processor and MNOS/SOS for the memory in the study programs.

In addition to the Air Force program, extensive study is being funded by the Naval Research Laboratory in Washington, DC. RCA, Hughes Aircraft at Newport Beach, CA, and others are attempting to perfect CMOS/SOS LSI for the Navy as a radiation-hard technology.

David N. Kaye
Senior Western Editor

Capt. Joe Dunn, components manager on the MX project at the Air Force Space and Missile Systems Organization, says: "We are interested in CMOS/SOS technology because of its radiation hardness, speed and low power dissipation. Although CMOS/SOS is not a requirement of the MX contracts, it may be required to do the job."



CMOS silicon-on-sapphire circuits, such as this 4008-type 4-bit adder from Rockwell International, are undergoing tests to develop radiation-hardened MOS/LSI circuits. This chip has 170-transistor complexity and a chromium-doped gate oxide.

Dr. Harold Hughes, head of experimental devices at the Naval Research Laboratory, notes: "We have seen encouraging results so far in experiments with simple CMOS/SOS inverters and adders. We are now developing and testing 8-bit adder circuits with respect to radiation hardness. When these tests are completed, we hope to commit CMOS/SOS technology to some hardware programs. This could happen within a year."

H. Dean McKay, president of AH Systems, Chatsworth, CA, says that the main advantage of SOS in a radiation environment "is the reduction of transient photocurrent generation." The military calls this ionizing dose rate tolerance.

Improved dose rate tolerance

Photocurrent generation is proportional to the volume of the bulk silicon in the channel between the source and the drain. In a conventional MOS device the circuit sits on a large chunk of silicon that has a large volumetric area through which the photocurrents can flow. In an SOS structure only a thin layer of silicon is deposited over a single crystal of sapphire.

The area in which the photocurrents can flow is so greatly reduced that, according to James E. Bell, director of engineering sciences at the Electronics Research Div. of Rockwell International, Anaheim, CA, "we see a three-to-four-order-of-magnitude improvement in ionizing dose-rate tolerance." The tolerance goes from about 10^6 rads/s to better than 10^9 rads/s, he says.

An increase in the tolerance to total ionizing dose can be achieved in more than one way. Rockwell builds CMOS/SOS with an aluminum gate and a silicon-dioxide gate insulator. Rockwell finds that chromium doping of the gate oxide increases total ionizing dose tolerance.

Bell points out that it is a two-step procedure. First, an ultra-clean gate oxide must be deposited. This is followed by shallow doping of chromium in the silicon dioxide. The doped gate insulator is not only resistant to charge trapping

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See the NI 2001 at IEEE INTERCON, April 8-10, Coliseum, New York, Booth 2732-4.

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INFORMATION RETRIEVAL NUMBER 10
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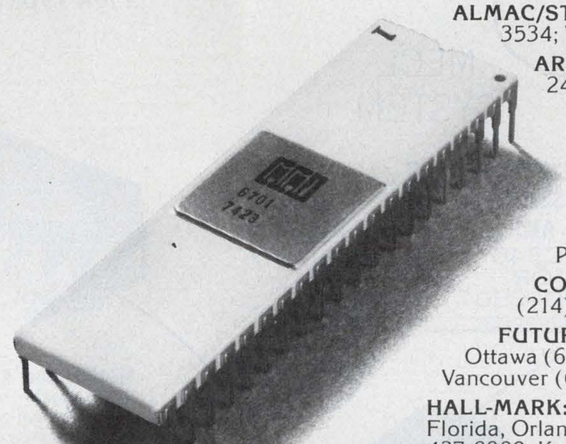

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HALL-MARK: Alabama, Huntsville (205) 539-0691; Florida, Orlando (305) 855-4020; Illinois, Chicago (312) 437-8800; Kansas, Kansas City Area (913) 888-4747; Minnesota, Minneapolis (612) 884-9056; Missouri, Kansas City Area (913) 888-4747, St. Louis (314) 521-3800; North Carolina, Raleigh (919) 832-4465; Oklahoma, Tulsa (918) 835-8458; Texas, Dallas Area (214) 231-6111, Houston (713) 781-6100; Wisconsin, Milwaukee (414) 476-1270.

INTERMARK: California, San Francisco Bay Area (408) 738-1111, Los Angeles Area (213) 436-5275, San Diego (714) 279-5200; Colorado, Denver (303) 936-8284; Washington, Seattle (206) 767-3160.

KIERULFF: Arizona, Phoenix (602) 273-7331; California, San Francisco Bay Area (415) 968-6292, Los Angeles Area (213) 685-5511, San Diego (714) 278-2112; Colorado, Denver (303) 343-7090; District of Columbia (301) 948-0250; Maryland, Baltimore Area (301) 948-0250; Massachusetts, Boston Area (617) 935-5134; New Jersey, Rutherford (201) 935-2120.

PIONEER: Indiana, Indianapolis (317) 849-7300; Michigan, Livonia (313) 525-1800; Ohio, Cleveland (216) 587-3600, Dayton (513) 236-9900; Pennsylvania, Pittsburgh (412) 782-2300.

SUMMIT: New York, Buffalo (716) 884-3450, Rochester (716) 334-8110.

TECHNICO: Maryland, Baltimore Area (301) 828-6416.

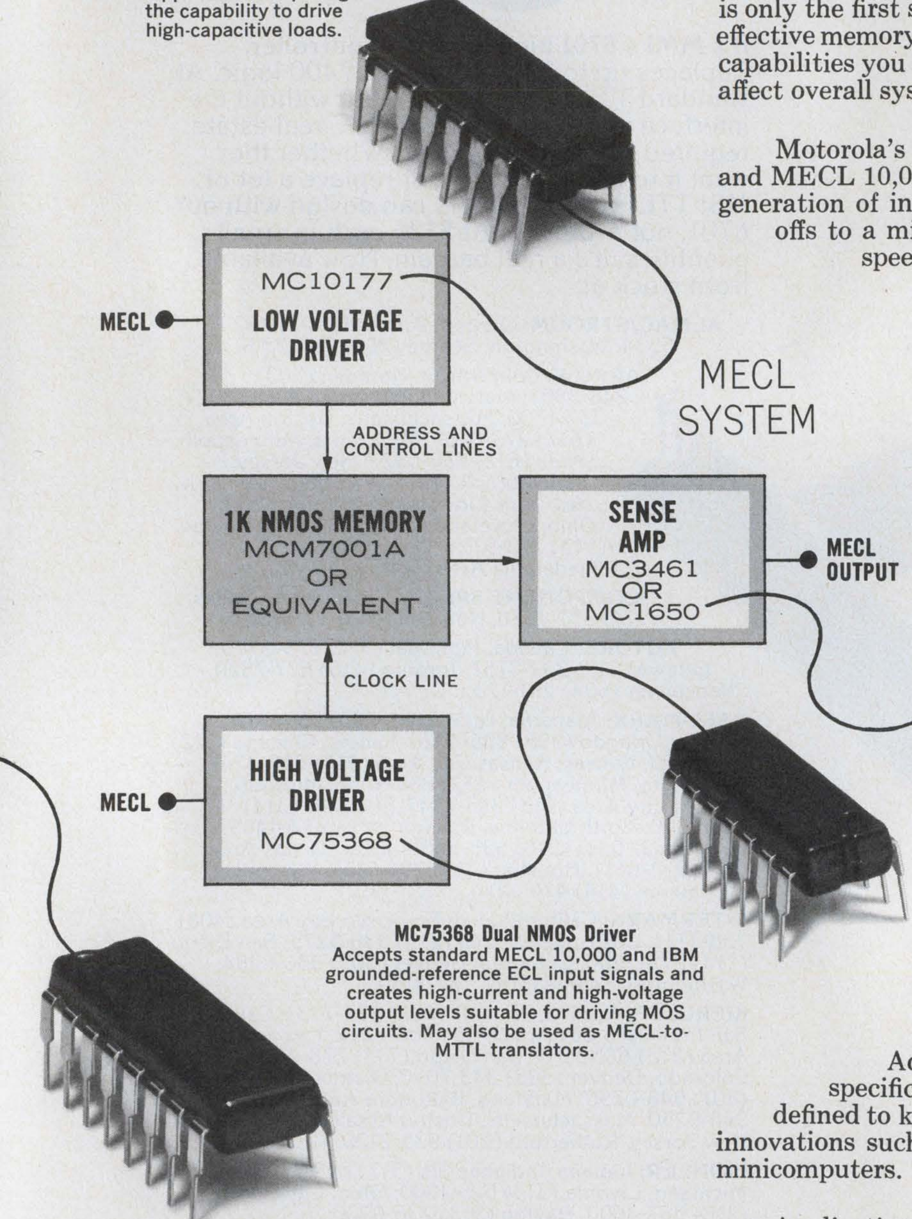
INFORMATION RETRIEVAL NUMBER 133

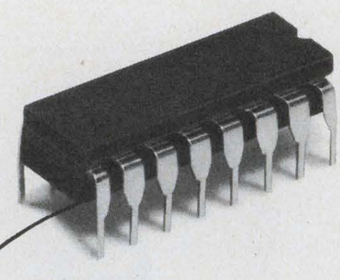
do not live memories alone...

MC10177 Triple MECL-to-MOS Translator (N-Channel)
Designed for NMOS memory systems as a Read/Write, Data/Address driver. May be used for other applications requiring the capability to drive high-capacitive loads.

Your selection of NMOS memories for that new system is only the first step in providing a high-performance, cost-effective memory system. To fully utilize NMOS technology capabilities you have to consider interfacing trade-offs that affect overall system performance.

Motorola's new interface functions draw upon linear and MECL 10,000 processing technologies to create a new generation of interface devices that reduce system trade-offs to a minimum. These new functions offer higher speed, greater drive capabilities, and increased package functionality. Take a look at a few typical application areas.





MC1650 Dual A/D Comparator
Used to maximize speed in MECL systems, typical prop delay 3.5 ns. Requires a low overdrive, low switching current, and has a latch for data storage. Complementary outputs permit maximum utility.

MC75368 Dual NMOS Driver
Accepts standard MECL 10,000 and IBM grounded-reference ECL input signals and creates high-current and high-voltage output levels suitable for driving MOS circuits. May also be used as MECL-to-MTTL translators.

MC75365 Quad MOS Clock Driver
Ideal for driving highly capacitive Address, Control and Timing inputs on a variety of MOS RAMs such as the "1103" and "6605" types. Usable over a wide latitude of supply voltages.

Interfacing is on the Move!

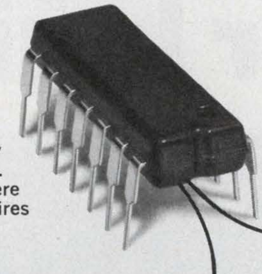
Your NMOS memory can't go it alone. Advanced memories dictate new interfacing specifications. Future functions have already been defined to keep pace with NMOS RAM expansion and innovations such as microprocessor chips and high-speed minicomputers.

Applications and device specifications for the functions displayed here are available on request from Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036 or any authorized Motorola distributor and OEM sales office. Evaluate your interfacing requirements now . . . we'll help you face up to your problems!

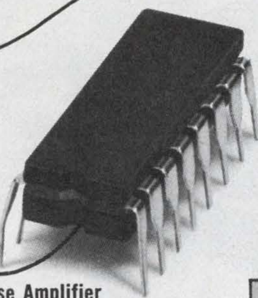
MOTOROLA LINEAR
Interface—The End Is Nowhere In Sight

INFORMATION RETRIEVAL NUMBER 132

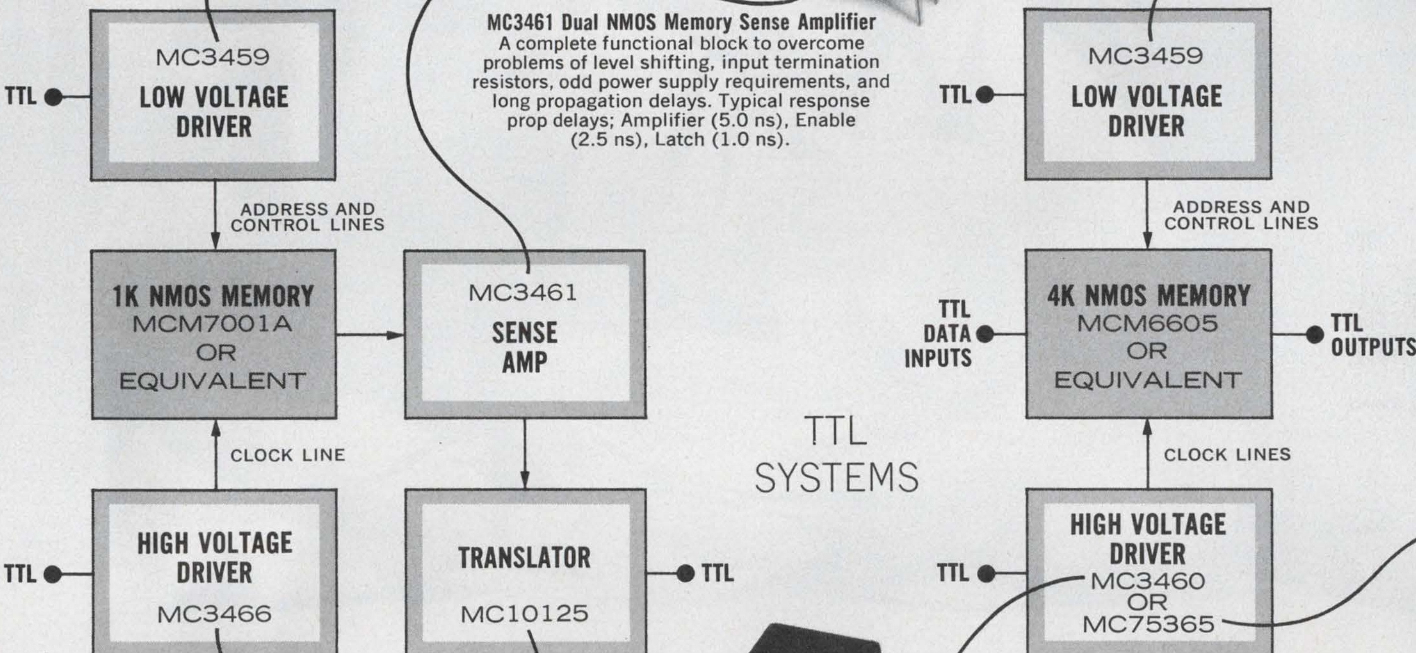
System designers by NMOS

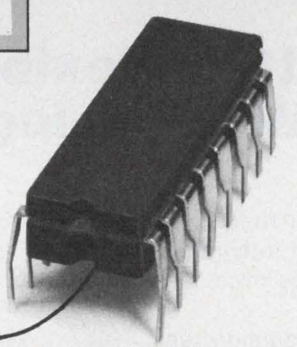


MC3459 Quad NMOS Memory Address Driver
Specifically designed to supply highly capacitive address line requirements. Especially useful in larger systems where paralleling of numerous memories requires a powerful driver.

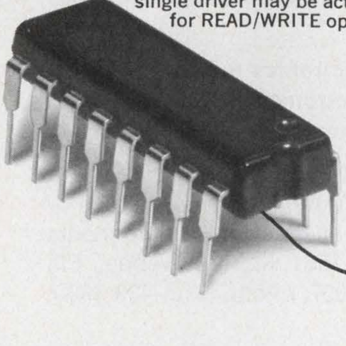


MC3461 Dual NMOS Memory Sense Amplifier
A complete functional block to overcome problems of level shifting, input termination resistors, odd power supply requirements, and long propagation delays. Typical response prop delays; Amplifier (5.0 ns), Enable (2.5 ns), Latch (1.0 ns).

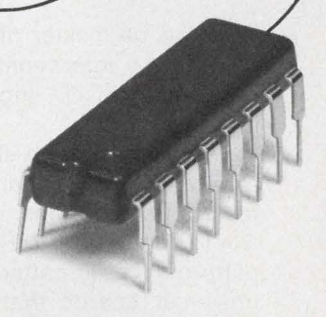




MC3466 Quad NMOS Memory Clock Driver
Meets the higher clock line voltage needs of "7001" type memory systems. With proper inputs, all four drivers may be deactivated for standby operation; or single driver may be activated for READ/WRITE operation.



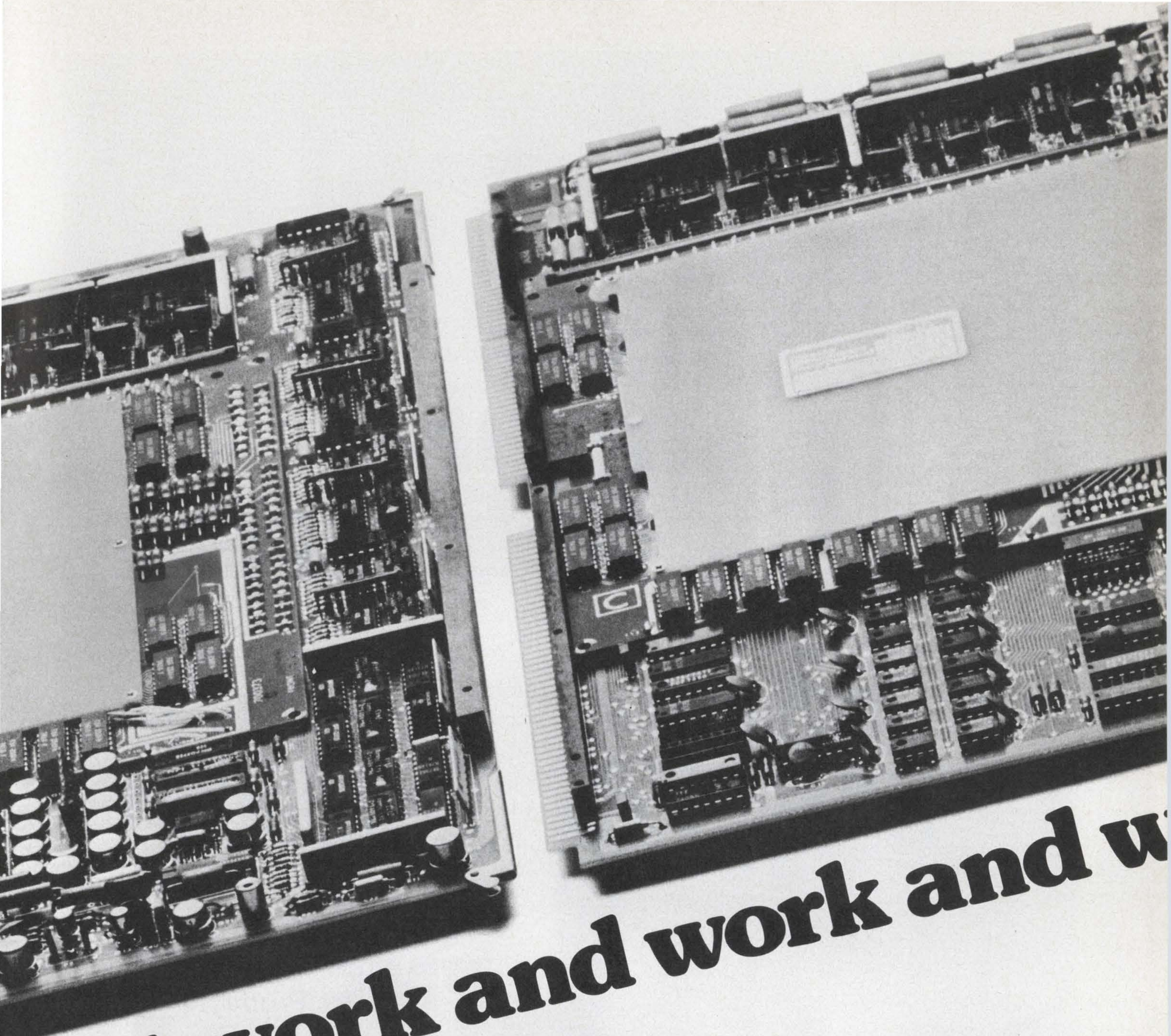
MC10125 Quad MECL-to-MTTL Translator
A versatile device for interfacing the sense amplifier MECL outputs to saturated logic sections of digital systems. Typical prop delay is 4.5 ns.



MC3460 Quad NMOS Memory Clock Driver
Similar to the MC3466 but is specified for 4K memory applications. Prop delay times with a 480 pF load and operating in the READ/WRITE mode are less than 25 ns. All four drivers may be activated for REFRESH operation.

INFORMATION RETRIEVAL NUMBER 131

INFORMATION RETRIEVAL NUMBER 30



tion by the most competent organizations. And to counter cries that the Government should never grant an exclusive license for a patent it owns, he said this was a good way of ensuring sometimes that an invention would not be used. In summary, Dann commented: "The more important the technological goal—whether it be energy, the environment, medicine or anything else—the more important become the incentives which patents provide."

FCC reconsiders overseas communications

The pace of technology is prompting the Federal Communications Commission to take a new look at its guidelines for licensing facilities for overseas communications. In 1970 the agency drew up the guidelines for use in the decade—such as promoting the development of both cable and satellite systems and authorizing systems with due regard for efficiency, economy, diversity and redundancy. Progress, however—particularly in long-distance submarine cables and satellite communications—plus the growth in requirements, has convinced the FCC its concepts may be in danger of being outdated.

So it's starting a re-evaluation of the trans-Atlantic situation as a starter, looking at expected traffic, available facilities and the proper mix, among other things. It will also review the state of technology, the expected service life of facilities and compare the facilities envisioned for the late '70s and early 1980s.

Capital Capsules: Random interlace cameras have been manufactured since the development of industrial television cameras, but there hasn't been a standard waveform for this class. Now the Electronic Industries Association has one: **RS-420 "Electrical Performance Standards for Monochrome Closed-Circuit Television Cameras 525/60 Random Interlace."** Also new from the EIA is a revision of "Minimum Standards for Portable/Personal Land-Mobile Communications FM or PM Equipment 20-1000 MHz," RS-316-A. . . . The Dept. of Commerce has **extended the life of its Telecommunications Equipment Technical Advisory Committee for two years.** This industry unit advises on technical matters and licensing procedures that may affect export controls on telecommunication equipment. . . . A one-year program to establish **quality-assurance criteria for hybrid microcircuit manufacturing lines** is a new project of the Army Electronics Command. . . . Companies or organizations interested in building and operating **a demonstration centrifuge enrichment facility** for ERDA now have until Sept. 2 to respond to a request for proposal from that agency instead of April 1. . . . The Air Force is **identifying companies that can participate in planned improvements** to the existing 487L survivable low-frequency communications system and the advanced airborne command post very-low-frequency/low-frequency system. . . . Under way is **a program for the development and production of a unique calibration receiver for the Navstar global positioning system.** The Air Force Systems Command says it's seeking sources among firms that have experience in receivers, calibration equipment, spread-spectrum technology and psuedo-noise and code-correlation techniques. . . . NASA officials say that **on-going research on gaseous fuel nuclear reactors indicate they may have a unique characteristic** that could make them prime candidates for the future—they can burn up the nuclear waste materials they generate. The theory is that radioactive wastes can be rendered harmless by bombardment by neutrons, which such units generate in large numbers.

washington report

Solar energy progress linked to silicon sheets

The nation's 1985 solar-energy objective is to establish a large-scale plant that could supply 500 MW of sun power a year, but success hinges on finding an automated process of producing silicon sheets. Other major tasks, according to the National Aeronautics and Space Administration, are developing higher-grade, lower-cost silicon, the automated assembly of solar-cell arrays and a successful program to prove technical feasibility by 1980.

If all goes well, several pilot manufacturing plants could be constructed in the early 1980s and a full-scale solar plant by 1985. There's a way to go yet, as pointed out by Jet Propulsion Laboratory specialists in a recent briefing on the nation's 10-year solar photovoltaic energy program. At present annual production of silicon photovoltaic devices in the U.S. amounts to only 60,000 W capacity, 90% of which is being used in the space program.

HEW hopes to replace its computer equipment

The Dept. of Health, Education and Welfare is planning the "fully competitive replacement" of all its large-scale computer equipment.

Working with General Services Administration, it will put the plan into operation in phases to minimize disruption. The first procurement of equipment will start in July. The procurement for most offices involved —such as the Social Security Administration, National Institutes of Health and departmental units—will span two to three years. HEW officials point out that the long-range acquisitions must be approved by the Office of Management and Budget, the Office of Telecommunications Policy and that final big hurdle—Congress.

Radical patent changes not in the cards

Don't look for great changes in the nation's patent policy, despite strong efforts by reformers in Congress and elsewhere. The Commissioner of Patents and Trademarks, C. Marshall Dann, speaking for the Ford Administration, recently chastised those "who are much more concerned with dividing up rights in whatever technology we have or may create than in providing the best climate for the creation of new technology."

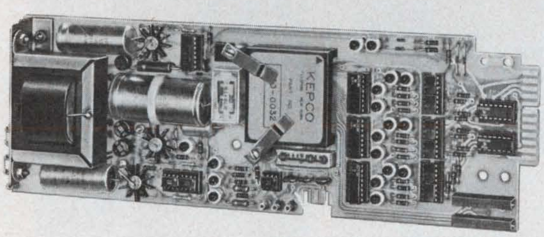
In response to arguments that all inventions emerging from Government-funded research should belong to the Government to the exclusion of the contractor, he warned that this would tend to discourage participa-

KEPCO | your source for digitally programmed d-c power supplies

This, for example, is a typical digitally-controlled voltage stabilizer, comprising a standard Kepco plug-in power supply with the new Kepco SN Digital Interface.

The combination produces 0–100 volts, 0–200 mA with 12-bits resolution. The power supply is a Model PCX 100–0.2MAT programmed by an SN–12 Digital Interface Card mounted on a slide adapter and fitted to a dual-slot bench style enclosure.

There are hundreds of similar Kepco Power Supplies, ranging from 0–6V @ 90 A to a model that can produce -5000V @ 5 mA. Because they're rated as *operationally programmable,* these models can be combined with one of the five Kepco SN Digital Interfaces to produce a custom digital voltage or current source, tailored to your needs.



The SN Digital Interface Card accepts your data input on parallel lines, strobed for noise immunity, and stores the data in a buffer register. For isolation, the program is transferred across optical couplers so that your digital signal and the power supply it controls can be up to 1000V apart.The five SN Cards offer a choice of BCD or complementary binary programming.

The analog output from the SN Card is in the form of a 0–1V/0–10V range selected signal* that is linearly amplified by the companion power supply to produce the desired output. In the illustrated combination of SN–12 and a Kepco Model PCX 100–0.2MAT, the power supply functions as a fixed gain-of-ten power amplifier to produce a digitally-controlled output, 0–100V with 12-bits (0.024%) resolution. The range selector on the SN allows the full resolution to be spread over the lowest 10% of the output: 0–10V d-c.

*The SN Card also produces ±10V & ±5V outputs to control bipolar power supplies and 0.5V, 1.0V outputs to control current stabilizers.

SN CARDS AVAILABLE

MODEL	RESOLUTION	LINEARITY
SN–2	2 BCD	±0.2%
SN–3	3 BCD	±0.05%
SN–8	8-bit	±0.2%
SN–10	10-bit	±0.05%
SN–12	12-bit	±0.01%

These SN Cards are fully self-contained digital programmers, featuring an on-card line operated power supply. Kepco offers a variety of housings and accessories to accommodate them to various programmable power supplies. As many as eight cards can be accommodated in a standard 5¼" x 19" panel.

TM

For complete specifications, write Dept. EW-5

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TWX #710-582-2631 • Cable: KEPCOPOWER NEWYORK

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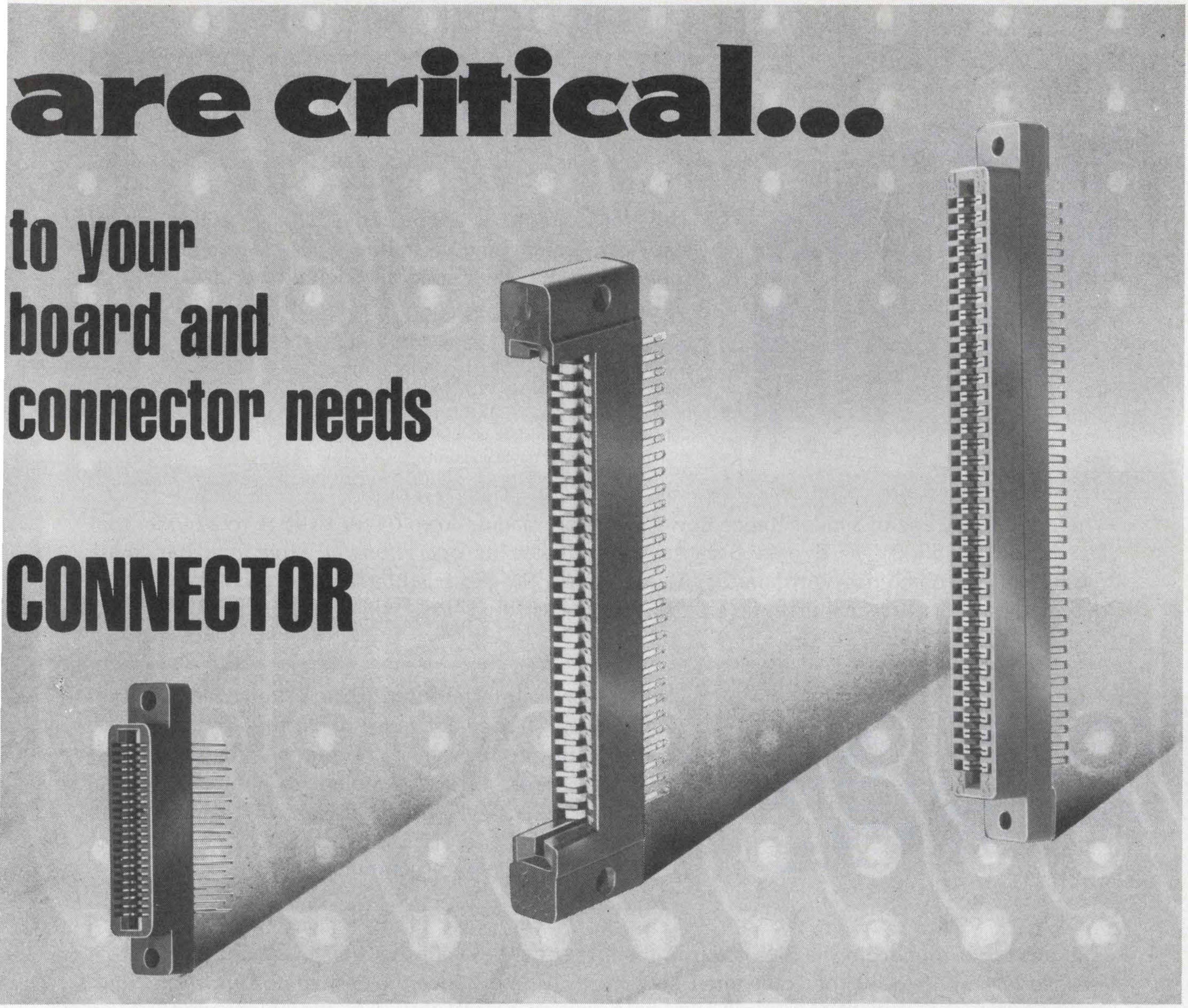
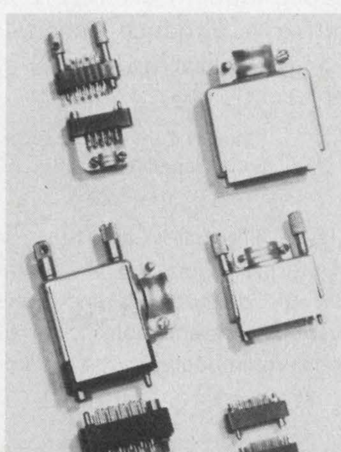


RACK AND PANEL

Microminiature . . . Subminiature
Miniature . . . Removable Contact

Choose from a wide variety of rectangular plug and socket connectors that meet or exceed applicable paragraphs of MIL-C-27848 specifications. Available with four to 104 contacts and optional polarizing screwlocks, aluminum hoods, protective shells and guide pins and guide sockets.



CATALOGS AVAILABLE!

CONTINENTAL CONNECTORS

CONTINENTAL CONNECTOR CORPORATION ▪ WOODSIDE, NEW YORK 11377

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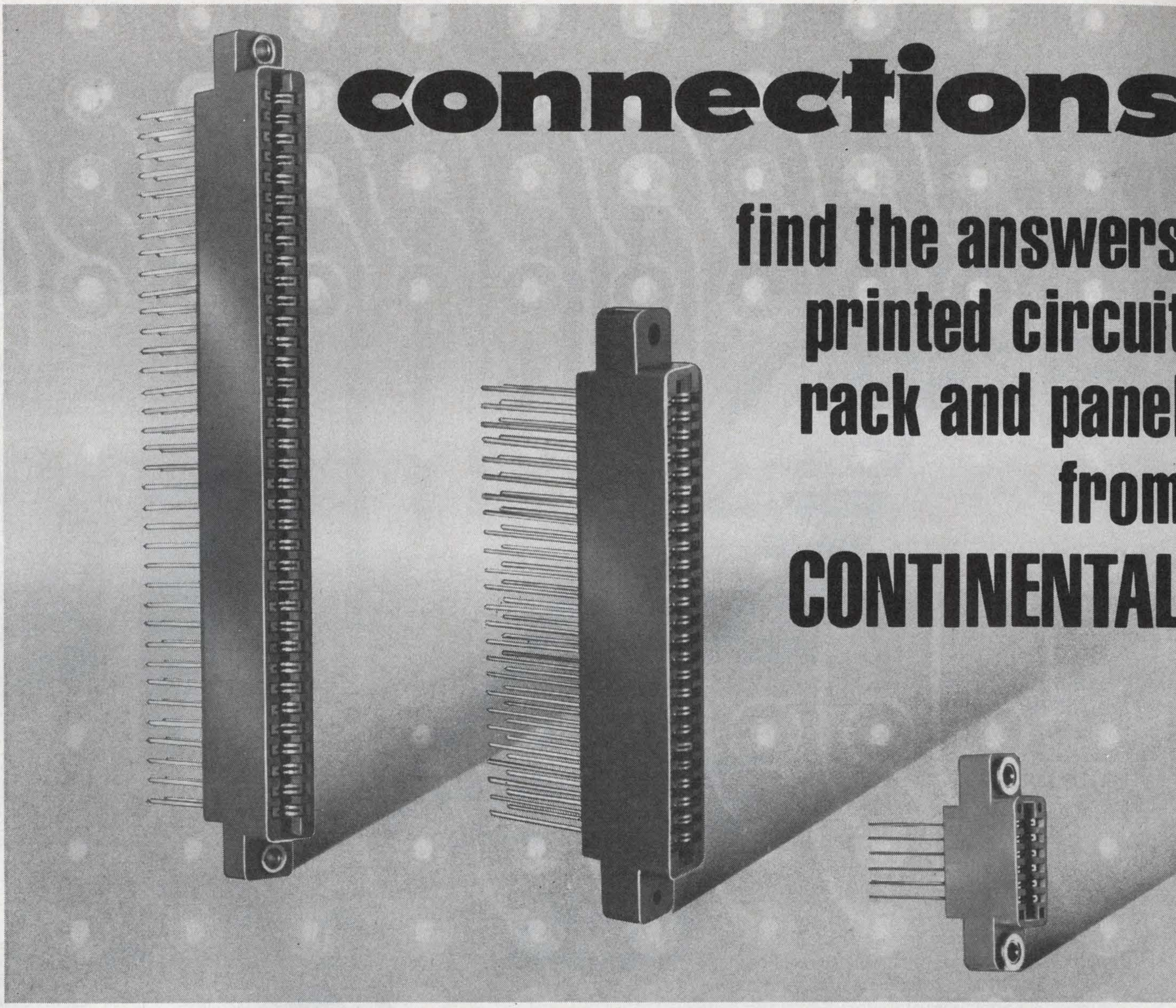
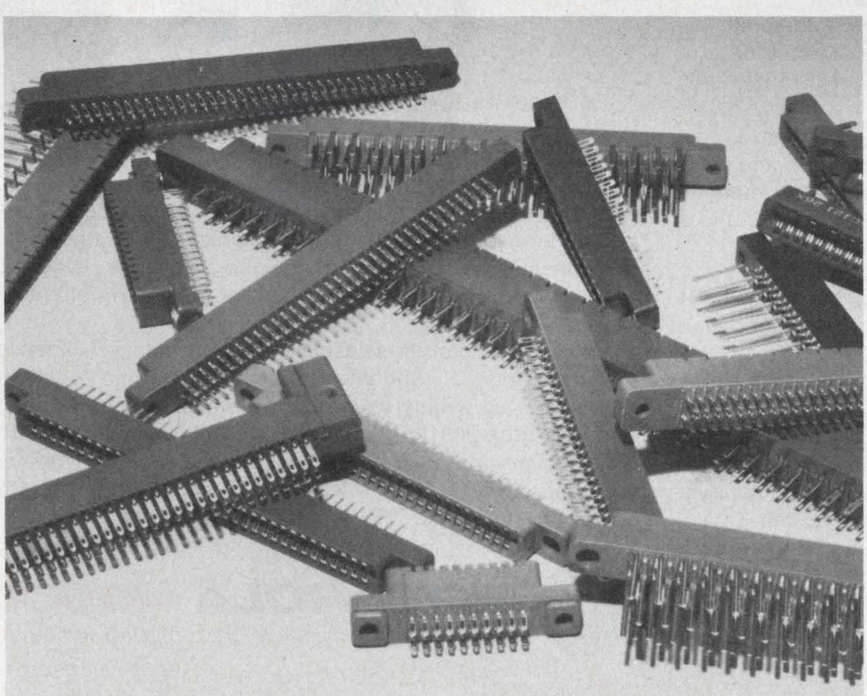
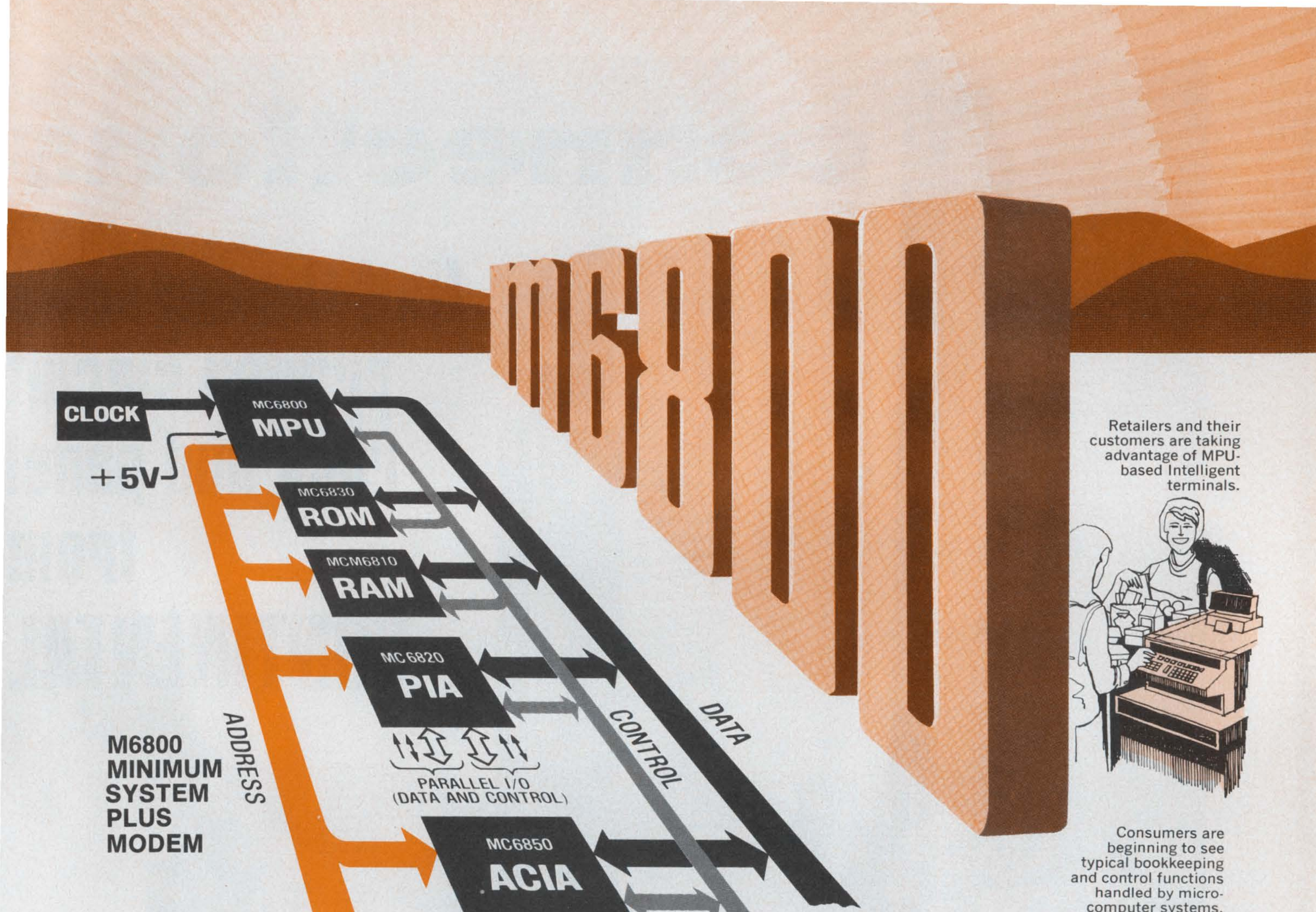




PRINTED CIRCUIT BOARD CONNECTORS

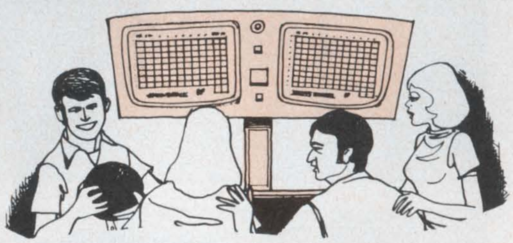
Extensive lines of receptacles, right angle plug and socket and test point provide positive, space-saving connections between printed circuitry and conventional wiring through pc boards, tape cable or "plug" mounted sub-assemblies. Receptacles accommodate 1/32", 3/64", 1/16", 3/32" or 1/8" board thickness with single or dual readouts on .050", .075", .100", .125", .150", .156" and .200" contact centers. Wiring styles include terminations for wire-wrapping (.025" and .045" square terminals), eyelet lug and dip solder.

For the Sales Representative Nearest You, See Our Listings in EEM & Gold Book Directories, or Phone (212) 899-4422 for Immediate Action



Retailers and their customers are taking advantage of MPU-based Intelligent terminals.

Consumers are beginning to see typical bookkeeping and control functions handled by microcomputer systems.



Additional devices support M6800 family

Next into the family's NMOS mix will be functions like a programmable timer module, 256 x 4 and IK x 1 static memories, and a synchronous serial data adapter. While the family includes memories, others are often desirable. Additional appropriate Motorola memories are the MCM6831 8K ROM, the MCM6832 16K ROM, and the MCM6815 dynamic 4K RAM.

Motorola's Linear products group has designed a new family of interface functions around the memories and MPU family, and our CMOS people have come up with supplemental functions including a bit rate generator available now, and a new RAM and Tone Encoder on the way.

M6800 Software and Hardware Motorola's M6800 support software is a cohesive, interactive system for program development and checkout available on both G. E. and United Computing Service timesharing. A Fortran IV source deck cross assembler for 16 and 32-bit machines is available for customer host computers.

Hardware system development tools are the MEC6800 Evaluation Module, a complete minimum microcomputer system on a single board with RS232 interface, and the EXORciser*, a system prototyping minicomputer complete with power supply and functional board options.

Other diverse support activities include a three-day technical design seminar in Phoenix and major U.S. cities throughout '75.

What it's all about: Simplify design, reduce costs!

All this distills to the simple idea that the M6800 family system architecture is designed to achieve •Minimization of components •Minimization of support packages •Interface simplicity •Minimization and simplicity of power requirements •System throughput.

There's a Motorola salesman ready to help you keep up with the leaders . . . and ahead of the rest. Get more detailed information by writing to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036. Discover why the M6800 family creates a new age as the standard against which all others must be measured: Why M6800 is now the benchmark family for microcomputer systems.

MOTOROLA M6800

Benchmark family for microcomputer systems.

Motorola's M6800 family
Creates the new age for microcomputer systems design

The M6800 family is the first LSI family designed as a coherent modular building block approach to the implementation of microcomputer systems. From the deceptively powerful MC6800 Microprocessor to the byte-organized family memories, to the capability expanding peripheral and communications interface adapters, the M6800 family plays together as the total product solution for microcomputer designs.

Shared qualities place M6800 family in leadership position.

Family devices are all state-of-the-art high performance N-channel Silicon Gate units requiring only a single common +5 V power supply. All peripheral bus devices are directly bus and TTL compatible. Among the many notable family features are •Basic I MHz operation •Direct Memory Access capability •64 kilobytes of directly accessible memory in any combination of ROM, RAM, or peripheral registers •Bi-directional data bus and wide address bus •Simple yet powerful instruction set with enhanced addressing modes. Beyond all else, the family is distinguished by a set of intelligent programmable logic interface adapters for I/O communications requirements.

Meet the family members

MC6800 Microprocessor. The executive control and processing block of Motorola's total product for microcomputer systems is the 8-bit MC6800 Microprocessor. The MC6800 is fast establishing a reputation for performance and throughput based on varied factors, including •Simple universal bus structure, powerful programming modes, and interrupt handling features •16-bit address bus for direct address of up to 65,536 memory locations •8-bit bi-directional parallel processing on a three-state data bus. These features only scratch the surface. MC6800 is a super 8-bit MPU.

MC6820 Peripheral Interface Adapter. The totally unique PIA is a universal interface between peripheral equipment and the MPU bus. It's a flexible method, virtually without external logic, of connecting the MPU to status line or byte-oriented peripherals. The PIA features •8-bit bi-directional data bus for MPU communications •Two 8-bit bi-directional peripheral interface buses •Handshake control logic for input and output peripheral operation. The functional configuration of the PIA may be changed by the MPU during system operation.


A revolution is anticipated in word processing.

There's more, but just remember this. The MC6820 provides total programmable logic for complete I/O task management.

Memories designed for microprocessors

Another system advantage of the M6800 family is the set of byte-organized memories designed to maximize efficiency in many systems. Just as useful in some situations is the fact that non-family memories also fit in, usually without sacrifice. Here are the family memories.

MCM6810 Static RAM. This 128 x 8 memory is designed for bus-organized systems. It needs no clocks or refreshing. Memory expansion is achieved with six chip select inputs. Two versions are available. The MCM6810L-1 is faster, with an access speed of 575 ns (max). Access time of the MCM-6810L is 1 μs.

MCM6830 ROM. The MCM6830 also is byte-organized for application in bus-organized systems. It's a mask programmable 1024 x 8-bit ROM with a maximum access time of 575 ns. Expansion is achieved with four programmable chip select inputs.

Communications power

One distinctive advantage of the M6800 family in the new wave of serial data communications systems is the inclusion of the necessary interface devices and MODEMs in the basic family.

MC6850 Asynchronous Communications Interface Adapter. The ACIA provides the data formatting and control to interface serial asynchronous data communications information to bus-organized systems.

The ACIA includes control lines for direct MODEM interface and features •8-bit and 9-bit transmission •Odd, even, or no parity •One or two stop bits •Optional divide by 1, 16, and 64 clock modes.

Functional configuration of the ACIA is programmed via the data bus during system initialization, using a control register programmed by the MPU. When all is said, the ACIA provides complete I/O task management for serial communications.

MC6860 MODEM. This 600 bps MODEM provides the necessary modulation, demodulation, and supervisory controls to implement a serial data communications link over a voice grade telephone channel.

The MC6860 offers compatible functions for 100 series data sets and 1001 A/B data couplers. Of course the MODEM interfaces directly with the ACIA in microcprocessor-based data comm systems.

M6800 family second source

Motorola has solved the alternate source problem of many engineering and purchasing managers by signing an agreement with AMI for a true second source, where we share similar processes and the same masks.

is synchronized with the array to respond only to light emitted during the normally dark periods, thereby only picking up the row that's flashing out of sync.

When the flashing row sweeps beneath the light pen, it is detected, and the row is thus identified. For example, if the pen picks up light and vertical row No. 3 is the only row flashing, the vertical line of position of the light pen is known. The horizontal row is then established and the point on the panel determined. This information is passed on to the array at the other end of the telephone wire, and remote writing takes place.

Images to be transmitted, such as photographs or diagrams, are photographed by a television camera or are line-scanned. The gradations between white and black are put into digitized form and transmitted by wire to appear on the screen of the remote terminal.

Bell's laboratory model has already proved that it can do the following:

- Record a person's signature and then display it on command.
- Reproduce pictures and charts at the rate of a few a minute.
- Display a list of telephone numbers. When the light pen is pointed at one, the number is automatically dialed.
- Serve as a desk-top calculator.
- Display the time and date on command.
- Display a typewriter keyboard, allowing hunt-and-peck entry to a computer.

The Bell unit is still in the research stage and not for sale at this time. The goal at this time is to reduce the control-circuit costs and lower the power needed to light the panel. ■■

Typewriter for handicapped uses special solenoid unit

Severely handicapped people can use a conventional electric typewriter when it's equipped with a specially designed keyboard for the feet and a solenoid unit to act as an interface.

Palmstienas Mekaniska Verkstad AB in Sweden, which built the keyboard, has also produced several other keyboards that can be operated by other parts of the body. The solenoid unit was manufactured by Magnetic Devices Ltd., Suffolk, England.

The foot keyboards are enlarged, modified versions of a standard typewriter keyboard. Pushbutton switches are mounted on a single printed-circuit board which links the switch terminals to a cable that plugs into the interface.

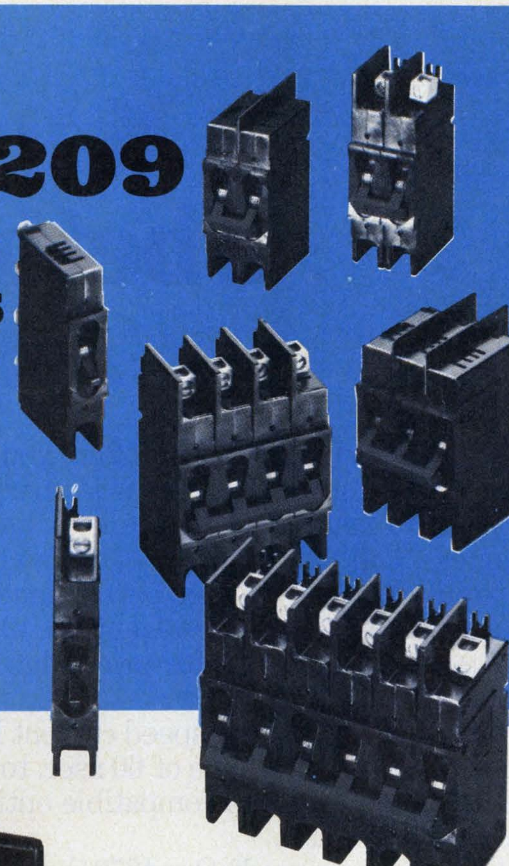
The unit is mounted over the keyboard by means of a simple clamp. Each solenoid is aligned so that when activated it pushes down the right key.

Operator controls are provided on a single three-way switch mounted on the interface unit. They allow the machine to be turned on and off and operated at various speeds, which are selected by varying a resistor in a time-delay circuit. ■■

INFORMATION RETRIEVAL NUMBER 22

AIRPAX™

TYPE 209 E-Frame Circuit Breakers



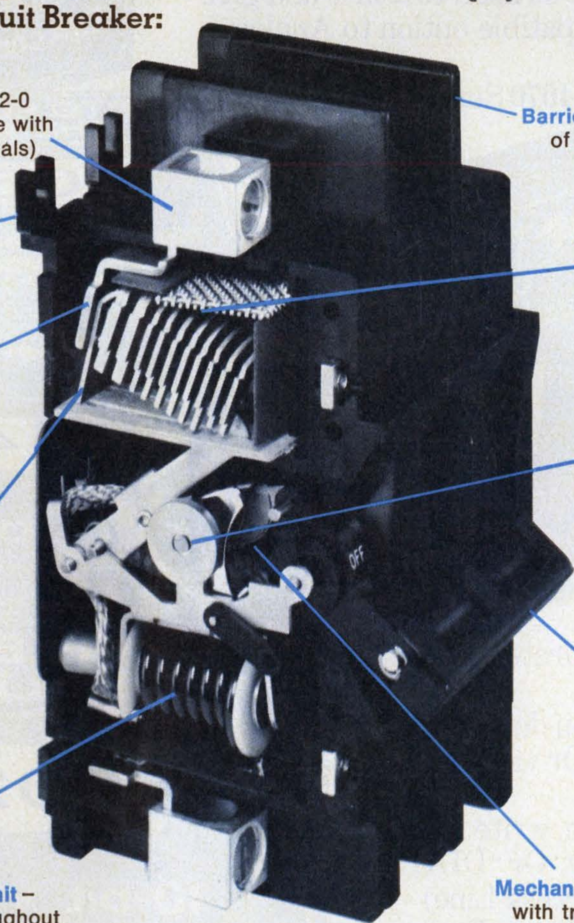
Airpax Type 209 molded-case circuit breakers are designed for use by the original equipment manufacturer. The hydraulic/magnetic principle provides stable trip points over a wide ambient temperature range. Typical applications include: refrigeration, air conditioning, power supplies, computers, and others.

Features:

U.L. listed for branch circuit protection.
Current ratings to 100 amperes.
Voltage: 125V dc 120/240V ac
240V ac 277/480V ac

Construction: Series, relay, shunt, auxiliary switch.
Terminations: Solderless connector, screw or stud terminals.
Time Delays: Instant, short, medium, or long.

Here's the inside story of the Airpax Type 209 Circuit Breaker:



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Cambridge, Maryland 21613
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AIRPAX™
Cambridge Division

Want to know more about these compact, competitive Type 209 breakers? Write for Airpax Bulletin 2012.

INFORMATION RETRIEVAL NUMBER 21

You won't get a better DAC deal. Anywhere.

Because Teledyne Philbrick offers you the broadest line. The tightest specs. The best price/performance.

We're talking about our economy line DACs, for starters. The **4020** Series of 8, 10, and 12-bit DACs feature adjustment-free high performance at very low cost.

And our **4039QZ** general purpose 12-bit DAC gives you a pin-for-pin, price-for-price edge in second sourcing the DAC-12QZ.

Our **4060** Series high speed current DACs have a guaranteed settling time of 60 nsec. to $\pm 0.1\%$ and give you a competitive and compatible option to Analog Devices and Datel.

Still not convinced? Our **4070** Series high speed multiplying DACs are unmatched in terms of specs and performance. Our **4072** is a 12-bit MDAC, the fastest in the industry with 500 nsec. at .01% accuracy.

In the high reliability, guaranteed performance area, we'll soon be announcing a 12-bit microcircuit DAC which will be the fastest and most accurate for MIL-STD applications.

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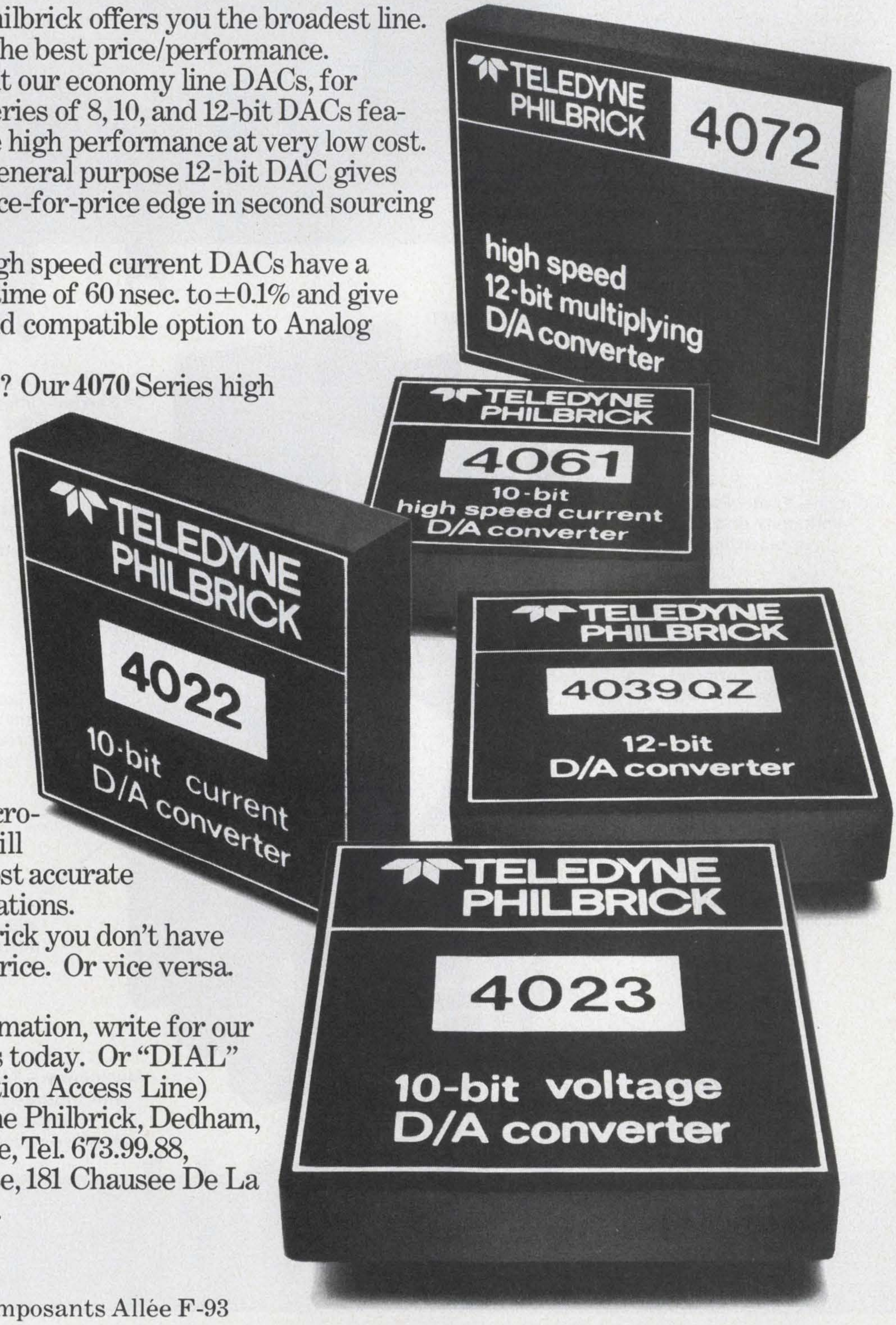

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INFORMATION RETRIEVAL NUMBER 20

the amplitude of oscillations to a level at which discrete transistor Q_c interrupts the coil current. When the oscillator amplitude has decreased below the switching level, a variable-feedback system in the IC maintains a minimum amplitude of oscillation.

System performance is comparatively independent of dQ/dt—that is, pulse amplitude and noise immunity are maintained over a wide range of rotor speeds. Capacitor C2 parallel-resonates the circuit at between 200 and 400 kHz.

An output circuit produces a switching signal, ϕ, at terminal 4 and its complement, $\overline{\phi}$, at terminals 6 and 7; signal ϕ is high in response to a high-amplitude oscillator state. When ϕ is high, Darlington-connected transistors Q_b and Q_c are driven by base current supplied via resistors R_f and R_g, so current flows through the primary winding of the ignition coil. The peak coil current is limited by a current-setting transistor, Q_a, in response to the voltage drop developed across current-sampling resistor, R_h.

A spark is generated when output pulse ϕ goes low and $\overline{\phi}$ goes high. Switching is initiated by a low signal at terminal 4 that turns transistors Q_b and Q_c off.

When the current flowing through the coil primary is interrupted, its stored energy is transferred to the secondary circuit, where it produces a high voltage that fires a spark plug.

Diode D1 protects Q_b and Q_c against excessive negative voltages and the application of reverse battery voltage. Components C1, R_c, D3, C5, R_1 plus the output amplifier assure that noise won't affect switching.

The 0.063-by-0.075-in. custom bipolar chip is in a 14-lead dual-in-line plastic package.

Sanquini notes that although the IC is designed mainly for automotive use, it is equally suited to a variety of industrial applications such as tachometers, speed-control and proximity detectors. ■■

Plasma-panel displays modified to transmit images via telephone

A flat-screen video system that transmits handwriting, reproduces pictures and can communicate directly with a computer has been demonstrated by scientists at Bell Telephone Laboratories, Holmdel, NJ.

Instead of the conventional CRT display, the system uses a commercially available plasma display, the Owens-Illinois Digivue 80-33, modified for added capability. The panel consists of an 80-by-256-element array of neon-gas cells.

With logic and control circuitry, the panel can detect the position on the panel of a passive, light-sensing pen. A grid coordinate corresponding to the pen's position is transmitted by telephone to a second display. Researchers can write or draw on a panel with a light pen and have the same image appear on the display connected by telephone many miles away.

Plasma panels were chosen instead of CRT for these reasons: They are flat, which makes them convenient to put in a desk-top terminal. They are completely digital, whereas a CRT is analog.

Flat-screen plasma panel transmits photographs, drawings and writing to remote panel by telephone wire.

And they have inherent memory; once a cell is lighted, it stays on.

To alter a picture—to change one portion of a drawing, for example—only the changes are transmitted. This permits a tremendous cut in required bandwidth. To change an element in a picture on a CRT, the entire picture must be retransmitted. This need for large hunks of bandwidth has been a deterrent to the picture telephone.

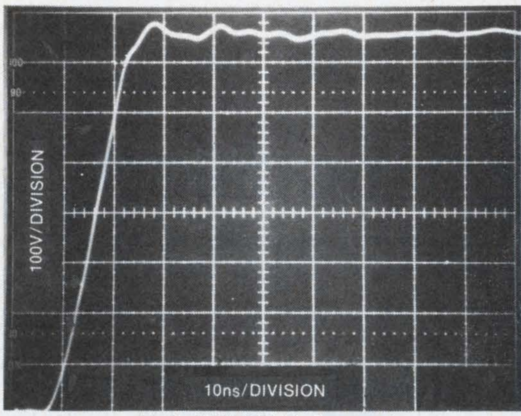
How is the light pen's position detected? William Ninke, head of Bell Laboratories' Digital Systems Research Dept., explains:

The array's cells are programmed to flash simultaneously for 1 μs once every 10 μs. This means that they are all dark for 9 μs out of 10. The eye doesn't detect this, of course, but sees instead a steady glow.

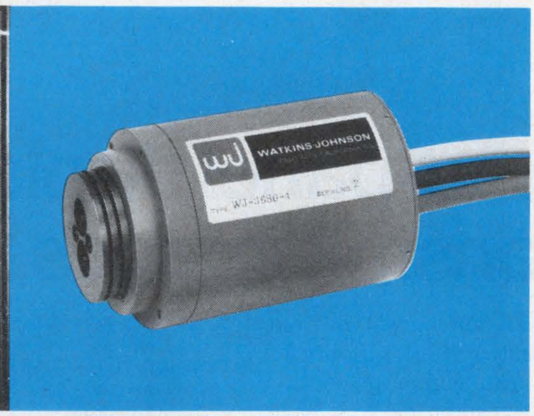
To use the light pen, the operator first touches the pen to the panel, thereby activating special circuitry that causes the panel cells, row by row, to begin flashing at an offbeat time during the 9-μs dark period.

The pen, a passive light sensor,

750 Volt Output in less than 12 nsec. from a new pulse amplifier



(Typical WJ-3860 Performance)



(Photo of WJ-3680)

Now available from Watkins-Johnson, this Electron Bombarded Semiconductor (EBS) has been designed for high-speed, short-delay, fast-rise-time switching and modulation applications.

The WJ-3680 provides up to 750 volts of peak output voltage and over 7 amperes of peak output current for fast-rise-time modulation of capacitive loads. Thus, this amplifier can produce a 750-volt pulse across a 100 pF load with a risetime of less than 12 nanoseconds, a pulse width of up to 50 microseconds and a 4 percent duty factor. Even faster risetimes can be achieved with lower load capacitance. Delay time is less than 5 nanoseconds and pulse-to-pulse jitter is negligible.

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INFORMATION RETRIEVAL NUMBER 19

First IC ignition system in cars offers better engine performance

What is reported to be the first use of an IC in a commercial electronic ignition system is giving every 1975 American Motors car an improved breakerless ignition system.

Details of the circuit were revealed at the recent Solid-State Circuits Conference in Philadelphia in a paper by Richard Sanquini, director of IC products at RCA's Solid State Div., Somerville, NJ, and William Roberts, engineer at the Prestolite Electrical Div., Toledo, OH.

Electronic ignition eliminates the need for breaker points in controlling the ignition coil used to fire spark plugs. Points are a significant maintenance item and, if worn, can directly affect engine performance.

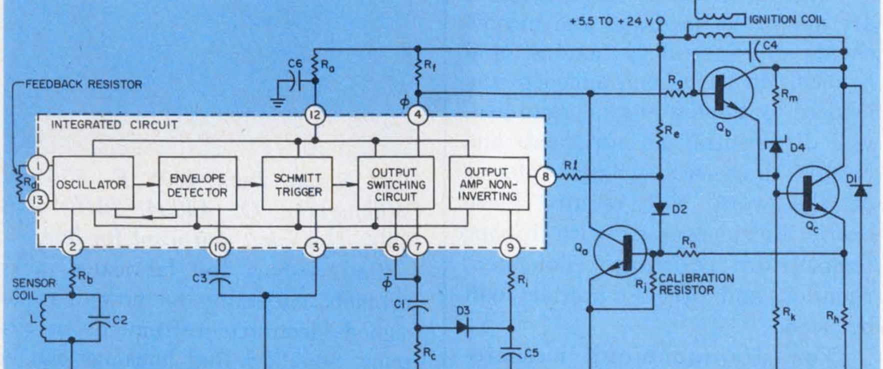
The circuit approaches that car manufacturers are using for electronic ignition differ significantly. General Motors—the first company to introduce such a system— employs a "unitized" ignition system consisting of hybrid thick-film circuits. Both Ford and Chrysler use discrete semiconductors on a PC board.

The RCA circuit is part of a new electronic ignition system developed by Prestolite—a major manufacturer of electrical parts.

Nonmagnetic sensor used

The complete breakerless ignition system consists of a distributor containing a toothed metallic trigger wheel, a nonmagnetic pickup coil (mounted on the distributor housing), an electronic control unit (with IC and other circuitry) and an ignition coil.

Electronic ignition hardware consists of distributor with trigger wheel, printed-circuit board with IC, sensor coil (mounted on distributor housing) and enclosure.



Operation of the integrated circuit in the breakerless ignition system depends on the accurate amplitude modulation of a resonant circuit oscillator in which the inductor—acting as the sensor—interacts with the trigger wheel in the distributor. The IC is manufactured by RCA for Prestolite.

According to Sanquini, the unique feature of the breakerless system is that it contains a nonmagnetic sensor in place of the magnetic pickup used in other commercial electronic ignition hardware.

"In today's systems using magnetic sensors, the sensor output varies from about 40 mV when cranking (about 2 rpm) to about 80 V at 6000 rpm," he notes. "This results in a considerable dynamic range problem and complex processing circuitry to assure the proper ignition coil voltage level—about 14 kV in a typical auto ignition system."

In the nonmagnetic sensor system, the sensor output voltage varies over a much smaller range (between 1.5 V and 8 V pk-pk). It does not depend on rotor (engine) rpm thereby assuring a good spark even at low battery voltages and at very low auto speeds.

Sanquini says the system is capable of delivering 17 kV pk at 5.5 V, at an engine rpm rate of less than 200 and a temperature of −40 C. At 5000 rpm, a 24-V supply and a temperature of +25 C the system delivers 30 kV pk.

Inductor doubles as sensor

Operation of the circuit (see diagram) is based on the accurate amplitude modulation of a resonant-circuit oscillator, in which the inductor acts as the sensor. When the conductive material of the trigger wheel in the distributor enters the field of the sensor (L), eddy-current losses in the nonmagnetic wheel tooth reduce the Q of the resonant circuit. This decreases the use of three acoustic receivers to point to the origin of the noise. The near-surface instrumentation includes acoustic and seismic arrays. Subsurface instrumentation consists of resistivity probes, geophones, gas-sampling tubes, gas-pressure gauges, tilt meters and displacement gauges.

To study characteristics of the burn front firsthand, thermal sensors will be used to determine its position, its uniformity, the rate of temperature increase ahead of the advancing front.

Resistivity sensors will be used on the surface of the earth to determine changes in resistivity at depth.

Tilt meters will be installed at one or more points above the seam in holes that the flame will pass. Changes in gauge position with respect to the vertical will indicate bending in the roof structure that may precede settling.

A differential displacement gauge may be used in selected holes nearest the center of a burn, in an attempt to measure the time and nature of settling.

Some of the equipment for the tests has already been selected:

Geophones will be the Geotech SC 20Es, capable of a response from 20 to 800 Hz. These receivers will be used for vertical displacement measurements.

Two-axis tilt meters made by Humphrey, Inc., San Diego, will have a sensitivity of ±0.5 deg. Sensitivity has been sacrificed for temperature hardness, Northrop says. The meters have been repackaged in waterproof cannisters with a Bendix compass.

Chromel Alumel thermocouples are magnesia-insulated and inconel sheathed. Special junctions and branchings have been added to the devices by Sandia engineers to provide differential measurements and circuit diagnostics. Later phases of the work will require more exotic thermocouples with higher temperature resistance. Tungsten, rhenium and other materials will be used.

"For displacement measurements, we'll be making gauges ourselves," Northrop says. "They'll be based on the constant-torque spring made by Celesco. The devices give you a potentiometric readout of displacement." ■■

burning, Sandia must drill a hole down to the coal seam for the injection of air and oxygen. The gas created by the heat—chiefly hydrogen and carbon monoxide—then escapes through other holes to the surface, where it is used to generate electricity.

A fairly large coal deposit can supply a generator for many years, according to Sandia's project manager for the experiment, David A. Northrop.

Precise and continuous knowledge of the burn front's location is needed so more—or less—oxygen can be supplied either to accelerate the burn, slow it or stop it altogether. Sandia's goal is to develop a process-control system that will make this almost automatic.

The first step will be to evaluate instrumentation sensors and measurement techniques in an in-situ coal gasification experiment. This work will be conducted from April through October near Hanna, WY, by the Energy Research Development Administration's Laramie Energy Research Center. The coal seam is about 30 ft thick and some 300 ft below the surface.

Detecting from the surface

Sandia wants to see how well various sensors can pinpoint the burn front as it proceeds through the coal seam, and at what distances they can do this.

Eventually Sandia hopes that sensors near the surface will be able to detect the burn front's location deep down in the seam. In the experiment, however, deep measurements will be made to learn more about the front's characteristics and to evaluate remote techniques.

Does the burn front make distinctive noises that will identify it? And if it does, will these noises be sensed over distances great enough for use in a process-control system?

It's possible that geophysical noises might block the burn front's noises or distort the readout.

To test this, the experimenters will induce their own noises by detonating small explosives of known power and location.

How will the burn front be pinpointed? A possible solution, Sandia says, is by triangulation—

New sensors spur 2nd try to gasify unmined coal

Wouldn't it be convenient if we could just burn coal in the ground, where nature put it, without ever having to dig it up? The heat would create gas, which could be piped to the surface to make electricity. The process would be cheaper than mining and infinitely less disturbing to the environment.

Well, the concept has been tried, but it's going to be tried again. About 15 years ago the Bureau of Mines attempted in-situ gasification of coal in Alabama, but the process was expensive, compared with the cost of natural gas at that time. And there were technical problems—they couldn't keep the fire going. At about the same time the bureau also tried to make liquid gas from coal deposits in Missouri, but this also was too expensive.

John F. Mason
Associate Editor

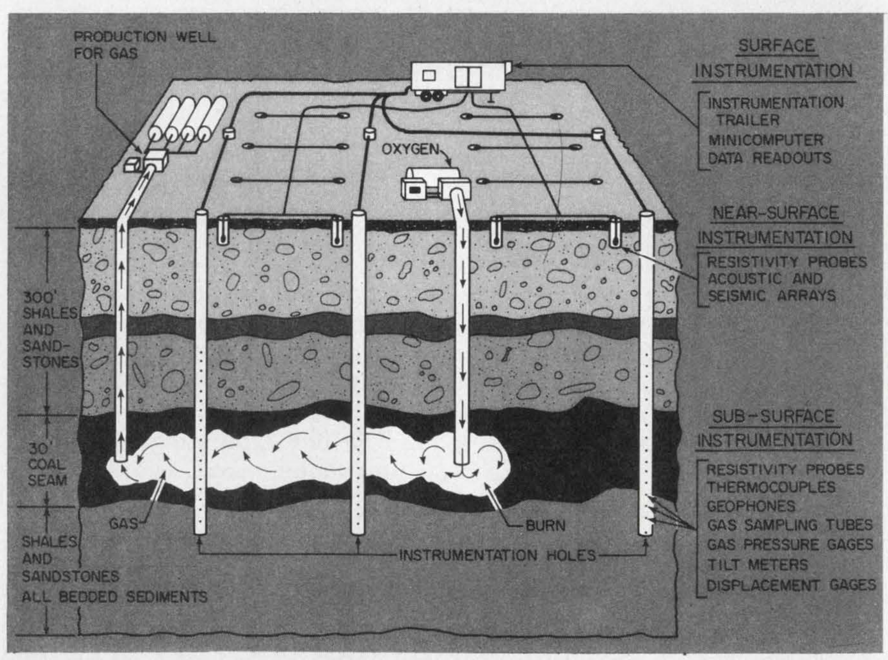
Today costs are regarded differently, instrumentation has improved and the minicomputer is capable of producing real-time maps of what's going on in the coal deposit. All this makes it possible to develop a process-control system for in-situ gasification, the U.S. Energy Research and Development Administration reasons.

As for keeping the fire going, this can be achieved, it is believed, if a thicker seam of coal is worked than the one in Alabama.

Undertaking the task for the new Federal energy agency is Sandia Laboratories' Energy Technology Dept. in Albuquerque, NM.

The test will require hundreds of sensors to be planted just beneath the earth's surface and others in 18 deep wells, or tubes, near the burning coal seam. A minicomputer and sensor readers will be housed in a trailer.

To ignite the coal and keep it



Near-surface instrumentation alone will ultimately monitor burning coal hundreds of feet below the earth's surface in an attempt to generate electricity. Initial tests, however, will require instruments near the burning coal, so the actual performance of the remote sensors can be accurately evaluated.

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Because the F77 also incorporates a very capable, independent sweep generator offering linear and logarithmic performance, with a selection of auxiliary outputs. Sweep up or down, sweep reset control, and continuous, triggered, burst, sweep-and-hold modes, too. Interstate's special frequency dial has a direct-reading sweep limit cursor, plus two calibration scales (X1 and X2) to improve resolution and permit continuous tuning across the 20 Hz-to-20 KHz audio band.

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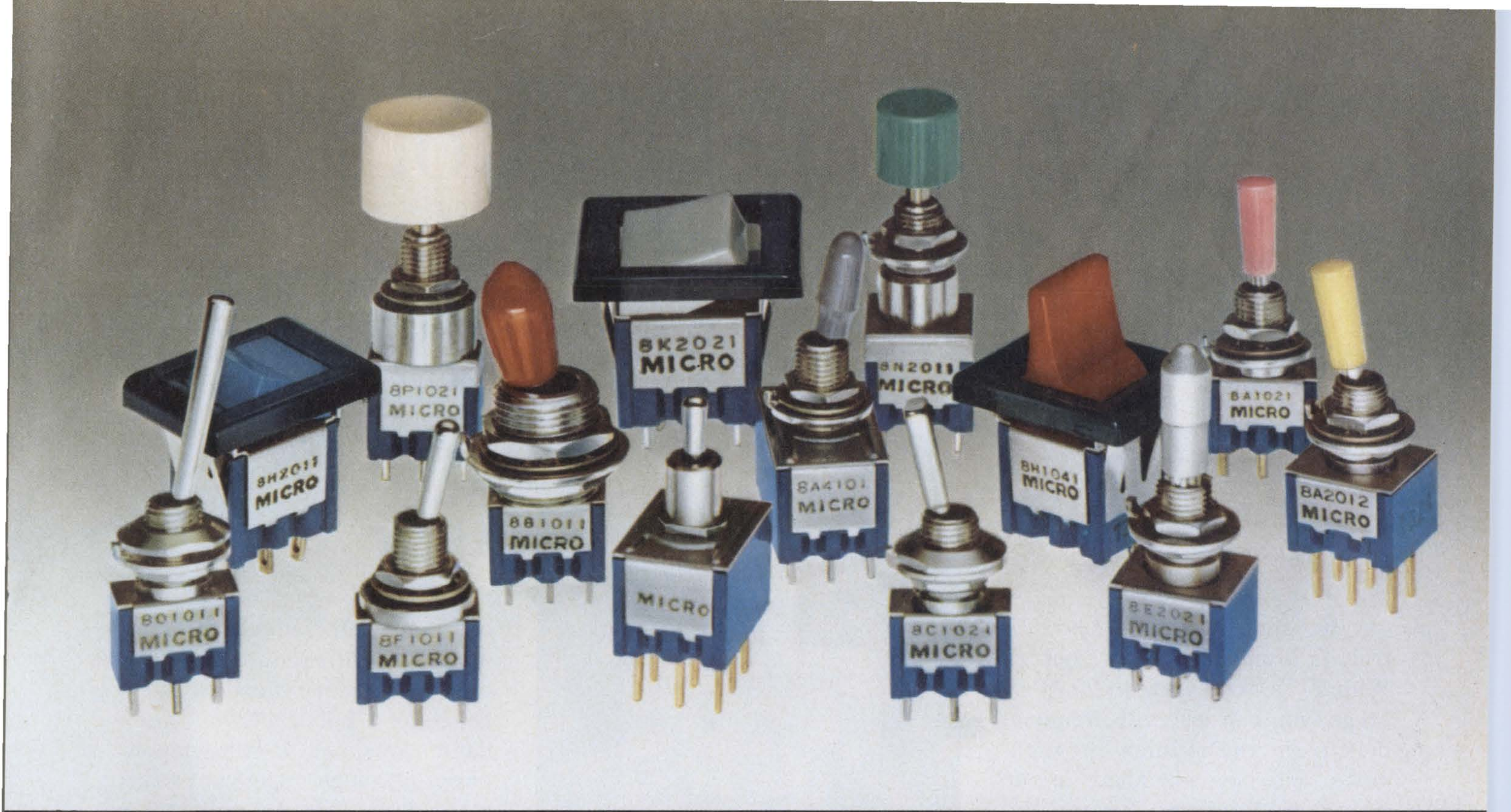

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but also increases the thermal stability of the MOS device.

RCA's Solid State Technology Center in Somerville, NJ, is also an active researcher into hardened MOS/LSI. But Stanley Rosenberg, manager of custom monolithics, reports: "We are looking into CMOS/SOS as well. We use a silicon-gate process and do not do any chrome doping of the gate oxide. Our approach uses conventional CMOS processing steps, but we grow the silicon gate at a much lower temperature than normal."

The RCA process, which is also reported to require an ultra-pure gate oxide, has the advantage of being self-aligning, resulting in faster circuits. RCA has demonstrated ionizing dose tolerance of better than 10^5 rads so far, according to Rosenberg, and he expects to achieve 10^6 rads shortly.

Rockwell also plans to go to a self-aligned structure in the next few months. It will still be a metal-gate process, but for alignment, the company will use a silicon-nitride layer that is deposited before the gate oxide. Once the channels are made, the nitride layer can either be removed or left in place to become part of a sandwich with a conventional silicon-dioxide gate insulator. Rockwell will probably try a silicon-gate process as well, but later in the program.

A third approach to the gate structure is being pursued at Hughes Aircraft under contract to the Navy. According to Kenneth Aubuchon, senior staff physicist: "Our devices are CMOS/SOS aluminum gate. We don't use chrome doping. We rely on a pure, controlled gate oxide. In tests on a triple inverter we have achieved ionizing dose tolerance of better than 10^6 rads."

Hughes is working on an 8-bit adder with a complexity of several hundred devices per chip. It also has worked with a nitride-layer, self-aligned gate process.

So far just logic

Most of the testing so far has been on logic circuits. Rockwell has done some work with 32-bit shift registers but has primarily concentrated on the 4007-type CMOS triple inverter. RCA has done most of its testing with 4007 CMOS 4-bit adders. These are MSI circuits with 170-transistor complexity.

Rockwell's program calls for later testing with a 550-transistor, 8-bit adder, a 714-transistor, 64-bit random-access memory and, ultimately, a circuit with at least 1000 transistors.

Everyone is aiming for good results at very high levels of complexity. Hughes notes: "We hope to be able to analyze chips with higher-level LSI, such as a microprocessor, within a year to 18 months. Until we get there, we won't truly know the extent of the problems involved in radiation-hardened LSI."

McKay of AH Systems observes: "Microprocessors might even allow alternate paths to the solution of some radiation problems. For example, with a microprocessor, a fast shutdown program would help avoid transient failures. We don't know yet whether the chips will be fast enough to do this."

An additional problem that Rockwell is working on is the formation of a back channel in the silicon by the trapping of charge in the sapphire itself. Impurities in the sapphire lead to charge trapping. These charges excite a layer of charge in the silicon that causes leakage current when the MOS transistor is otherwise off. The result is that the device has higher stand-by power dissipation. A possible cure, Bell notes, is boron doping of the silicon near the sapphire interface. This would be done with deep ion implantation.

Rosenberg of RCA points out: "A pleasant fact to report is that the process of hardening MOS/LSI does not seem to affect the electrical performance of the circuits in any adverse way. It ultimately looks like we will achieve the same densities and performance with hardened MOS that we now achieve with commercial chips." ■■

Three radiation problems cause concern

The three radiation problems of most concern to the military are ionizing dose tolerance, ionizing dose-rate tolerance and neutron fluence tolerance.

X-rays and gamma rays cause photocurrents to flow from source to drain while the rays are impinging upon an MOS device. A dose rate of 10^6 to 10^8 rads/s is enough to change the logic state of most MOS devices. For a device to be considered hardened, it must be able to withstand an ionization dose rate of better than 10^8 rads/s. Once the X-rays and gamma rays cease, the photocurrents stop.

However, in addition to the creation of photocurrents, the X-rays and gamma rays cause charge to be trapped in the gate oxide. This charge is cumulative as long as the bombardment by radiation continues. The charge-trapping causes the threshold voltage of the MOS device to move to a higher level.

At about 10^4 rads the threshold voltage starts to change rapidly in most MOS devices. The ionization dose tolerance required before a device can be said to be fairly hard is on the order of 10^6 rads—that is, the threshold must not start changing significantly until the total dose exceeds 10^6 rads. These radiation dose numbers are approximate and vary with device, materials and construction technology.

In addition to X-rays and gamma rays, the circuit is likely to be bombarded with neutrons. The rate of bombardment in neutrons/cm^2 is called the neutron fluence. MOS devices are inherently resistant to neutrons. The neutron-fluence tolerances for MOS devices, even commercial ones, are in excess of 10^{15} neutrons/cm^2.

Neutron fluence is a problem in bipolar devices, however. It leads to degraded current gain. Gold doping is used to lessen the problem in TTL integrated circuits and other bipolar devices.

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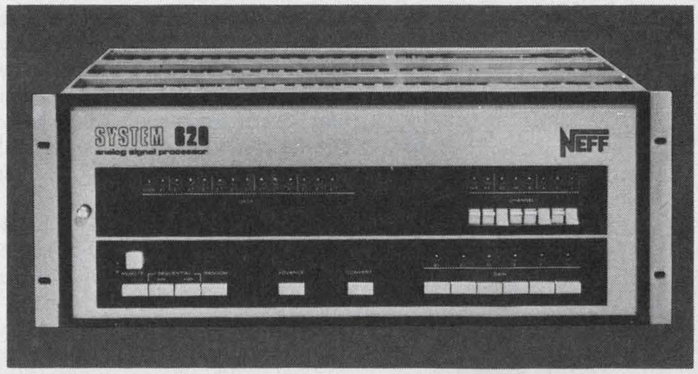

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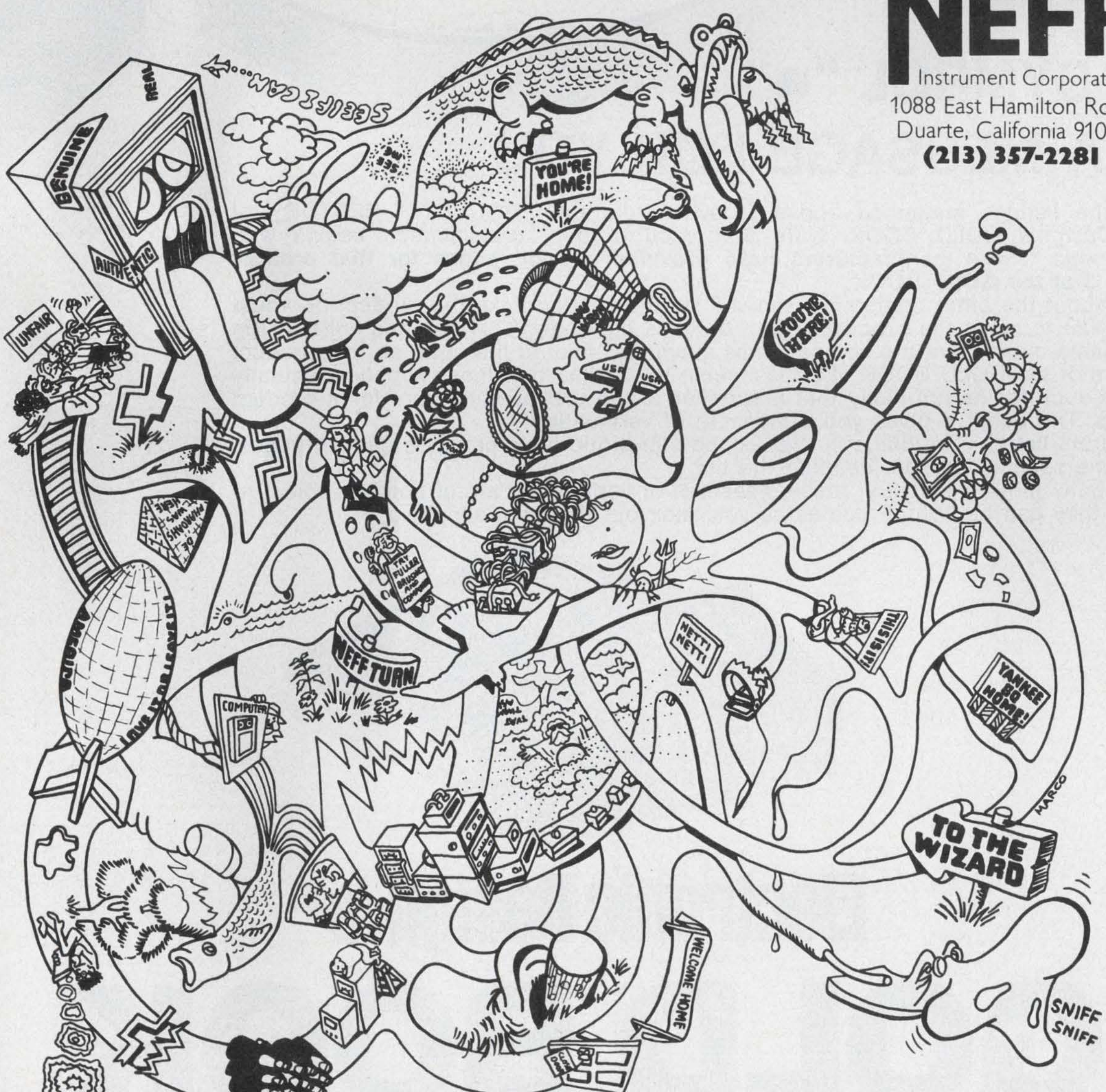

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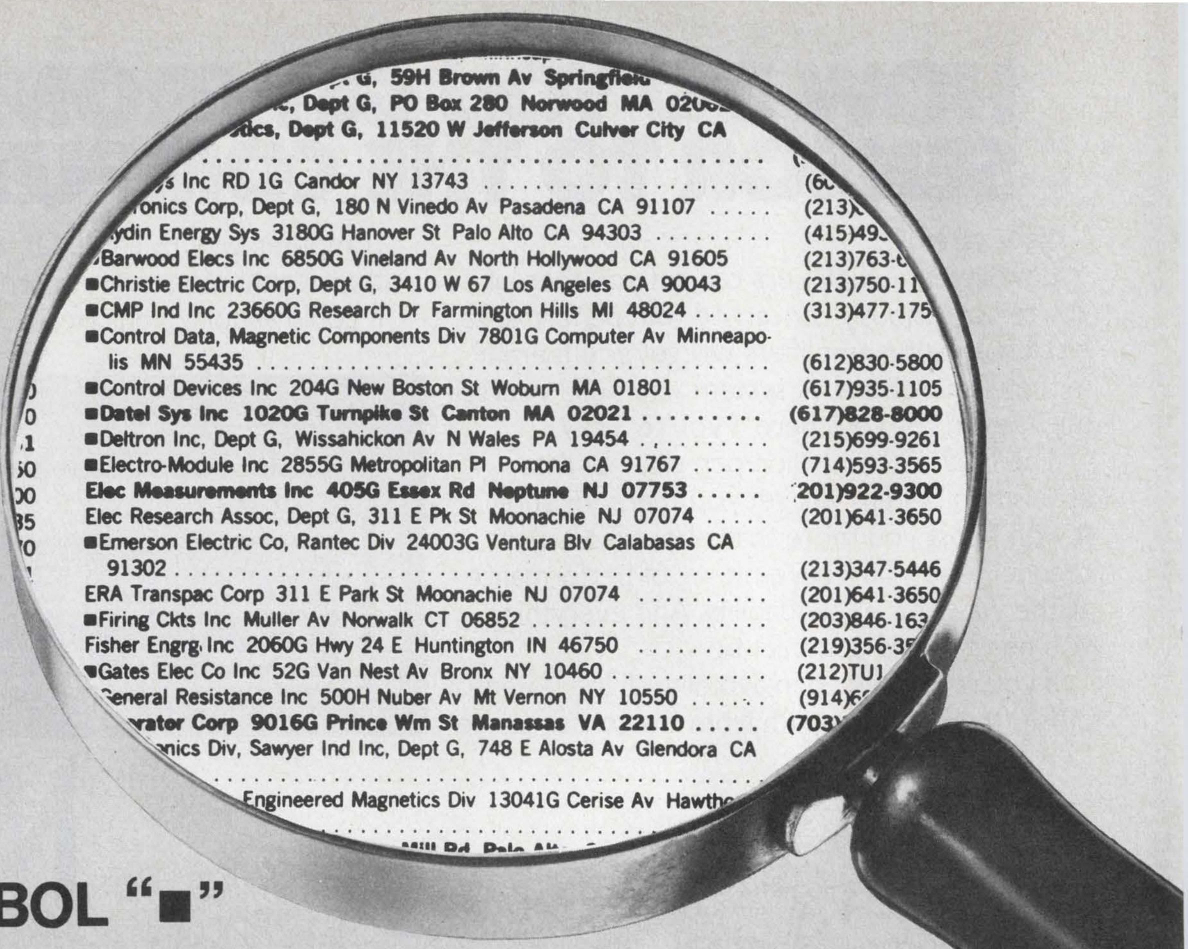

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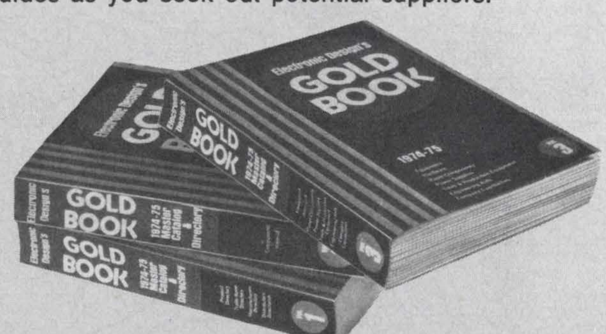

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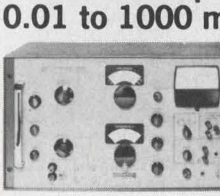

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The 102A is engineered for your convenience. That's why we've designed a front panel that is easy-to-use and understand, why we have the specifications decaled on the top of the instrument in plain view, why we've added a unique adjustable "feel" main drive mechanism for easy narrowband receiver setting, and why we have a full list of optional goodies—like a detected AM output to verify our negligible phase-shift for VHF omni-testing, fused RF output with replaceable elements, and external clock input.

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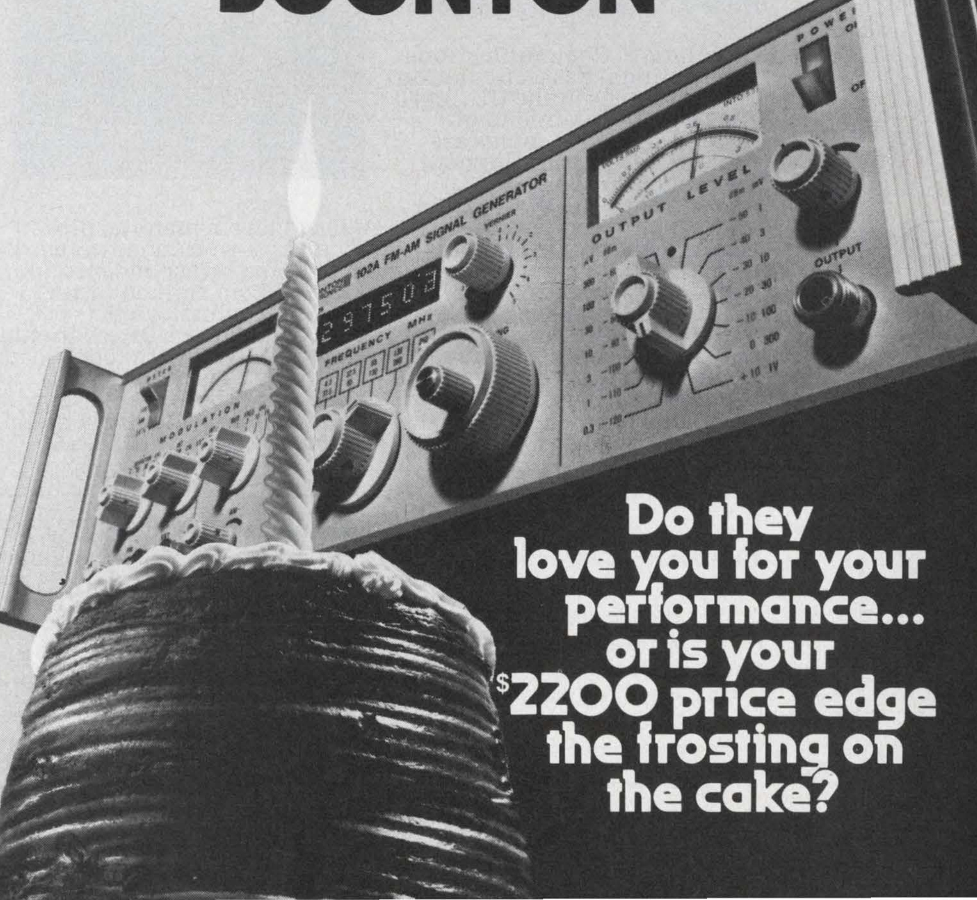

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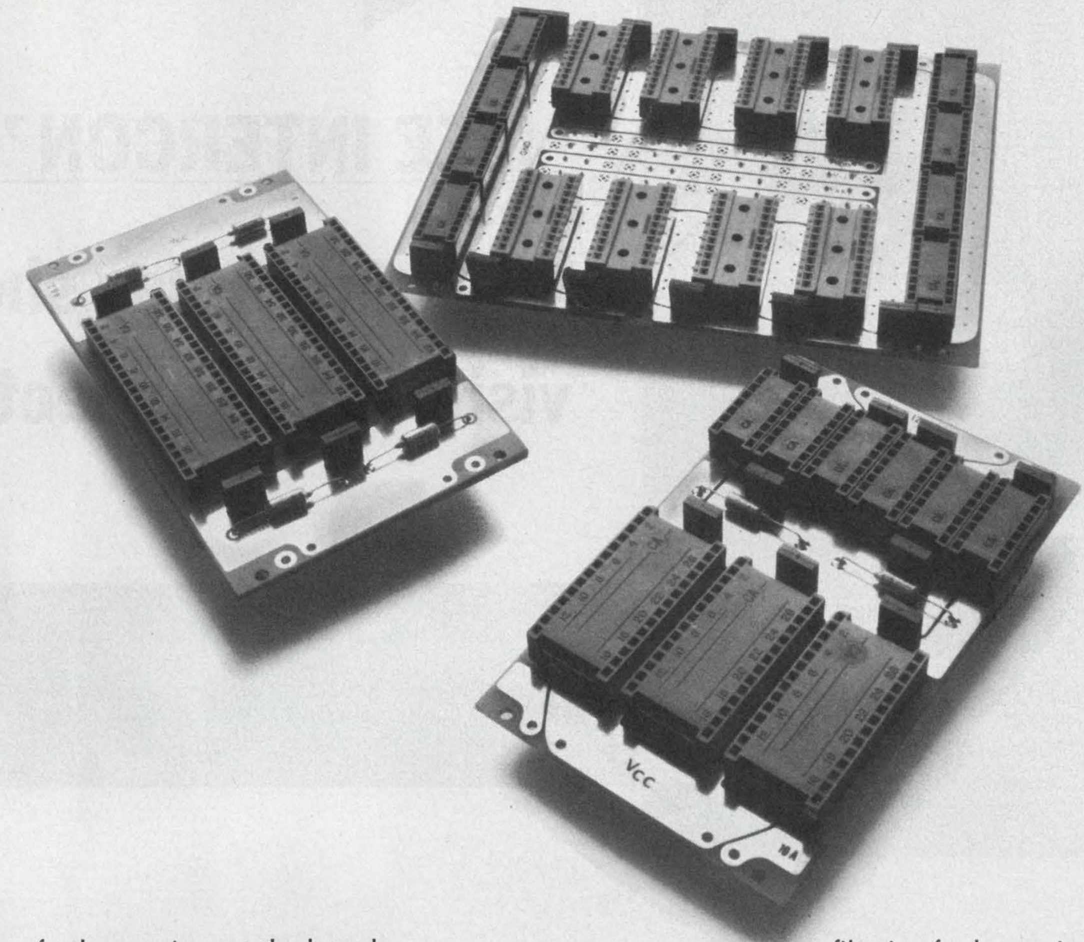

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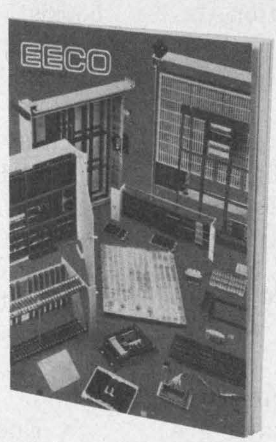

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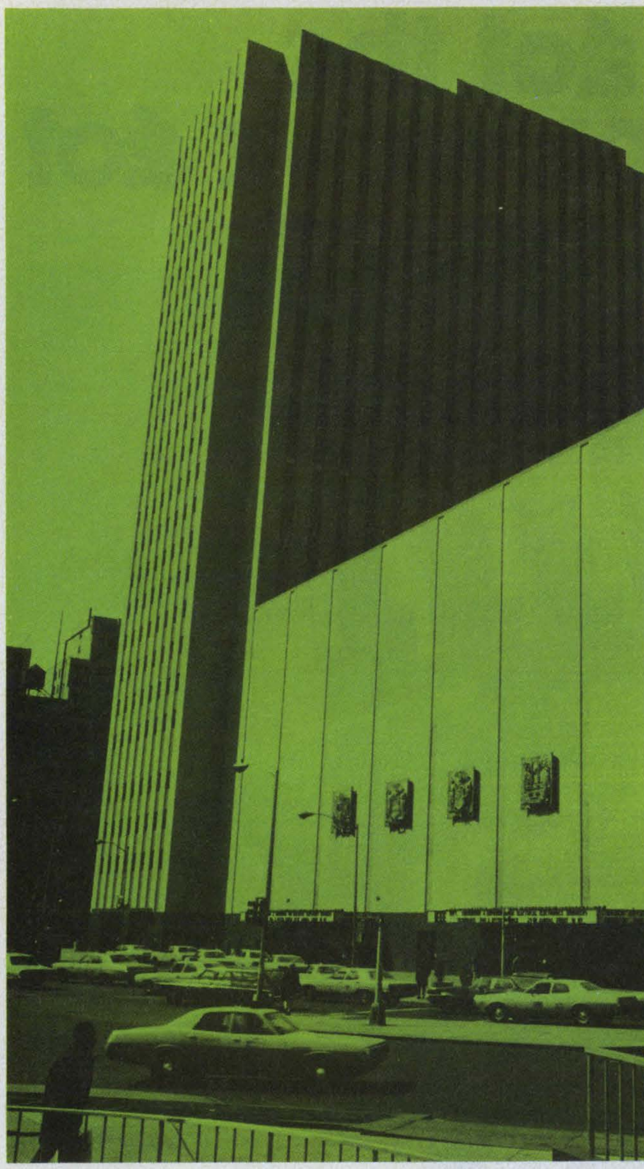


IEEE INTERCON '75

It's a 3-day show visitors are expected

Big changes are in store for the IEEE show the next two years. Breaking with tradition, Intercon '75 moves into a new month and will be held in April instead of March. It also becomes a three-day event rather than four.

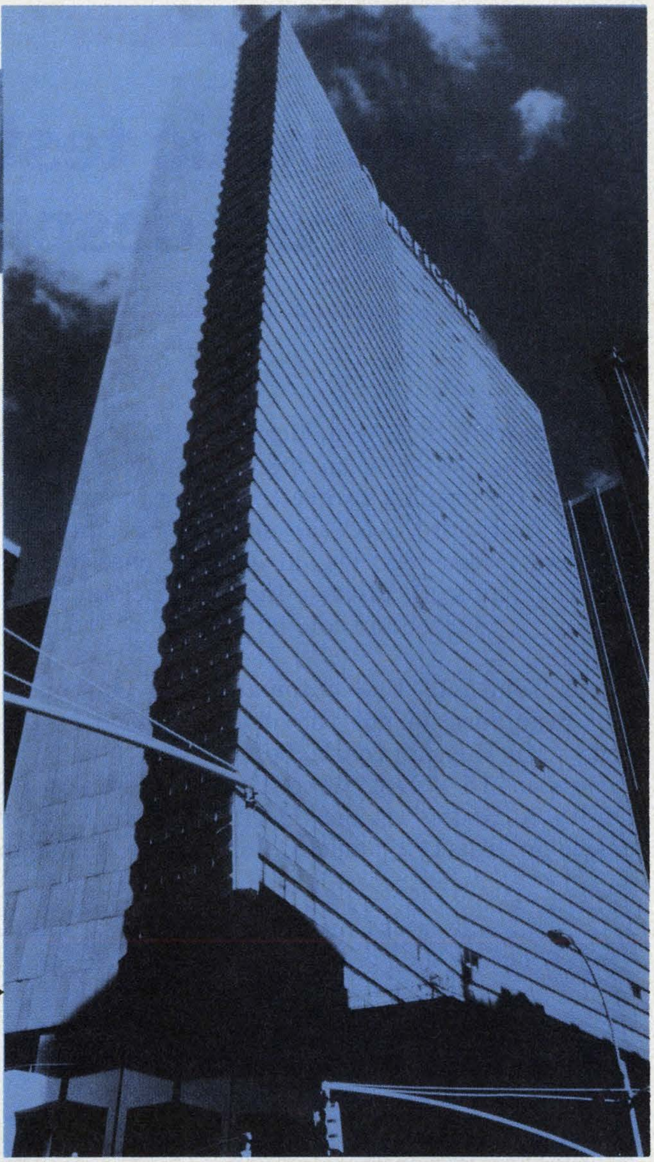
In 1976 a new IEEE convention and product exposition called "Electro" will debut. This follows the merger last year of IEEE's Intercon and the Northeast Research and Engineering Meeting (NEREM). Electro '76 will be held in Boston and then move back to New York in 1977, alternating between the two cities in succeeding years.

Today's uncertain economic picture makes Intercon size predictions difficult, but estimates are that some 300 companies will show their products in 340 booths—an increase of about 10% over 1974. Attendance is expected to be in the neighborhood of 25,000.

The exhibition will be held April 8-10 in the New York Coliseum. The major technical program will be in the Hotel Americana and will consist of 37 three-hour sessions—six concurrently on the mornings and afternoons of April 8, 9 and 10, with a highlight session Wednesday evening dealing with the social implications of nuclear power plants.

On Monday, April 7, there are 10 specialized sessions, organized by IEEE groups and societies to serve more "vertical" interests. These sessions will be on:

- Data Privacy and Security.
- Systems Approach to Energy Management.
- Control and Reduction of Automotive Pollution.
- Energy: The View From 2000.
- Space-Shuttle Experiments.
- Technology Forecast—The Future of Components.
- The Engineer in Transition to Management.
- Advanced Industrial Applications of Infrared Techniques.



now, but 25,000 to tour 340 booths

▪ Open Forum on the Society-Technology Interface.

▪ A Forecast of Computer Hardware and Software 1975-1985.

The technical papers cover the latest technological developments and trends in several key areas. Session 15, for example, looks at ways of simplifying the testing of LSI devices, while Session 33 reports on new measurement techniques in telecommunications.

In computers, the action is still in microprocessors but, as reported in Session 1, the scene has shifted from discussions of different designs to new uses for these versatile devices.

The latest design trends in digital logic devices are covered in Session 18. Papers here discuss renewed interest in triple-diffusion technology and a movement among manufacturers of small-scale CMOS parts to buffered output devices.

A wrapup of these and other significant technical papers is offered in the following pages.

Design trends in major engineering areas

Outstanding new products on display at the New York Coliseum exhibit areas.

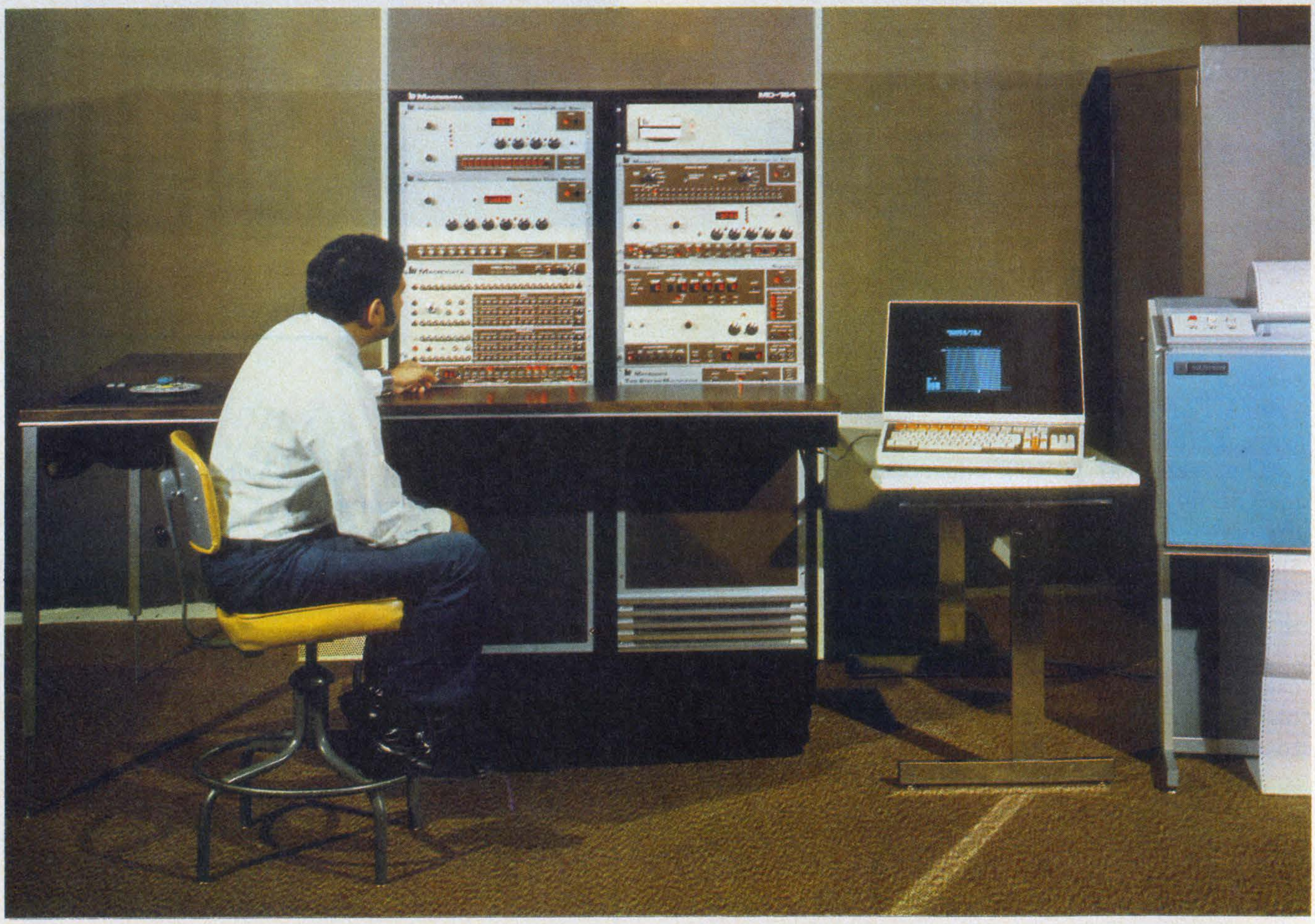
Automatic testing of LSI devices favored, despite some problems

The testing of LSI devices, like ROMs, RAMs and microprocessors, has become costly, says Arnold M. Greenspan, project engineer for the AAI Corp., Baltimore. And the problem is compounded, says Greenspan, organizer and chairman of IEEE Session 15, because the LSI package is becoming a subsection of larger, more complex systems.

His solution? Use automatic test equipment. But designers do not yet have too much experience with this approach, he concedes.

Session 15, "Test Generation Techniques for Digital Circuits," is considering how to make it easier to test LSI devices. Jon Squire, manager of operational software at the Westinghouse System Development Div., Baltimore, points out that whereas tests for PC boards with many ICs can be simplified by the addition of more test points to the board, this cannot be done with LSI. It requires too much chip area.

As an example of these test problems, Squire points to long shift registers, which may be 64, 28 or even 1024 bits. On a PC board a reset line can be included to set all the flip-flops into a known state, but an equivalent LSI chip has no space for the reset line, Squire notes in his paper, "Generating Tests for Digital Circuits Employing LSI Technology."



Charge-coupled devices must be tested in real time because information on the device is volatile. For test they require a special type of computer, like this Macrodata MD415 that handles simultaneous data fields.

The solution here, he explains, is to add to the chip one small circuit consisting of a NAND gate, an AND gate and an input pad. This can provide resets to all of the shift-register stages.

One problem when LSI circuits are analyzed for automatic testing, Squire says, is that it is difficult to model the circuit and to simulate it accurately. This can be simplified, he continues, by use of a clump of gates—instead of individual transistors—for the functional model. This approach, he reports, has enabled Westinghouse to produce accurate test tapes.

A unique test-design approach for a new 16-bit microprocessor by General Instrument has substantially decreased the design, development and debugging time of that company's CP-1600, says Richard Rubenstein, a member of the technical staff in the General Instrument Corporate Technical Center, Clifton, NJ.

In his Session 32 paper, "A Total Test Plan for a 16-Bit Microprocessor," Rubenstein explains that General Instrument uses the assembler it developed for the microprocessor to write the test patterns—an application of advanced software techniques to support testing.

"What we did," says Rubenstein, "was to fabricate the full CPU chip and another test chip on which we isolated the data path of the processor from the main-state ROMs, the control ROMs and the branching ROMs. With the test chips, we were able to debug the full CPU, the memory portion of the chip and the data-path portion—all independently of each other. This was possible because the art work of the microprocessor and its memories can be laid out so they can be easily separated for testing."

Rubenstein says General Instrument used the state diagrams of the device to generate the automatic test sequences. "We inserted bit patterns as a function of the state patterns and the instruction set," he notes.

A new LSI device—the charge-coupled device—presents a unique test problem because it is a volatile array that must be tested in real time, according to Roger Standridge, application manager of large systems for Macrodata, Woodland Hills, CA. In his Session 32 paper, "Charge-Coupled Device Testing," he describes the testing of a CCD photosensitive array, like the type used in CCD cameras.

"These area arrays have a set of bucket-brigade shift registers," Standridge explains. "A set of vertical registers feeds into horizontal registers to produce a serial line scan. We set the chip up in the dark and inject a specific dark current that corresponds to a gray level.

"We couple the CCD to a high-speed pattern-generator microprocessor—the Macrodata MD-154—which is a parallel microprocessor that can handle three separate data fields simultaneously.

The use of telephone voice channels for digital data transmission requires special line quality measurements. This Hewlett-Packard 4940A Transmission Impairment Measuring Set separates and simultaneously measures six types of transient line disturbances.

The CCDs typically run at 7.5 MHz, so a decision must be made by the computer in about 130 ns as to whether an individual cell of the array is good or bad.

"The computer looks for variations in the output about the specified test input-current level—that is, you're looking for a gray level, but you may get a dark spot or a light spot.

"If the output of an individual cell is above or below a given gray-level tolerance, we store the address of that cell in a high-speed memory. The test data are then reduced and put on a nine-track magnetic tape from which a batch-process analysis of the test is made to detect the flaws."

The demand for new data-communication facilities has far outstripped the construction of high-quality data networks, consequently most data-communication equipment uses low quality voice-band telephone circuits, and this presents problems in the testing and monitoring of line quality. Many factors that can be ignored for voice alone can contribute substantially to data-transmission error. A review of these problems and trends in the design of equipment to cope with them are the subject of Session 33: "Advances in Telecommunications Measurement Techniques."

Robert H. Allen, engineering manager of Hewlett-Packard's Delcon Div., Mountain View, CA, is the co-author with John H. Wetzel, product manager of a Session 33 paper on "Trends in Testing Analog Parameters for Data Transmission." The paper points out that these factors can produce data errors: amplitude distortion; dropouts, or abrupt large decreases in channel gain; gain hits, or sudden positive or negative gain change exceeding a preselected level; phase hits, or sudden shifts of channel phase beyond preselected limits; impulse noise; phase noise, or jitter; frequency shift, and longitudinal noise, or noise from line to ground. Allen sees two main trends in phone-line test-equipment design; (1) The combining of several formerly independent analog test sets into one master test set (like the HP 4040A Transmission Impairment Measuring Test Set), and (2) The increasing use of digital signal analysis (the HP 5453A Transmission Parameter Analyzer).

In the HP 5453A, a test signal is sent over the line and digitized on the receiving end. Signal analysis and line evaluation are accomplished by digital computer processing. ■■

COMPUTERS

Rise of microprocessors is cutting data processing and memory costs

Single-chip microprocessor devices can now perform many of the functions of the central processor in conventional computers, and this may just be the beginning. The use and application of these versatile circuits is the subject of Sessions 1 and 7.

Another computer-related subject of increasing importance, the design of fault-tolerant digital systems, is treated in Session 11.

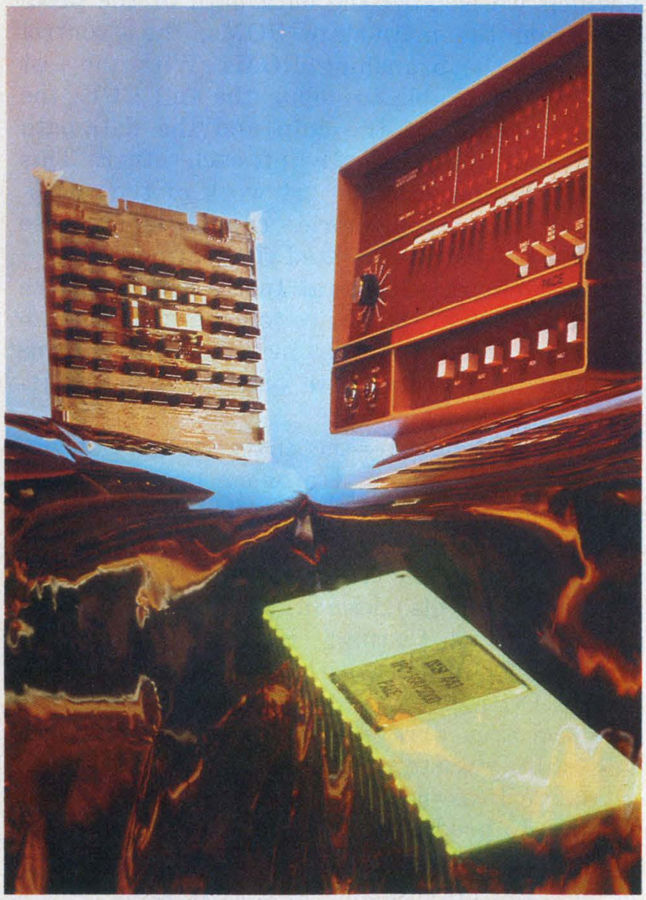
Carver A. Mead of the California Institute of Technology, Pasadena, CA, says of microprocessors in his Session 1 paper: "Historically a large fraction of the costs of a computing system has been in the central-processing unit and associated memory. The availability of single chips with the complexity of our current larger computing system reduces the cost of data processing and memory to an insignificant level. Computational horsepower can be distributed in all the nooks and crannies of a data-processing system."

Looking to the future, Mead observes: "No information will be sent over communications links without first being highly processed and formatted, having all its irrelevancies removed and being put in the most optimum form for its receiver."

A decade away, Mead predicts an LSI read-only memory will be available with a capacity of 10^7 bits and access time of approximately 1 μs. "Ultra-fast cycle times are not needed," he notes, "nor will they be available at this level of complexity." System cycle times will, however, be shorter than those of today, he says. This follows from the fact that the signal paths will be very short.

Practical microcomputer systems require low-cost peripherals, and Richard M. Smets of Q1 Corp., Farmingdale, NY, considers this problem in a Session 1 paper.

"Floppy disk drives have reduced the cost of direct-access storage so that it will be compatible with other microcomputer system costs," he points out. "The small storage capacity of floppy disks need not be a prohibitive limitation, because the disks can be changed so quickly and easily that putting a file on several disks becomes feasible."



The first 16-bit microprocessor on a single chip is the Pace from National Semiconductor. It has a 45-instruction set that cannot be modified. Instruction cycle time is typically 10 μs. Shown also is the Pace microcomputer card prototyping systems.

Smets notes further that electrostatic printers will be as cheap as serial-impact printers, yet be able to print thousands of lines per minute. In addition, he says, solid-state memory should get so cheap that it won't even be necessary to use disks. With mass solid-state memory and fast microprocessors, he believes, a microcomputer system will be able to handle data processing that is now done by a medium-sized computer center.

2 microprocessor advances stressed

Two significant technological contributions have been made by microprocessors, according to William H. Davidow of Intel Corp., Santa Clara, CA: (1) Microprocessors and their associated circuits, including memories, have reduced by an order of magnitude the cost of putting significant amounts of computational and control complexity into a device, and (2) Microprocessors have caused users to standardize on processors, LSI peripheral circuits and subsystem design, thereby permitting manufacturers to economize in component manufacture.

Doug Clifford of Hewlett-Packard, Loveland, CO, in a Session 7 paper, suggests that buyers ask the following when picking microprocessors:

- How many inputs and outputs are needed?
- How fast must the system operate?
- Is the job mainly one of software?
- How much software support is available?
- Is a second source required?
- How much TTL must be driven?
- How much room is available for circuitry?
- How much extra circuitry is needed around the processor?
- How much will it cost?

In a paper on the design of microprocessor-based computer terminals, Ronald K. Bell of Sperry Univac, Salt Lake City, UT, notes that a key advantage of the microprocessor is control of the communications interface. He says:

"The microprocessor-controlled communications interface uses the existing MOS/LSI transmitter and receiver circuits both to assemble input data into words, which are then passed to the processor, and to serialize output words for transmission to the host or other interface. All the procedures for the communication lines are contained in the software program. This includes message recognition, message synthesis, status, error recovery and error checking. The complexity of these functions is now under software control, and a significant reduction in hardware can be realized."

Session 11 emphasizes fault tolerance in computer design. Dale G. Holden of the NASA Langley Research Center in Hampton, VA, describes the design of a fault-tolerant computer known as HOME (Hard-Over Monitoring Equipment). It is a special-purpose computer that monitors the flight-control commands in a helicopter. According to Holden, "HOME detects the issuance of a hazardous, hard-over command for any of the four flight-control axes and transfers the control of the helicopter to the flight-safety pilot. The design of HOME incorporates certain reliability and fail-safe enhancement design features, such as triple modular redundancy, majority logic voting, fail-safe dual circuits, independent status monitors, in-flight self-test and a built-in preflight exerciser."

T. Basil Smith of the C. S. Draper Laboratory, Cambridge, MA, is concerned with digital communications networks and their vulnerability to damage. He notes that "the conventional bus organization currently in use in distributed digital systems is highly vulnerable to damage." He prefers a network using alternate data paths.

In his paper, Smith analyzes a variety of data-path techniques and settles on a hierarchical network of supervisory and subordinate nodes. ■■

Digital Equipment Corporation's new midicomputer, the PDP 11/70, employs a special memory architecture in which a 2 k byte bipolar cache memory acts as a buffer between main memory and the unit's general purpose registers. 32-bit internal data paths carry data to and from the cache memory, permitting data transfers between memory and registers to approach the 300-ns execution time of the central processor.

Yield, density, performance increasing through new trends in chip fabrication

Triple-diffusion semiconductor technology has been around for a long time. Its recognized advantages are simplicity, high yield and high density. But without LSI bipolar chip fabrication, interest in it was limited. Now this has changed.

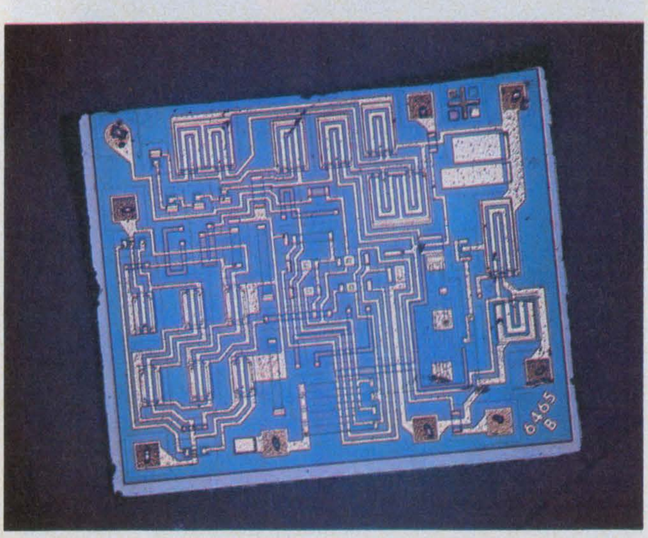
There is also a new trend among manufacturers of small-scale CMOS ICs. They are switching to buffered output devices. Won't this make CMOS SSI chips larger? Yes, but it will also improve the performance of the devices.

These and other developments in semiconductor technology are discussed in Session 18, "Configurations and Characteristics of Future Digital Logic Devices."

Triple diffusion is an early technology that has only recently been revised for LSI chip fabrication. Renewed interest has been expressed in the process, because of its simplicity, high yield and high density characteristics, notes Jim Buie, an engineer for TRW Systems, Redondo Beach, CA.

In his paper, "3D-LSI Compatible Logic Family," Buie notes that during the last three years, over 50 LSI designs have been produced at TRW, with chip sizes ranging from 100 × 100 to 300 × 300 mils. Densities as high as 20,000 devices per chip have been realized.

According to Buie, a main reason for the use of triple-diffused technology, instead of the more prevalent epitaxial method, is higher yield. Although present 3D practice produces devices with lower alpha cutoff frequencies than epitaxial devices, this is not a particular handicap for medium-speed applications that require frequencies between 5 and 30 MHz.



Operation and applications of the CA3130, RCA's tri-technology op amp are discussed in Session 24.

Defining triple diffusion, Buie notes that it is a bipolar process that offers the simplest means of producing electrically isolated transistors and resistors on the same chip. This process consists of impurity deposition and distribution, done three times in sequence.

Npn transistors and resistors are self-isolated by pn junctions. Pnp's are vertical devices, with collectors common to the substrate. The resistors are n-type and are either of the collector or collector-pinched variety.

Triple-diffused technology has been used primarily for digital applications, Buie notes. It is generally considered less attractive for analog functions because of the limited voltage breakdown and gain-bandwidth of the transistors. However, it has been used in the analog mode to provide reference voltage control and in digital-to-analog converters.

CMOS is covered by two authors at the same session. Jim Foltz, Motorola Semiconductor's manager of digital systems research and development, discusses conventional CMOS, while Walter Kalin, CMOS marketing manager for Solid State Scientific, discusses CMOS/SOS.

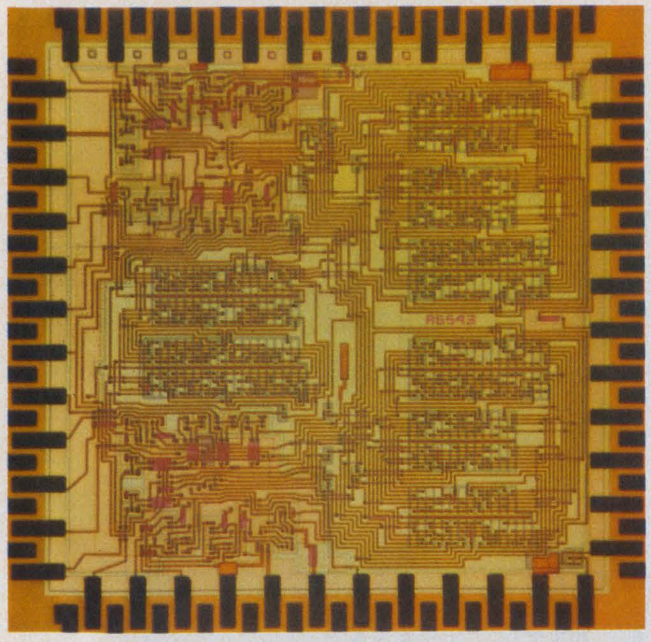
According to Foltz, there is a trend developing among manufacturers of small-scale CMOS ICs to switch to buffered output devices. While this would make SSI chips larger, it would also improve the performance of these devices.

SSI devices, says Foltz, suffer from pattern-sensitivity problems. With the addition of a two-stage inverter to the output of SSI devices, this sensitivity can be reduced. Almost all CMOS manufacturers will be switching to buffered outputs for gate-level components, Foltz says.

For MSI and LSI devices, the goal is to increase density. The density of CMOS devices has traditionally been limited by interconnects, gate alignment and the need for guard rings. Techniques to overcome these limitations are being investi-

Timetable to the technical sessions at Intercon '75

Tuesday, April 8		Wednesday, April 9		Thursday, April 10	
10:30 a.m. - 1:00 p.m.	2 p.m. - 5 p.m.	9:30 a.m. - 12:30 p.m.	2 p.m. - 5 p.m.	9:30 a.m. - 12:30 p.m.	2 p.m. - 5 p.m.
Session 1 The Microcomputer Revolution	**Session 7** Microprocessors: An Alternative to Random Logic Design	**Session 13** Will Robotics Answer Industry's Needs?	**Session 19** Microprocessors in Instrumentation	**Session 25** Access to Computer Networks	**Session 31** Computer Systems for Medical Applications
Session 2 Electronic Instrumentation in Medicine	**Session 8** Loop Electronics—The New Frontier	**Session 14** Trends in Electronic Measuring Instruments	**Session 20** Impact of New Technology on Hierarchical Memory and Storage Systems	**Session 26** Computer Technology During Hard Times (Panel)	**Session 32** Testing LSI Devices
Session 3 Future Projections of Instrument Design	**Session 9** The Reality of Standardization in Automatic Test Equipment (Panel)	**Session 15** Test Generation Techniques for Digital Circuits	**Session 21** Diagnostic Techniques for Logic-Circuit Boards	**Session 27** Maintenance and Service of Automatic Systems	**Session 33** Advances in Telecommunications Measurement Techniques
Session 4 Advanced Techniques for Automatic Test Equipment (ATE)	**Session 10** Controversial Topics in Digital Communications	**Session 16** Electronics in Modern Transportation	**Session 22** Instrumentation in Oceanography	**Session 28** Efficient Product Planning and Development	**Session 34** Hybrid Microelectronics Clinic on Component Parts
Session 5 Conservation of Communication Channel Capacity and Network Capability	**Session 11** Practical Aspects of Fault-Tolerant Computer Design Techniques	**Session 17** Marketing Strategy in the New Markets	**Session 23** Computer Communication Techniques	**Session 29** Satellite Communications Systems	**Session 35** Advanced Navigation Concepts for Low Cost Applications
Session 6 Component Specs and Applications: "What You Don't Know Can Hurt You"	**Session 12** Establishing Effective Semiconductor User/Supplier Relations	**Session 18** Configurations and Characteristics of Future Digital Logic Devices	**Session 24** Monolithic Linears—The Sleeping Giant Awakens	**Session 30** The Role of Hybrids in Producibility	**Session 36** Component Infant Mortality—Causes and Cures
			Highlight Session 7 - 10 p.m. Social Implications of Nuclear Power		



Random logic I²L array fabricated by Bell Laboratories has the equivalent of 256 gates on it.

gated. Included are a low-voltage process that will reduce the necessary guard area, the use of surface or subsurface oxide-guarding techniques and the use of SOS to eliminate the guard rings.

Because the SOS substrate is an insulator, guard rings are not needed, Kalin notes. In comparing the two major SOS fabrication techniques —aluminum-gate and silicon-gate—Kalin says that silicon gate results in higher density.

Commenting on future developments the Solid State Scientific marketing manager sees a number of 4000-series devices being produced in CMOS/SOS. Further down the road, he says, is an 8-bit microprocessor that his company is developing with General Electric and a 4-k SOS RAM. The microprocessor is expected to be completed by the fourth quarter of this year and the 4-k RAM sometime in 1976.

I²L technology described

In a Session 18 paper on "I²L—An MOS Competitive Bipolar Logic Technique," Richard A. Pedersen, supervisor for bipolar IC development at Bell Telephone Laboratories, Allentown, PA, says that I²L can lead to significant system simplification through reduction or elimination of special interfaces between the system and the LSI function.

I²L can be fabricated with standard buried collector technology, he notes, and is therefore compatible with other, more conventional circuitry on the same chip. The flexibility of having digital and linear interface circuitry on the same chip, he continues, adds to the attractiveness of I²L for LSI functions.

The basic logic element in I²L is an inverter that is formed from a multicollector npn transistor. The base drive for the npn is supplied by the collector of a lateral pnp transistor operating in a current source mode. The emitter of this pnp is referred to as the injector.

I²L is unusual in that it is free from dependence on resistors. All logic is powered from the lateral pnps, and the current that reaches each logic element is simply the total injector current multiplied by the alpha of the lateral pnp and divided by the number of units associated with the injector. What this means, Pedersen points out, is that a single design can be operated over a wide range of currents and speeds, simply by alteration of the total current flowing into the injector.

Developing trends in linear ICs are discussed in Session 24: "Monolithic Linears—The Sleeping Giant Awakens." The papers are all product-oriented, and according to the session organizer and chairman Art Fury of National Semiconductor, each of the papers discusses products that are deceptively simple on the outside and complex inside.

In a paper on "Integrated Circuits for Communications Applications," Gary Kelson, an engineer for Signetics, Sunnyvale, CA, describes two newly developed ICs for use in both high-performance and low-quality receivers.

One device is a front-end circuit that contains two dual-gate FETs for use as rf amplifiers and mixers. The IC is fabricated with double-diffused technology (DMOS), which combines the high-frequency, low-noise performance of bipolar devices with the low distortion of FETs. The front-end circuit is designated SD6000, and it incorporates one dual-gate DMOS device optimized for rf amplification and another dual-gate device optimized as a mixer in an economical eight-pin mini-DIP.

The SD6000 can be used for both AM and FM front ends, Kelson notes, and for narrow or wide-band reception up to 250 MHz.

The second IC developed especially for communications is the NE563, a phase-locked-loop demodulator. It has several advantages as a frequency-selective FM demodulator, Kelson says. It eliminates the inductors generally used and makes it easy to get a high Q circuit.

At the same time the 563 eliminates the problem of a limited dynamic range and VCO temperature drift associated with some phase-locked loop circuits.

The operation and applications of a recently introduced operational amplifier that is constructed with CMOS, MOS and bipolar technologies will also be discussed at the session. The amplifier, RCA's CA3130, features operation from both single and dual power supplies. ■■

Satellites and fiber optics gain favor for the transmission of digital data

Satellites are receiving increasing attention as vehicles for digital communications over long distances. For shorter distances, fiber optics is moving to the forefront. Session 29 looks at various aspects of satellite communications, and Session 5 emphasizes fiber optics.

William L. Cook and Ashok K. Kaul of Comsat Laboratories, Clarksburg, MD, cite the many advantages of satellites for digital data transmission. They include the following:

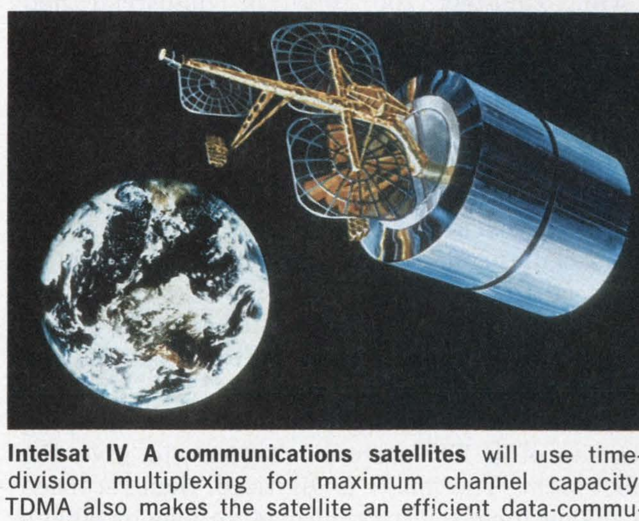
- Communications costs are lower. They depend only on total network traffic and are independent of the number of nodes in the system.
- A single random-access channel can service a multitude of nodes.
- Speeds in excess of 30 Mb/s can be transmitted almost error-free.
- Enormous capacity can be shared by a number of users on a demand-assignment basis, thereby tailoring the resources to individual needs.
- Point-to-multipoint (broadcast) capability is available. This permits simultaneous transmission to all nodes in the network.

According to Cook and Kaul, multiple narrow-beam antennas are desirable for computer networks. Central computer facilities are often clustered near one or more metropolitan areas. Narrow spot beams can be used to increase the data-transmission rates to those points.

Time-division multiplexing (TDMA) as the multiple-access technique for future communications satellites is emphasized in three papers concerned with European (Eurosat), Canadian (Telsat) and international (Intelsat) satellite communications systems. Pierre J. Bartholome and Simon E. Dinwiddy of the European Space Research Organization (ESRO) in Noordwijk, the Netherlands, argue that TDMA is the technique to use for maximum satellite capacity. They also suggest the use of phase-shift-key modulation for maximum capacity. The first phase in the development program in Europe is the design of an orbital test satellite for operation in 1976. It will not use the Intelsat 6 and 4-GHz up-and-down-link frequency bands. Rather ESRO has selected an up-link band of 14 to 14.5 GHz and down-link bands of 10.95 to 11.2 GHz and 11.45 to 11.7 GHz. These frequencies were chosen to avoid conflict with Intelsat signals. ESRO expects significant atmospheric attenuation at 11 and 14 GHz in heavy precipitation, but it plans to build sufficient gain margins into the equipment to minimize the problem.

Light weight, freedom from interference and broad bandwidth are key advantages of fiber-optic communications systems. John E. Fulen-

Synthetic speech is being produced with 1/50th the previously required digital information. The digital coding scheme developed at Bell Laboratories is ideal for transmission over a fiber-optic link. The screen shows a graphic representation of synthetic speech.



Intelsat IV A communications satellites will use time-division multiplexing for maximum channel capacity. TDMA also makes the satellite an efficient data-communications vehicle. Shown here is the current generation of satellites built by Hughes Aircraft.

wider of GTE Laboratories, Waltham, MA, devotes his Session 5 paper to the potential impact of fiber optics and integrated optics on world communications. He sees significant application in military systems, cable television and telephone systems.

"In vehicles such as ships and aircraft," he points out, "optical transmission cables have advantages due to their small size and light weight. Electrical isolation of the points in communication permits more freedom in packaging and installation, since a common system ground is not needed."

Fulenwider sees optical cables and integrated optics as significant steps towards the much maligned "wired city" goal of cable TV. Laser sources would be required to achieve the high light outputs in such a system, according to Fulenwider. But the cables would be immune to lightning, he notes, and optical cable could be installed overhead without surge protectors.

In telephone systems, the main use for fiber optics will probably be in interoffice trunking, Fulenwider says. Fewer repeaters are required per circuit than with screened metallic cable. And savings accrue from the light weight, lower installation costs and potentially lower cable costs. ■■

INDUSTRIAL

New workers for factories promised: Intelligent robots that 'feel' and 'see'

"By 1983 the industrial robot will have as large an impact on manufacturing as farm automation has had on agriculture."

So says J. Engelberger, president of Unimation, Inc., Danbury, CT, producer of programmable machines that are loosely called robots. His prediction answers without qualifications the question posed by Session 13: "Will robotics answer industry's needs?"

Engelberger, who has just returned from visiting factories in the Far East and Europe, says in a paper at the session that Japan leads the world in the number of active robotic developments, with "approximately 30, while Europe has about 15 and the United States, 10."

Approximately 200 types of industrial machines are doing routine jobs in plants in the world, Engelberger says, but those under development will be able to do much more work.

At present a programmable machine is taught a job. It is manually led through an operation, overriding the hydraulic system. With this record-playback programming technique, the machine can then do over and over again what it has been taught.

A real robot, of course, Engelberger explains, is one that can do a host of different things, and it should be able to "feel and see."

Besides tactile sensors, Unimation is studying the use of a TV scanning camera to give the robot sight. The image is digitized, then returned to analog form to give the robot an idea of what's going on. Also possible for providing sight is the use of a laser range finder to tell the robot the shape and distance of objects.

Work to develop intelligent industrial devices at the C. S. Draper Laboratories, Cambridge, MA, is described by James L. Nevins and D. E. Whitney in their paper "Assembly Research at Draper Labs."

"The things we've got now aren't robots," Nevins says. "We have put-and-place machines that remove a screw here and put it over there, repeating this routine until the machine is turned off.

"At the labs, devices are being developed that have sensor arrays to measure force at the wrist joint. They measure three linear forces and three

Robots don't look like people, but they can do routine chores endlessly without suffering boredom or injury. Unimation is working to give its factory machines both sight and hearing.

torques. What we're trying to do is to take information that you can measure when two pieces interact during assembly, and from this information try to construct control algorithms that can later be used during assembly to keep tolerances within prescribed limits."

Draper and the MIT Mechanical Engineering Dept. under the sponsorship of the National Science Foundation are exploring possibilities for developing such intelligent systems for industrial assembly lines.

"If we add to these sensors imaging systems that permit the machine to react to the environment, or more importantly to the changes in the environment, we will have systems that are adaptable as well as programmable," Nevins says.

Stanford Research Institute, Menlo Park, CA, is emphasizing the cost-effectiveness of units to handle a wide variety of chores, such as materials handling, inspection and assembly. The work is described by C. A. Rosen and D. Nitzen in a paper on "Overview of SRI's Industrial Assembly Project."

To date, advanced systems have been built primarily to "demonstrate principles," the authors say, without enough attention to questions of cost and program complexity—questions of major importance to industry.

Programs to test robots with visual capability, for example, have been too elaborate, Rosen and Nitzen say. The robots have been designed to see and identify every object they encounter, where in an actual factory situation they would need only to recognize a relatively small number of parts. It's not necessary for the assembly-line machine to be nearly as expensive as the elaborate test device, the authors point out.

The first goal, the paper says, is to develop computer programs that control a system of manipulators and also visual, tactile and force sensors, end-effectors and auxiliary devices that will perform a wide range of tasks, such as materials handling, inspection and assembly.

Second, SRI is developing a user's language, so that the programs can be operated by factory personnel who do not have computer expertise.

SRI has had good results with its tests so far, Rosen and Nitzen report. In one experiment an automotive casting was randomly placed on a moving conveyor. A robot called Unimate, equipped with visual and tactile sensors, acquired the casting and then transported and deposited it at a specified position and orientation.

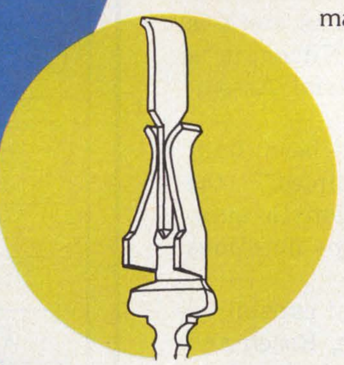
To investigate the possibilities of computer-controlled mechanical assembly, IBM has built an experimental system—hardware and software—to assemble mechanical objects. The work is described in a paper by Peter M. Will and David D. Grossman, members of IBM's T. J. Watson Research Center, Yorktown Heights, N.Y. ■■

MICROPHOTOS

...of high-reliability

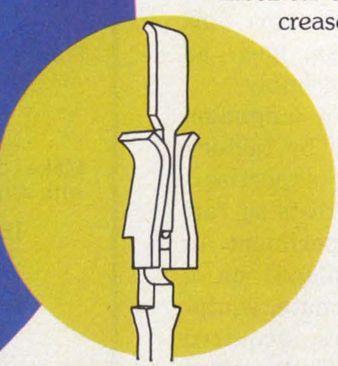

22X magnification, unretouched

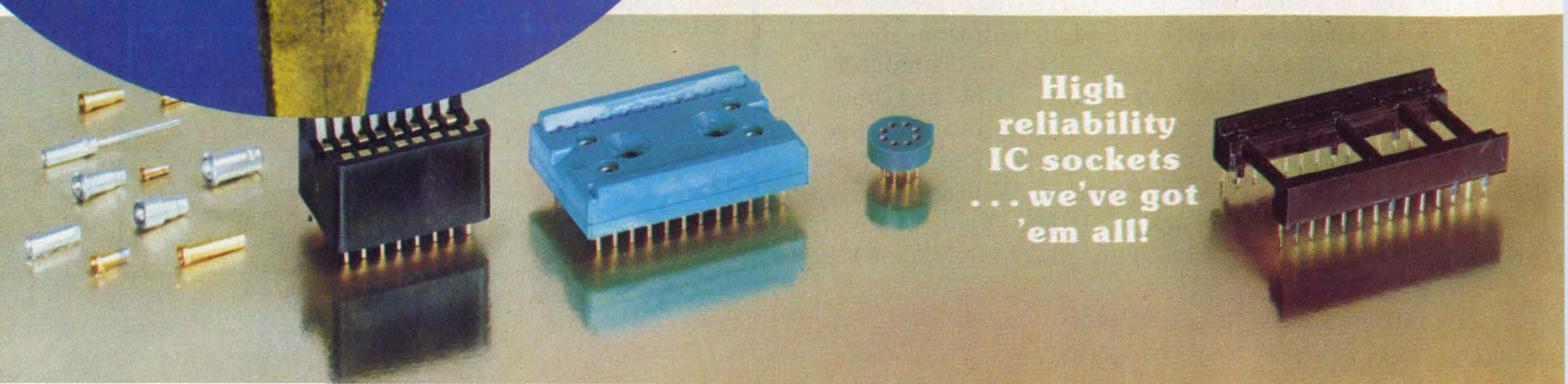
ROBINSON-NUGENT "SIDE-WIPE" SOCKET CONTACT after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. See how the RN contact—because it mates with the *smooth, flat side of the IC lead frame*—retains its surface integrity. This 100% greater lead frame contact results in minimum electrical resistance—continued high reliability for your IC connections.


*Lead frame in place in RN **"side-wipe"** contact.*

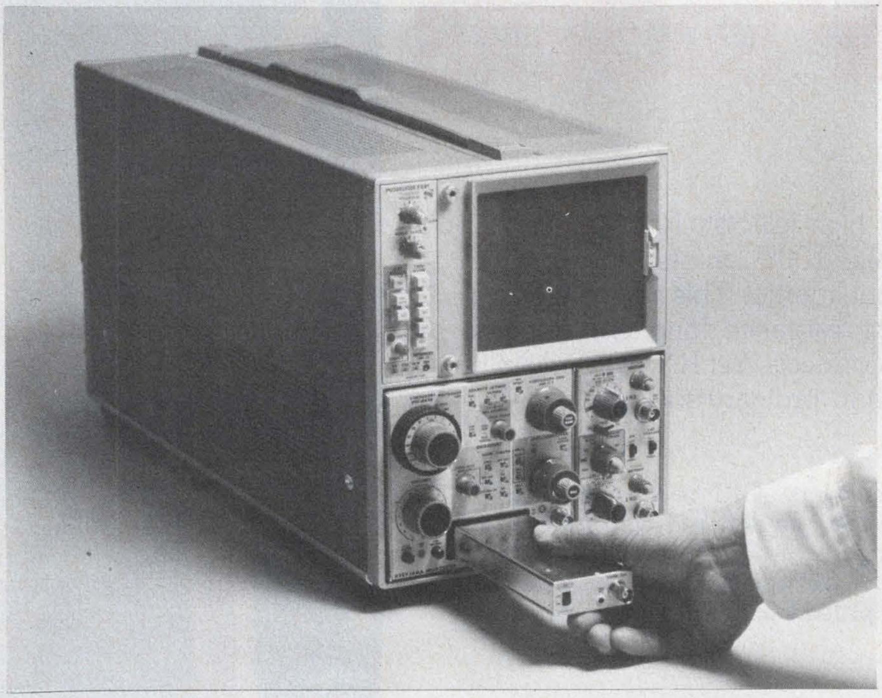

22X magnification, unretouched

AN ORDINARY EDGE-BEARING SOCKET CONTACT after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. Notice how the contact has scars and abrasions from *rough, irregular edge of IC lead frame.* Electrical contact is degraded and resistance is increased. Reliability is obviously reduced.


*Lead frame in place in an ordinary **edge-bearing** contact.*



5-MHz spectrum analyzer averages signals digitally to cut noise



Tektronix Inc., P.O. Box 500, Beaverton, OR 97005. (503) 644-0161. See text.

One word—digital—describes the new 7L5 5-MHz spectrum analyzer from Tektronix. From controls to storage to readout, an all-digital design brings improved performance and gives the user a number of benefits either previously unattainable or available only at a much higher price. Among the improvements are these:

- Digital averaging—a first in spectrum analyzers—cleans signals with no need to increase sweep times.
- Front-end digital frequency synthesis and digital control of signals—two more firsts—give high stability (less than ±5 Hz/h drift) with essentially no warmup time needed.
- MOS digital processing chips automatically set the optimum resolution and sweep rate, change the scale factors and CRT readout units, and also give the user 151 discrete level settings in 1-dB steps.

And these benefits aren't all. A preprogrammed turn-on sequence ensures that the 7L5 always comes on at a +16-dBm reference level and zero input frequency. This means you won't readily burn out the input mixer or have to search for the 0-Hz marker on the CRT.

Two other innovations of the Tektronix unit—which plugs into any 7000-series scope—are its input buffer control and a plug-in front end: a plug-in within a plug-in. The input buffer control trades attenuation for i-f gain to give over 80-dB of intermodulation distortion immunity (so you can pinpoint the source of the IM), while the plug-in module lets you change the input characteristics.

At present a 50-Ω module is available, calibrated in dBm and dBV. Future modules will provide differential/single-ended operation and other impedances and calibrations. Gains and scale factors are automatically switched to accommodate the module in use.

Frequency in the 7L5 is set by a single control—actually an optically encoded digital switch—that works in two modes: coarse (10-kHz steps) or fine (250-Hz steps). Settings are displayed in six digits directly on the CRT. Also displayed are span/div, volts/div, dBm or dBV, reference level and resolution bandwidth.

A small dot, called the frequency dot, can be horizontally positioned along the screen, and the numeric display then shows the frequency at the dot's location.

Resolution bandwidth of the 7L5 ranges from 10 Hz to 30 kHz in eight steps, while the span and sweep rate vary, respectively, from 50 Hz/div to 500 kHz/div and 0.1 ms/div to 10 s/div.

Other key specs include a dynamic range of 80 dB, a residual FM of less than 1 Hz (pk-pk) for spans between 0.05 and 2 kHz/div and a filter shape factor (60 to 6-dB ratio) of 10 or better (10 Hz to 1 kHz), and 5 or better from 3 to 30 kHz.

Equivalent input noise of the Tektronix unit depends on the selected BW: at 30 kHz, noise is −110 dBm (or less); at the narrowest BW, of 10 Hz, noise drops to −140 dBm. Range in the log-2 dB/div mode is from −130 to +21 dBm.

While split digital storage and peak hold aren't new in an analyzer, Tektronix has added a few wrinkles of its own. Not only can two signals be memorized and compared, you can digitally average and set the level at which the vertical display is either peak-detected or averaged—that is, you can move a horizontal cursor on the screen to the point where you want averaging to stop and peak display to take over.

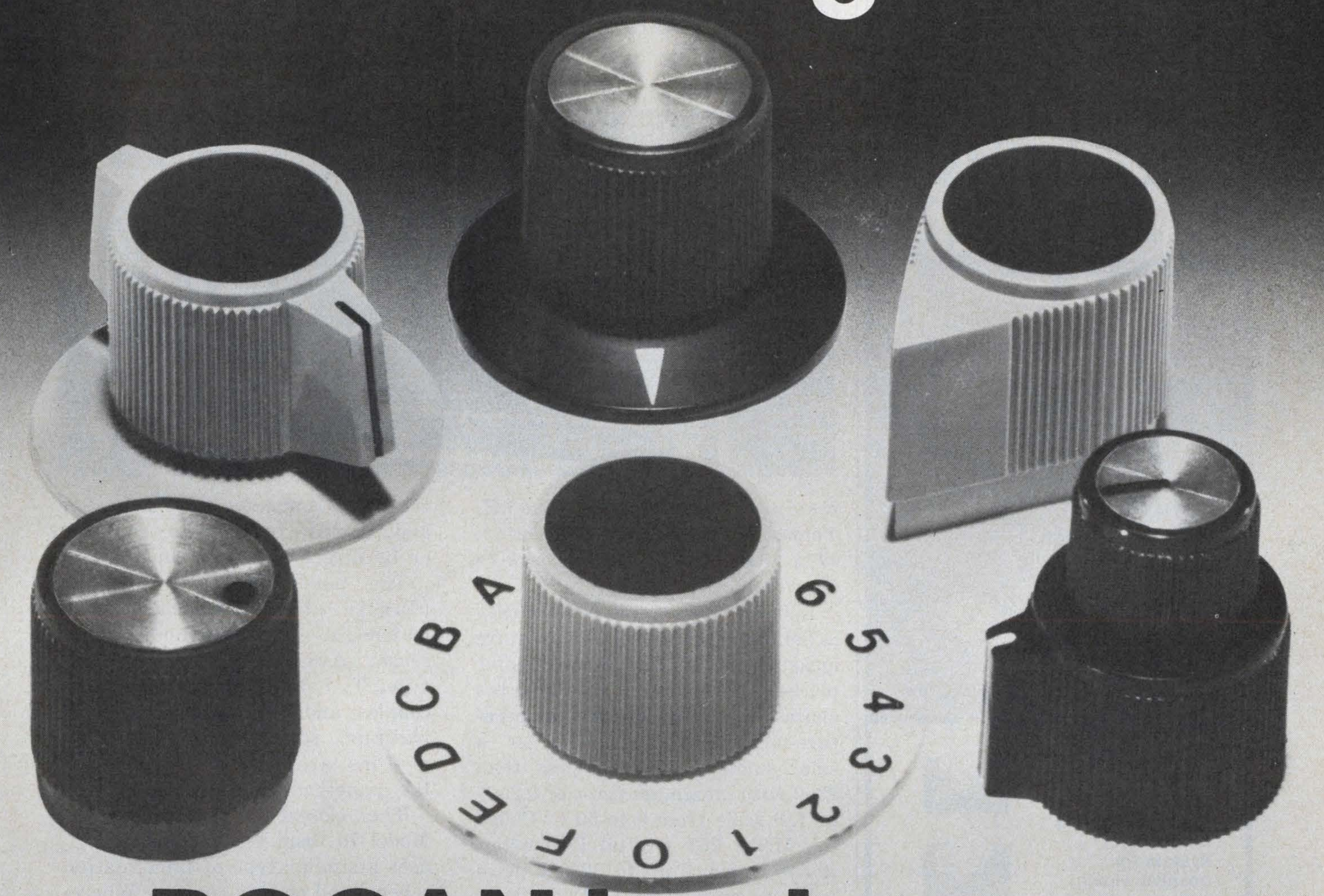
Thus noise at the bottom of the display is minimized for greater sensitivity, while larger (pulsed) signals are detected simultaneously. And you can bypass storage to display signals conventionally.

No price was available for the 7L5 at press time.

Booth No. 2302-2307

Circle No. 306

Front panel components should look good.



ROGAN knobs and dials do.

Today's market is aesthetics-conscious. An attractive front panel adds to the acceptance of your product. Front panel components, including control knobs and dials, must contribute to the overall design. Some knobs and dials simply look better than others. We think that the Rogan line illustrates superior styling details, while offering the largest selection of functional shapes and sizes available.

Obtain a copy of our catalog by contacting Rogan . . . the control knob and custom dial company.

ROGAN CORPORATION

3455 Woodhead Drive, Northbrook, Illinois 60062
Phone: (312) 498-2300 · TWX: 910-686-0008

INFORMATION RETRIEVAL NUMBER 33

3-3/4-digit panel meter is accurate to within 0.25%

Newport Laboratories, 630 E. Young St., Santa Ana, CA 92705. (714) 540-4686. See text; stock to 30 day.

Laboratory-instrument accuracy is being approached in temperature measurement at digital-panel-meter prices. Newport Laboratories claims the only digital temperature-measuring instrument at a small-quantity price of less than \$300 with maximum error of 0.25% of full scale from 0 to 50 C. Called the Model 267 Digital Pyrometer, it can measure up to 3200 F with 1-degree resolution. LED displays, 0.5-in. high, are used and reach a maximum count of 3999.

An analog linearization scheme is employed, as opposed to the digital read-only memory linearization techniques on instruments that cost more. Conformity to National Bureau of Standards requirements is better than 0.2% over the full span.

Nonisolated BCD data outputs are a standard feature, as are out-of-range and broken-thermocouple indications. Options include buffered BCD data outputs that are optically isolated—up to 300 V—from thermocouple inputs, power line or earth ground. Also available are an analog output to drive a strip-chart recorder and an internal single-limit set point. Set-point selection may be made by permanent hard-wire jumpers on the rear connector for dedicated applications, by remote switches or by direct computer control.

The panel meter comes with plug-in circuit boards, each matched to a different temperature sensor. Available are plug-ins for types T, J, K, E, R and S thermocouples and for three ranges of platinum resistance devices. The plug-ins are sold as options for the panel-meter mainframe.

The closest competitor, the Model 70 from Ircon (Skokie, IL), uses a similar type of linearization scheme and plug-in concept. Whereas the Ircon unit costs \$485 in small quantities with a single plug-in (additional plug-ins cost \$75 each), the 267 from Newport costs only \$150 in small quantities as a bare mainframe with no plug-ins. Plug-ins for J, K and E thermocouples and two of the platinum resistance devices cost \$75 each in small quantities, and plug-ins for the type R, S and T thermocouples and one of the platinum devices cost \$120 each.

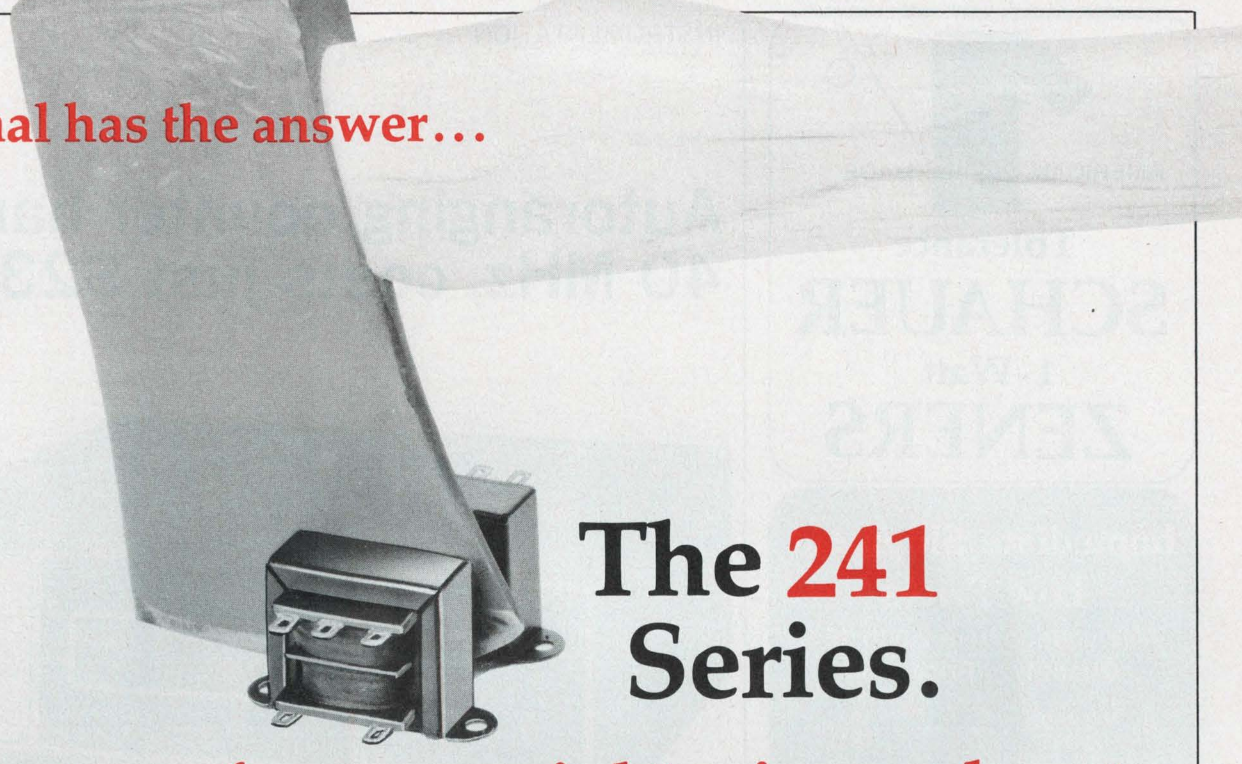
With a single low-cost plug-in, the 100-unit price for the Newport 267 is \$146.25. With the more expensive plug-in, the 100-unit price is \$175.50.

The meter is housed in a Lexan case, 1.68 × 3.92 × 5 in.

Booth No. 2122-2124

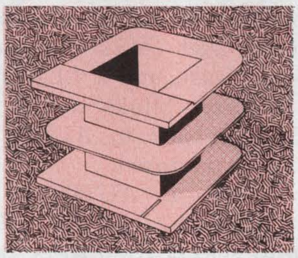
For Newport *Circle No. 303*
For Ircon *Circle No. 304*

Signal has the answer...



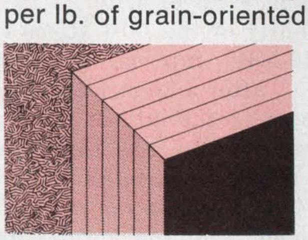
The 241 Series.

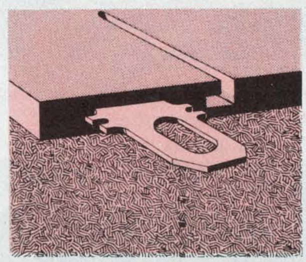
Cuts transformer weight, size and cost almost in half!



Special "split" bobbin (secondary wound alongside primary rather than over it) effectively isolates primary and secondary and reduces inter-winding capacitance. An electro-static shield is not required in all but the most sensitive applications. Hipot rating of 2500V RMS is standard. Bobbin winding technique affords a 40-50% savings in winding space over conventional layer winding. "Split" bobbin eliminates the need for inter-winding insulation and cross-over of primary and secondary leads.

Grain-oriented steel core is used at higher saturation flux densities and results in about a 40% reduction in turns required. Although the cost per lb. of grain-oriented steel is higher than that for ordinary silicon steels, the net cost is less, since less core weight is required and a significant reduction is made in copper weight.





Terminals, which are wedged into the bobbin wall, are designed so that they can be used as solder lugs or as 0.187" quick-connect types. Lead slots are incorporated in the bobbin wall leading to the terminals. It is not necessary to tape the start lead since it comes to the top of the coil through the slot and is thus separated from the winding. Separate lead wires or terminal boards and the extra assembly time to use them are eliminated.

Fresh thinking in engineering design and material selection has reduced material and labor cost and results in a series of small power transformers which cut weight, size, and cost almost in half. Therefore, we named them the "2-for-1" series...

signal transformer co., inc.
1 Junius Street, Brooklyn, N.Y. 11212
Tel: (212) 498-5111 • Telex 12-5709

-and Signal has it in Stock!

INFORMATION RETRIEVAL NUMBER 35

Autoranging counter handles 40 MHz, costs just $230

B&K Precision, 1801 W. Belle Plaine, Chicago, IL 60613. (312) 327-7270. $230.

Almost a contradiction in today's inflationary economy, frequency counters have been plunging in price, yet soaring in performance. B&K Precision's Model 1801 typifies the trend. For $230, the instrument gives automatic ranging from 20 Hz to 40 MHz, 1-Hz resolution and a 6-digit LED display of frequency in either kilohertz or megahertz.

TTL circuitry automatically updates the reading at a rate of up to five times per second. And when you set the function switch to AUTO, the 1801 fills all the display positions, suppresses the least significant digits, if necessary, and shows the range on kHz/MHz indicator lights.

To get the maximum resolution of 1 Hz, you switch the function knob to the 1-sec mode. In this position the kHz display lights up and the decimal point moves left to show the least-significant digits.

If, for example, you're checking the color carrier frequency of 3.579545 MHz and want the best resolution, you'd use the 1-sec mode. The LEDs would then show 579.545 kHz—if the carrier was right on target. Here, the most significant digit (MSD) is traded off for the least, and a LED over-range indicator blinks to tell you this. But go back to AUTO and the MSD is restored.

Gate periods in AUTO are 10, 100 or 1000 ms. The B&K Precision unit selects from these three for best accuracy and fastest reading. The input is ac-coupled and can vary over a fairly wide range with no level adjustment normally needed.

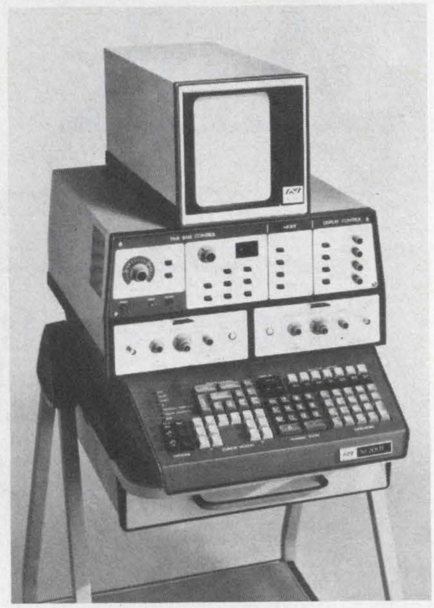
Sensitivity of the 1801 is guaranteed at 30-mV rms, with the maximum input (peak ac + dc) listed as 200 V to 500 Hz, linearly derated to 100 V at 1 kHz to 5 MHz, and again linearly dropping off to 50 V at 40 MHz.

Stability of the 1801 stems from the 10-MHz internal time base. At 25 C, after a 30-m warmup, you can expect settability of ±0.1 ppm and variation of less than 1 ppm for ±10% line variations. Tempco from 0 to 50 C is no worse than ±10 ppm. And the crystal aging rate is specified at 1 ppm/month over the short term and 10 ppm/year for the long haul. If you'd like greater accuracy, you can hook up your own external time base.

Booth No. 2718-20 Circle No. 302

INFORMATION RETRIEVAL NUMBER 37

Calculating scope programs with keyboard



Norland Instruments, Fort Atkinson, WI 53538. (414) 563-8456. $13,400 with monitor and two single-channel plug-ins; start May 31.

A smart oscilloscope—the NI 2001—combines all the capabilities of a digital scope and a microprocessor in a single mainframe. The unit requires no computer instructions or programming experience. Preprogrammed, fixed-function buttons on the keyboard allow you to calculate rise times, integrals, differentials, peak areas, rms values, peak-to-peak measurements, n-point averaging, frequency and square root.

The Norland instrument uses plug-in data-acquisition units with controls similar to those of a standard scope and provides a CRT display of signals and alphanumerics. The unit also features high-speed real-time data storage and it has an interactive keyboard to calculate, convert units, and program for automatic signal processing.

The data memory consists of a 4 k × 12-bit, 900-ns RAM and a program memory of 200 keystrokes. The 2001 accepts two plug-ins for up to four channels of data with 8, 10 or 12-bit resolution at a sample rate up to 1 MHz. Either signal-acquisition or calculating plug-ins can be used.

Booth No. 2732-34 Circle No. 301

5 amp high voltage fast switching power Darlingtons

SDM 22301-03
SDM 22311-13

Solitron's new fast switching NPN Darlington transistors are high voltage units offering gain ratings at collector currents of 2 to 5 amps and voltages from 150 to 350. And they don't come any more rugged, packaged in an all steel TO-3 case. The result? Whatever you build will switch faster and offer more reliability than comparable units now on the market.

These Darlingtons were designed for power switching, hammer drivers, audio amplifiers, series and shunt regulators. Available in quantity, they're competitively priced — and waiting for you right now. Write Solitron today for specification sheets and more information.

TYPE NO.	$h_{FE(typ)}$	$V_{CEO(sus)}$	$V_{CE(sat)}$	$V_{BE(sat)}$	$f_{T(typ)}$
	@ $I_C = 2A$, $V_{CE} = 5V$		@ $I_C = 2A$, $I_B = 0.02A$		
SDM22301	150	150V	1.6V	2.4V	$10MH_Z$
SDM22302	150	250V	1.6V	2.4V	$10MH_Z$
SDM22303	150	350V	1.6V	2.4V	$10MH_Z$
	@ $I_C = 5A$, $V_{CE} = 5V$		@ $I_C = 5A$, $I_B = 0.2A$		
SDM22311	70	150V	2.6V	3.5V	$10MH_Z$
SDM22312	70	250V	2.6V	3.5V	$10MH_Z$
SDM22313	70	350V	2.6V	3.5V	$10MH_Z$

Solitron
DEVICES, INC.

1177 Blue Heron Blvd., Riviera Beach, Florida, 33404 • (305) 848-4311 • TWX: (510) 952-7610

INFORMATION RETRIEVAL NUMBER 39

520-MHz sig gen offers calibrated, metered FM

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $2400.

Calibrated and metered frequency modulation over the full range of 10 to 520 MHz are featured by the Model 8654B rf signal generator. Four FM peak-deviation ranges are available to the user—0 to 3 kHz, 10 kHz and 30 kHz over the full range of the unit, and 0 to 100 kHz over 100 MHz. Distortion is below 1%. AM specs of the earlier 8654A are preserved in this "B" version by Hewlett-Packard.

The combination of 520-MHz range, amplitude and frequency modulation, wide output range (+10 to −120 dBm), and light weight (16 lb 5 oz.) make the unit an attractive general-purpose signal generator to test and align narrowband FM receivers.

The frequency settability of the unit has been improved with a fine-frequency vernier that can tune to 5 ppm of the carrier; this is a necessity to align receivers with channel spacings of 12.5 and 25 kHz. The instrument's solid-state oscillator drifts less than 10 ppm per 10 minutes after warmup.

The 8654B's internal AM at 400 and 1000 Hz modulates 0 to 90%, with less than 1% distortion at 50% AM. And the new internal FM holds distortion below 1%, except at highest ranges, where it's specified as less than 2%. A multifunction meter reads AM, FM and output level. Deliveries start in June.

Booth No. 2518-2531

Circle No. 307

LED analog panel meter has 5-in. linear scale

Simpson Electric, 853 Dundee Ave., Elgin, IL 60120. (312) 695-1121. $130.

The AnaLed Models 7527 and 7527SM combine the best of analog and digital displays. Advantages of this indicator include a bright, high visibility, 5-in. long, direct-reading LED scale; a virtually instantaneous response (15 ms maximum) with no overshoot; a dc sensitivity of 1-μA full scale; a full-scale ac reading, which can be obtained with as little as 10 mV pk-pk; and the ability to display both linear and nonlinear signals (square-law, log, dB, ohms, etc.) as a linear function. Models are available for horizontal or vertical indication. The dimensions of the AnaLed are 200 mm × 50 mm (the latest proposed IEC standard 7.87 × 1.97 in.). The front panel depth is 0.75 in. for the surface mounted version and 0.5 in. for the through panel model.

Booth No. 2218 *Circle No. 347*

V and I standards set to high accuracies

Zi-Tech Division, Aikenwood Company, 223 Forest Avenue, Box 26, Palo, Alto, CA 94302. (415) 326-2151.

TE2004 dc voltage standard offers high precision and a stable built-in reference. Accuracy is 0.005% and a calibrated sensitive null detector is included. Output voltages in four ranges from 11 mV to 11 V fs can be set with better than 1-ppm resolution. The unit has the convenience of a line power/battery unit. TE609S current calibrator can supply accurate dc currents from nanoampere levels up to 100 mA. Five thumbwheel switch decades permit precise selection and display of current on each of five ranges. Accuracies of 0.05%and 0.02% are available.

Booth No. 2223 *Circle No. 342*

Automatic counter covers 20 Hz to 18 GHz

Systron-Donner, One Systron Drive, Concorn, CA 94518. (415) 682-6161.

Model 6054A automatic microwave counter spans 0.02 to 18 GHz in one band with one connector input. Dynamic input range covers −15 to +30 dBm with no dead zones. The instrument boasts a unique protection system that warns of pending overloads, and provides two measuring modes—a narrow mode for 1-Hz resolution in 1 s and a wide mode to track drifting signals. Readout is with an 11-digit LED.

Booth No. 2426-2431

Circle No. 346

Multipoint recorder uses thermal writing

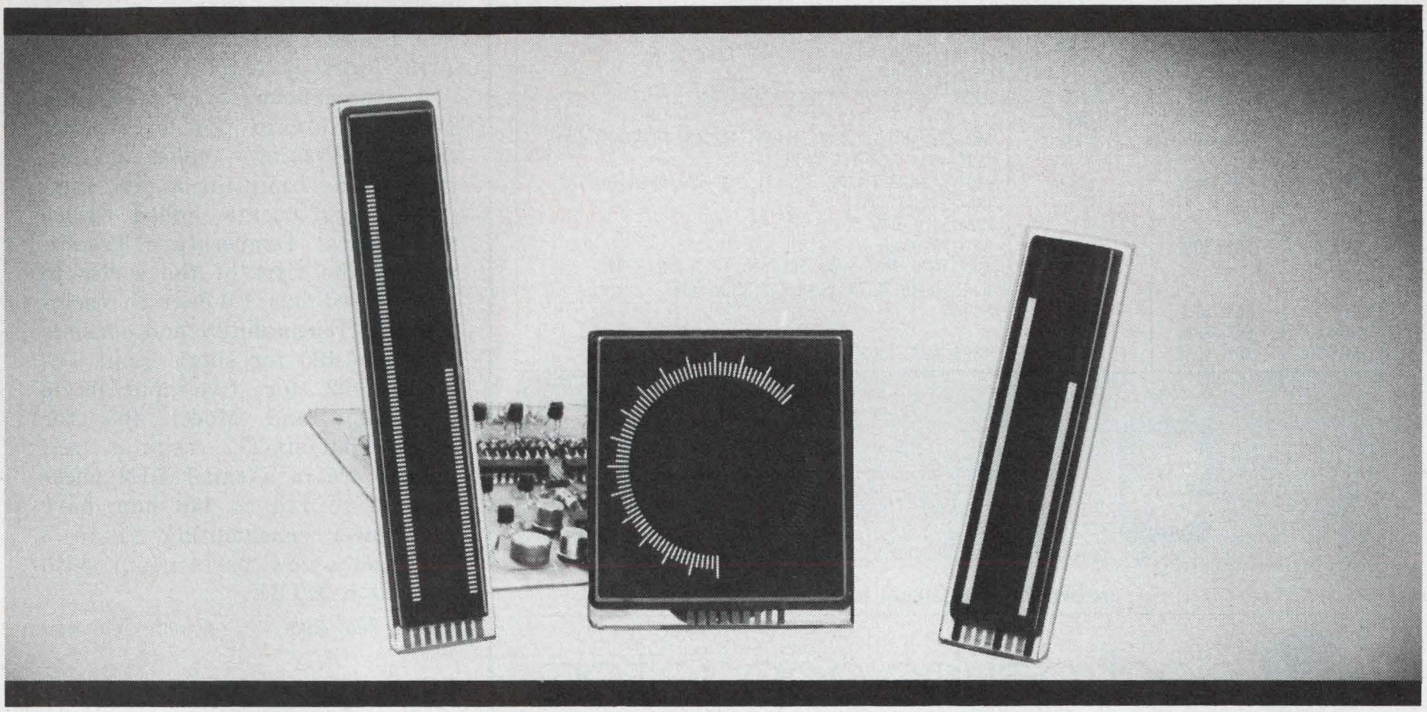
Gould, 3631 Perkins Ave., Cleveland, OH 44114. (216) 361-3315.

A thermal writing multipoint recorder, the Brush 816, is designed for general-purpose recording in the laboratory, shop or field. The unit records up to eight channels of analog information on fanfold chart paper at sampling rates of up to 16 points per second. The maximum channel span of 4.5 in. provides good display resolution. The multiplexed, overlapping traces with positive channel identification are ideal for data comparison, quick look readout and data reduction.

Booth No. 2513-2517

Circle No. 348

NOW... FOR THE BURROUGHS SELF-SCAN® BAR GRAPH DISPLAY



A DO-IT-YOURSELF CREATIVITY KIT–

WE SUPPLY THE PARTS – YOU DO THE ASSEMBLY

PUT IT ALL TOGETHER . . . and you have a functional BURROUGHS bar graph display that's ideal for experiments, development, evaluation, and demonstration.

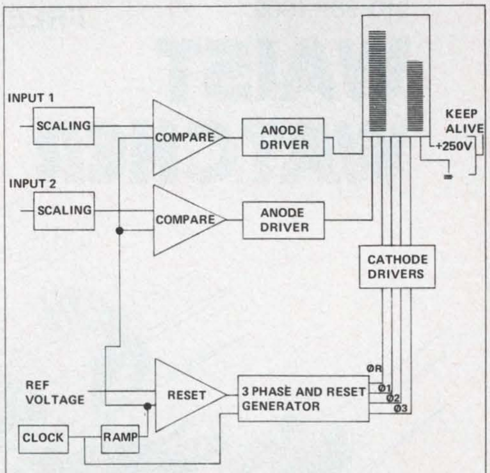
Here's an easy and inexpensive way to see what Burroughs bar graph displays can do for you. These breadboard kits are supplied with printed circuit board, all necessary active and passive components, and a SELF-SCAN bar graph display unit.

There are three standard bar graph displays currently available: dual 200- and 100-element bar graph displays with ½% and 1% resolution in each channel with only 8 connections to the display; and a full circle 120-element bar graph with 3-degree resolution with only 9 connections to the display.

We've worked out the electronics for you so you can put it together quickly. Then, all you have to do is tie in your analog inputs (any signal up to 30V), connect +5V and +250V power supplies, and your bar graph display is in operation!

Your choice of 3 kits: Kit K-1, a dual 100-element linear bar graph at $79.95; Kit K-2, a dual 200-element linear bar graph at $99.95; or Kit K-3, a 120-element circular bar graph at $109.95; each contains the display, the proper drive circuit, components, and instructions for assembly. The +5V and +250V power supply, Kit K-4, is available at $29.50.

Available from stock from all Burroughs distributors: Hamilton/Avnet Electronics, Cramer Electronics, Arnold Barnes Associates, and Jack Weiss Company, Ltd.



This block diagram for a dual linear bar graph shows you how simple the operation really is.

For further information, write or call Burroughs Corporation, Electronic Components Division, P. O. Box 1226, Plainfield, N. J. 07061, or call 201-757-3400 or 714-835-7335 in California.

Burroughs

INFORMATION RETRIEVAL NUMBER 44

INSTRUMENTATION

Temperature indicators offer high reliability

Doric Scientific, 3883 Ruffin Rd., San Diego, CA 92123. (714) 565-4415. Start at $300.

A proprietary ion-implanted PMOS LSI chip that does practically everything—analog and digital—is the basis for a new family of instruments, called Series 400 Digital Temperature Trendicators. The first of the series to be released has 1.0-degree resolution and repeatability and consists of Model 400 for single-input TC, Model 402 for five-input/single TC type; and Model 403 for single-input/six-TC types. All models are in a small DIN package, 72 × 144 × 173 mm, have low power consumption (1 to 3 W), and a low parts count with 100,000 h MTBF.

Booth No. 203 *Circle No. 340*

High-speed synthesizer also boasts low noise

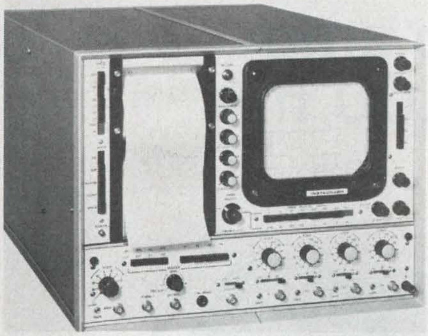
Ailtech, 815 Broad Hollow Rd., Farmingdale, NY 11735. (516) 595-6471. $8995; 60 days.

The first in a new line of direct frequency synthesizers, series 360, covers 10 kHz to 180 MHz and offers low noise and high switching speed. Discrete spurious outputs are 100-dB down (to 60 MHz) and the noise floor is 138-dB below the output level in a 1-Hz bw. Harmonics are typically 35-dB down. Switching speed is 20 μs. Frequency selection is by 11 pushbutton digits or by remote programming. The line will eventually extend to 1.4 GHz.

Booth No. 2324, 2326

Circle No. 337

Four-channel CRT has built-in chart recorder



Mirvalle Electrics, Manor Way, Old Woking, Surrey GUZZ 9JU, England.

The Instagraph, a high-speed four channel X, Y, T and Z direct-recording system, uses an inertia-less recording method. The unit produces dry 100-mm wide records in seconds. It uses recording techniques perfected by the company in the field of medical instrumentation and is a general-purpose recording oscilloscope for research and industry. Other Instagraphs available include models without monitoring CRT (useful in OEM applications) and models with 200-mm wide recording paper.

Booth No. 2308 *Circle No. 349*

Linear IC tester handles quad devices

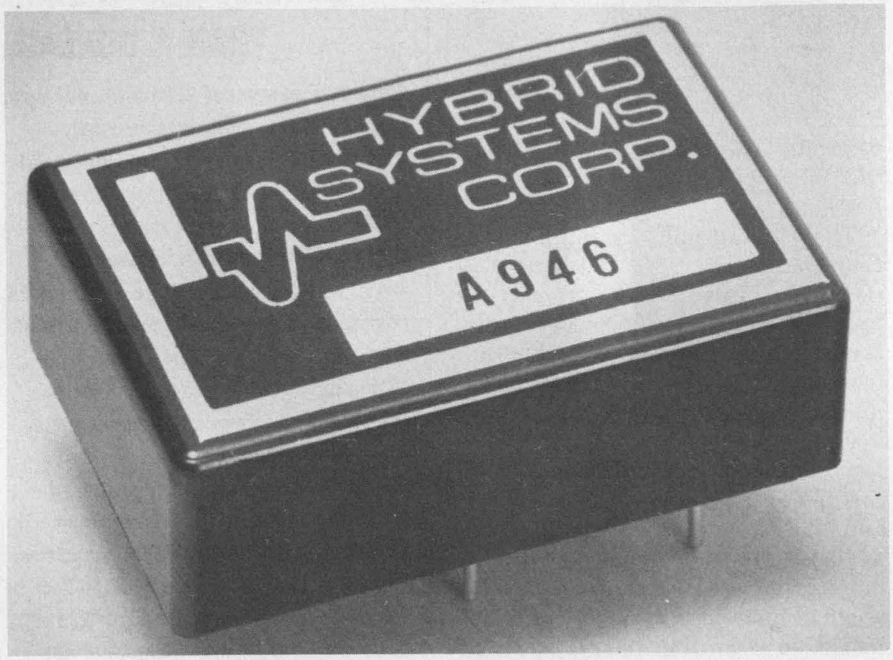
Teradyne, 183 Essex St., Boston, MA 02111. (617) 482-2700.

The J149 is a bench-top test instrument for inspection of industrial linear ICs. It performs dc parametric tests on op amps, comparators, and voltage regulators. The tester will repeat test sequences for dual, triple, and quad devices. Test results are indicated on a single "reject" lamp, with other displays indicating the reason for rejection. The J149 uses two programming boards to test each device: a family board for each major class of component (such as op amp); and a device board for each unique device within a family (e.g., 741). Limits can be programmed through a keyboard entry or, optionally, through preprogrammed ROM modules that plug into the test deck. Socketing accommodates DIPs, cans, and flat packs.

Booth No. 2532-2537

Circle No. 336

Fast settling op amp delivers up to 100 mA



Hybrid Systems, 87 Second Ave., Northwest Park, Burlington, MA 01803. (617) 272-1522. P&A: See text.

A fast-settling modular op amp, the A946, can slew at 1000 V/μs typical and deliver 100 mA. It thus fills many needs, such as in fast converters, video pulse transmission and CRT deflection systems.

Two versions are available from Hybrid Systems: the A946A and A946B. The A model has an offset voltage drift of 100 μV/°C, while the B has a drift of 25 μV/°C.

Both models have many common specs—for instance, settling time to 0.01% is 250 ns, max, in the inverting mode and 300 ns, max, in the noninverting mode. The slew rate for either operating mode stays at a high 750 V/μs, minimum, and 1000 V/μs, typical.

Frequency response for either amplifier is guaranteed at 25 MHz, minimum, for unity gain and 10 MHz, minimum, for full power.

The amplifier input circuits have an impedance of 10^{11} Ω and a bias current of only 200 pA, max, or 40 pA, typical. Offset current is even lower—only 40 pA, max, and 10 pA, typical.

Amplifier voltage noise over a 0.01-to-1-Hz bandwidth is typically 10 μV, pk-pk. Over a 5-Hz-to-2-MHz bandwidth it increases to 40 μV rms. Current noise over the 0.01-to-1-Hz bandwidth is a low 0.1 pA, pk-pk.

In the differential operating mode the A946 amplifiers can handle ±15-V differential signals and ±10-V common-mode signals. The common-mode rejection ratio of 60 dB, min., and 80 dB typ., is measured at ±5 V and 10 Hz.

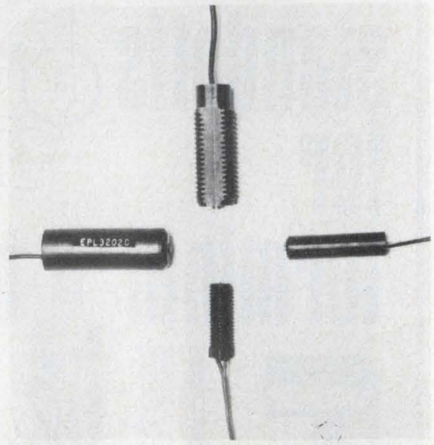
The power-supply operating requirements are ±15 V with a 55 mA quiescent current.

The output circuit of the op amp handles loads up to 100 mA and load capacitances as high as 400 pF in the inverting mode and 100 pF in the noninverting. The amplifier has a minimum gain of 25,000 and a typical gain of 50,000.

A 1.8 × 1.2 × 0.6 in. encapsulated package houses the op amp. The A946A is priced at $62 and the A946B at $85, when purchased in 1-to-9 lots. The units are available from stock.

Booth No. 2226 *Circle No. 305*

Magnetic sensors cased in low-cost plastic



Electro Corp., 1845 57 St., Sarasota, FL 33580. (813) 355-8411. Stock.

A series of low-cost, molded-plastic magnetic sensors is designed for the computer peripheral market. The reduced size of these noncontact sensing units makes them ideal for limited-space applications. Four models are available for use in synchronization applications in high-speed printers and disc drives. Two 0.25 in. dia. models, one threaded and one with a smooth barrel, have 12 V pk-pk outputs; and two 0.4725 in. dia. models, one threaded and one with a smooth barrel, can generate higher voltages.

Booth No. 2611 *Circle No. 350*

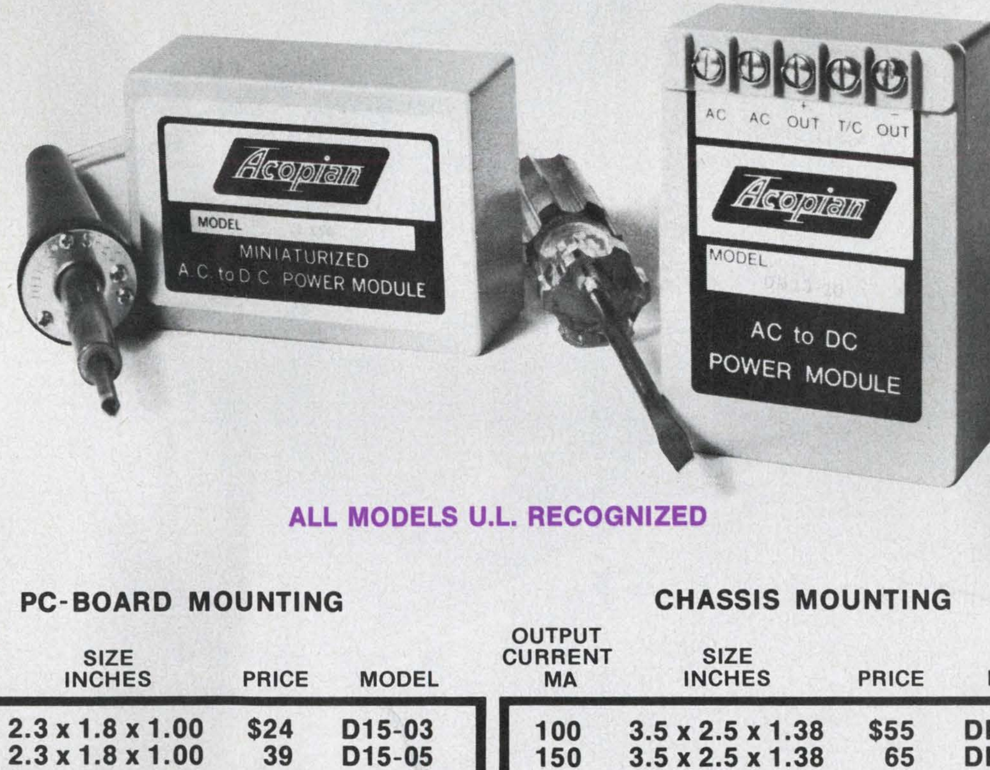
Voltage references have 0.02% initial accuracy

Micro Networks, 324 Clark St., Worcester, MA 01606. (617) 852-5400. From $50; 2 to 4 wk.

A family of 10-V precision reference sources is available in miniature, 14-pin DIPs. Four models are offered: The MN2000 and MN2001 are positive 10-V reference units, and the MN2002 and MN2003 are negative 10-V references. All units are laser trimmed for initial accuracy of better than 0.02% at 25 C. The MN2000 and MN2002 guarantee accuracy of 0.05% over the operating range of 0 to 70 C. For full MIL range applications, the MN2000H and MN2002H guarantee 0.5% accuracy over the range of −55 to +125 C. Models MN2001 and MN-2003 guarantee accuracy of 0.1%.

Booth No. 1426 *Circle No. 351*

±15 VOLT POWER MINI'S FOR OP AMPS



ALL MODELS U.L. RECOGNIZED

PC-BOARD MOUNTING

OUTPUT CURRENT MA	SIZE INCHES	PRICE	MODEL
25	2.3 x 1.8 x 1.00	$24	D15-03
50	2.3 x 1.8 x 1.00	39	D15-05
100	3.5 x 2.5 x 1.00	49	D15-10A
200	3.5 x 2.5 x 1.00	69	D15-20
300	3.5 x 2.5 x 1.25	105	D15-30
500	3.5 x 2.5 x 2.00	130	D15-50

CHASSIS MOUNTING

OUTPUT CURRENT MA	SIZE INCHES	PRICE	MODEL
100	3.5 x 2.5 x 1.38	$55	DB15-10
150	3.5 x 2.5 x 1.38	65	DB15-15
200	3.5 x 2.5 x 1.38	75	DB15-20
300	3.5 x 2.5 x 1.63	105	DB15-30
350	3.5 x 2.5 x 1.63	110	DB15-35
500	3.5 x 2.5 x 2.38	135	DB15-50

Line/load regulation, ±0.1% or better; ripple, 1 mv; input, 105-125 VAC. Other single and multiple output models from 1 to 75 volts, to 2.5 amps. Liberal quantity discounts. Three-day shipment guaranteed.

Complete details on these plus a comprehensive line of other power supplies and systems are included in the Acopian 74-75 catalog. Request a copy.

Acopian Corp., Easton, Pa. 18042. Telephone (215) 258-5441.

INFORMATION RETRIEVAL NUMBER 52

Reliability is 756 little dents and one big one.

The big squeeze.

The heelpiece and frame are the backbone of our Class H relay. The slightest squiggle or shimmy out of either and the whole relay is out of whack.

756 tiny dents on the heelpiece, plus one big one on the frame, make sure this'll never happen.

They're the result of planishing, a big squeeze. Planishing is an extra step we go through in forming the pieces to add strength and stability by relieving surface strain. It also makes the parts extra flat.

This takes the biggest press in the industry and the biggest squeeze. Both exclusively ours.

A different kind of coil.

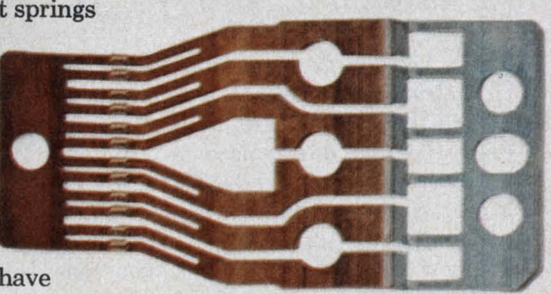
The heart of a relay is the coil. If ours looks different, it's because we build it around a glass-filled nylon bobbin. It costs us more, but you know how most plastic tends to chip and crack.

Also, moisture and humidity have no effect on glass-filled nylon. No effect means no malfunctions for you to worry about. No current leakage, either.

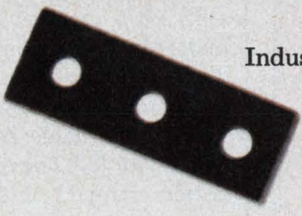
The coil is wound on the bobbin automatically. No chance of human error here.

Springs and other things.

We don't take any chances with our contact assembly, either. Our contact springs are phosphor-bronze. Others use nickel-silver. Our lab gave this stuff a thorough check, but found nickel-silver too prone to stress-corrosion. Atmospheric conditions which cause tarnish and ultimately stress corrosion have almost no effect on phosphor-bronze.



Even things like the pileup insulators (those little black rectangles) get special attention. We precision mold them. Other manufacturers just punch them out.



It makes a lot of difference. They're stronger, for one thing; and because they're molded, there's no chance of the insulators absorbing even a droplet of harmful moisture. Finally, they'll withstand the high temperatures that knock out punched insulators.

Two are better than one.

Our next step was to make sure our contacts give a completed circuit every time. So we bifurcate both the make and break springs.

Each contact works independently to give you a completed circuit every time. Contact material is pure palladium with a gold overlay because no alloy works as well.

Edge-tinned contact springs save you the job of solder tinning them later. Also, edge-tinning enables you to safely use the same relay with sockets or mounted directly to a printed circuit board. A simple thing, but it takes a big chunk out of the inventory you have to stock.

Finally, superior protection.

Out of the dozens of plastics to choose from for our dust cover, we picked a durable polycarbonate. The same material used for plastic windshields and special vehicle bodies. It's strong, resists high temperatures, and is unaffected by most cleaning solvents.

Then, for extra safety, we put a disposable cap over the cover's open end. This seals out dirt and dust while preventing damage to the terminals during shipping and handling.

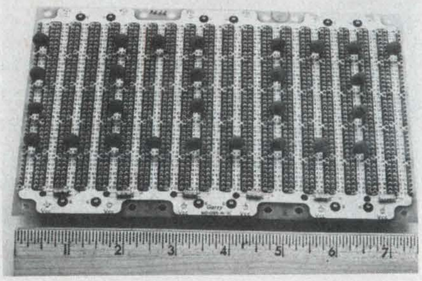
Etc. Etc. Etc.

There's a lot more to tell about what makes our Class H relay reliable. Now we're waiting to hear from you. GTE Automatic Electric, Industrial Sales Division, Northlake, Illinois 60164.

GTE AUTOMATIC ELECTRIC

INFORMATION RETRIEVAL NUMBER 53

Modular IC board offers layout flexibility



Garry Manufacturing Co., 1010 Jersey Ave., New Brunswick, NJ 08902. (201) 545-2424.

New boards, Series MD, offer more ground and voltage plane area per square inch than any other known comparable units, according to Garry Manufacturing. The boards are available with or without decoupling capacitors, and either wrap-wired and ready for assembly or blank and ready for prototype production. Options available include committed or noncommitted power and ground planes, laminated bus bars for noise suppression and contact pins in a variety of lengths for one, two or three-level wire wrapping. Pins are available in various thicknesses of gold plating over ductile nickel.

Booth No. 1526-1528

Circle No. 331

Triaxial cable connector designed for video use

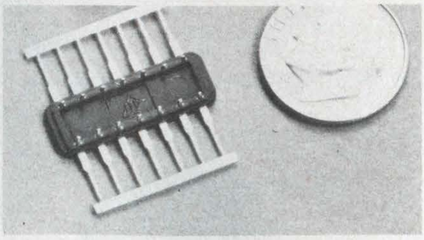
Kings Electronics, 40 Marbledale Rd., Tuckahoe, NY 10707. (914) 793-5000. From $31 to $53 (100-up).

The Tri-Loc connector series, for television broadcast equipment, is designed for use with triaxial cable. The quick disconnect rf connectors terminate 0.375 and 0.5 in. diameter triaxial cables. When mated, the connectors are completely weatherproof. This rugged construction and the company's durable TR-5 weather-resistant finish, make the connectors suited for outdoor use. The connectors have an interface retention greater than 100 lb. and cable retention greater than 200 lb. The contacts can be either crimped or soldered.

Booth No. 1515-1517

Circle No. 352

DIP headers and covers house components



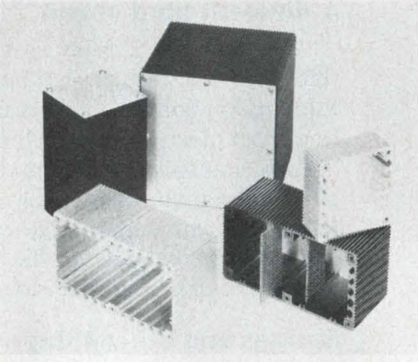
Moldtronics, Inc., 703 Rogers St., Downers Grove, IL 60515. (312) 968-7000.

A family of DIP headers and covers for 14, 16, 20 and 24-lead configurations is available with tin or gold-plated leads. Over-all width is 0.270 in. and lengths vary from 0.770 to 1.270 in. according to the number of leads. These packages can house such components as ICs, transformers, resistor networks and custom circuits.

Booth No. 1621-27-29

Circle No. 333

Enclosures made from slide-together panels



Vero Electronics, Inc., 171 Bridge Road, Hauppauge, NY 11787. (516) 234-0400.

A series of low-cost extruded enclosures in six sizes from 4 × 2 × 2 to 4 × 4 × 8 in. is supplied in kit form with black-anodized side walls and clear-anodized end panels. Simple slide-together construction keeps assembly time to a minimum. Finned exterior walls enhance the heat-sinking properties of the enclosures and parallel interior walls facilitate component mounting and machining. Guide slots are provided in each section to accommodate PC boards or metal deck plates.

Booth No. 1718-1720

Circle No. 328

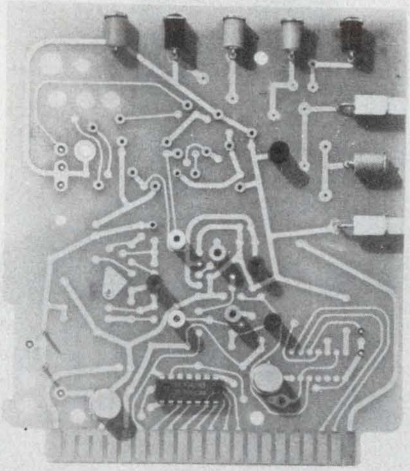
New test chamber holds 20 ft^3 of equipment

Tenney Engineering, Inc., 1090F Springfield Road, Union, NJ 07083. (201) 686-7870. From $4000.

A new temperature-humidity environmental test chamber, TH-20, simulates temperatures and humidities in the intermediate range. The chamber features a new ceiling-mounted conditioner and machinery compartment for efficient conditioning and easy service. Outside width and depth are 33-1/2 in. to allow it to pass through standard laboratory doors. Inside capacity is 20 ft^3. Electronic-bridge temperature controllers for dry and wet bulbs hold conditions to close limits. The unit operates on 115 V ac.

Booth No. 2717 *Circle No. 334*

Line of sockets includes large variety of styles



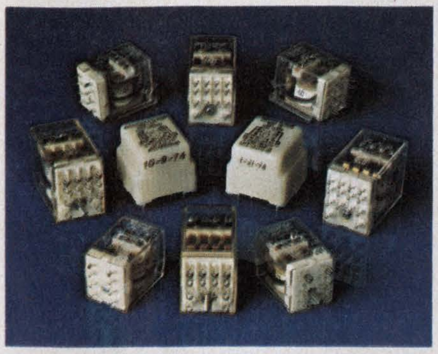
Sealectro Corp., Mamaroneck, NY 10543. (914) 698-5600.

A complete line of sockets fits PC boards, multilayer and flex circuitry and metal chassis. Noninsulated sockets can be press-fitted or swaged and feature beryllium-copper contacts in precision-machined brass sheets. Insulated sockets are offered in floating and nonfloating styles. Both styles are designed for metal-chassis applications. Press-fit Teflon insulators force flow through mounting holes to automatically lock the socket in place.

Booth No. 1215-1221
Circle No. 330

Thirteen

just became your lucky number!



Three new 10 amp relays give you 13 small enclosed relays from which to choose.

Your Guardian Angel calls them the 1300 series, of course.

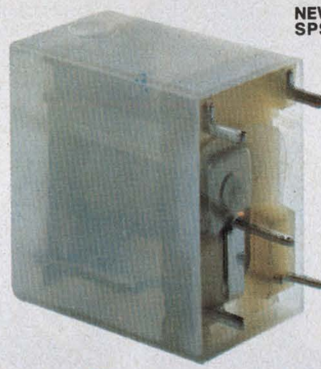
Amazing. Versatile. Small. Enclosed. Multi-pole. These five words sum up Guardian's 1300 line of 13 basic models . . . in hundreds of variations. Each relay in a choice of AC or DC, solder lug or printed circuit termination. Each with its own mating socket. Each your ideal spec for any application requiring uncompromising high quality at low, affordable price.

NEW! 1345DC relay in your choice of SPST-NO, SPST-NC or SPDT. Small in size but built to take hard knocks. Just over a cubic inch small, yet specifically designed for a minimum of 50,000 miles of maintenance free operation in automotive controls . . . or an equally amazing trouble-free life anywhere you need small size, long life and low, competitive price.

NEW 1390 and 1395 DPDT

NEW! 1390AC and 1395DC relays, DPDT with 10 amp rating in a space-saving, compact new design. To give you large control capacity in a package about half the size of competitive relays that do the same job. The cost? Just about the same as competitive units . . . in many cases quite a few cents *less.*

NEW 1345 SPST-NO, SPST-NC, SPDT



SEND FOR THE BOOK THAT TELLS IT ALL:
Guardian's 48 page relays catalog. Full of facts and specs to make selecting a relay a snap. Yours free for the asking.

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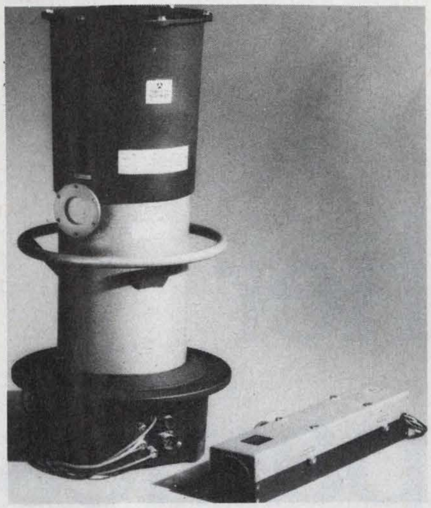
INFORMATION RETRIEVAL NUMBER 58

TWTs transmit at 6 and 14 GHz



Thomson-CSF, Groupement Tubes Electroniques, 8 rue Chasseloup-Laubat, 75737 Paris Cedex 15, France.

The company's line of 6-GHz earth-station TWTs now includes five models that reportedly have been proven in the field. Among these are the TOP 1487, a 1.2-kW power unit, and the TH 3508, a 250-W unit that can transmit a 24-telephone-channel carrier. Also, the company has developed these 14-GHz transmitters: a 20-W model, 100-W helix tube and a 2-kW coupled-cavity TWT employing forced-air cooling.

Island A *Circle No. 353*

Tuners handle mismatches

Alford Manufacturing Co., 120 Cross St., Winchester, MA 01890. (617) 729-8050. $550 to $650; 30 days.

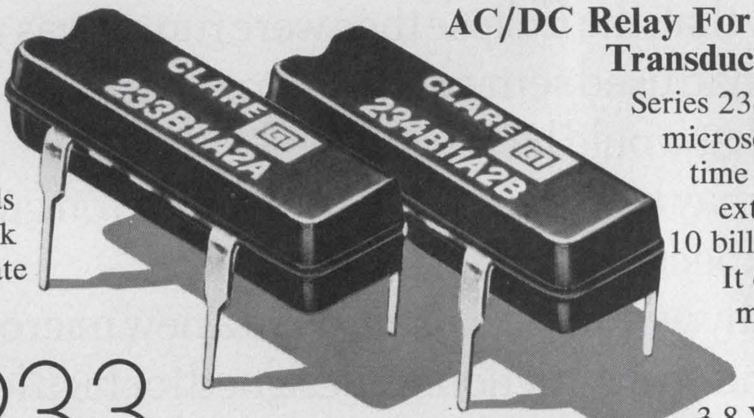
Types 5135 and 5059 twinsleeve tuners are adjustable tuning networks that can match devices mismatched by as much as 10:1 at 10 GHz. At the band edges, 7.5 and 12.4 GHz, the maximum SWR that can be matched is 8:1. The tuning sleeves, made of a dielectric material, do not provide a dc path between the inner and outer conductors. Thus, a bias injected through the coaxial transmission line will not be short circuited as it would with, say, double stub tuners.

Booth No. 2432 *Circle No. 354*

Why are other computer companies refusing to run benchmarks against the Eclipse?

INFORMATION RETRIEVAL NUMBER 60

Two New DIP SOLID STATE RELAYS from CLARE



If you have pcb designs that need fast, long-life switching for DC loads to 250 Volts —or AC/DC loads to 50 Volts—check these new solid-state relays from C. P. Clare & Company. They're DTL/TTL compatible, packaged in full-molded epoxy cases with a standard DIP footprint, and sized to fit 0.5″ pcb centers. Rugged . . . reliable . . . versatile.

233

234

AC/DC Relay For Analog And Transducer Switching

Series 234 features a 1-microsecond response time plus a long life extending beyond 10 billion operations. It offers 50 V/80 mA peak output with input ranging from 3.8 Vdc to 10 Vdc. A natural choice for analog and transducer switching, choppers, A-to-D converters, multiplexers, scanners and other sensing/input circuits for automatic process control and test equipment . . . or for line drivers between computers and their peripherals.

Two Choices For DC Load Switching

Series 233 relays feature a 1-microsecond response time plus a long life extending beyond 10 billion operations. They give you a choice of 60 Vdc/400 mA or 250 Vdc/100 mA peak outputs, both controlled by 3.8 to 10 Vdc input. They're ideal for solenoid, motor and lamp drivers in process controls, automatic test equipment and peripherals . . . or data couplers and line drivers in digital communications transmission networks.

Want To Know More?

All Series 233 and 234 models are SPST (N.O.) devices, rated for dielectric withstanding voltage of 1500 Vac and insulation resistance of 10^9 ohms. Operating and storage temperatures range from $-20°$ C to $+100°$ C. All models are in stock for immediate shipment. For specification data, contact your nearest Clare sales office or distributor. For more comprehensive application information, contact Rick Prieto, C. P. Clare & Company, 3101 W. Pratt Avenue, Chicago, Illinois 60645. Or Phone (312) 262-7700.

QUALITY, SERVICE, RELIABILITY

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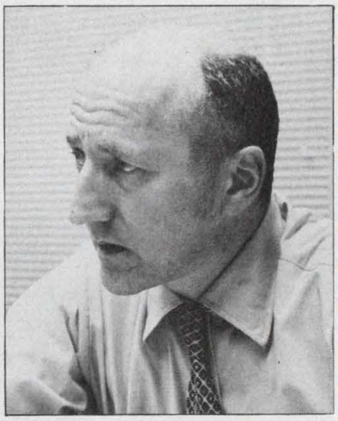
INFORMATION RETRIEVAL NUMBER 61

editorial

Jobs



It's beginning to look better out there. Business seems to be picking up and the bottom of the recession may be behind us. But the pickup isn't uniform. Some companies are still hurting. And when companies hurt, their engineers hurt, too.

While most of us who have survived the recession will probably ride out its last period unscathed, some of us won't. Some of us may soon be unemployed.

Electronic Design would like to help. We're not running an employment agency; we'd probably be awful at it. Yet we might be able to connect some companies needing good engineers with some engineers needing good companies. We may be groping at this, so if you have any better ideas, please let us know. But here's what I propose.

If you expect to need a different engineering job soon, send me a letter enclosing several resumes that I can forward to possible employers. If you know some engineers who have already lost their jobs, have them send me several resumes, too.

On the other hand, if you're looking for engineers, send me a letter describing the qualifications you'd like to find. I'll try to match resumes with available jobs.

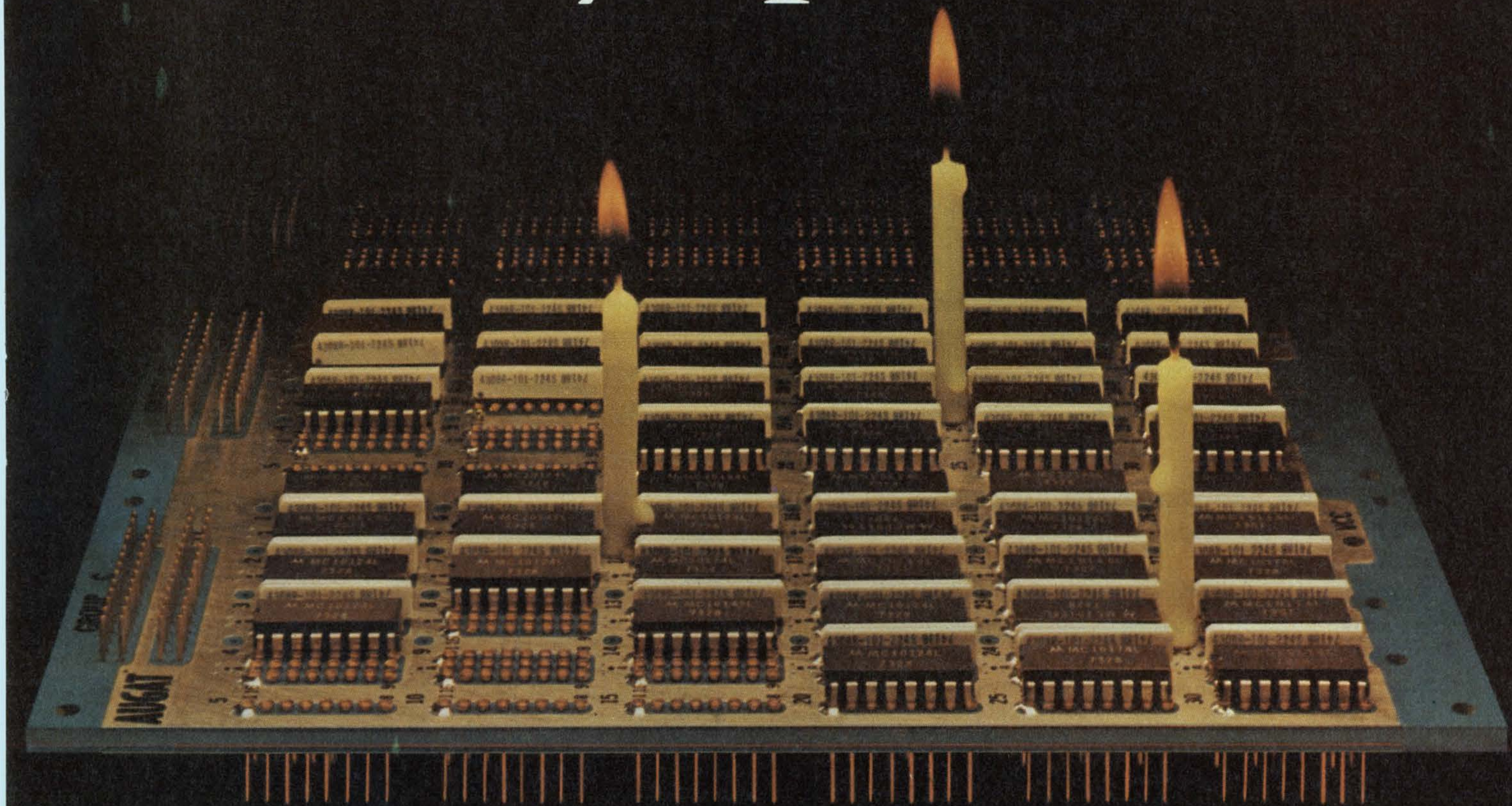
I can't guarantee success. It's quite possible I may never find good matches. But I'll try. Further, I probably won't be able to answer your letters either, and that's going to hurt because I like to answer any reader who takes time to write to me. In this case, however, the volume of mail might outstrip my capacity to reply. Please forgive me for that.

This is, of course, a free service of Electronic Design. But I hope you won't need it.

George Rostky

GEORGE ROSTKY
Editor-in-Chief

ECL design just became a three-layer piece of cake.



Augat ECL Board with −2 volt bus for terminating single in-line package (SIP) resistor network.

Compared to methods of the past, the Augat series of socket, Wire-Wrap® ECL boards makes ECL design a piece of cake. Even for circuits in the 125 to 500+ MHZ range.

They can save you 90 percent or more in breadboarding and prototyping time. Tens of thousands of dollars in start-up costs. And many costly hours in field maintainability.

With this proven advance in three-layer interconnection technology you don't have to design in controlled impedance interconnections, mess around with transmission lines, or commit power connections for different ECL logic modules. All of which frees you to concentrate on the partitioning of logic functions and the preparation of a wiring list.

And unlike a multi-layer P.C. board, there is no loss in planar density. Two 16-pin ECL and associated pull down and decoupling components fit into one square inch on every Augat ECL board.

The nice thing, too, is that Augat ECL boards are standard catalog items available in any quantity at any time from Augat distributors around the world. You can contact them directly or write Augat, Inc., 33 Perry Avenue, Attleboro, Mass. 02703. Tel. 617-222-2202. TWX 710-391-0644.

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FOCUS on Semiconductor memories

It's best to be a pessimist when you consider delivery promises and product specifications for IC memories. Unfortunately young technologies don't lend themselves to early standardization. And vendors, continuously under pressure to introduce new memories, may announce ICs before they are fully characterized—or even manufactured.

In the heat of competition, a vendor may circulate a data sheet that seems to guarantee "min/max" specs. But the sheet may bear the legend "tentative," "preliminary" or some other variant of "we hope we can make the part." "Tenative" specs, like "projected" prices for a new circuit, often are more attractive than firm specs and market prices for an established unit.

Prices rate as much attention as the specs. If the price is low, it may be because the vendor has yet to make the memory, or he has built a single chip and hopes that production quantities will drop the cost.

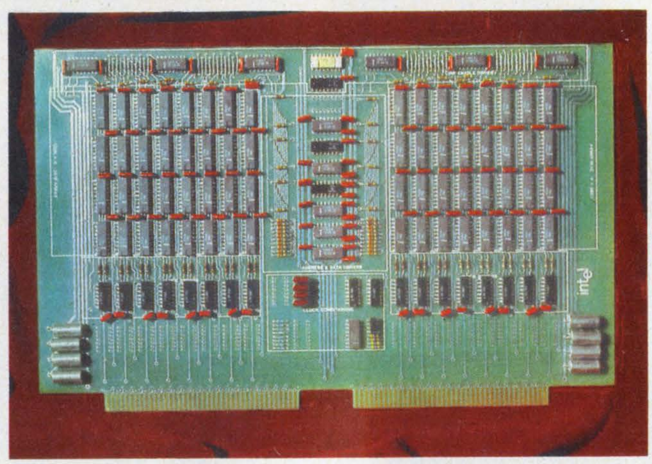
Moreover, the IC-memory business has some peculiarities: In many cases the laws of supply and demand are completely abandoned in both good and down times. Prices can plummet for a memory that everybody wants and nobody can make.

Specs are interdependent

Because memory specs are closely linked to one another, it's a formidable task to characterize a circuit fully—even for a conscientious vendor and even for a well-established memory. You have to be aware of your own requirements and prepared to ask a lot of questions.

When a vendor writes, for example, that a memory is available in different speed ranges, it would be prudent to ask, "What else changes?"

Edward A. Torrero
Associate Editor



16-k bit CCD memory chips—Intel's 2416—are the main element of a 1-Mbit prototype board. Of all the packages, 30% provide support circuits.

This question must be raised often. Vendors are always pushing the state of the art. Often they advance one or more specs, but not all. You have to know what sacrifices were made, what tradeoffs to get the new spec.

It's necessary, too, to determine if a particular advance is useful in your application. A new memory designed to work with the company's LSI microprocessor, for example, would be fine—in a microcomputer that uses the vendor's processor. It could easily be out of place in a mainframe application.

A vendor may emphasize that a RAM or ROM features full decoding on the chip. But you might cut costs and save nanoseconds in your system by having undecoded storage chips share a decoder/driver.

A vendor may hail the TTL compatibility of his MOS memory, perhaps forgetting its need for external pullup resistors. Though they're cheap, resistors may take up precious board space. Another memory might not need the external components, but your system could benefit from the use of level translators external to the MOS chip.

Programmable ROMs (PROMs) introduce additional problems. Many dc and most ac characteristics—including speed—can't be readily obtained. As supplied by the vendor, a PROM isn't a finished product. Thus a spec sheet for a new PROM is often based more on preliminary data than on final characteristics.

Be guided by worst-case specs

As with most electronic products you buy, your selection of an IC memory will eventually be based on comparison of data sheets. Bear in mind that some key specifications might be incomplete, others might mislead if taken too literally and still others may not be given. Check for absolute worst-case values for all specs. After selecting a memory, you'll want to design around these values.

Access times, for example, are widely favored specs to indicate the prowess of memory circuits. But "maximum" access times are often specified only for room-temperature and nominal supply-voltage conditions. Over the full temperature range and supply tolerances, the memory can be a lot slower than you first thought.

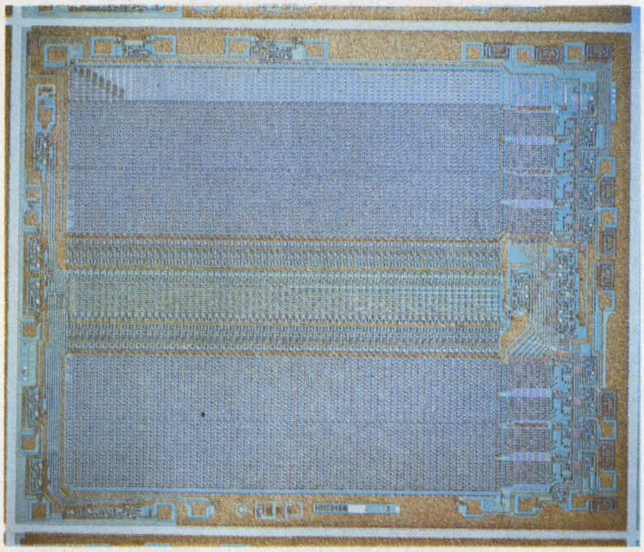
Different vendors may quote different access times for equivalent devices. They may have different definitions. MOS RAMs, especially early versions, sometimes emphasize chip-enable access—input-to-output delay, with the address present, when the chip-enable signal is applied. This chip-enable access time can be much shorter than the more commonly specified address access, in which chip enable comes after the address. Memory systems use both access modes. However, the difference is wide enough to mask some of the speed advantages of a bipolar memory over a MOS circuit, in the same application.

And "access" times don't measure a memory's system speed as well as "cycle" time, which tells you the speed for repetitive addressing. Typically read or write cycle times can vary markedly for different circuits that have the same access and internal architecture. Also, bipolar RAMs, which are static, have roughly equal access and cycle times, while MOS versions have cycle times that can be two to three times greater than the access spec.

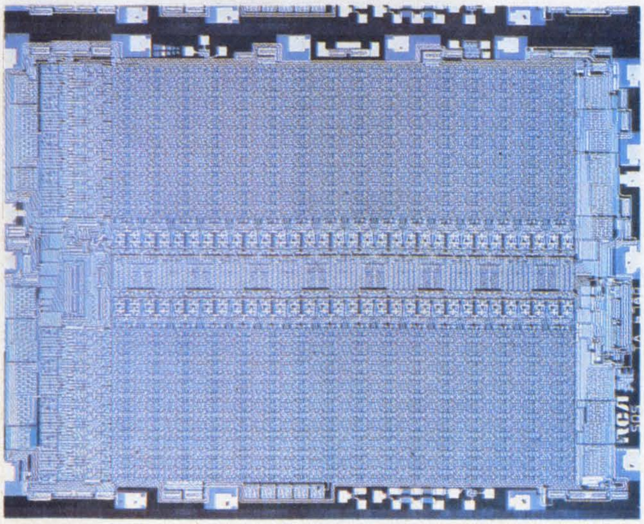
Moreover access times aren't always guaranteed or consistent with such critical timing parameters as address hold time and write pulse width. And a specified access can depend on the characteristics of external control signals—like sharp rise and fall times from clock drivers. As a result, system operating speeds may have to be reduced from those indicated, because of requirements that are difficult to meet.

Other problems can arise with specifications for refresh, which is needed by dynamic memories to replenish data on internal storage capacitors. Here again, the data sheets frequently specify refresh periods only at room temperature. But at the maximum operating temperature, refresh is needed more often, and you can't always project the refresh requirements to the higher temperature.

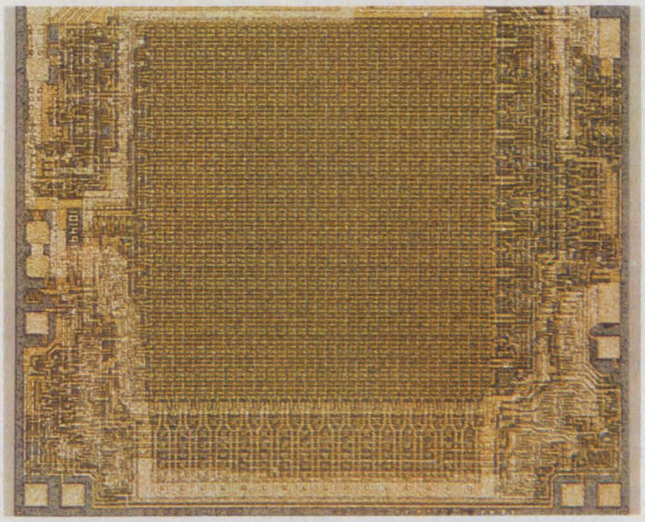
In addition, refresh power constitutes a significant portion of the total standby power in many dynamic RAMs. But listed standby-power



Bipolar PROMs reach 4-k bit densities. Here is Monolithic Memories' 5340, the first 4-k bipolar PROM. The IC has a typical programming time of 5 ms/bit.



By combining CMOS and silicon-on-sapphire techniques, RCA obtains a 1-k bit static RAM. The package pinout is that of popular bipolar memories.



The largest ECL-10,000 PROM—Motorola's MCM 10149 —has 256 × 4-bit organization and maximum access of 25 ns. The bipolar PROM employs fusible links.

specs don't always include the refresh increment. If they don't, you can be way off in power estimates for a backup supply system.

The standby, or power-down, feature of static and dynamic memories lets you maintain data when not reading or writing. This feature can substantially reduce over-all power requirements. But some data sheets don't guarantee what supply levels you can safely reduce to. The omission can be serious. At relatively low supply levels, system noise may lead to loss of data.

Specs reflect test methods

Manufacturers establish specifications around the test procedures they use, and measurements are almost always automated to keep costs low. But chances are that your system won't duplicate the conditions on the manufacturers' test equipment.

A memory's listed speed and drive capability, for example, often assume a fixed load connected right next to a memory's output. In any practical design that load could be a distributed variable. Hence you'll probably be able to achieve either the specified fanout or input-to-output delay—but not necessarily both at the same time.

More important, manufacturers don't test all operating-mode combinations, which would reveal so-called pattern sensitivities. In the worst case, these sensitivities show that some data can be lost unintentionally. Usually, though, so-called soft-bit errors are revealed—operational characteristics change with timing or data conditions.

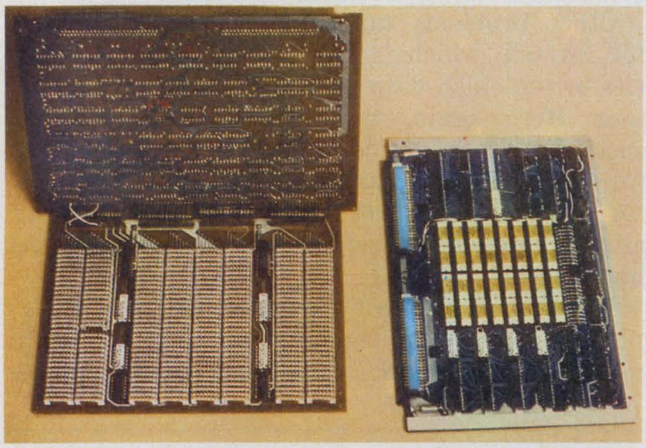
Most manufacturers use special test patterns —which differ from one vendor to another— to keep testing time down and presumably to check for worst conditions. But don't expect to find sensitivity information on the data sheet. Manufacturers rarely publish this.

The problem of pattern sensitivities decreases when you operate the memory well within its specification limits. And it's less of a problem for a static circuit than for a dynamic one. In any case, you may have to check for specific patterns that occur in your system.

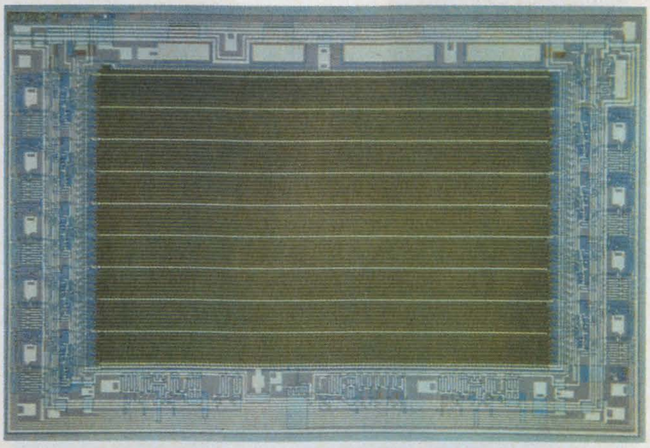
The inability of manufacturers to test PROMs fully poses special problems for the unwary user. A PROM user takes over some of the manufacturer's functions—and some of his yield problems. Only about 70 to 95% of the PROMs you purchase can be programmed successfully. Moreover newer high-density memories tend to give the lowest yields, while the smallest—256-bit—have the highest.

Thus to obtain, say, 100 good PROMs, you have to order 110 or 120. Of course, you can expect the manufacturer to replace rejects. But if you didn't purchase the extra units ahead of time, the additional time lag could neutralize the advantage of quick turn-around ROMs.

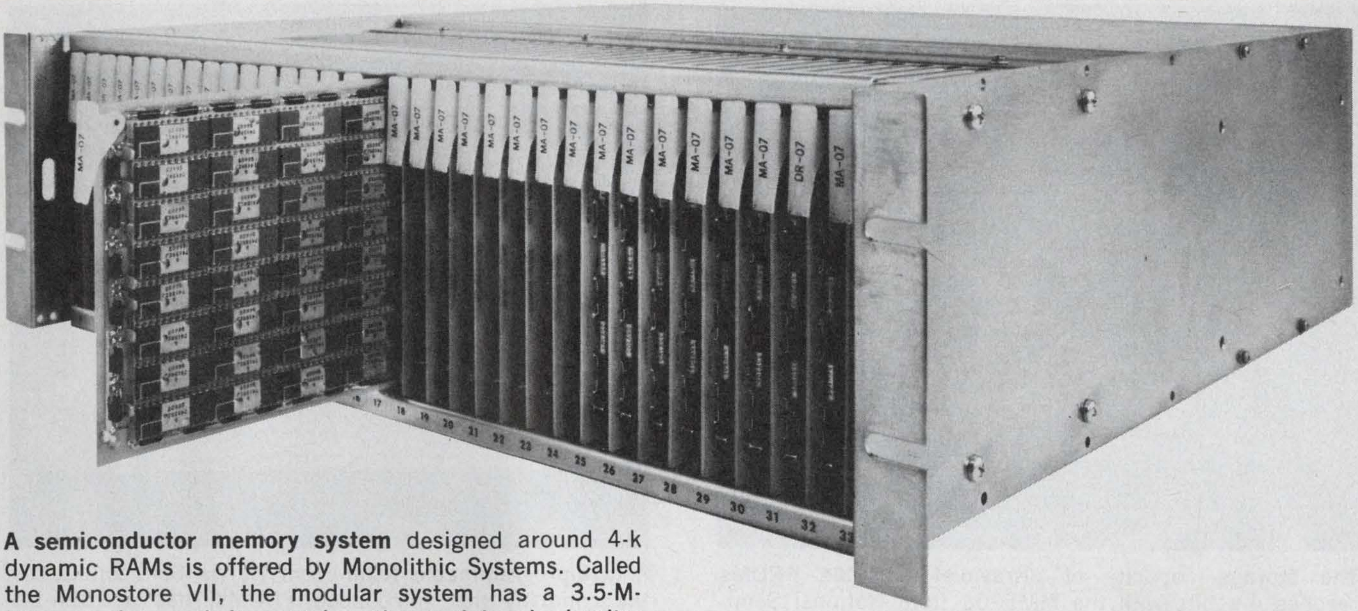
One solution is to have a distributor or pos-



Memory boards employ 512-bit CMOS static RAMs—American Microsystems' S2222. The boards are used in Rolm's Rugged Nova system.



The first CCD memory chip—Fairchild's 9-k-bit circuit —employs nine 1024-bit registers that are shifted in parallel. The operating frequency is specified at 3 MHz.



A semiconductor memory system designed around 4-k dynamic RAMs is offered by Monolithic Systems. Called the Monostore VII, the modular system has a 3.5-M-bit capacity, and it contains the peripheral circuitry needed by the RAM chips.

sibly the manufacturer program the memory. Post-programming tests weed out rejects prior to shipment. However, the increased cost of this approach usually precludes its use in low-volume applications.

Also, total costs can be higher than expected if you choose to use PROMs from different vendors. No two vendors' PROMs will program in exactly the same way, though they may have the same post-programming electrical characteristics and the same pinouts. Furthermore PROMs from the same vendor can have different programming requirements, too. Hence you can't simply program a company's new high-density PROM with the same equipment, and equipment settings, that you used for the vendor's pin-compatible, lower density PROM.

Programming equipment doesn't come cheaply. In addition to the basic mainframe, or chassis, you need a special module that tailors the equipment to a specific PROM. The module costs a few hundred dollars, while the chassis can set you back several thousand. Some equipment can handle a wide range of PROMs, but these programmers cost much more.

Some of the benefits

In spite of their many problems, available memories are getting cheaper, faster and bigger. And despite predictions that 1975 will be a down year, manufacturers are moving ahead with plans for even better memories.

As with other components, the cost of IC memories falls as market demand increases, and this year is no exception. Though a bad year for the industry, it's shaping up as a good one for semiconductor memories. Thus volume quantities of bipolar RAMs now selling at 0.7 to 0.9 cent per bit are expected to drop to less than 0.5 cent next year. And MOS memories, which are generally cheaper than their bipolar cousins, are heading down in price, too.

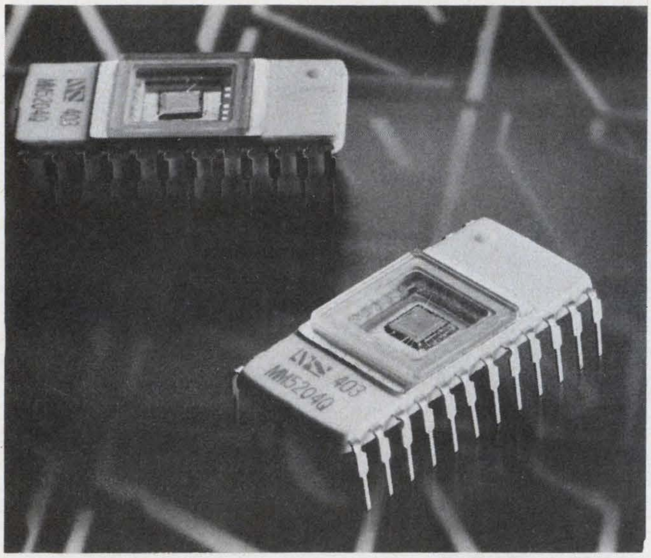
In addition a whole crop of new memories is emerging for LSI-microprocessor applications. Besides tailoring memory specs to the needs of processor chips, these new memories are organized to reduce the number of packages needed.

The newest, primarily microprocessor-oriented, memories are yielding the highest densities yet. Already a 16-k bit bipolar ROM has emerged, and 4-k—even 8-k—erasable MOS PROMs have been announced. In the wings and due for introduction shortly are MOS ROMs with bit capacities of 32 k and possibly 64 k.

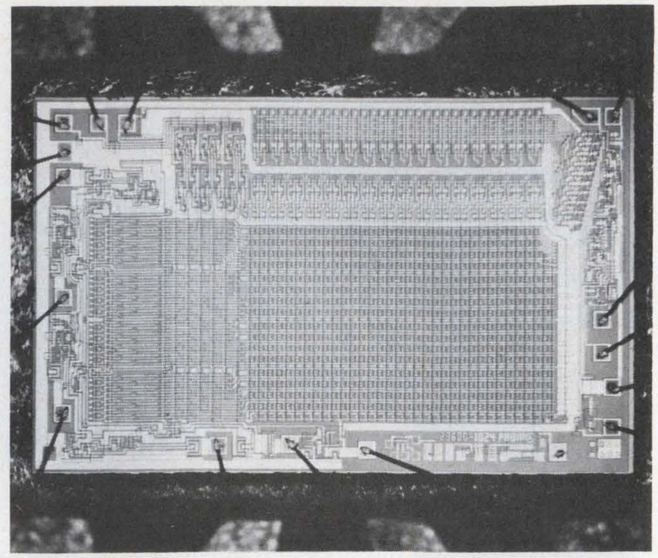
MOS RAMs move up to 4-k bit level

Meanwhile steady improvements in the design of memory chips have simplified the use of recent memories, such as the new 4096-bit MOS RAMs. In previous models dynamic memories offered higher speeds with less dissipation than static types. The tradeoff, however, was increased support circuitry because of critical timing specs and the need for several clocks or large voltage swings. The newest dynamic RAMs relax some of these conditions without sacrificing speed.

The latest entries in the suddenly crowded 4-k MOS RAM race are shifting the spotlight from basic performance toward system savings. Though faster, the newest versions also emphasize smaller packages for heightened PC-board densities. And one new 4-k RAM (from EMM Semi) features static operation—all others are dynamic. The result is an automatic reduction in



The storage capacity of ultraviolet erasable PROMs reaches 4-k bits with the MM5204 from National Semiconductor. The listed programming time is 30 sec.



A field-programmable ROM from Harris Semiconductor, the company that introduced PROMs, has a 1024-bit capacity. The PROM features access time of 50 ns.

support circuitry and external components.

Most of the earliest 4-k RAMs, which surfaced about a year ago, are similar in fabrication, performance and packaging. Generally they are n-channel, silicon-gate circuits with maximum access times of about 300 ns and maximum cycle times of about 500 ns. And except for Mostek's MK 4096, which comes in a 16-pin DIP, all others—including the Microsystems International 7112, the first on the market—are offered in a 22-pin DIP. However, the various units differ in external-component requirements, refresh cycles, pinouts and alternate sources.

American Microsystems and Motorola obtained alternate sources the easy way: They developed the 6605 jointly. Among available 4-k dynamic RAMs, this unit has one of the lowest refresh requirements: only 32 cycles of refresh every 2 ms, compared with 64 every 2 ms for most other RAMs. (Western Digital's RM1701 needs a lower refresh: 16 cycles every 2 ms.) Reduced refresh lessens the read/write "down" times. And the 6605 also has low standby power of 2.6 mW (including refresh) and short access, 230 ns.

Ever shorter access times are being sought by several manufacturers. AMI and Motorola, for example, plan to develop an upgraded version of the 6605 that will guarantee a maximum access of 150 ns or less.

Starting with different chip designs and different pinouts, Intel and Texas Instruments got together on a common pin arrangement for their 4-k RAMs—the 2107 and the TMS 4030, respectively. The Intel/TI pinout, like Mostek's, has become a standard. Most new 4-k RAMs in 22-pin DIPs are using this pinout, just as new 4-k RAMs in 16-pin DIPs (such as Fairchild's) are adopting the Mostek pattern.

The most recent version of the Intel/TI RAM —TMS 4060/2107B—offers maximum access of 200 ns. This is the fastest yet specified for recent 4-k dynamic silicon-gate RAMs, and Intel and TI share this top speed with newer versions announced by Mostek, National Semiconductor and Western Digital among others. Many of these high-speed versions also list the top cycle time of 400 ns.

While Intel and TI use the same 22-pin pattern, they have gone in different directions on a smaller package. Intel plans to offer a version of the Mostek 16-pin RAM, while TI has its own 18-pin RAM, the TM 4050, which has the same speed ratings as its high-speed TMS 4060.

The 18-pin TMS 4050 multiplexes input and output data on a single terminal. The feature has the benefit of simplified interfacing to bussed systems. But in contrast with the Mostek unit, which requires multiplexed addressing, the TMS 4060 provides a full 12-line address. Also, the TI RAM eliminates the chip-select terminal by having the chip-enable clock and read/write-mode control perform the enable function.

A different arrangement is used in the only other 4-k RAM in an 18-pin DIP—National Semiconductor's MM5270. With a technique the company calls Tri-Share, the National RAM replaces three leads with one that serves the functions of read/write, logic chip select and V_{CC}.

Proving that static memories don't have to be slower and consume more power than their dynamic cousins, EMM Semi recently announced the first 4-k static NMOS RAM with specified access of 150 ns and a cycle of 300 ns (Model 4402). However, the static memory requires an external sense amplifier.

The sense amp can be eliminated by use of a modified version (the 4401) which provides TTL outputs directly. However, this adds about 30 ns to the access time, bringing it up to 180 ns. The 4401 and 4402 dissipate about 60 mW in the standby mode and 300 mW when accessed. The chips come in 22-pin DIPs that use the Intel/TI pinout.

1-k MOS RAMs: Industry workhorses

Compared with 4-k RAMs, which have yet to undergo a shakeout, 1024-bit MOS RAMs present a more stable picture. Product improvements continue, to be sure, but the industry has settled on some workhorses: the 1103 dynamic RAM and the 2012 static RAM, both introduced by Intel, and the 7001, an "in-between" RAM introduced by Advanced Memory Systems. These ICs and upgraded versions from original and alternate sources are used in the great bulk of memory applications.

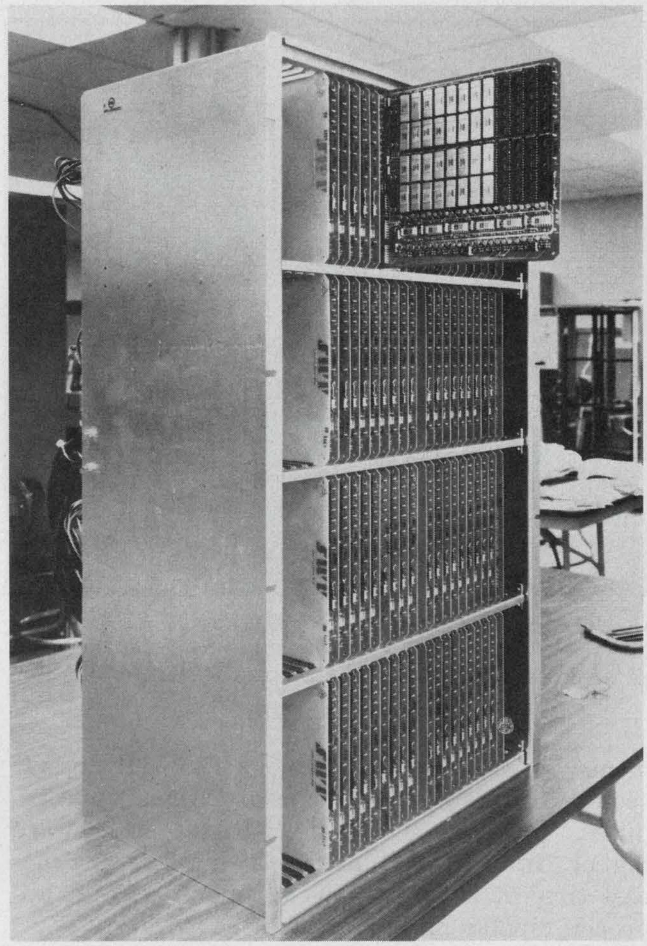
With the introduction of the 1103 and other 1-k RAMs in 1970, computer manufacturers began to consider semiconductor memories seriously in their designs. Though power dissipation was on a high side and the IC needed external components to make it work, the 1103's over-all specs and price were attractive.

One problem of the original 1103 was its critical overlap timing spec. The memory's timing involved a short, moving "window," or overlap, between precharge and chip-enable signals. For too short an overlap, the read-data lines could not discharge properly; for too large an overlap, the read lines could discharge prematurely. Hence carefully designed timing circuits were needed to ensure fast rise and fall times and accurate sequencing.

Later versions from Intel and other manufacturers have eliminated this problem and brought other improvements. Synertek, for example, recently announced the SY 1103A-1, which eliminates the precharge clock altogether. The silicon-gate RAM uses ion-implantation techniques to achieve worst-case access times of 145 ns. Chip-enable capacitance reduces to 18 pF, so that clock dissipation, as well as the number of system clock drivers, can be decreased.

For a host of applications, however, the performance of fast 1103-type memories isn't needed. Designers are willing to trade off speed for reduced support circuitry and increased TTL compatibility. For these reasons and more, the static NMOS 2102 has become the most widely alternate-sourced memory, either MOS or bipolar.

Manufacturers and designers alike agree on the 2102's ease of use. It operates from the same 5-V supply as TTL, and it can provide TTL interface characteristics without the need for external components. They say you can replace an equivalent TTL circuit with a 2102, and the system won't know the difference.

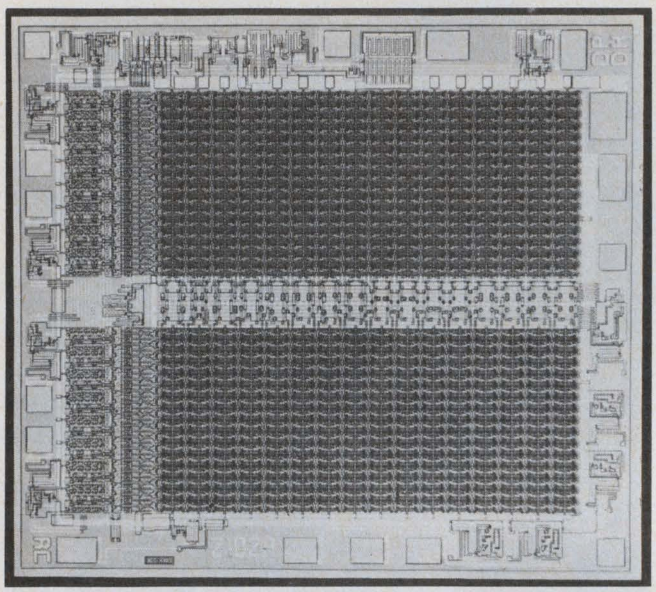


In addition to manufacturing chips, Advanced Memory Systems offers complete memory systems. The memory chips include 4-k dynamic RAMs and 1-k SOS arrays.

Standard 2102s have access times of 1000, 600 and 400 ns, and power dissipations that are somewhat less than those of comparable, though higher-speed, bipolar units. However, 2102s with higher speeds and lower dissipations are available. Advanced Micro Devices, for example, combines access of 300 ns with dissipation of 140 mW in the 9100 series—the company's version of the 2102. A triple ion-implantation process is used to create depletion loads, rather than the usual enhancement loads, in the memory's cells. The depletion load, which is normally on, doesn't need the half volt required by an enhancement type. This small saving produces much of the improvement.

Top speeds in the 9100 series reach 225 ns, but with some increase in dissipated power. Also, the series has a fanout of two TTL loads, compared with one for typical 2102s, and the logic levels are guaranteed to be identical to TTL levels.

Filling some of the gap between the 2102 and 1103 memories, the 7001 and similar versions combine the features of static and dynamic



One of the most popular memories is the 2102, introduced by Intel. The 1-k NMOS static RAM can be used as a direct replacement for comparable bipolar ICs.

memories. Like a static memory, the 7001 doesn't require refresh, so peripheral circuitry is reduced. But like a dynamic RAM, speeds are higher. In fact, 7001 memories, with typical access time of 60 ns and cycle time of 180 ns, approach bipolar memories in speed.

Externally the 7001 appears static, although the internal cells operate dynamically. A so-called charge pump, external to the RAM, compensates for internal storage-capacitor losses caused by leakage. The replenishing doesn't require any power-down time, and the pump signal can be a simple sine wave with a frequency of about 1 MHz.

Advanced Memory Systems has come out with an improved version of the 7001 that simplifies the memory's interface to TTL circuits. Called the 7001I, it doesn't require the input pullup resistors that the original circuit does, since the input levels are now those of TTL. And for the chip-select input, current-drive requirements have been reduced from 20 to 8 mA. The select input can be driven by an emitter follower rather than a complementary pair.

The redesigned chip maintains the fast access and cycle times of the original memory. In addition standby power is now spec'd at 0.5 μW/bit, down from 60 μW/bit. The spec on maximum power dissipation remains the same at 640 μW/bit. The 7001I is also being offered by RCA.

Bipolar RAMs race ahead

On the bipolar side of the RAM picture, 1024-bit memories have been introduced by Fairchild, Intersil, Monolithic Memories, Raytheon and Signetics, among others. The most widely discussed and probably most widely sold—Fairchild's 93415—uses the company's Isoplanar process. It employs silicon-nitride masking to permit oxide isolation instead of diode isolation, allowing substantial reduction in cell size. Raytheon's V-ATE process achieves much the same effect by using an air notch, which also cuts the empty spaces between devices.

Several Signetics' RAMs prove that 1-k bipolar memories don't necessarily need an advanced form of passive isolation. However the company does employ Schottky processing with such refinements as dual-layer metallization. Using the same pinout as the 93415, the company says its versions can directly replace the Fairchild unit without change in system circuitry. For much larger storage than 1 k, though, Signetics plans to turn to special density-enhancing techniques.

Fairchild's first Isoplanar 1-k RAM, introduced in 1972, measured about 130 × 150 mils and had an average speed of 60 to 65 ns. This version was reduced in two stages to 104 × 109 mils, with an increase in speed of 20 ns. And by the middle of this year, Fairchild expects to have an even smaller chip—the 93415A—with typical speeds of 30 to 35 ns. Besides speed, the bipolar memory has a power advantage. Dissipation decreases as temperature increases. Typically the standard 93415 dissipates about 1/2 W at room temperature.

For systems using ECL-10,000 logic, Fairchild has a 1024-bit ECL RAM, the 10415. Motorola, which introduced ECL-10,000, is preparing to introduce a similar version, the MCM 10146. Both versions feature compatibility with the popular high-speed logic family.

While 1-k ECL RAMs will be able to reduce package count, much smaller memories still provide the fastest speeds. A 64-bit RAM in the ECL-10,000 family has access times of about 10 ns. Assuming that you interconnect 16 packages —for 1024 words—within a 1-ft radius, you lose only a few nanoseconds in the wiring. But you gain about 30 to 40 ns over a 1-k RAM package.

SOS/CMOS challenges bipolar

Meanwhile a new challenger to 1-k bipolar RAMs is emerging in the form of an SOS/CMOS chip. This 1024 × 1-bit static memory from RCA and Advanced Memory Systems is called the TA6780 (preliminary numbering) and the AMS-5001, respectively. It provides speeds comparable to those of the 93415. And the less power-hungry SOS/CMOS RAM has 93415 pinouts, too. (RCA and Advanced Memory Systems also may come out with a 256 × 4-bit version aimed at bulk CMOS sockets.)

The new SOS/CMOS memory (RCA calls it COSMOS) consumes about 20 mW of active dissipation and 1 mW of standby power at 10 V (compared with about 1/2 W for the 93415 at 5 V). Access time at 10 V is about 120 ns in the initial version. RCA expects later versions to achieve access of 80 ns, and by year's end, 60 ns—the level of the 93415s. The circuit operates down to 4 V., and it has an upper limit of 12 V. Also, it can hold data with standby supplies at just 1.2 V.

An unusual feature of the chip's fabrication is the use of both silicon-gate and ion-implantation techniques in addition to silicon-on-sapphire. In the past most manufacturers have used one, or perhaps two, of these techniques. RCA says the combination boosts speed, reliability and yield.

In bulk CMOS memories, the industry has moved up to 1024-bit static RAMs, with products announced by several companies, including Intel, Intersil and Siltek. In its 1501, Intel provides a 256 × 4-bit configuration, rather than the more common 1024 × 1. And the first CMOS content-addressable memory, or CAM, has been built by Solid-State Scientific, another company that plans to introduce SOS/CMOS memories.

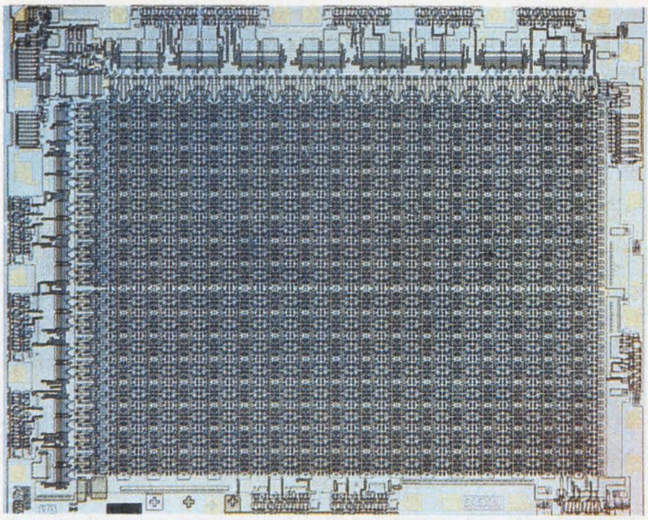
For high speed and low power, a CMOS RAM with a somewhat unusual organization—512 × 1 —surpasses most of its CMOS RAM competition not only at the 1-k level but also for 256-bit units. The 512-bit unit, American Microsystems' S2222, has the top access time, 400 ns, and cycle time, 940 ns. Moreover it has the low power drain of 20 nW/bit (standby) and 15 μW/bit (operating). The static RAM operates from a single 10-V supply and has a single read/write control line.

Memories for LSI microprocessors

Many of the latest RAMs, ROMs and PROMs —both bipolar and MOS—have emerged as parts of LSI-microprocessor chip sets from such manufacturers as Intel, Motorola, National Semiconductor and Rockwell. In some cases the memories have been extensions of popular circuits, like the 2102; in others, they represent major departures.

In Motorola's M6800 MPU microprocessor set, for example, the 6810 RAM can be described as a 2102 with eight outputs, rather than one. The 6810, with an organization of 128 × 8 bits, is intended to work with the company's 8-bit microprocessor. And since the chip set's ROM, the 6830, also provides 8-bit words (up to 1024), a minimum system can include the 8-bit microprocessor and only one RAM and one ROM. All three ICs employ n-channel MOS technology, and they operate from a single 5-V supply.

Similarly Intel has provided special memories for the company's popular MOS microprocessors: the p-channel 8008, the first 8-bit processor chip, and the n-channel 8080, described as the "first second-generation CPU chip." Like the Motorola units the Intel memories provide the logic levels, timing and speed required, while keeping the number of packages down.



A 1024-bit CMOS static RAM, Intersil's IM6508, offers 250-ns access time over the full temperature range with a 5-V supply. Access drops to 100 ns at 10 V.

Rockwell goes one step farther with its memories for the PPS-4 and PPS-8 systems—4 and 8-bit microprocessor systems, respectively. For example, you can get a combination ROM/RAM chip for additional convenience. The A08 memory includes a 704 × 8-bit ROM and a 76 × 4-bit RAM. By the middle of the year, Rockwell expects to have a 256 × 8-bit electrically erasable ROM (the 10443).

A 42-pin DIP is the standard package for Rockwell's PPS circuits, including the memories. The large package accommodates additional circuitry that simplifies interfacing to the processor and special peripheral ICs, such as CRT and floppy-disc controllers. But because the memories are so closely linked to the company's microprocessors, applications other than for microcomputers tend to be limited.

ROMs find growing use

As microprocessors expand their applications, manufacturers are developing ever larger mask-programmable and precoded ROMs. In various forms—such as code converters, character generators and lookup tables—the precoded ROMs offer designers one way to beat mask charges, short of high-volume buying. For similar reasons, manufacturers are now precoding microprocessor software routines into their ROMs, and they are looking down the road toward more ambitious developments.

A debug program for Motorola's MPU system, for example, comes in two 6830 packages. Called Mikebug, the program can exercise each function of the microprocessor and its peripheral circuits. The two 8-k ROMs may be replaced with a single package when Motorola introduces its 16-k NMOS ROM, the 6832. It is organized as 2-k × 8 bits. Other manufacturers developing 16-k NMOS ROMs include Electronic Arrays, Intel and Microsystems International.

Moreover, with even larger ROMs, it's possible that even Fortran compilers will be offered on one or a few precoded chips. These would greatly simplify program development. Manufacturers report that NMOS ROMs reaching 64-k bit storage could be available by the end of the year. Motorola, for one, may have an 8-k × 8-bit NMOS ROM with access times of about 600 ns—about the upper limit needed for NMOS microprocessors. According to the company, package dissipation, rather than chip technology, is the major barrier.

Meanwhile the largest ROM has just been announced by MOS Technology. The p-channel MOS memory, called the MCS 2029, allows 32-k bits of storage. Its access time is 800 ns, and it features TTL compatibility.

By comparison, the largest bipolar ROM is National Semiconductor's recently introduced 16-k bit memories, DM 8531/8581. The two versions have typical access time of 300 ns, latched inputs and Tri-State outputs. But they differ in organization and packaging. The DM 8531 provides 2-k words, each 8 bits long, and it comes in a 24-pin DIP. The DM 8581, in a 40-pin DIP, has a 1-k × 16-bit organization. The DM 8531 can be used with the company's 8-bit microprocessors, and the DM 8581 with 16-bit processors.

PROMs handle 4-k bits

The largest bipolar PROMs provide 4-k bits of storage, and chips are being offered by several manufacturers, including Signetics and Intel. The first 4-k PROM available was Monolithic Memories' 5340. It features maximum access time of 90 ns. And maximum times for enable access and enable recovery are guaranteed to be 40 ns.

The Monolithic Memories' PROM uses fusible nichrome links, and its speed is achieved with Schottky-TTL processing. Programming can be attained at the typical rate of 5 ms/bit, or less than 25 seconds per PROM. The 5340 operates from a 5-V supply and has a dissipation of about 170 μW per bit.

Fusible nichrome links are used by several bipolar-PROM vendors. Beside Monolithic Memories, other manufacturers of this type of PROM include Fairchild, Harris Semiconductor, National Semiconductor and Signetics. Other types of PROMs are offered by additional vendors. Intersil uses AIM, or avalanche-induced migration, while Intel and Advanced Micro Devices stress polysilicon fuses. And Texas Instruments emphasizes titanium-tungsten. Each technique provides a different tradeoff for programming power needs vs long-term reliability.

More recently, several manufacturers are seeking to upgrade the testing of PROMs. With additional circuitry built into the PROM chip, for example, Monolithic Memories expects to achieve improved ac and dc measurements. Among other features, the new testing techniques can provide enhanced correlation between programmed and unprogrammed circuits.

Similarly Harris Semiconductor—the company that introduced PROMs—plans to offer a new family of products called Generic PROMs. In addition to improved measurement capabilities, each member of the family will have the same programming requirements and the same input and output characteristics. Generic PROMs, which will have standard bit capacities, are slated to offer guaranteed access times over operating temperature and voltage-supply ranges.

On the MOS side of PROMs, ultraviolet erasable memories with increased storage are emerging from National Semiconductor and Intel. The National unit, the MM5204, is a 4-k PROM with a programming time of 30 sec. The Intel PROM, the 2708, has a capacity of 8-k bits and an access of about 500 ns. Its chip design resembles that of the company's popular 1702A ultraviolet-erasable PROM, which has a 2-k bit storage capacity.

Another approach to a reversible PROM electrically alters the program. And a process that allows this is MNOS—short for metal-nitride oxide semiconductor. Compared with Intel's FAMOS (floating-gate avalanche-injection metal oxide semiconductor) erasable ROMs, memories using MNOS generally specify faster write and erase times but slower read times. However, the acceptance of MNOS memories may be on the upswing. In addition to NCR and Nitron, the major suppliers to date, Fairchild says it plans to enter the field.

From Energy Conversion Devices comes yet another way to achieve electrically alterable PROMs. The company's memories employ a matrix of amorphous glass and silicon diodes. A switch at each matrix cross-point can be changed from a relatively high resistance to a low one and back again; so a program is easily changed.

Enter CCD memories

However, the memory technology currently in the spotlight is the charge-coupled device (CCD). With the introduction of the first 16-bit CCD memory chip—Intel's 2416—charge-coupled-device ICs have become serious contenders for many mass-storage applications now filled by discs and drums.

The new memory combines a maximum serial-data rate of 2 Mbits/sec with an average access time to any bit of less than 100 μs. And compared with electromechanical storage, the CCD memory requires a fraction of the space and power.

However, Intel's CCD memory may face stiff competition from another 16-k bit chip expected from Fairchild. Recently, the latter announced the first CCD memory, a 9-k bit chip, and described a 16-k CCD now being readied for introduction. According to preliminary data, the 16-k bit CCD is expected to have shorter access times and higher data rates than the Intel version.

CCD memories combine features of conventional shift registers and RAMs. Like a RAM, the Intel 2416 uses a 6-bit address input to select an internal memory region. But the memory regions accessed on the CCD chip are organized as shift registers.

A total of 64 shift registers divides the memory's over-all capacity of 16,384 bits into equal lengths. Hence each of the randomly addressable registers is 256 bits long. And a specific bit location can be accessed with only 128 shift operations, on the average—corresponding to half the total length of a register. (Were the 2416 built as a continuous register, 8192 shift operations would be needed, on the average, to access a specific bit.)

External four-phase clocks determine the data-shift rate, which can be any frequency from about 125 kHz to more than 1 MHz, over a 0-to-70-C temperature range. Depending on the shift rate, the average access time to any bit ranges from less than 100 μs to 1 ms. The shift registers recirculate data automatically, so long as the four-phase clocks are applied continuously and no write command is given.

Data rates can be increased to more than 2 MHz by the sequential addressing of several registers between successive shift operations. This mode has the advantage of decreasing the clock-driver power, which always exceeds the dissipation of the memory chip. ■■

Need more information?

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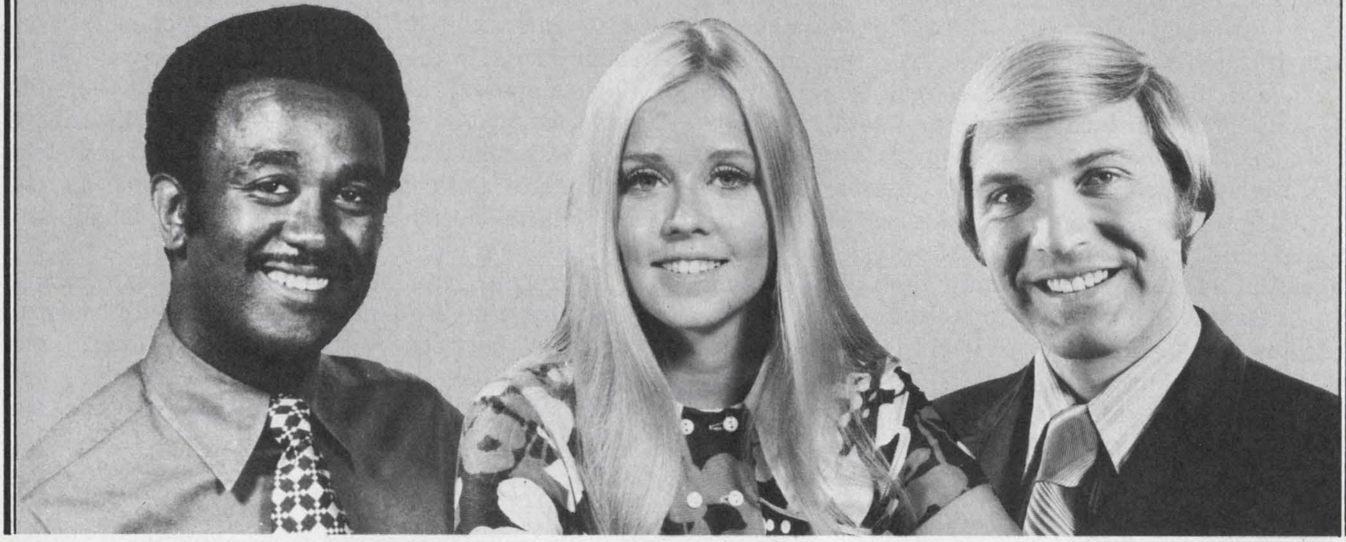

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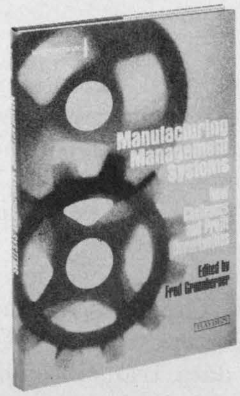
An Open Letter To Manufacturing Managers.



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Use v/f converters for analog data transmission.

Here are four circuits that provide conversion accuracies from 0.4% to 0.01% and dynamic ranges of 10,000:1.

Analog-to-digital conversion can be simplified with low-cost voltage-to-frequency converters. These produce output frequencies that are directly proportional to an input voltage.[1,2] And v/f converters with accuracies of 0.01% and frequency ranges of 10 kHz can be built for as little as $30. Applications include remote data acquisition, digital voltmeters and medical instruments.

V/f converters usually require less complex wiring for data transmission than conventional a/d converters. In many cases the a/d's parallel digital output must be converted into serial form for transmission over a limited number of cables. And even with the parallel-to-serial conversion, an extra line is required to couple the clock pulse from the data-acquisition system to the a/d.

A v/f needs only a single line for a serial pulse train. A clock signal and a counter at the receiving end of the system decode the pulse train.

The typical v/f output signal is a pulse train, which can be encoded by a digital counter. This approach yields an a/d converter (Fig. 1). For an a/d converter, the technique provides a monotonic response. But the need for a counting interval that is at least as long as the period of the lowest frequency signal results in slow conversion. Thus for v/f output frequencies down to about 1 Hz, the counting interval must be at least 1 s. Such conversion times are compatible with many remote data-acquisition and instrument requirements.

Faster conversion, as well as improved accuracy, can be attained with input ranging schemes such as those used in digital voltmeters and other instruments. Input ranging reduces the required v/f dynamic range, and it restricts operation to the higher frequencies, where shorter counting intervals are possible. To add input ranging, you need only use switchable summing resistors on the input amplifier.

Common-mode line-voltage drops can be removed from the v/f signal with simple isolation techniques. The pulse-train signal can be transmitted easily through isolating transformers or optical couplers. This makes v/f's particularly useful for medical monitoring, where even small ground differences represent a hazard.

Jerald Graeme, Manager of Monolithic Engineering, Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734.

Which v/f converter?

Accuracy and conversion-time requirements determine which voltage-to-frequency converter is right for an application. Accuracy is governed by the errors and thermal drifts of the offset, gain and linearity of the v/f.

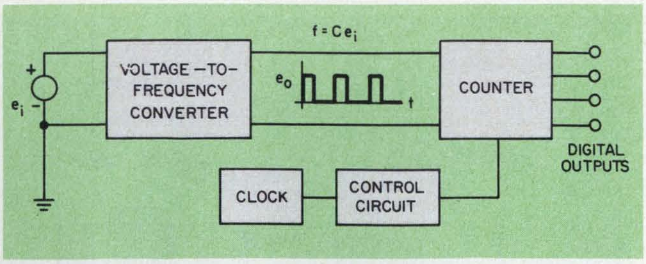
The greater the circuit accuracy, the wider its useful dynamic range. If only the upper portion of a v/f's dynamic range is used, shorter conversion times are possible than if the entire range is used. Conversion time can also be reduced by modification of the circuits for high-frequency operation—provided, of course, that larger errors can be tolerated.

Let's look at some low-precision circuits, with total errors of 0.4% and 0.1%, and some high-precision circuits, with errors of 0.03% and 0.01%.

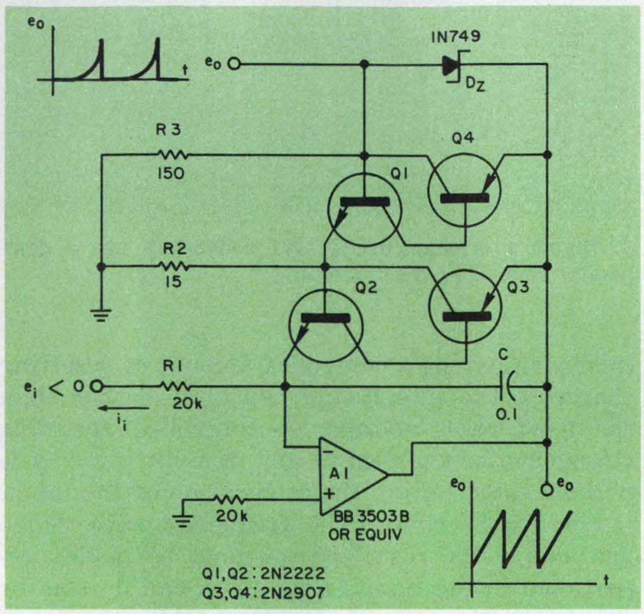
For applications that can tolerate full-scale accuracies of 0.4% or worse, you can build a v/f with an op amp and some transistors (Fig. 2). The circuit is basically a zener-controlled relaxation oscillator formed with an integrator and level-detecting reset switch. A constant, negative, voltage input to the integrator causes the output to increase linearly unil the reset switch is triggered.

Triggering occurs when the output voltage forward-biases the zener and the emitter-base junction of Q_1. Then Q_1 drives Q_4 on, and positive feedback between these transistors rapidly increases their currents. As a result, Q_1 generates a voltage pulse at its emitter to turn on another positive-feedback coupled pair, Q_2 and Q_3. Current from Q_2 and Q_3 overrides the signal current, i_i, and discharges the capacitor for reset. Discharge continues until the capacitor voltage drops below a level equal to the emitter-base voltage of Q_2 and the saturation voltage of Q_3. When this happens, Q_2 and Q_3 turn off, and the capacitor begins recharging to repeat the cycle.

During each cycle the change in capacitor voltage, ΔV, equals $V_Z + V_{sat}$. The cycle time, Δt, is determined by the rate at which the input



1. **The output of a v/f converter** can be encoded by a digital counter to simulate an a/d converter.



2. **A low-precision (0.4%) v/f converter** uses an integrator and a voltage-sensing reset switch.

current, i_i, can charge the capacitor by ΔV, as long as the reset time is negligible. If the input signal remains constant during the cycle, the capacitor charges linearly, and $\Delta t = C\ \Delta V/i_i$. From this, the output signal frequency is theoretically

$$f = \frac{1}{\Delta t} = \frac{-e_i}{R_1C\ (V_Z + V_{sat})}.$$

For this equation to hold, the input signal frequency must always be much less than that of the output signal. The output frequency will vary from 1 Hz to 1 kHz in response to input voltages from -10 mV to -10 V for the component values shown.

The actual response deviates from that expressed above because of offset, linearity and gain errors. The converter output zero is offset by the op-amp input offset voltage and current:

$$\Delta f_O = \frac{V_{OS} + I_{OS}\,R_1}{R_1C\ (V_Z + V_{sat})}.$$

Note that the amplifier offset voltage, V_{OS} can be adjusted to null this error, and for the circuit shown, it can be reduced to 0.01 Hz.

The reset discharge time and amplifier-gain error govern the response linearity. While the discharge time, t_D, is negligible for low frequencies, it becomes significant as the frequency increases, creating an error of f^2t_D. Discharge time, t_D, which is generally limited by the amplifier slew rate, S_r, equals $(V_Z + V_{sat})\ S_r$. The integrator gain error, important at low frequencies, is approximated by $f(V_Z + V_{sat})/A_Oe_i$. Together, the two nonlinearities produce a frequency error of

$$\Delta f_N = f(V_Z + V_{sat})\ (f/S_r + 1/A_Oe_i).$$

With the components shown in Fig. 2, this error reaches -0.2% of full scale.

Tolerance variations of R_1, C, D_Z, Q_1 and Q_2 cause gain errors in the circuit. By adjusting R_1, you force the initial gain error low. But high gain-error drift, caused by thermal sensitivity of switch thresholds, limits improvements.

The principal causes of sensitivity are the thermal variations of the emitter-base voltage of Q_1 and Q_2. If you match these transistors, you can counteract most thermal variations. But their vastly different currents, and the pulse operation, limit the improvement that can be achieved. Thus gain drift remains about $0.05\%/°C$. The total circuit error under limited temperature excursion is about 0.4% of full scale.

Improve v/f converter accuracy

If you use a comparator to define the thresholds of the reset switch more precisely, you can improve v/f accuracy (Fig. 3). Once again, an integrator converts the input voltage to a ramp that increases with time in proportion to the input voltage magnitude. The comparator uses a zener diode to control the high threshold and has hysteresis to provide a low switching threshold.

The circuit operation is similar to that of Fig. 2. Negative input voltages cause the integrator output to increase to $e_c = nV_Z + (n + 1)V_f$. At this point the comparator output swings positive, turning on the reset switch Q_1, to discharge C. Discharging continues until e_c reaches the low comparator threshold. This threshold equals V_f, since R_2 supplies no feedback. Diode D_2 blocks any positive feedback during the reset mode as long as the comparator output is positive. Because of D_1, the low threshold stays above zero. This is necessary since Q_1 cannot discharge C below the transistor saturation voltage.

The change in capacitor voltage during each cycle between the two comparator switching points is $n(V_Z + V_f)$. The time required for this change determines the operating frequency. The charging time—if i_i remains constant during the charging cycle, $\Delta t = C\ \Delta\ e_c/i_i$—helps determine the frequency:

$$f = \frac{1}{\Delta t} = \frac{-e_i}{nCR_1(V_Z + V_f)}.$$

For the component values of Fig. 3, the frequency changes from 1 Hz to 1 kHz as the input voltage varies from -10 mV to -10 V.

The error performance of this v/f depends on offset, linearity and gain. Offset, produced by A_1,

$$\Delta f_O = \frac{V_{OS1} + I_{OS1} R_1}{nCR_1 (V_Z + V_f)} .$$

By adjusting V_{OS1}, you can reduce the offset error to about 0.02 Hz.

Nonlinearities, introduced by t_D and by the limited gain of A_1, become significant at opposite ends of the frequency range where t_D and the gain produce increasing deviations from the ideal response. Expressions for these errors result in a linearity error of

$$\Delta f_N = f \left[f t_D + \frac{n(V_Z + V_f)}{A_O e_i} \right] .$$

The slew rate of the op amps or the maximum current of discharge switch Q_1, whichever is more limiting, determines the reset time, t_D. With the high-speed op amps shown the slew rate doesn't limit t_D. As a result, nonlinearity is held to $\pm 0.04\%$ of full scale.

Again, gain error stems from the tolerance variations of the R_1, C, R_2, nR_2, D_1 and D_Z. A compensating adjustment of R_1 reduces this error to a level limited only by the thermal gain drift. And the gain drift of this v/f is much lower than that of the v/f in Fig. 2, since a comparator sets the switching thresholds. Threshold drift becomes mainly that of V_Z and V_f. If you choose a zener diode with a drift that counteracts that of V_f, the gain drift can be reduced to 0.01%/°C. The total error for operation under limited temperature excursion will be less than 0.1% of FS.

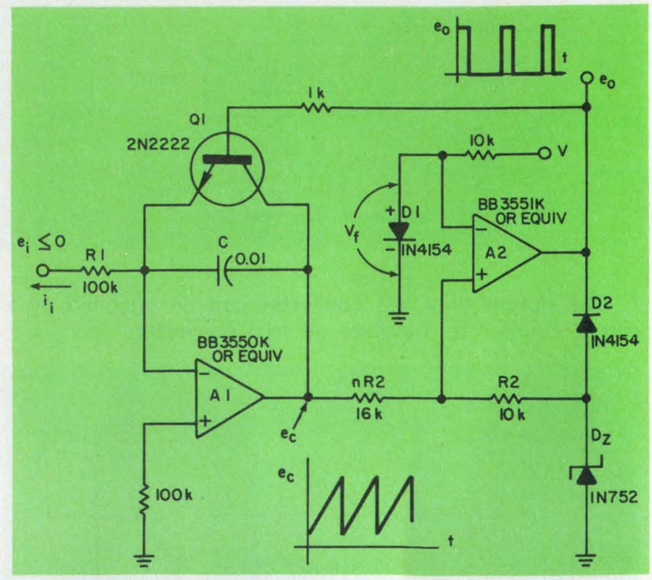
Higher accuracy with higher frequency

V/f converters with still better precision generally require a correspondingly wider dynamic range for increased resolution. As we have seen, for 0.1% accuracy, a 1000:1 dynamic range is needed. Smaller dynamic ranges are possible only when you use input range switching, but this usually can't be done in remote monitoring.

Conversion time places a limit on the minimum operating frequency. And for practical conversion times not exceeding 1 s, the minimum usable converter frequency is 1 Hz. Thus you must extend the high-frequency end of the operating band to get greater dynamic range.

However, the time required for resetting the integrator capacitor limits the high-frequency operation of these circuits. To reduce the nonlinearity error introduced by the reset time to 0.01%, the reset time must be no more than 0.01% of the minimum signal period, or 10 ns. Such short reset intervals are difficult to achieve, and they produce similarly short output pulses that are absorbed by long line capacitance.

Thus extended dynamic range for improved precision requires capacitor reset by some means that does not introduce timing error. You can do



3. **Higher precision (0.1%) v/f converters** use a comparator-controlled reset circuit.

this by supplying a controlled amount of resetting charge to the integrating capacitor rather than the fixed reset voltage. A controlled resetting charge can be supplied at any time during a cycle without interrupting the integration of the input.

For v/f operation, the frequency with which you supply the reset charge must be made proportional to the input signal. You can do this by supplying the reset charge each time the input signal charges the integrating capacitor to a reference voltage. This operation uses an integrator whose output rises to a reference level, E_R, at a rate determined by the current i_i, from an input signal (Fig. 4). At the reference level, a discharge current, I_D, discharges the capacitor for a period, t_D. As this process repeats for a given i_i, the charging and discharging voltages are equal, and charges are equal and opposite:

$$Q_C = i_i t_C = -Q_D = I_D t_D .$$

The frequency of oscillation can be calculated

$$f = \frac{1}{t_C} = \frac{i_i}{I_D t_D} = \frac{-e_i}{R I_D t_D} .$$

If I_D and t_D are constants, the frequency is proportional to the input signal.

Let's look at a circuit

One circuit that uses this reset-charge scheme has an integrator and a resetting comparator (Fig. 5). While these two elements of the circuit are similar to those in Fig. 3, the comparator now provides a controlled discharge current, I_D, and a fixed discharge time, t_D. This ensures a constant reset charge of $Q_D = -I_D t_D$. You can derive the controlled discharge current by driving the integrator summing resistor, R_{2a}, with a fixed voltage from a zener diode. To produce a fixed discharge time, rather than a fixed voltage, couple the input signal to the comparator.

Application of a negative input signal starts the v/f oscillation. The negative signal drives the comparator A_2 to its positive output state, where it conducts a current through D_4, D_Z and D_6. This establishes a voltage of $V_Z + V_{f6} - V_{f1}$ on R_{2b} and creates a discharge current of

$$I_D = \frac{V_Z}{R_{2b}}, \text{ for } V_{f6} = V_{f1}.$$

Since this current is greater in magnitude than i_i, the integrator output is a negative-going ramp. The ramp continues to the first comparator trip point. Only e_i controls this trip point because D_2 disconnects the comparator positive feedback for positive values of e_o. As a result, the first trip point is at $e_c = e_i/K_2$, where $K_2 = R_4/(R_3 + R_4)$.

When the voltage reaches the trip point, the circuit switches to the charging mode. The comparator output switches to its negative state, reverse-biasing D_1 to disconnect the discharging current. Current i_i then charges the capacitor until it reaches the second trip point.

Both e_i and the positive feedback of the comparator control the second trip point. In this negative output state, D_2 connects the positive feedback, caused by forward bias, to the comparator, and the diode bridge inverts the voltage presented by the zener diode. Thus the same zener diode establishes the second trip point and the discharge current. This ensures the matching required for good linearity. The zener creates a voltage of $-V_Z - V_{f5} + V_{f2}$ on the comparator feedback resistor, R_{2b}. Together the voltage and input signal define the second comparator trip point at

$$e_c = K_1 (V_Z + e_i/K_2) + e_i/K_2, \text{ for } V_{f5} = V_{f2}.$$

The difference in trip points fixes the change in e_c at

$$e_c = K_1 (V_Z + e_i/K_2).$$

Note that the reset voltage, Δe_c, is a function of e_i rather than a constant. This makes the discharge time, t_D, a constant, as required for the response $f = e_i/RI_Dt_D$. The discharge time is

$$t_D = \frac{\Delta e_c C}{I_D - i_i} = \frac{\Delta e_c C}{V_Z/R_{2b} + e_i/R_1}.$$

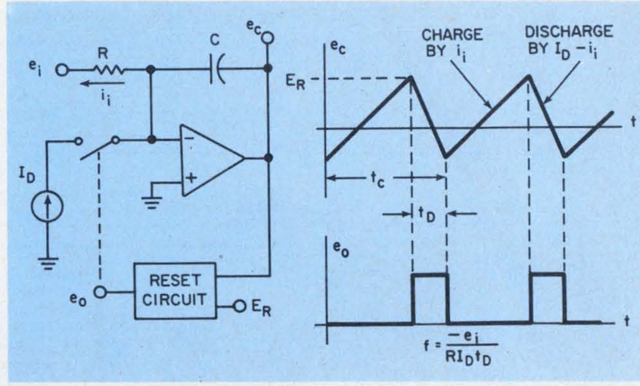
If Δe_c was a constant, t_D would vary with e_i. But Δe_c in this case has a compensating variation with e_i, and

$$t_D = \frac{K_1 (V_Z + e_i/K_2) C}{V_Z/R_{2b} + e_i/R_1} = K_1R_{2b}C \text{ for } R_1 = K_2R_{2a}.$$

With t_D a constant, the converter response relates linearly to e_i:

$$f = \frac{-e_i}{R_1CK_1V_Z}, \text{ for } R_1 = K_2R_{2a}.$$

The performance of the v/f in Fig. 5 is determined by component selection and the resulting offset, gain and linearity errors. For the components shown, a 1-Hz-to-10-kHz output range is developed by an input signal range of -1 mV to -10 V. While this converter provides 0.01% resolution, accuracy is limited to about 0.03% of full scale by the error factors.



4. **Controlled-charge reset circuits** eliminate the linearity error caused by a separate reset interval.

Minimize errors for best performance

The offset error for this circuit is

$$\Delta f_O = \frac{V_{OS1} + I_{OS1} R_1}{R_1C K_1 V_Z}.$$

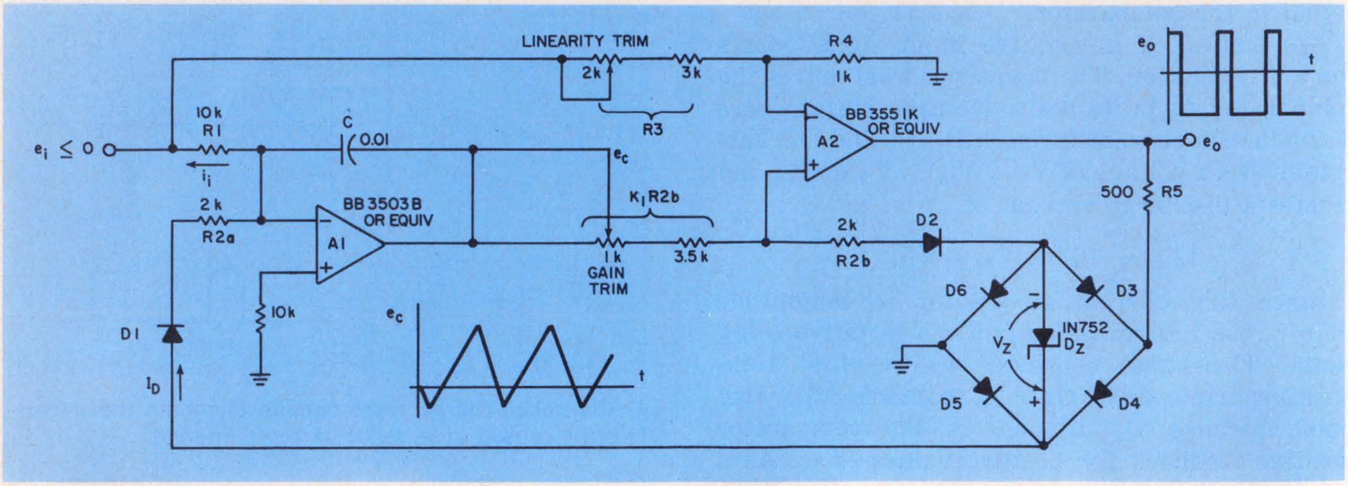
There is a value of V_{OS1} for which Δf_o is zero. The offset control of A_1 can be adjusted to reduce the frequency offset to about 0.1 Hz. Gain error results from the tolerances and drifts of R_1, C, D_Z, D_1, D_5, D_6, R_{2a}, R_{2b} and K_1R_{2b}. These errors are compensated by adjustment of the gain-trim potentiometer and reduced to about 0.003%.

Linearity depends upon the open-loop gain of A_1, the switching time of A_2, the $R_1 = K_2R_{2a}$ ratio, and the frequency sensitivity of two matched-diode pairs. Limited open-loop gain in A_1 causes an input error signal that introduces nonlinearity at low frequencies.[1] At low frequencies, the input signals are at their smallest and are sensitive to amplifier input error signals. Thus a high-gain op amp should be used.

At the high end of the frequency range, the comparator switching time and error in the resistance ratio introduce nonlinearity. Increasing frequency also degrades the diode voltage matches. An increasing frequency is associated with an increasingly frequent supply of reset charge. This requires a greater duty cycle for matched diodes D_1 and D_6 and a lesser duty cycle for the matched pair D_2 and D_5.

As a result, the diode temperatures vary, disturbing the match needed in forward voltage drops to maintain constant I_D and t_D. Best results are achieved if monolithic dual devices are used. The combined nonlinearity can be reduced to 0.02% of full scale by the linearity trim potentiometer. Added to this trimmed error is thermal drift of typically 0.006%/°C.

You can improve the v/f accuracy further by using clock control of the discharge time. The



5. **A 10,000:1 dynamic range and accuracy of 0.04%** are obtained when controlled-charge reset is used.

price you pay is that of an external clock supply and extra wiring. As in Fig. 4, the controlled charge reset is applied for a response of $f = e_i/RI_Dt_D$ to provide a 1-Hz-to-10-kHz frequency range. The clock signal control permits 0.01% accuracy. The reset circuitry, controlled by the clock, permits the discharge current to flow for one period of a precision clock signal (Fig. 6).

The integrator capacitor is charged by the input signal until the integrator output reaches a reference level. In this case the reference level is the threshold voltage of a flip-flop. While this reference is not precise, it need only be constant during each cycle to ensure linear response. When the integrator output reaches the flip-flop threshold, it keys the flip-flop for switching at the next clock pulse. And the next clock pulse causes the Q output to switch to its low state while the $\overline{Q}$ output switches to high state.

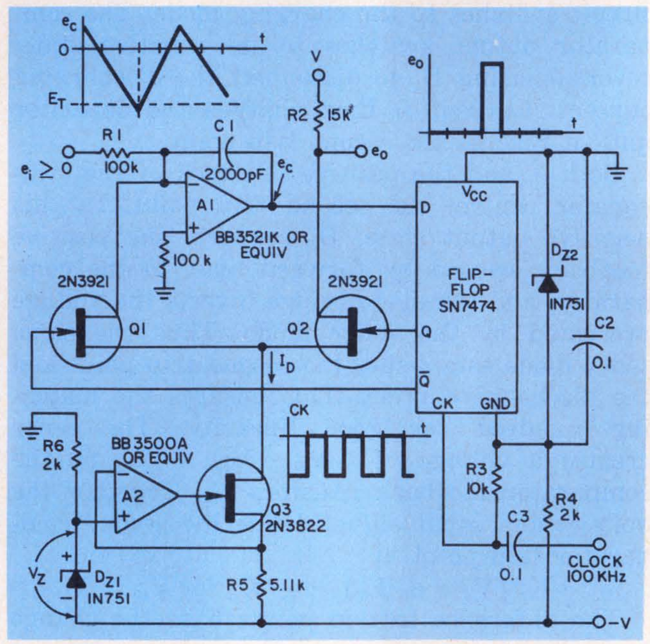
In this mode Q_1 turns on and supplies discharging current, and Q_2 turns off and provides a low output state. By appropriate choice of I_D, the integrator output will be discharged beyond the flip-flop threshold before the next clock pulse arrives, and the circuit will then be switched back to its charging state. This operation fixes the discharge time at the precise period of the clock pulse. For a constant reset charge, you also need a constant discharge current. This current is supplied by a precision current source formed by A_2 and Q_3, and $I_D = V_Z/R_5$.[2] The v/f response is then

$$f = \frac{R_5 e_i}{R_1 t_D V_Z}.$$

As with the previous circuits, the performance limitations are specified in terms of offset, gain and linearity errors. Offset error is once more determined by the dc input errors of the integrator, and it will be

$$\Delta f_O = \frac{R_5 (V_{OS1} + I_{OS1} R_1)}{R_1 t_D V_Z}.$$

By means of the A_1 offset control, this error can



6. **If clocked control of the discharge time is used,** accuracies to within 0.01% are obtainable.

be reduced to 0.1 Hz. Gain errors are produced by the tolerances and drifts of R_1, C, D_{Z1}, R_5 and the clock pulse period. To adjust gain, trim R_1. Nonlinearity is all but removed as a source of error. Variation in the discharge time only produces a slight gain error.

The only other error that varies with frequency to introduce nonlinearity is the gain error of the integrator. As long as this amplifier has high gain, nonlinearity is controlled to permit over-all circuit accuracy of 0.01% of full scale. ■■

References

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2. Graeme, J., "Applications of Operational Amplifiers —Third Generation Techniques," McGraw-Hill, 1973.

3. Connors, S., "Voltage-to-Frequency Converters: A/Ds With Advantages," *EDN*, June 5, 1974.

Switch your high-power supply design to an off-line regulation technique. The benefits include less energy wastage, simpler designs and lower cost.

With a direct, off-line regulation approach to power-supply design, it's possible to build a 1000-W, 5-V power supply that boasts a number of advantages over conventional units. Some benefits of the supply include:

- High efficiency—80% or more.
- Compactness—the design occupies 6 × 6 × 12 in. and weighs just 6 lb.
- Dual input voltages—115 or 230 V ac, single or three phase.
- Simplified design—less than 100 parts, with no need for a front-end transformer.

Traditional power-supply designs usually take the transformer-rectifier-low-voltage-regulator route. While this method is adequate for low-power (< 200 W) designs with single-frequency inputs, higher-power applications suffer from high cost and low efficiency—two serious drawbacks of the traditional method.

But these problems can be avoided. The way out is to use transistor choppers to regulate at high frequency (20 kHz), and to design with all TTL to simplify the circuit. And with Schottky diodes in the output rectifier—to hold down switching and forward-drop losses—efficiency is boosted even more.

The power switching circuit is a half-bridge configuration that has several advantages over the usual push-pull approach to off-line regulation: The output transformer primary gets 100% use—as opposed to 50% in push-pull circuits—and the output transistors have just half as much voltage stress. This means that the unregulated bus voltage can be double that of a comparable push-pull circuit but with the same current and voltage stress at the transistors. Note that a doubling of the bus voltage also doubles output power.

The single-phase ac input can be 95 to 130 V, or 190 to 260 V, at frequencies from 50 to 400 Hz (or higher). Or the input can be 190 to 260 V three-phase over the same frequency range. Output is 5 V at 200 A, with a ripple and regulation envelope of 50 mV. Overload protection is to 250 A.

Taking the place of a front-end transformer is an off-line rectifier that delivers unregulated, 300-V dc bus power, which is first chopped at 20 kHz by transistor switches, then transformed down to the secondary voltage required to feed the output rectifiers (Fig. 1). To achieve regulation, the conduction time of the high-voltage switching transistors is controlled at the 20-kHz rate.

Smooth dc is generated at the output terminals by integration of the pulse train after rectification. A dc regulator senses the output voltage and current and supplies a feedback error signal to the pulse-width control circuit.

To accommodate both 115 and 230-V inputs, a voltage doubler is used in conjunction with a conventional bridge rectifier. Self-heating thermistors are needed to limit the turn-on line inrush current caused by the low impedance of the filter capacitors (Fig. 2). The rectifier shown is a three-phase bridge with a peak-reverse voltage of 600 V minimum and a current capability of 8 A.

Because of the fast response of the switching regulator, input-line variations—including line ripple—are, in effect, filtered by the pulse-width-modulation action. It is, however, still necessary to keep the dc bus within the voltage regulation range of the control circuit, and this requires the use of bus filter capacitors. In actual operation from 50-Hz, 95-V lines (worst case), the dc bus will have about 20-V peak-to-peak ripple at full load with 2500-μF filter capacitors.

The peak line currents at the input terminals depend on the line impedance, as does the rectified bus voltage. The surge limiting thermistors prevent excessive peak line currents at the expense of about a 5-V drop on the dc rectified bus under full-load conditions.

Power Darlington forms switch

Darlington transistors, connected as a bridge, switch the unregulated bus at the 20-kHz rate (Fig. 3). Drive signals are applied at the bases

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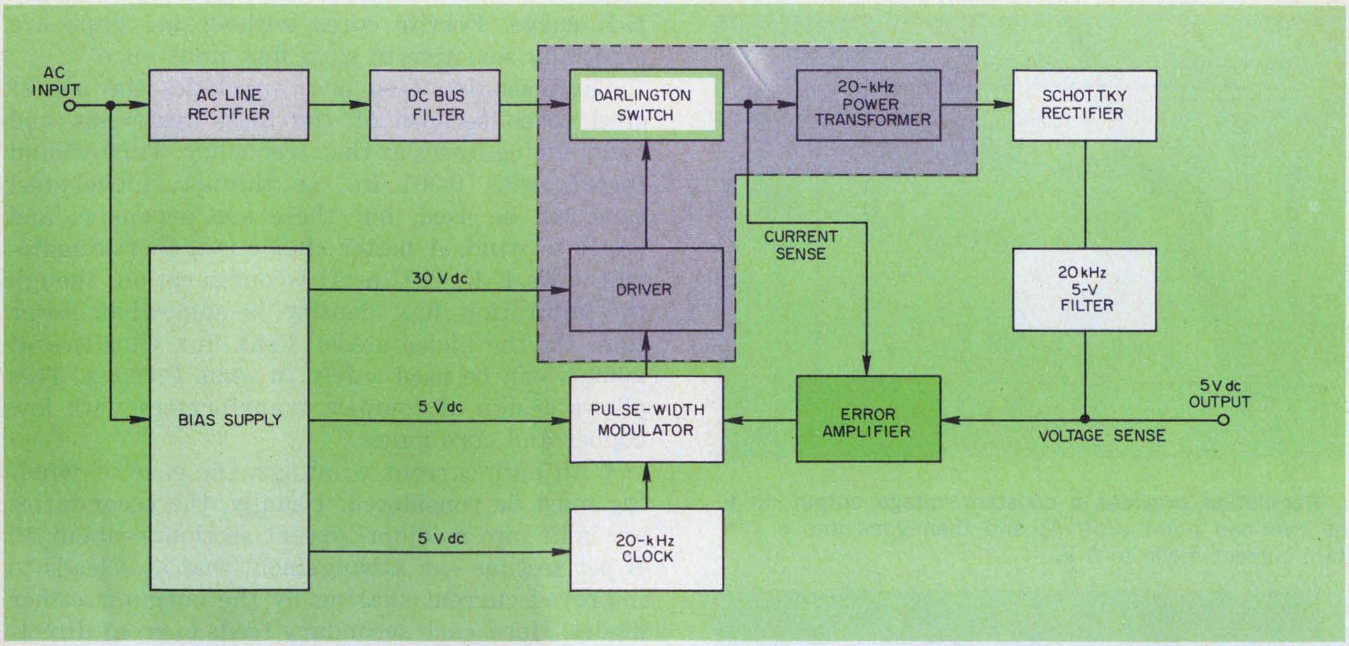
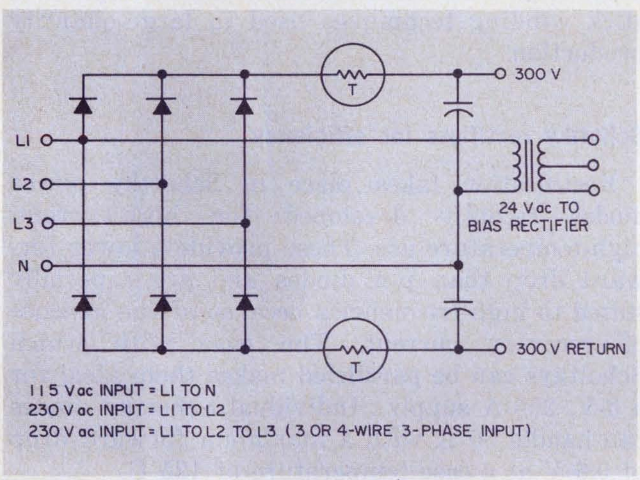
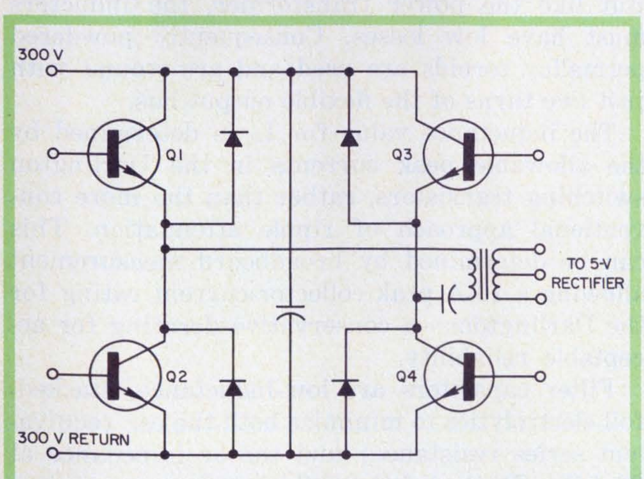


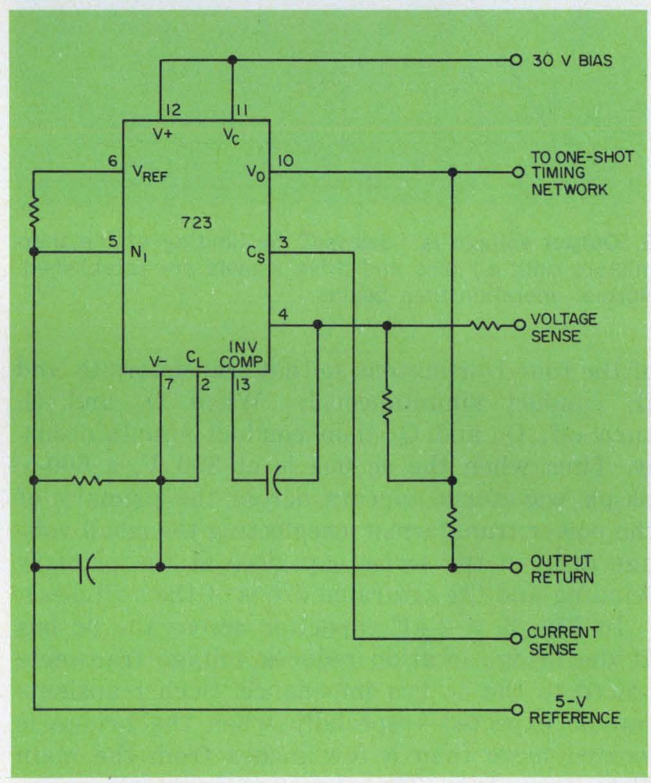
1. **In an unusual approach** to power-supply design, the ac input is first converted to a 300-V unregulated dc bus. The high voltage is then chopped at 20 kHz by a Darlington switch and transformed to a lower, secondary level. Regulation is obtained by pulse-width modulation of the switched waveform.



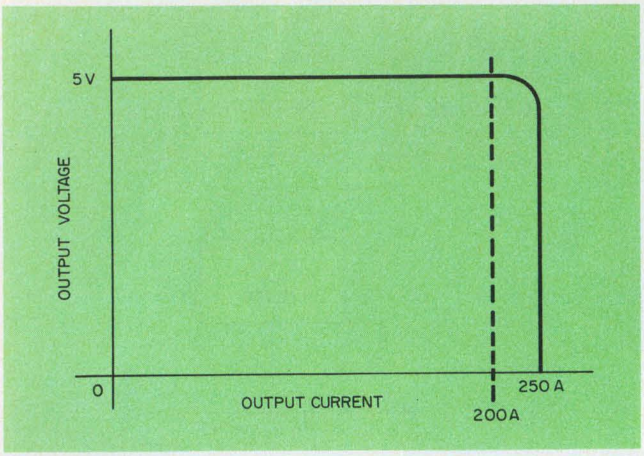
2. **A three-phase bridge rectifies the input,** which can be 115 or 230 V, single or three-phase. The thermistors limit line-inrush current.



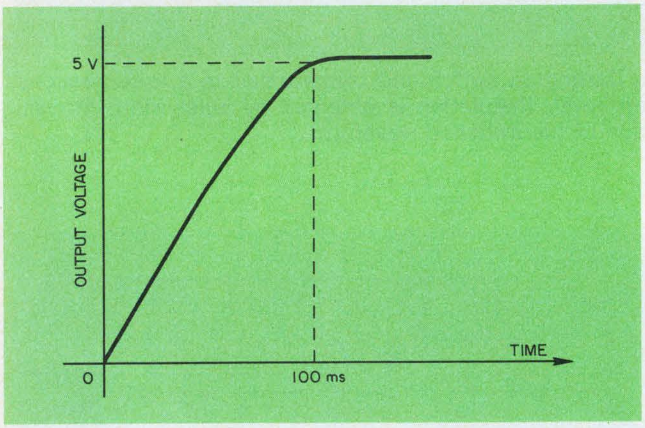
3. **Darlington transistors in a bridge** arrangement switch the 300-V bus. Transistors Q_1 and Q_4 conduct simultaneously for half the cycle, while Q_2 and Q_3 are cut off. The situation reverses on the second half cycle.



4. **Both output voltage and current are sampled** and generate an error signal in a 723 regulator. The error signal modulates the pulse width of a one-shot multivibrator to provide the voltage regulation.



5. **Regulation provides a constant-voltage output** up to the overload point (250 A) and then goes into a constant-current mode to 0 V.



6. **Output voltage is "delayed"** by limiting of the thermistors until all bias and drive signals are established. Normal operation then begins.

of the four Darlingtons so that transistors Q_1 and Q_4 conduct simultaneously. When Q_1 and Q_4 turn off, Q_2 and Q_3 then conduct simultaneously. Thus when the dc bus is at 300 V, a 600-V pk-pk waveform appears across the primary of the power transformer (neglecting the small voltage drop in the series capacitor at the primary winding and the saturated drops of the switches).

In Fig. 3, a 2-μF capacitor across the dc bus at the bridge location reduces voltage transients traced to the dc bus impedance. Such transients can be expected—especially when the bridge is located more than a few inches from the main filter capacitors. The capacitor is usually polycarbonate but must have low-loss characteristics to handle adequately the 20-kHz ripple currents.

Another 2-μF polycarbonate capacitor in series with the transformer primary blocks dc and thereby prevents possible saturation of the core by small imbalances in the volt-second product applied at each half cycle. There are always some differences in switching times and transistor saturation voltages that cause the core flux excursions to "walk" to one of the saturation regions of the B-H curve. Ferrite cores without air gaps are especially sensitive to such flux imbalance.

The operating frequency precludes the use of steel cores because of the high hysteresis and magnetizing losses at that frequency. Tape-wound toroids with 0.001 in., or thinner, nickel-steel tape can be used, but these are expensive and costly to wind. A better choice is a ferrite material in an E-E, U-U or U-I configuration, though the saturation flux density is somewhat lower than for the nickel steels. Peak flux densities of 2000 G can be used safely in some ferrites. This allows design of compact transformers with low copper and core losses.

With high-current windings, the ease of winding must be considered. Usually, the secondaries are split into medium-current sections—about 50 A per section—an arrangement that also leads to improved current sharing by the output rectifier diodes. Here, each secondary feeds current directly to just one output-rectifier anode. Thus current sharing is optimized, and there are no secondary terminals to cause power losses.

The primary winding is layer wound in the usual way. This lends itself to the multiple-coil, stick winding techniques used in large-quantity production.

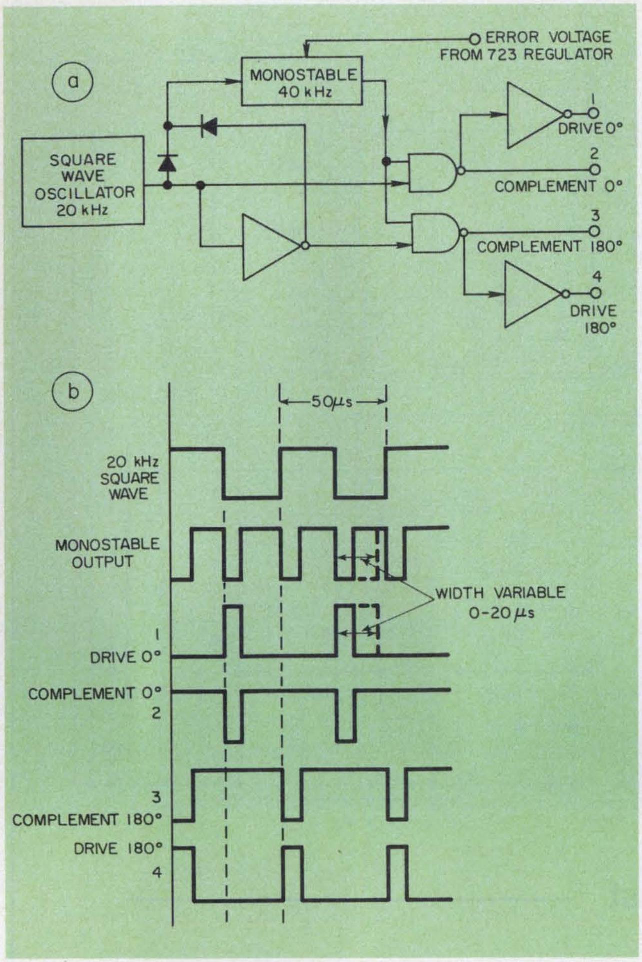
Schottky rectifiers for efficiency

Rectification takes place in Schottky power diodes—recently developed for high-current, high-temperature use. These provide a lower forward drop than p-n diodes and are especially suited to high-frequencies because of the absence of recovery current. The ease with which Schottkys can be paralleled makes them ideal for a 5-V, 200-A supply: Individual Schottky diodes can handle 50 A with a maximum forward drop of 0.6 V at a case temperature of 125 C.

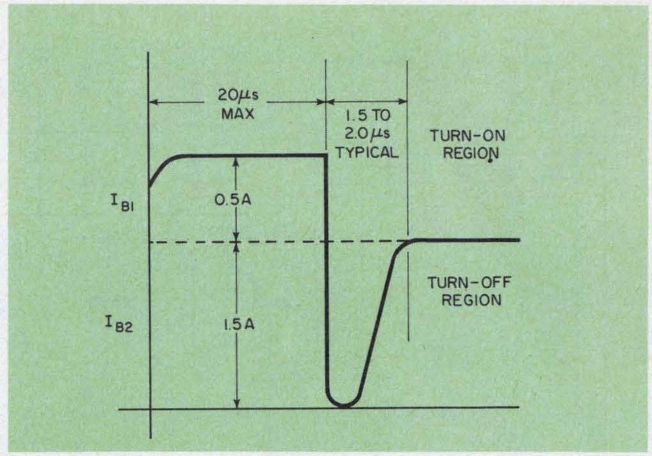
Because of the regulation method, the rectified output is a pulse train that must be transformed into the smooth dc required at the output. Conventional L-C filter techniques are used to do this. But like the power transformer, the inductors must have low losses. Consequently powdered permalloy toroids are used and are wound with just two turns of the flexible output bus.

The inductance value for L_1 is determined by the allowable peak currents in the Darlington switching transistors, rather than the more conventional approach of ripple attenuation. This can be determined by broadboard measurement allowing a 10-A peak collector-current rating for the Darlingtons—a conservative derating for acceptable reliability.

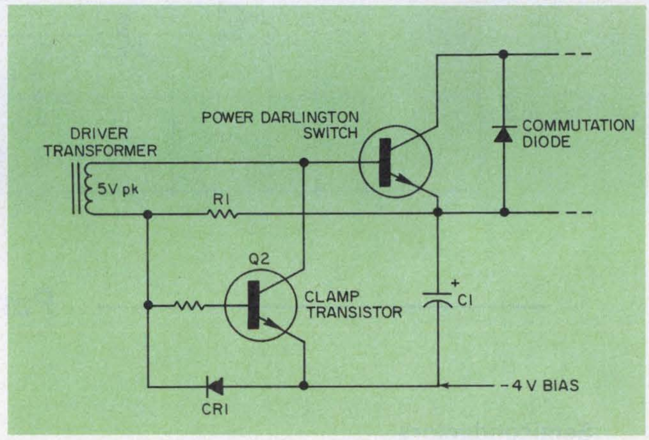
Filter capacitors are low-inductance, stacked-foil electrolytics to minimize both the esr (equivalent series resistance) and the ac impedance at 20 kHz. Stacked foil exhibits inductance values



7. **To derive the four signals** to drive the Darlington bridge, the one-shot output is "mixed" with the 20-kHz clock in two NAND gates (a). The resulting waveforms consist of two out-of-phase signals and their complements (b).



8. **Critical to proper operation** is the Darlington base-drive current, which must have fast transitions.



9. **Turn-off current, I_{B2},** is provided by a transistor clamp arrangement at the base of the Darlington.

as low as 2 nH and provides superior ripple-current ratings. Small series inductors (T_5) are formed between the capacitor sections of the filter by passage of the dc bus bars through powdered permalloy toroids. With C_{11}—a low-impedance capacitor located directly across the output—T_5 forms a second section of the output filter. This technique further reduces the common-mode ripple voltage at the output.

ICs simplify design

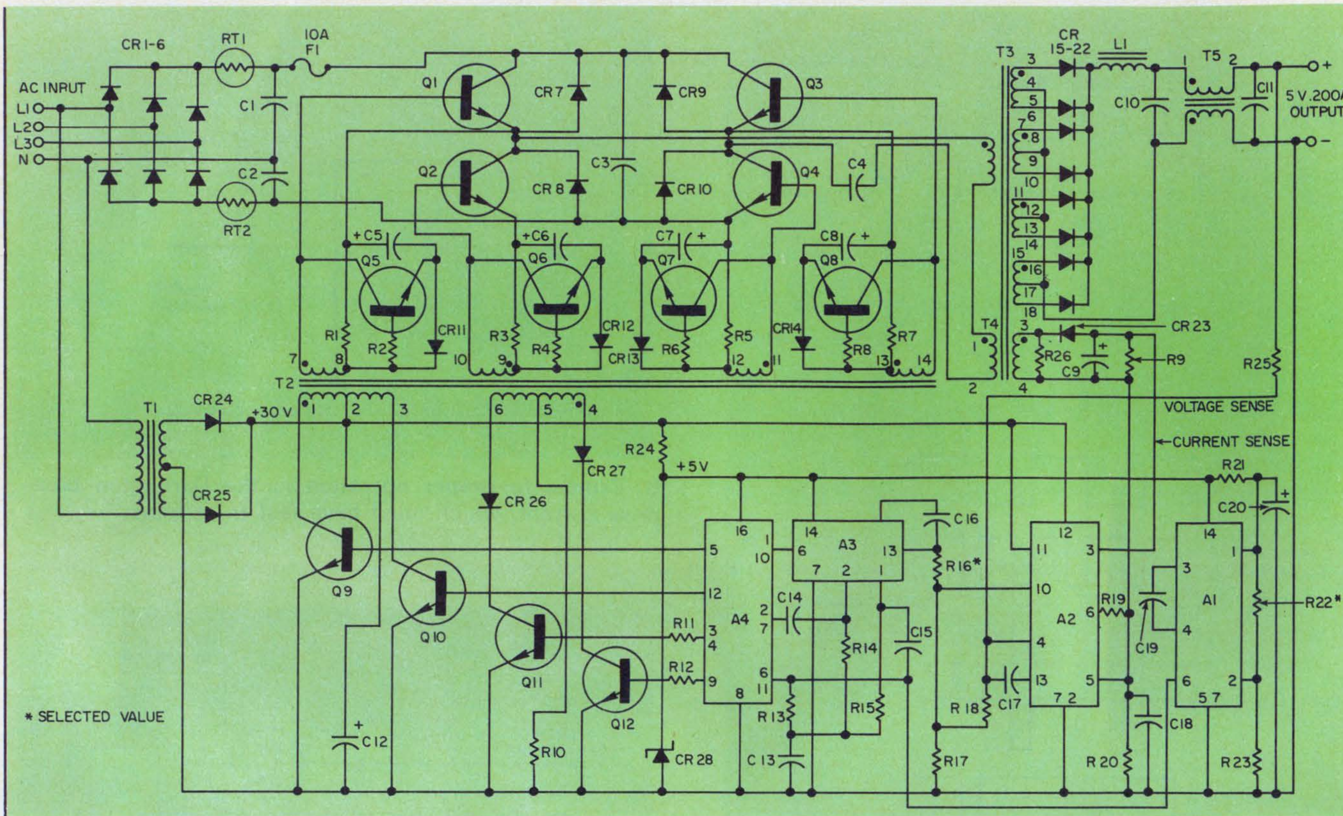
Two functions are performed by the error-amplifier circuit: voltage regulation and current limiting. A 723-type regulator generates the error signal needed for regulation (Fig. 4). By rectification of the output voltage of a current transformer in series with the power-transformer primary, a voltage proportional to the primary current can be generated. This signal is also applied to the 723 regulator, and in such a way that the error signal becomes current-dependent above a predetermined load current. Thus the regulation envelope exhibits constant voltage up to the overload point, and then constant current down to zero voltage (Fig. 5).

During start-up, the dc bus voltage is delayed to ensure that all bias voltages are established and drive signals are applied to the Darlington power stage before power is switched. This delay is performed by the inrush limiting thermistors in the input filter. At the end of this delay time the dc bus falls within the regulation limits and normal regulation is established (Fig. 6).

To form the pulse-width modulator, a free-running TTL multivibrator (MC4024) generates a 20-kHz square wave, which triggers a monostable multivibrator (8601) on the leading and trailing edges. The output of the monostable is a pulse train of 20-μs width and a 40-kHz repetition rate.

Four signals generated

By use of the 723's error signal to vary the monostable's R-C time constant, the pulse width can be varied proportionately from 0 to 20 μs. The resultant one-shot pulse is applied to one in-



Parts list

Semiconductors

$Q_{1,2,3,4}$	TRW	SVT6001	
$Q_{5,6,7,8,9,10}$	TRW	SVT60-5	
$Q_{11,12}$		2N2222	
$CR_{1,2,3,4,5,6}$		1N1204	
$CR_{7,8,9,10}$	TRW	SVD400-12	
$CR_{11,12,13,14,23}$	TRW	DSR3051	
$CR_{15,16,17,18}$	TRW	SD-51	
$CR_{19,20,21,22}$	TRW	SD-51	
$CR_{24,25}$		1N4002	
$CR_{26,27}$	TRW	DSR3051	
CR_{28}	TRW	LVA-51A	
A_1	MOTOROLA	MC4024	Voltage-Controlled multivibrator
A_2	NATIONAL	LM723C	Voltage regulator
A_3	NATIONAL	DM8601	Monostable multivibrator
A_4	NATIONAL	DM8090	Dual NAND, Quad Inverter

Resistors

$RT_{1,2}$	5Ω	Themistor, 5DA5RO (Rodan Industries)
$R_{1,3,5,7}$	10Ω, 5W	
$R_{2,4,6,8}$	51Ω, 1/2W	
$R_{9,14,15,25}$	1K, 1/2W	
R_{10}	10Ω, 1/2W	
$R_{11,12}$	270Ω, 1/2W	
$R_{13,23}$	10K, 1/2W	
R_{16}	100K, 1/2W(selected)	
R_{17}	1.5K, 1/2W	
R_{18}	470K, 1/2W	
R_{19}	2K, 1/2W	
R_{20}	5.1K, 1/2W	
R_{21}	100Ω, 1/2W	
R_{22}	6.8K, 1/2W(selected)	
R_{24}	270Ω, 2W	
R_{26}	39Ω, 1/2W	

Capacitors

$C_{1,2}$	2500μF, 200V	Sprague type 36D
$C_{3,4}$	2μF, 400V	
$C_{5,6,7,8,13,20}$	22μF, 6V	
C_9	56μF, 6V	
C_{10}	47000μF, 7.5V	Sprague type 432-D
C_{11}	10μF, 50V	
C_{12}	1100μF, 50V	Sprague type 39D
$C_{14,15,16}$	0.001μF, 50V	
C_{17}	100pF, 300V	Elmenco type DM
C_{18}	0.1μF, 50V	
C_{19}	0.01μF, 50V	

Transformers

T_1	FT-14	TRW/UTC Transformers
T_2	Special Driver	TRW/UTC Transformers
T_3	Special Power	TRW/UTC Transformers
T_4	Special Current	TRW/UTC Transformers
L_1	Special Filter	TRW/UTC Transformers
T_5	Special Balun	TRW/UTC Transformers

Fuses

F_1	10A fast blow	Bussman type 3AG

10. **The complete power-supply schematic.** Ferrite transformer cores keep losses down and provide a compact design. Paralleled Schottky diodes perform the final rectification, and also keep switching and forward-drop losses down. An L-C filter at the output smooths the pulse train into the 5-V dc output.

put of two NAND gates and the 20-kHz square wave—and its inverse—are applied to the other inputs (Fig. 7a).

The gate outputs are therefore pulse-width-regulated signals, one in phase and the other 180 degrees out of phase with the 20-kHz clock signal. An inverter connected to each of the NAND-gate outputs provides drive signals that are also 180 degrees out of phase with each other, but are complements of the NAND-gate outputs (Fig. 7b).

Thus four pulse-width-modulated signals—from the NAND gates and the inverters—are generated and constitute the base drives for the power Darlington switches. As shown in the figure, the single driver transformer has two center-tapped primaries. One primary connects with a pair of push-pull driver transistors; the other short circuits the core flux during those periods when zero drive is required at all the Darlington switches. This short-circuiting technique ensures that noise pulses or other spurious signals cannot falsely trigger the power switches during periods of no conduction.

A factor in the successful operation of high-voltage switching regulators lies in the base-drive

Transformer winding data

DRIVER TRANSFORMER (T_2)

Core:
TDK, part number H6A-P18/14-52H, pot core.

Windings:
(1-2)(2-3) 60T Bifilar, #32 single sodereze.
(4-5)(5-6) 30T Bifilar, #36 single sodereze.
(7-8)(9-10) 10T Quad, #26 single sodereze.
(11-12)(13-14)

Terminations:
Self leads to 14 pin header mounted to core.

POWER TRANSFORMER (T_3)

Core:
Stackpole, part number 50-631, ceramag 24B, 0244.

Windings:
(1-2) 32T, #14 Teflon covered flex.
(3-4) thru (17-18) 1T, #8 PVC covered solid core.

Terminations:
Self leads, length as required.

CURRENT SENSE TRANSFORMER (T_4)

Core:
Magnetics Inc., part number 52056-1D.

Windings:
(1-2) Bar primary formed by passing T_3 primary lead thru core.
(3-4) 34T, #30HF

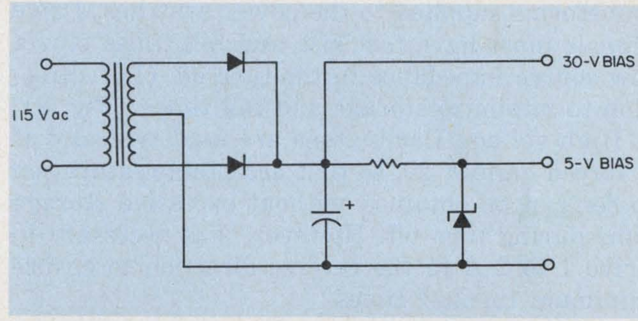
Terminations:
Self leads, length as required.

BALUN TRANSFORMER (T_5)

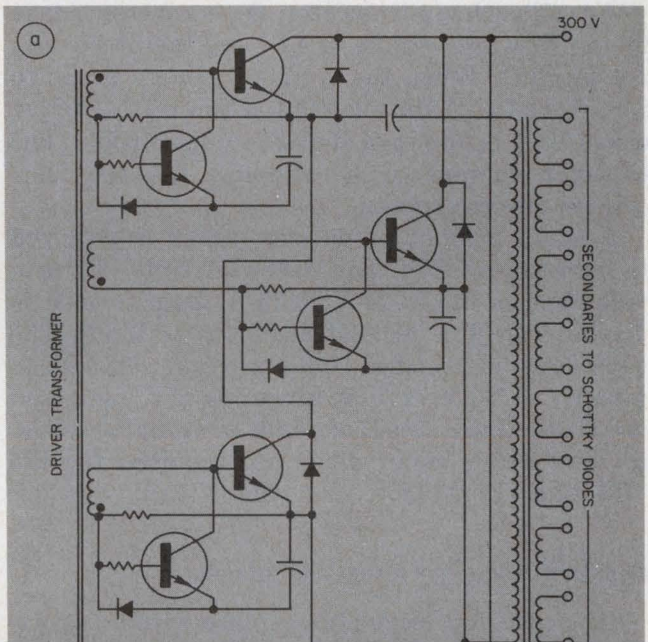
Formed by passing output bus bars through Magnetics, Inc., core part number 55436-A2, 1 turn each bus bar.

FILTER INDUCTOR (L_1)

Formed by winding 2 turns of positive bus bar through 2 Magnetics, Inc., cores part number 55436-A2.



11. **Bias power for the TTL and driver circuitry** is provided by a simple auxiliary supply.



12. **Power stage for a 1000-W output (a).** Commutating diodes and other circuitry shunt the output-transformer inductive currents to ensure proper turn-off. If only 500 W are needed, a half-bridge connection can be used (b).

waveforms supplied to the power switches. Drive signals must have fast rise and fall times plus a low source impedance in the turn-off (I_{B2}) direction to minimize storage and fall times (Fig. 8).

High-voltage Darlingtons are used typically at a forced gain of 20, so that acceptable saturation losses can be obtained without excessive storage time during turn off. However, it is necessary to drive 1 to 2 A in the reverse direction to ensure minimum turn-off times.

Base current, I_{B2}, is supplied by a clamp circuit (Fig. 9). During the forward-drive condition of the Darlington, voltage is dropped across R_1, limiting I_{B1}. At the same time, the drop across this resistor charges C_1 to approximately 4 V dc. The clamp transistor, Q_2, is reverse biased by the forward voltage of CR_1 and therefore does not conduct. When the winding voltage drops to zero, because of the shorting action of the driver circuit, Q_2 is forward driven to saturation. The collector current of Q_2 supplies I_{B2}—the Darlington reverse current.

A small amount of dc bias power is required to operate the TTL and driver circuits. To provide this, a 115-to-24-V, 0.25-A, transformer is driven from line to neutral of the ac input. The secondary is rectified full-wave and filtered to give about 30 V at 1 A. Since the 5-V logic load is substantially constant, only a dropping resistor and a 5-V zener diode are required for the TTL bits (Fig. 11).

Constant frequency offers advantages

In switching regulators, pulse-width regulation may be performed with any of the following methods:

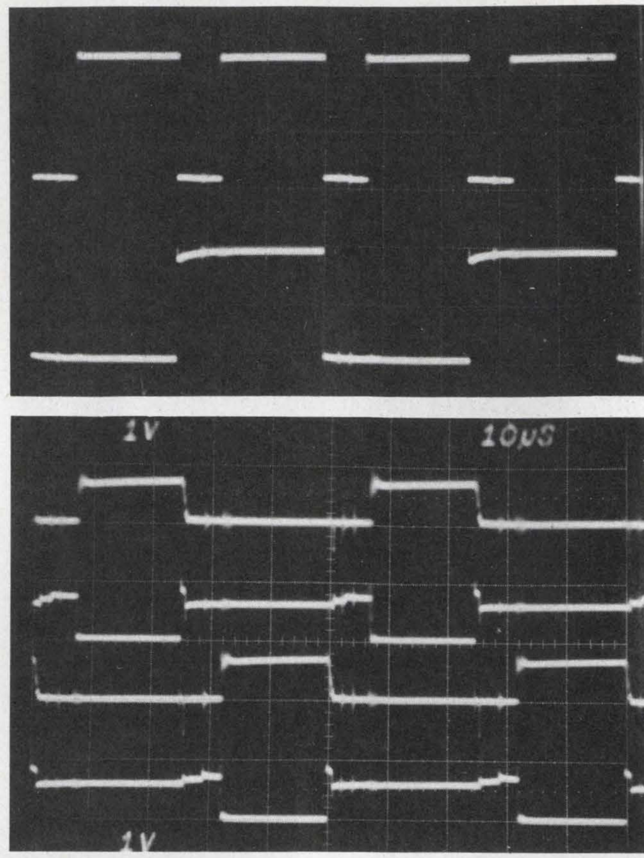
- Constant frequency, variable ON time.
- Constant ON time, variable OFF time.
- Constant OFF time, variable ON time.
- Variable ON time, variable OFF time—or random-switching—regulator.

All these methods follow the basic equation

$$V_{out} = V_{in} \frac{t_{on}}{t_{on} + t_{off}} .$$

Of the four methods, the constant-frequency approach—used here—is preferable because of the predictable performance of magnetic components and the simpler rfi suppression methods available at constant carrier frequency. By varying the ON time, the regulator modulates the output power in response to the internally generated error signal.

For the power stage and driver, the bridge connection of four Darlingtons can provide 1000 W. If less power is required ($<$ 500 W), only two transistors are needed. In this case, the transistors are connected in a half-bridge circuit and, of course, the transformer primary ac voltage is then half as much as for the full bridge. With either circuit, the same driver and TTL logic are required, but the half-bridge uses only two of the driver secondary windings.



Signal and phase relationships (top to bottom): DM8601, MC4024 and DM 8090 outputs at full load, nominal line.

Figure 12 shows the power stages with the necessary turn-off circuits and commutating diodes that provide paths for inductive currents in the power transformer (Fig. 8 illustrates the typical base-current waveform, generated by the turn-off clamp circuits of Fig. 12). Base current, I_{B2}, is limited by the impedance of the clamp transistor at saturation, the esr of the bias capacitor and the impedance at turn off of the Darlington. Values of 1.5 to 2.0 A are typical of I_{B2}.

For the power transformer, a low-loss ferrite core material is chosen with an E-E configuration to minimize winding costs. Stackpole 24B Ceramag material has a saturation density of 5.1 kG at 9.0 Oe. The core loss is approximately 3 W/1b at 20 kHz and 1 kG. With a duty cycle of 80% (corresponding to a low ac input condition), the secondary voltage must be 6 V on the average. This allows 0.6 V to be dropped in the Schottky diodes, and another 0.4 V in the choke and output busses, to give 5 V at the output.

Calculations show that to develop and support 6 V for 25 μs would require approximately 1600 G with one turn or 750 G with two turns at 3 V per turn. The transformer is designed therefore at a flux density of 1500 G. The complete supply schematic is given in Fig. 10. ■■

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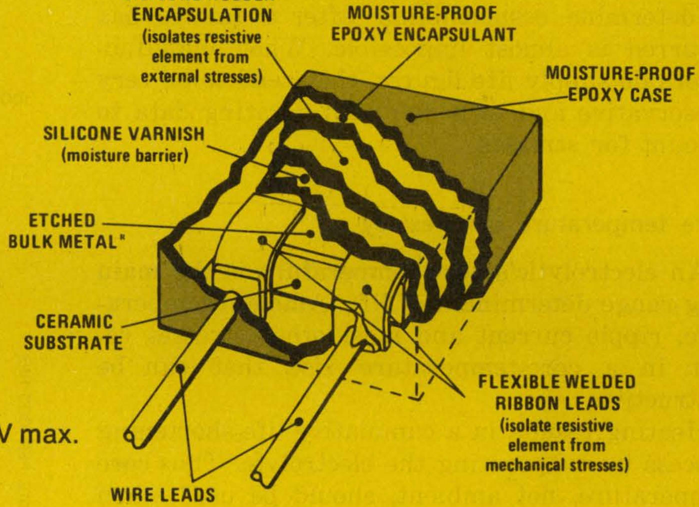

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INFORMATION RETRIEVAL NUMBER 72

Stretch electrolytic capacitor life

by avoiding six deadly no-no's. And use core temperature, not ambient, when interpreting manufacturer specs.

An aluminum electrolytic capacitor eventually fails. The only question is, when?

Stresses that can shorten electrolytic capacitor life include:

- High temperature.
- Excess dc leakage current.
- Ripple current above 80% of rated value.
- Operating voltages above 80% of rated value.
- Excessive transients.
- Improper venting of internally generated gases.

Capacitor manufacturers only reluctantly specify or guarantee life, because of a history of abuse when designers apply the devices. Analysis to determine responsibility after a failure has occurred is almost impossible. When manufacturers do supply life figures, they tend to be very conservative and to hedge with derating data to account for stresses.

Core temperature can destroy

An electrolytic's core temperature is the main long-range determinant of life. Ambient temperature, ripple current and most other stresses result in a core-temperature rise that can be destructive.

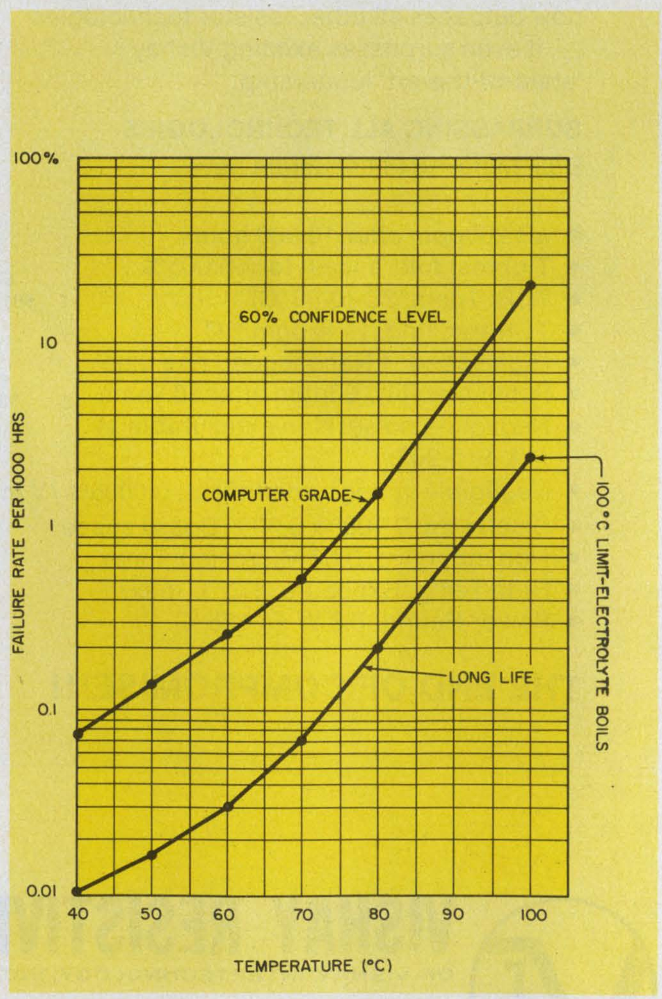
Heating results in a cumulative life-shortening process by evaporating the electrolyte. Thus core temperature, not ambient, should be used when manufacturers' data are interpreted. For an aqueous electrolyte, the core-temperature limit of an 85-C ambient-rated aluminum electrolytic capacitor is 93 to 95 C.

Warning: Manufacturers' test data are usually measured with ripple-free dc voltages only.

Ambient and core temperatures are then about equal, because no ripple current flows and dc leakage in a good capacitor is low. However, when a capacitor is used in a dc power-supply filter or like application, ripple currents can be high and core temperatures may rise to 55 C or

Bob Eimar, Vice President of Engineering, ACDC Electronics, Inc., 401 Jones Rd., Oceanside, CA 92054.

Core temperature is easy to measure with a thermocouple attached to the capacitor's positive terminal.



1. **An electrolytic capacitor's core temperature** strongly affects its failure rate. Core temperature can be much higher than ambient, when ripple current flows.

more above ambient.

The failure rate-vs-temperature data in Fig. 1 were derived with the use of ripple-free dc voltage; ambient and core temperatures are nearly equal. Note the dramatic increase in failure rate—more than tenfold—as the temperature rises only 20 C, from about 75 to 95 C. A typical computer-grade capacitor can have a 20-year life at a core temperature of 45 C, but life is only one year at 85 C.

The core temperature can be measured without cutting into the capacitor's case. A thermocouple or other sensor, if installed carefully on the capacitor's positive terminal, can provide a close approximation to this internal temperature.

Calculating ripple current

Ripple current is very difficult to calculate in filter applications, because of nonsinusoidal-current waveforms, difficult-to-define transformer and rectifier impedances and the nonlinearity of rectifier voltage-current characteristics. In measuring the ripple current's true rms, be sure the current meter and all connections and terminations have very low series impedance, so the capacitor's own low equivalent-series resistance (ESR) is not masked.[1]

Ripple current can also be determined if you measure the true rms ripple voltage and divide this value by the impedance of the capacitor at the ripple frequency. This impedance is

$$\sqrt{(\mathrm{ESR})^2 + (1/2\ \pi f\ C)^2}.$$

The rms ripple voltage can be measured with a true-rms voltmeter, or the value can be approximated from the peak value of its waveshape (Fig. 2).

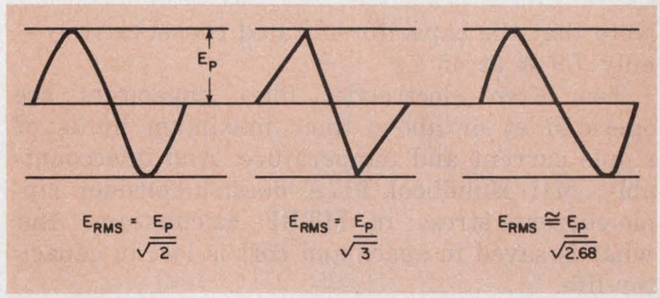
The ripple current, in flowing through the ESR, heats the capacitor's core, and the core's temperature rise depends upon the thermal resistance of the core to the ambient. The thermal resistance is determined by the size of the capacitor's case, the details of the device's construction and the materials used for the housing and internal filler. If a capacitor has a maximum allowable core temperature of, say, 95 C, its thermal resistance can be calculated if the ESR and maximum rms ripple current is known for corresponding allowable case temperatures.

For example, a particular 16,000-μF, 15-V capacitor has an ESR of 0.07 Ω and ripple-current ratings of 4.4 A at 85 C and 7.9 A at 45 C. When the core temperature is 95 C and the ambient 85 C, the thermal resistance for this 10-C rise is

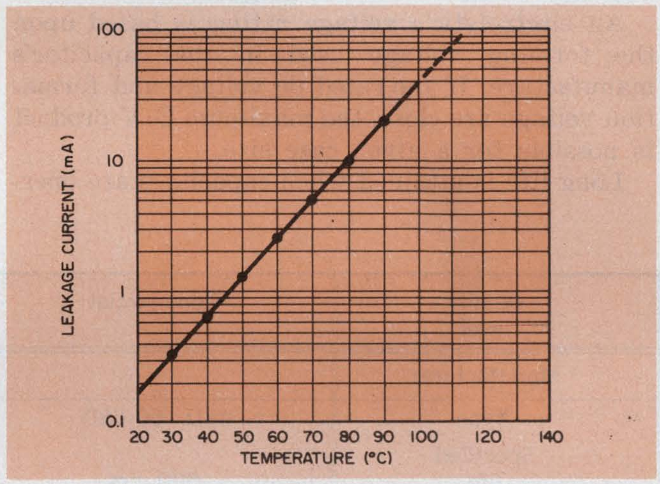
$$\Delta T/I^2(\mathrm{ESR}) = 10/[(4.4)^2 \times 0.07] = 7.35°\mathrm{C/W}.$$

At a case temperature of 45 C, the maximum allowed ripple current would be

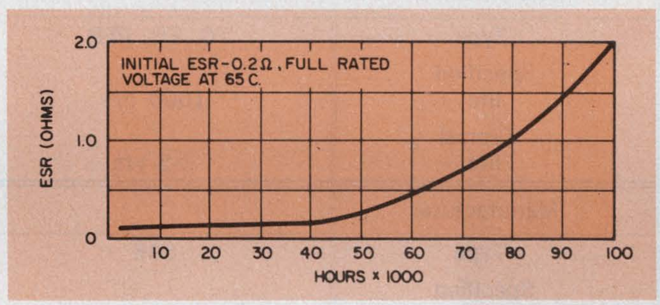
$$I = \sqrt{(95 - 45)/(0.07 \times 7.35)} = 9.85\ \mathrm{A}.$$



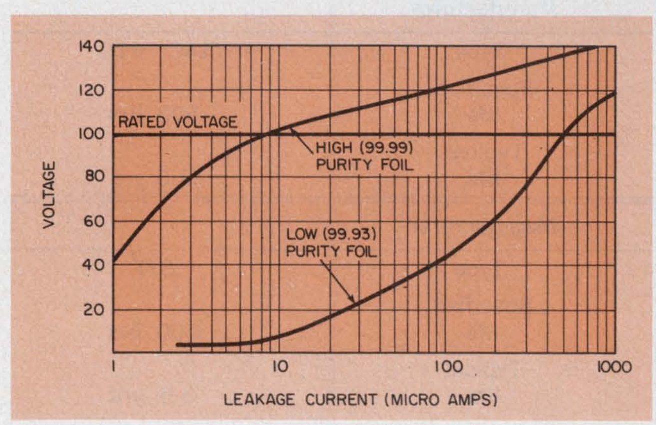
2. **The approximate rms value of ripple current** can be calculated from the current's peak value and a constant determined from the waveshape.



3. **Leakage current doubles** every time the core temperature rises about 10 C.



4. **A capacitor's ESR increases with the unit's age,** mostly because of loss of electrolyte.



5. **Leakage current is strongly affected by the purity of the aluminum foil** used in manufacture.

Note that the capacitor is rated conservatively—only 7.9 A at 45 C.

Too often electrolytic filter capacitors are operated at or above their maximum limits of ripple current and temperature. And unaccountably, MIL-Handbook 217A doesn't consider ripple-current stress in MTBF calculations. But what is saved in space and cost is lost in capacitor life.

Be cautious of high C·V capacitors that are operated at or very near rated voltage and temperature. This is particularly true for bargain-basement units of obscure origins.

An electrolytic's voltage rating is based upon the forming voltage used in the capacitor's manufacture. If the rated dc voltage and formation voltage are close, the maximum C·V product is possible for a given case size.

Long life is attained when capacitors are operated at derated levels of voltage and ripple current. But most manufacturers agree that voltage derated to less than 80% of the rated value does not appreciably improve life. In fact, if a capacitor operates at 50% of its rating for prolonged periods, the aluminum foil's oxide film deteriorates and reforms to a lower voltage rating.

The two aluminum foil strips of an electrolytic capacitor have an aluminum-diode dielectric on one or both strips.[2] The oxide-film thickness is a function of the forming voltage. A paper spacer acts as a reservoir for the electrolyte and as a mechanical separator for the strips. The electrolyte is the capacitor's true cathode and the medium that carries charge to the dielectric surface. The electrolyte also provides oxygen to maintain the oxide film throughout the capacitor's life.

ESR and leakage depend mainly upon the com-

Quality level	Commercial	Computer grade	Long life
Manufacturer	Sprague		
Type	43D, 60-68D	39D, 36D	34D, 32D
Specified life	500 hrs	750 hrs @ 65 C	1500 hrs
Typical life	3-5 yrs	5-10 yrs	10-20 yrs
Manufacturer	Mallory		
Type	TC, FP, PFP	TCW, CGS	TCG, CG
Specified life	1000 hrs	1000 hrs	1500 hrs
Typical life	3-5 yrs	10 yrs	10 yrs
Manufacturer	Sangamo		
Type	505	DCM	500
Specified life	500 hrs	1000 hrs	1500 hrs
Typical life	10 yrs	10 yrs	10 yrs
Manufacturer	STM		
Type	14C, 41C	39C, 91C	71C
Specified life	500 hrs	1500 hrs	2000 hrs
Typical life	3-5 yrs	10 yrs	10 yrs
Manufacturer	General Electric		
Type	87F	84F, 86F	88F
Specified life	500 hrs	500 hrs	1500 hrs
Typical life	3-5 yrs	5-10 yrs	10-20 yrs

6. **For industrial applications,** manufacturers offer three grades of aluminum electrolytic capacitors—commercial, computer and long-life. Entertainment-grade units are generally not reliable enough.

position, quality and amount of electrolyte. Oxide thickness and foil length also affect ESR and leakage.

High temperature accelerates loss of electrolyte, which increases leakage (Fig. 3) and ESR. High leakage and ESR, in turn, mean still higher temperatures and further electrolyte loss, or even thermal runaway. Overheating raises internal pressure high enough to leak electrolyte through the vent or even to rupture the capacitor's vent seal and destroy the capacitor. To allow normal venting, capacitors should never be mounted in an inverted position. And keep them away from heat sources and as cool as possible. Provide airflow where possible.

Temperatures below about 25 C cause a rapid ESR increase, but the ESR decreases only slightly with a temperature rise.

And ESR increases with time. The life of a capacitor (Fig. 4) may extend to 100,000 h, because the data were derived with ripple-free dc. The same capacitor at its rated ripple current would probably fail in less than 50,000 h.

Quality is hard to measure

What determines capacitor quality? One factor, of course, is the material used. Manufacturing details associated with good quality include:

- High foil purity.
- Use of uncontaminated, highly absorptive separator paper to hold the electrolyte.
- High ratio between the formation voltage and specified operating voltage.
- No skimping on the quantity of electrolyte.
- Careful, continuous quality control of materials and processes.
- 100% testing.

Purity of the foil material is particularly important. It has great influence on leakage, ESR, capacitance stability and life (Fig. 5). Metallic contaminants occluded or alloyed into the aluminum provide parasitic leakage paths and cause galvanic couples. Couples break down the electrolyte and generate gases that can rupture the vent or even the case.

Manufacturers offer four grades of electrolytic capacitors: entertainment, commercial, computer and long-life (Fig. 6). Except in low-cost TV and radio sets, entertainment grades do not meet the needs of most industrial-control or instrumentation applications.

Of course, the quality of any product is a reflection of the manufacturer. He must have a proven reputation for quality and reliability. ■■

References

1. Bowling, E. L., "Look Out! All Electrolytic Capacitors Are Not Alike," *Electronic Design*, Jan. 4, 1974, pp. 138-140.

2. Forssander, P. H., "Aluminum Electrolytics Are Hard to Beat," *Electronic Design*, Oct. 11, 1974, pp. 78-82.

Active filter improves tracking and capture ranges of PLL

An active low-pass filter can be inserted into many phase-locked-loop (PLL) circuits to provide additional loop gain, convenient control, extended tracking and capture range. The tracking and capture ranges can be increased by as much as 10 times, when compared with passive-filter circuits.

Consider a linear model of a PLL (Fig. 1). The dc loop gain is $K_dK_oF(0)$ and it determines the tracking range, Δf_t. $F(0)$ is the current gain of the external low-pass filter at dc, and K_d and K_o are the transfer characteristics of the phase detector (PD) and current-controlled oscillator (CCO), respectively. The tracking range can be empirically related to the dc loop gain (Fig. 2), as follows:

$$\Delta f_t = \pm\sqrt{\pi}\, K_dK_oF(0)\ \text{(Hertz)}. \tag{1}$$

If a passive low-pass filter is used in the loop, then $F(0)$ is less than unity, and thus the tracking range can't be increased over that set by the PLL's K_dK_o product. However, with an active filter, $F(0)$ can be made greater than one, and with only a single gain adjustment, R_3 (Fig. 3).

The active low-pass filter is also a current amplifier that drives the CCO of an HA-2825 PLL IC. The dc current gain of the active filter is

$$A_i = \frac{i_2}{i_1} \cong -\frac{e_o/R_3}{e_o/R_2}, \tag{2}$$

when the impedance at CCO input, pin 9, is considered to be small compared with R_3.

Thus the gain is

$$A_i \cong -\frac{R_2}{R_3}, \tag{3}$$

and the tracking range of the PLL can be controlled easily by adjustment of R_3:

$$\triangle f_t = \pm\frac{\sqrt{\pi}\, K_dK_oR_2}{R_3}\ \text{Hz}. \tag{4}$$

It is better to adjust R_3 than R_2, because R_2 and C_1 determine the -3 dB cut-off frequency, f_1, for the filter and thus the capture range, $\triangle f_c$. In Fig. 2

$$f_1 = \frac{1}{2\pi R_2C_1}\ \text{Hz}. \tag{5}$$

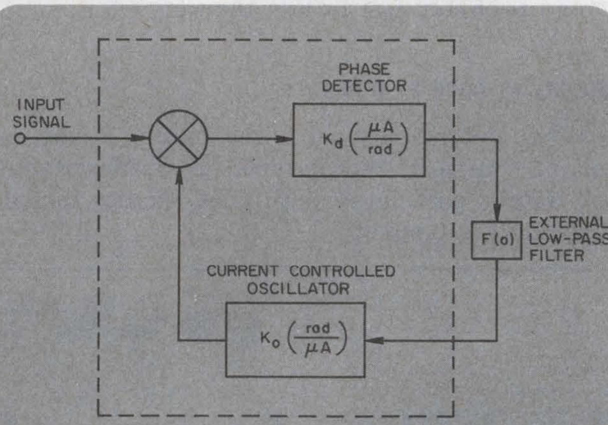
And the capture range is empirically given by

$$\triangle f_c = \pm\left(\sqrt{f_1\frac{K_dK_o}{\sqrt{\pi}}A_i} + \frac{K_dK_o}{\sqrt{\pi}}\right)\ \text{Hz}. \tag{6}$$

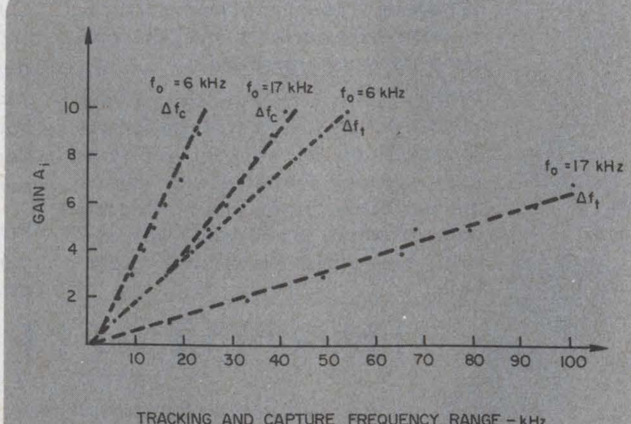
To obtain K_o in dimensionally correct form from the usual specification in percent, the ratio $\triangle f/\mu A$ must be multiplied by the desired CCO free-running frequency. For example, K_o for an HA-2825 PLL has a specification $\Delta f/\mu A$ of 1%. For a free-running CCO frequency of 10 kHz, K_o becomes $(0.01)\cdot(10^4)$ rad/sec/μA.

Experimental data (Fig. 2) show that the empirical Eqs. 4 and 6 are correct to 5% for gain values between 1 and 10. For $|A_i|>10$, the CCO input stage begins to saturate, and the linear model no longer applies.

To prevent the input impedance of the active



1. **PLL circuit's performance** can be improved by use of an active external low-pass filter that provides gain in addition to filtering.



2. **Experimental data** show the relationship of filter gain and the PLL's tracking and capture frequency ranges.

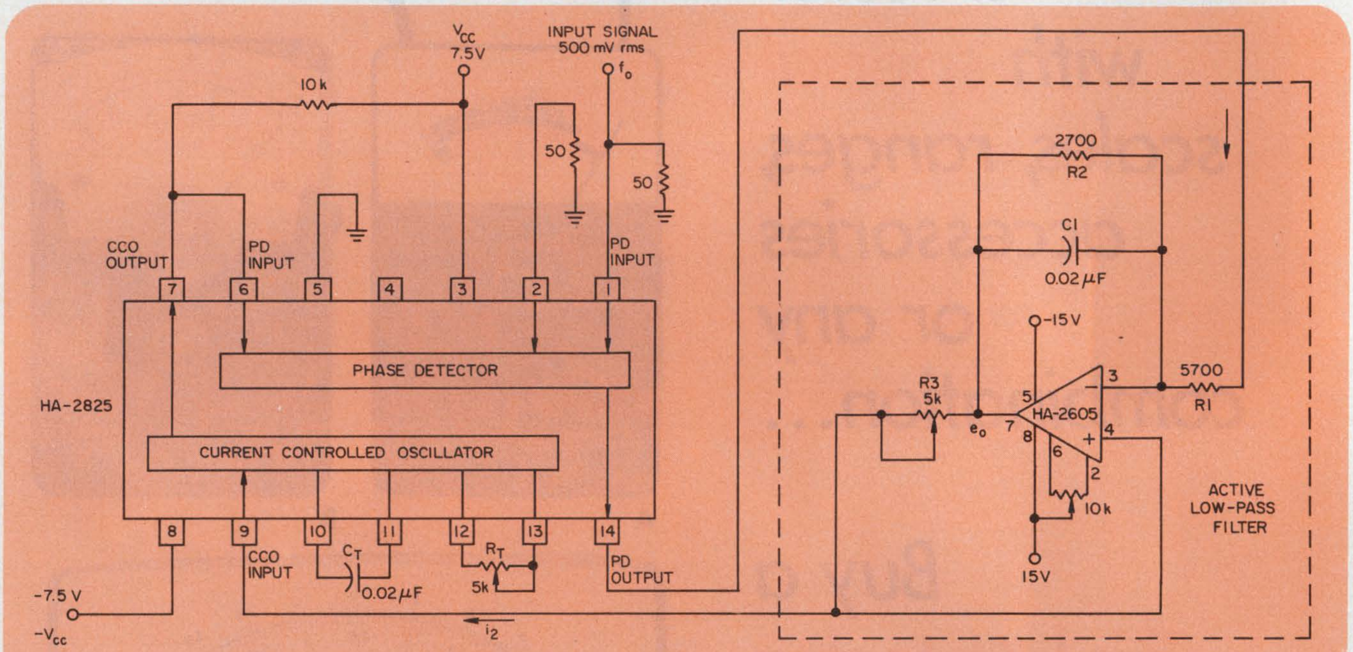
filter from going negative—which would lock up the op-amp's output at either plus or minus V_{cc}—resistor R_1 is chosen as

$$R_1 > \frac{R_2}{R_3} R_L. \qquad (7)$$

Resistor R_L is the input resistance of the CCO—typically 500 Ω for the HA-2825 PLL. Also, the op-amp input offset voltage must be nulled carefully, since a dc offset would be amplified and shift f_o.

J. A. Connelly, Associate Professor of Electrical Engineering, and Glenn Prescott, Georgia Institute of Technology, Atlanta, GA 30332.

CIRCLE NO. 311



3. **The gain of the active filter** is controlled with R_3 and R_2C_1 determines its cut-off frequency.

Complete phase-locked loop made from part of a quad EX-OR gate

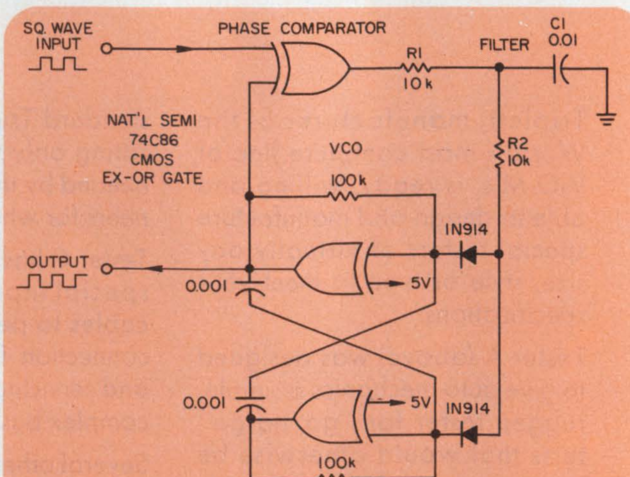
A complete phase-locked loop circuit, which includes a VCO, phase comparator and filter, can be made from three-quarters of a CMOS quad EXCLUSIVE-OR gate.

The circuit operates on 5 V and produces a square-wave output in quadrature with the input signal. The lock and capture ranges are determined by the values of the filter, R_1, R_2 and C_1. For the circuit shown, the center frequency is nominally 10 kHz. The loop can capture the input frequency over better than a 1.5:1 range and track over about a 4:1 range.

As with most phase-locked loops, the loop also will lock to input signals that are multiples of the VCO frequency.

William Hearn, Electronic Engineer, Lawrence Berkeley Laboratory, Bldg. 71, Berkeley, CA 94720.

CIRCLE NO. 312



The lock and capture ranges of the phase-locked loop are determined by R_1, R_2, and C_1.

High-voltage power supply from 5-V source regulated by timer feedback circuit

The addition of a simple feedback-controlled timer circuit converts a high-voltage supply[1] to a regulated supply. The output voltage is adjusted with a single control, and the circuit operates from a +5-V source. The output voltage is directly proportional to C_1's charging time, T_{on}, if T_{off}, the discharge time, is held constant. Time T_{on} is controlled by R_1, and T_{off} by R_2. Thus

$$T_{on} \cong \frac{1.5\ V_{out}\ L\ I_L}{V_c^2} = 0.693\ (R_1 + R_2)\ C_1 \quad (1)$$

and

$$T_{off} \cong \frac{V_c}{V_{out}} \cdot T_{on} = 0.693\ R_2\ C_1\ . \quad (2)$$

Transistor Q_1 is on when C_1 charges, and the current increases approximately linearly to store energy in the inductor's magnetic field. The maximum value of current is given by

$$I_L \cong \frac{(V_c - V_{ce}(sat) \cdot T_{on})}{L}\ .$$

During T_{off}, Q_1 turns off and the collapse of the magnetic field of L generates a voltage, $V_L = Ldi/dt$, which charges C_2 via D_1.

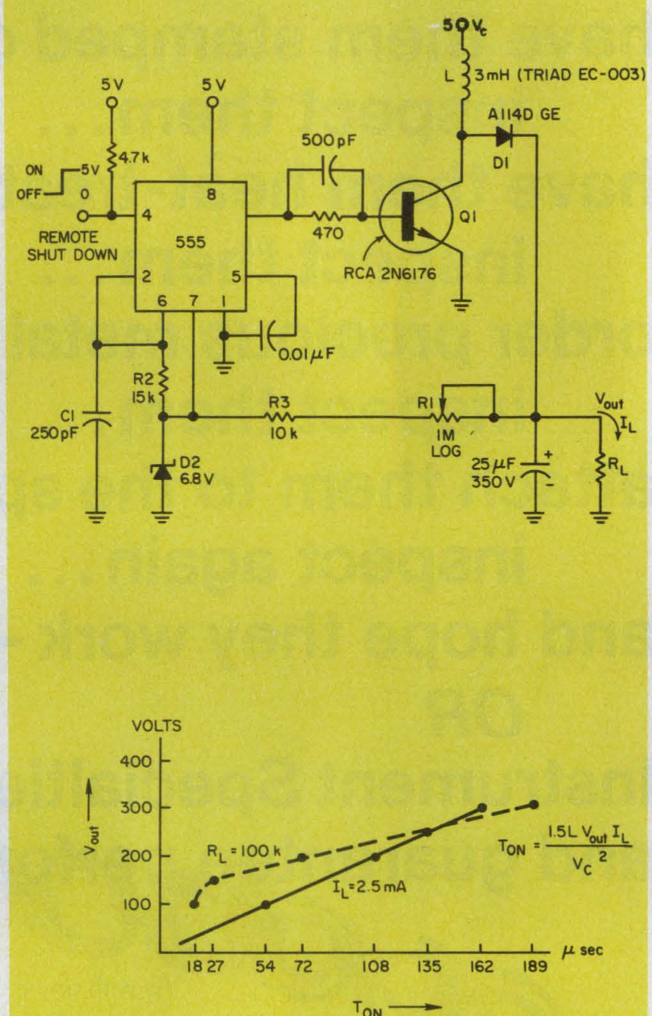
Regulation results from the negative-feedback action of V_{out}. A decrease in V_{out} decreases the charging rate of C_1 and increases T_{on}. Load regulation is approximately 2%. Output ripple is given by

$$V_r = \frac{I_L\ T_{on}}{C_2} = 12\ \text{mV}\ ,$$

for a 2.5-mA load at 250 V. Rectifier-diode D_1 should be a fast-switching type, and zener-diode D_2 protects the timer input.

Reference
1. William, J., "Boost Transistor-Level Supply Voltages to Make a Low-Power, High-Voltage Supply," *Electronic Design*, Oct. 11, 1974, p. 126.

K. R. Johnson, Manufacturing Engineer, Ames Co., Division of Miles Lab, 5635 Fisher Lane, Rockville, MD 20852. CIRCLE NO. 313



Output voltage of a regulated high-voltage power supply is controlled by variable-resistor R_1.

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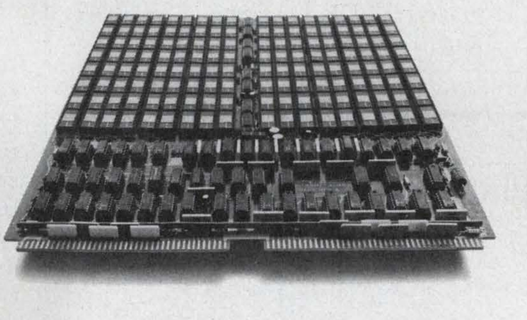

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INFORMATION RETRIEVAL NUMBER 76

international technology

Image-sensor array enhanced by JFETs

An experimental image-sensor array that uses photosensitive junction field-effect transistors (JFETs) has been constructed at Philips Research Laboratories, Eindhoven, the Netherlands.

Undesirable differences in element sensitivity, caused by inherent variations in individual element threshold voltages, have been overcome by a new resetting method, Philips reports. And the JFET photosensitive elements have the advantages of gain and nondestructive readout.

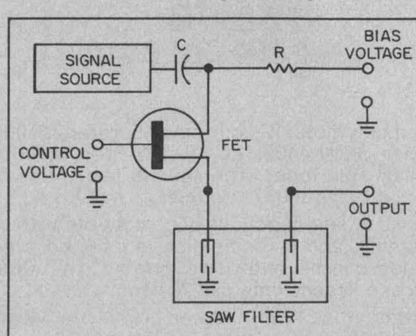
To solve the threshold-voltage problem, the n-channel JFET has a buried photosensitive floating gate and an annular surface control gate. In this configuration the FET threshold voltage is about equal to the punch-through voltage between the control and the floating gates.

When a sufficiently high negative pulse is applied to all control gates, two subsequent punchthroughs are produced in opposite directions between the control and floating gates. Each element is then set automatically at its individual threshold voltage. As a result, the response to a given light level becomes identical for all elements, in spite of threshold-voltage differences.

Possible applications of the new array may be a photo-detection matrix for a holographic memory and in character recognition.

Filter circuit controls amplitude and frequency

A surface-wave filter circuit that can electrically control amplitude and frequency response has been designed at the Faculty of Physics of Sofia University in Bulgaria. A control voltage in the circuit is applied to the gate of a field-effect transistor, which is connected to an acoustic surface-wave filter (see figure). The input is a high-frequency signal that reaches the transducer via a capacitor and the FET.



The filter output voltage is dependent on both control and bias voltages. The emission of acoustic energy in the filter is controlled by the FET gate voltage. The output-vs-control-voltage curves for various bias voltages show substantial linear portions.

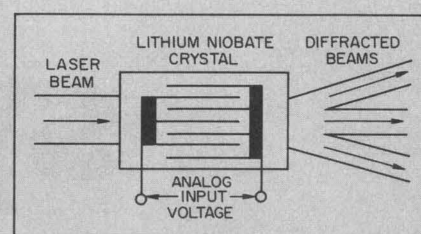
Control of frequency response is achieved by use of a system made up of several transducers, each of which receives the input signal via a separate FET. The frequency response is shaped by adjustment of the phase relationships of control voltages applied to the transistor gates. A single wideband transducer receives the acoustic wave for output.

The designers envision program-controlled filters and delay lines based on this circuit.

Electro-optics employed in new a/d converter

An experimental electro-optic a/d converter, based on a diffraction modulator, has been designed at University College in London. Design advantages include reduction of conversion delay time and of comparator components. The inventors see it as an interface between wideband analog and high-speed digital subsystems.

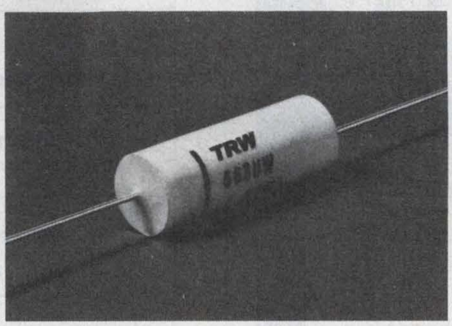
The diffraction modulator is a thin crystal of lithium niobate carrying an interdigitated electrode structure (see drawing). Application of voltage to the electrode system terminals produces spatially periodic variations in the refractive index of the crystal. As a result, a laser beam passing through the crystal is modulated in intensity, as different orders of power are diffracted in controlled directions.



Diffracted low-order beams are directed onto an array of photodiode detectors. The analog signal applied to the crystal electrode system is digitized as threshold detectors, in series with the diodes, pass on their outputs to NAND gates. A total output in the form of a Gray code is obtained.

The response time can be reduced to the order of a nanosecond if the input capacitance of the modulator and the optical transit time through the crystal are lowered. The drive level can be minimized by use of a very thin crystal. It may be possible, the researchers say, to use a LED and a pinhole instead of a laser.

Check the specs on this one



...when you need a subminiature capacitor offering "instrument" quality

With its skin-tight plastic case, TRW's Type 663UW Mylar* dielectric capacitors offer you major space savings with *no* compromise on life or reliability.

Use these TRW 663UW capacitors for high-density circuitry in computers, instruments, MIL applications. *Conservatively* rated to assure trouble-free performance in your equipment.

Complete specs on 663UW capacitors—along with a look at TRW's overall Mylar/foil capability—available on request. Write TRW Capacitors, an Electronic Components Division of TRW, Inc., Box 1000, Ogallala, Neb. 69153. (308) 284-3611.

DF: less than 1.0% at 1000 ±20 Hz

IR: greater than 70,000 megohm-microfarads at 25°C (5X paper dielectric capacitors)

Dielectric strength: twice rated voltage for one min.

Temp. range: −55°C to +85°C (to +125°C with derating)

Stability: easily pass 10,000 hr. test with negligible drift in capacitance and DF

Tolerances: to ±1%

*Du Pont T.M. for polyester film.

TRW® CAPACITORS

INFORMATION RETRIEVAL NUMBER 77

new products

Microcomputer has PDP 11/05 performance

Digitital Equipment Corp., Components Group, One Iron Way, Marlborough, MA 01752. (617) 481-7400.

A microcomputer backed by memories and I/O boards dubbed the LSI-11 offers mini-level performance at low cost. The microprogrammed NMOS processor (KD11-F) has the 400 instruction PDP-11 repertoire and optional floating or fixed point arithmetic. The processor uses four chips: data, control and two control ROMs, and offers PDP-11/05 execution speed as well as vectored interrupt logic. The processor with 4 k memory mounted on an 8.5 × 10 in. board costs less than $1000. Support products include, on 8.5 × 5-in. boards, the DLV-11 serial data interface (50 to 9600 baud); the DRV-11 parallel I/O module plus PROM and RAM. Core is also available in units of 4 k words on an 8.5 × 10 in. board. Memory is expandable to 64 k bytes; the computer handles DMA rates to 833 kHz. A typical system which includes CPU, two parallel I/O units, serial unit, PROM board and backplane sells for $1616 (qty. 100).

Booth No. 2202, 4, 6

Circle No. 323

Dot-matrix printer includes case and supply

Victor Comptometer, Business Products Group, 3900 N. Rockwell St., Chicago, IL 60618. (312) 539-8200.

Model 5005, a dot-matrix printer includes case, power supply printer (plus associated circuits). Space is available for the user to install keyboard, microprocessor and associated circuitry. Print capacity is 34 char/line at rates up to 4 line/s. A 7-dot column is used; the font is user supplied, usually 5 × 7 or 9 × 7. Unit price is $611 with substantial discounts for quantity orders.

Booth No. 2423 Circle No. 320

Voice synthesizer acts as computer output

Vocal Interface Div., Federal Screw Works, 500 Stephenson Hwy., Troy, MI 48084. (313) 588-2050. Under $2000 (prod. qty.); 60 to 90 day.

The Votrax electronic voice system is an information output device that provides output messages in verbal form. Votrax has unlimited vocabulary capability so that any message can be spoken. In addition, the unit is small and completely solid state, thus allowing flexibility and ruggedness. Data requirements are held to a minimum. Votrax can produce continuous speech with a data input rate of as low as 150 b/s. In addition, the electronic voice system is available in a wide range of interface options.

Booth No. 2710 Circle No. 355

Versatile buffer can also change data mode

International Communications Corp., 8600 N.W. 41 St., Miami, FL 33166. (305) 592-7654. $3105 (small qty).

Comstore 1032 is a versatile buffer that can also act as a speed changer and converter between synchronous and asynchronous line operation. An internal MOS memory holds up to 40,000 characters. The unit accepts or outputs asynchronous or synchronous data at any rate to 9600 bit/s. In addition, data can be inputted and outputted simultaneously at combined speeds up to 9600 bit/s.

CIRCLE NO. 356

Hand-held computer thrives on statistics

Litton Monroe, 550 Central Ave., Orange, NJ 07051. (201) 673-6600. $795; stock.

A hand-held microcomputer offers the statistician computer power at a fraction of the cost. Preprogrammed into the Monroe 344 is a set of commonly used statistical functions that include: standard deviation (grouped or ungrouped), linear regression, Z-score, t-dependent and independent, logs and anti-logs, coefficient of correlation, expected y from regression coefficients, slope and intercept, square root, reciprocal, and integer-fraction separation. Ten independent storage registers with full arithmetic support the store, recall and exchange control. Other features include: large 10-digit display plus 2-digit exponent; automatic lighted commas for punctuation; zero suppression and separate error and overflow indication. The arithmetic and function sequence (including constants and data points) are stored automatically when calculation is performed in load mode and automatically executed when the program switch is in Run. Program step numbers are displayed when program switch is in Load position.

Booth No. 2503-2507

Circle No. 321

Pair of printers offer speed at low cost

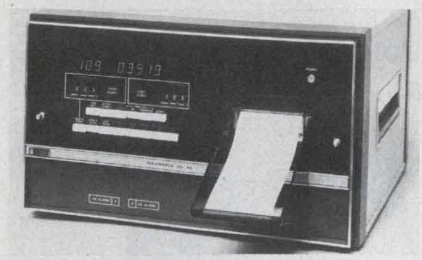
General Electric Co., Data Communications Products Dept., Waynesboro, VA 22980. (703) 942-8161. See text; stock.

In addition to a 120 char/s printer, General Electric offers a low-cost 30 char/s unit called the TermiNet 30. The slower unit, a keyboard-printer configuration, sells for $1200 (qty), prints 7 × 9 dot-matrix characters, 80 to the line, and uses 9-in. paper forms. A ribbon cartridge makes for clean ribbon replacement. The keyboard, a Hall-effect unit, provides ECMS, ANSI and APL character sets among others. The 120 char/s printer designated the TermiNet 120 offers LED diagnostics and uses a print belt to provide increased speed.

CIRCLE NO. 357

DATA PROCESSING

Data logger with μP is easy to program



Doric Scientific Corp., 3883 Ruffin Rd., San Diego, CA 92123. (714) 565-4415. From $4000; 60 days.

A wide range of data acquisition capability coupled with user-oriented programming are offered by a digital multipoint recorder called the Digitrend 220. The unit uses an Intel 8008 CPU microprocessor and will scan 20 to 1000 points at speeds to 20 point/s. Standard range/functions offered are: Four ranges of linear dc voltages with resolution to 1 μV and automatic ranging, with thermocouple compensation; two ranges of current transmitter inputs to handle process signals of 4-20 mA and 10-50 mA. Nine interface circuit cards are available as options to couple to a variety of peripheral equipment such as computer random access ports with parallel BCD output, 7-track or 9-track incremental magnetic tape recorders, TTYs and modems.

Booth No. 203 Circle No. 324

Disc packs can store up to 80 Mbytes

Ampex Corp., 401 Broadway, Redwood City, CA 94063. (415) 367-4151. See text; third quarter '75.

A family of disc drive devices for small and medium-sized computer systems is available. The DM-940 single density module offers 40 Mbytes of storage. The DM-980 offers 80 Mbytes. And a single DM-940 will replace several cartridge disc units. The DM-940 and DM-980 are designed to meet large capacity requirements through use of a five-high removable disc pack, which is equivalent to the CDC Models 9876 and 9877. Quantity prices are $5000 and $6500, respectively.

CIRCLE NO. 358

Voice response unit uses simple logic decoding

Master Specialties Co., 1640 Monrovia Ave., Costa Mesa, CA 92627. (714) 642-2427. $1695; 12-14 wks.

EVA is the name of an expandable voice system, with whole-words stored in ROM, that outputs limited word-size messages. Whole-word storage helps produce a synthesized voice that is difficult to distinguish from the original yet uses simple logic decoding. All voice inflections and natural qualities are there. And it's a simple matter to access each ROM and call up the words one at a time in the required sequence. The unit is modularly expandable from 10 to 30 words. In the standard model, the first 10 words are the numeric words zero to nine with additional words added as specified. EVA accepts either binary address or 10 mutually exclusive switch closures for the numeric words. Additional words, after the first 10, require binary address only.

Booth No. 2708 Circle No. 325

Smart calculators aided by peripheral storage

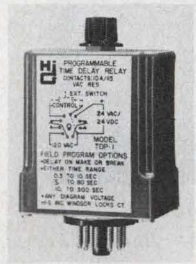
Litton Monroe, 550 Central Ave., Orange, NJ 07051. (201) 673-6600. See text; stock.

A series of programmable calculators dubbed 324 Micro Scientist, Beta 326 and Alpha 325 ranges from hand-held portables to desktop printing units. The Model 324 for $645 can be handheld yet offers 13 digit accuracy, 20 functions and dual 80-step storage. Ten registers with automatic capability hold results which are displayed with a 10-digit mantissa and 2-digit exponent. The 326, also handheld, features over 100 functions, 13-digit accuracy, has program capacity of 160 steps. Other features include TTL and CRT terminal compatibility plus program editing capability. The desktop 325, price $1795, has all the capabilities of the 326, boasts a 416-step memory and has a built-in printer. Model 92, an optional cassette storage, holds up to 50,000 instructions or 9000 data items for the 325 and 326 and costs $995.

Booth No. 2503-07 Circle No. 322

NEW PROGRAMMABLE TIME DELAY RELAYS

For R&D, low volume & production requirements.



Featuring CMOS digital circuitry; DPDT contacts—10 amps resistive; no "false" operation on delay on make function; competitive pricing; low inventory requirements.

Model TDP-1: Each unit easily field selected for delay on make or break; for 24VDC, 24VAC, or 120VAC; and for delay ranges of 0.3 to 10, 3 to 80, or 10 to 300 seconds—adjustable to min/max of each range.

Low cost conventional, adjustable and fixed, single mode timers also available.

for further information contact
Hi-G, Inc./Windsor Locks, CT 06096
Area Code (203) 623-2481
see complete Hi-G line in EEM

INFORMATION RETRIEVAL NUMBER 82

FOR THE UTMOST IN RELIABILITY

RECYCLING TIMERS Series RC

This multi-cam timer is one of a family of very versatile recycling timers that are available in single or recycling types with up to 20 control circuits. Control cams are independently adjustable from 2% to 98% of the total time cycles enabling the timer to be used as a programming device. And with supplied interchangeable gear and rack assemblies you can select from 700 time cycles ranging from 2/3 second up to 72 hours. All our timers are made to give you service far beyond what you'd reasonably expect. Our line consists of 17 basic types, each available in various mountings, voltages, cycles, circuits and load ratings . . . and with whatever special wrinkles you may need. Bulletin #206 tells all about our line of reliable Recycling Timers. Write for it or a catalogue of our entire line. If you have an immediate timer requirement, send us your specifications. Or for fastest service, call (201) 887-2200.

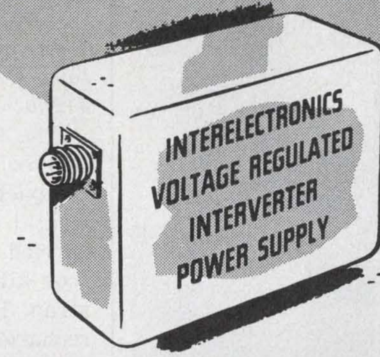
INDUSTRIAL TIMER
A UNIT OF ESTERLINE CORPORATION

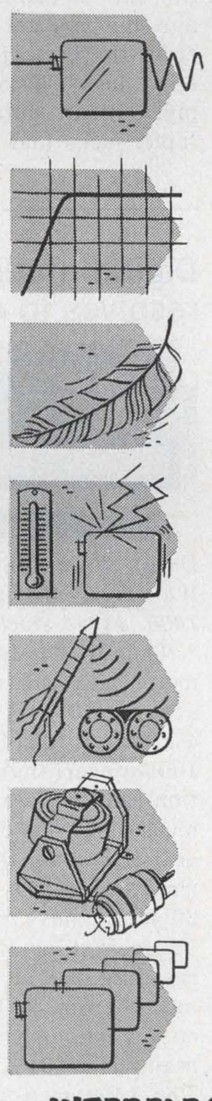
INFORMATION RETRIEVAL NUMBER 83

PROVEN RELIABILITY—

SOLID-STATE POWER INVERTERS,

over 260,000 logged operational hours—voltage-regulated, frequency-controlled, for missile, telemeter, ground support, 135°C all-silicon units available now—





Interelectronics all-silicon thyratron-like gating elements and cubic-grain toroidal magnetic components convert DC to any desired number of AC or DC outputs from 1 to 10,000 watts.

Ultra-reliable in operation (over 260,000 logged hours), no moving parts, unharmed by shorting output or reversing input polarity. High conversion efficiency (to 92%, including voltage regulation by Interelectronics patented reflex high-efficiency magnetic amplifier circuitry.)

Light weight (to 6 watts/oz.), compact (to 8 watts/cu. in.), low ripple (to 0.01 mv. p-p), excellent voltage regulation (to 0.1%), precise frequency control (to 0.2% with Interelectronics extreme environment magnetostrictive standards or to 0.0001% with fork or piezoelectric standards.)

Complies with MIL specs. for shock (100G 11 mlsc.), acceleration (100G 15 min.), vibration (100G 5 to 5,000 cps.), temperature (to 150 degrees C), RF noise (I-26600).

AC single and polyphase units supply sine waveform output (to 2% harmonics), will deliver up to ten times rated line current into a short circuit or actuate MIL type magnetic circuit breakers or fuses, will start gyros and motors with starting current surges up to ten times normal operating line current.

Now in use in major missiles, powering telemeter transmitters, radar beacons, electronic equipment. Single and polyphase units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics—first and most experienced in the solid-state power supply field produces its own all-silicon solid-state gating elements, all high flux density magnetic components, high temperature ultra-reliable film capacitors and components, has complete facilities and know how—has designed and delivered more working KVA than any other firm!

INTERELECTRONICS CORPORATION

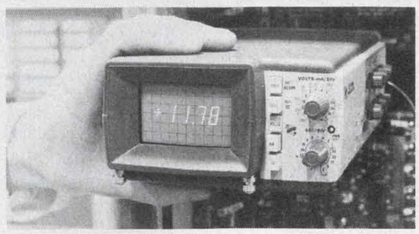
550 U. S. Route 303, Congers, N. Y.

Telephone: 914 ELmwood 8-8000

INFORMATION RETRIEVAL NUMBER 84

INSTRUMENTATION

Portable scope also has built-in DMM



Tektronix, P.O. Box 500, Beaverton, OR 97005. (503) 644-0161. $1200; stock.

The Model 213 is a DMM and a 1-MHz oscilloscope housed in one compact instrument. The lightweight (3.7 lb) unit can easily be carried anywhere in a briefcase, tool kit or on a convenient neck strap. The built-in battery charger recharges the batteries any time the 213 is connected to line voltage, but you get 3.5 h of operation from the batteries. The DMM and scope share a common power supply, built-in voltage probe, current input jacks and input attenuators.

Readout for both devices is on the 6 × 10 division CRT (0.5 cm/div). In DMM mode true rms reading capability makes the 213 especially convenient for nonsinusoidal ac measurement applications. Full scale dc and ac voltage ranges extend from 0.1 to 1000 V. Dc and ac current ranges are 0.1 mA to 1 A and resistance ranges span 1 kΩ to 10 MΩ. For easy readability, the 3-1/2-digit-plus-sign readout occupies a 1 × 4 cm area on the CRT. In the oscilloscope mode the 213 has a dc-to-1-MHz voltage bandwidth with calibrated deflection factors from 20 mV/div to 100 V/div (extends to 5 mV/div at 400-kHz bandwidth). Current waveforms are displayed with deflection factors ranging from 5 μA/div to 100 mA/div. Horizontal sweep rates range from 2 μs/div to 500 ms/div, and a variable sweep magnifier provides up to 0.4 μs/div. Both internal and external triggering provide stable displays over the entire bandwidth.

Booth No. 2302-2307 Circle No. 359

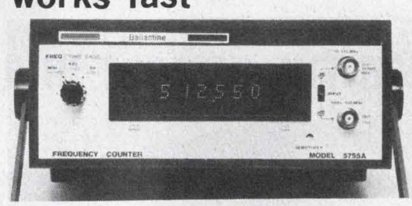
Digital multimeter resolves to 4-1/2 digits

Data Precision, Audubon Rd., Wakefield, MA 01880. (617) 246-1600. $325; stock.

The Model 1450 digital multimeter is a full function bench instrument with a 0.5-in.-high, 4-1/2-digit display. The unit has 100% overranging and 21 function-range operation. Dc volts are measured from 100 μV to 1000 V; ac volts from 100 μV to 500 V rms; resistance from 100 mΩ to 20 MΩ; and current, both ac and dc, from 1 μA to 2 A. Frequency response for ac current and voltage is from 30 Hz to 50 kHz. Accuracy on dc volts is ±0.02% of reading ±0.01% of f.s., ±1 digit. The 1450 measures 8.5 × 3.5 × 7.25 in. and comes with its own test leads and a combination carrying handle/tilt stand.

Booth No. 2719-2721 Circle No. 360

512-MHz counter works fast



Ballantine Laboratories, P.O. Box 97, Boonton, NJ 07005. (201) 335-0900. $745; stock.

Model 5755A frequency counter is said to give full, 6-digit resolution in half the time of similar competing models. The unit counts directly from 10 Hz to beyond 512 MHz. The instrument weighs only 5 lb. and is housed in a high-impact plastic case. Truly portable, the unit can be operated from ac or an 11 to 18-V battery. The unit measures through two input ports: Its high-impedance input (1 MΩ shunted by approximately 25 pF) covers the range from 10 Hz to 100 MHz with a sensitivity of 35 mV rms up to 40 MHz, increasing to 50 mV rms at 100 MHz. Its 50-Ω input is used for frequencies from 10 to 512 MHz.

Booth No. 2632 Circle No. 339

DPM offers 13-mm LED 2-year warranty, low $

Newport Laboratories, 630 East Young St., Santa Ana, CA 92705. (714) 540-4914. $81. (100); stock-2 wks.

Model 203 3-1/2-digit DPM is the first in a new series of high-reliability meters featuring low component count and a low-voltage, 13-mm (0.51 in.) LED display with an estimated life expectancy of over 11 years in continuous operation. The series features a 2-year warranty, voltage, current and ratio measurements, automatic polarity, automatic zeroing and standard BCD output. Full-scale input voltage ranges are 200 mV, 2, 20 and 200 V with instantaneous warm-up to full rated accuracy and total error of ±0.05% of reading ±1-1/2 counts.

Booth No. 2122-2124

Circle No. 338

350-MHz analyzer grabs spectra easily

Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. (415) 493-1501. $4650 (includes mainframe); 30 days.

A new 350-MHz fully calibrated spectrum analyzer, Model 8557A, emphasizes ease of use with lab-grade performance. Most measurements can be made with just three controls. Frequency response is ±0.75 dB, over-all absolute amplitude-measuring accuracy is ±2.25 dB, and frequency readings are correct to ±3 MHz. Dynamic display range exceeds 70 dB. The new instrument is a plug-in for the company's 180-series scope mainframes.

Booth No. 2518 to 2531

Circle No. 343

Notch filter eliminates line interference

Xetron Corp., 11079 Reading Rd., Cincinnati, OH 45241. (513) 563-4880. $1500 to $3000.

This digital comb notch filter, the LINX, eliminates all interfering 60-Hz harmonics throughout the entire audio band by provision of almost 200 distinct, equally spaced, notches. The unit is also available for 400-Hz power sources. A special feature is the ability to lock onto the power-line frequency and track it when any drift occurs. This keeps the interference frequency automatically held at the center of the notches and eliminates manual adjustments.

CIRCLE NO. 361

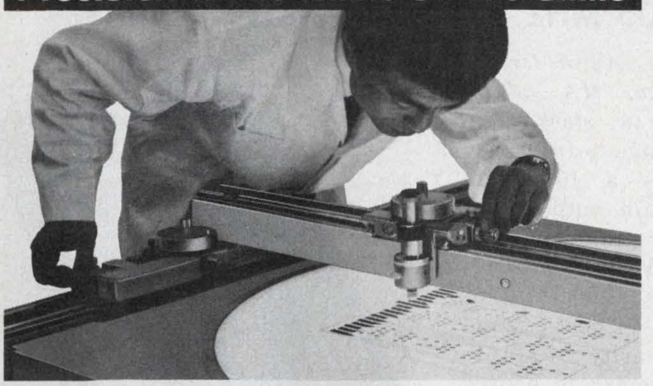
Sweep generator covers 200 kHz to 1000 MHz

Telonic Altair, Box 277, Laguna Beach, CA 92652. (714) 494-9401. $1695; 30 day.

The Model 1210 solid-state sweep generator covers 1 to 1000 MHz in a single sweep. The unit uses a patented electronic switching technique that couples two sweep sources. The instrument provides a continuous band of frequencies from 200 kHz to the full 1000 MHz. The Autoplex switching system eliminates any need for manual switching from one range to another and gives the user a complete response curve of the unit under test. For accurate determination of frequencies, the instrument can be equipped with harmonic and single frequency markers of the Birdy bypass type. Individual marker frequencies are determined by the particular application of the instrument, which will accept up to seven marker plug-in cards. The generator is available in a 50-Ω version, Model 1210, and a 75-Ω version, Model 1240. Both have the 1000-MHz sweep range, 200-kHz-to-1000-MHz sweep width, 0.5-V-rms output, ±0.5-dB flatness and 1% linearity.

Booth No. 2322 *Circle No. 362*

Precision Is The Name Of The Game



The MICRO/PLOTTER Coordinatograph by MUTOH is a "certified" winner.

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There is also another name to the game: "VERSATILITY." MUTOH believes it's equally important because they are engineers like you. Take for instance tools. THE MICRO/PLOTTER has a complete line of quick change drafting, measuring and plotting tools to adapt to every conceivable function. Both rectangular and rotary work tables are available, equipped with back-lighted translucent glass work surfaces.

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INFORMATION RETRIEVAL NUMBER 90

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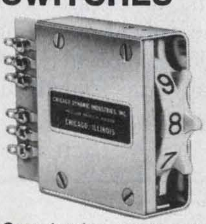
Customizes Switches Like CDI Nor Has a More Complete Line

THUMBWHEEL SWITCHES



Completely sealed against hostile environments.

ROTARY SWITCHES

Snap-in, snap-out modules in seconds, eliminating downtime.

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Mounts on ½" centers, retrofits most panel openings for miniature thumbwheel switches.

Miniature add/subtract units retrofit most minithumb-wheel switch panel openings.

CDI earns its reputation every day for Consistently High Quality, Consistently Good Delivery.

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Phone: 312, 935-4600

INFORMATION RETRIEVAL NUMBER 91

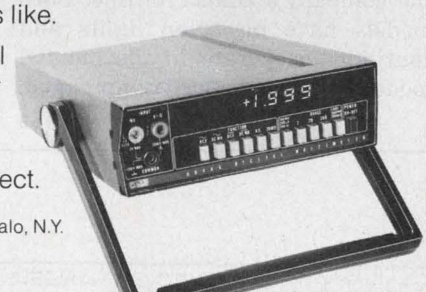
This may look like a multimeter... but it's really an autoranging multi-function counter

We've had a lot of comments that our new 1900A multi-function counter looks like our 8000A multimeter. We agree. In fact we planned it that way. Both are attractively styled and designed for user convenience. But inside they're vastly different instruments.

The 1900A is an advanced LSI/MOS multi-function counter with . . . autoranging in both frequency and period mode . . . 5 Hz to 80 MHz range with 25 mV sensitivity . . . event counting to 10^6 . . . automatic overflow . . . six digit LED display with automatic annunciation . . . all for the unbelievably low price of $349.*

Plus you can order a rechargeable battery option, or a data output option that lets you use the 1900A in systems applications.

And just in case you're wondering – here is what the 26 range, 5 function 8000A multimeter looks like.



Phone your local Fluke distributor to-day for a demonstration, or contact us direct.

*U.S. price F.O.B. Buffalo, N.Y.

FLUKE®

COUNTER DIVISION

John Fluke Mfg. Co. Ltd.
Counter Division
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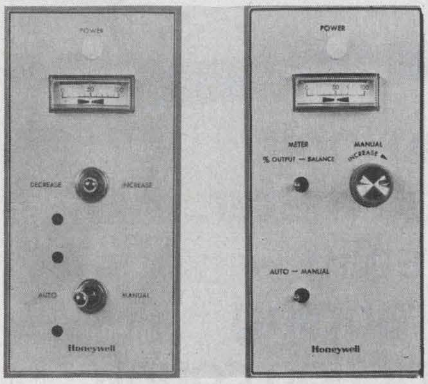
TWX 610-492-3214

INFORMATION RETRIEVAL NUMBER 92

FOR DEMONSTRATION 184

Auto/manual stations designed for control



Honeywell, 1100 Virginia Dr., Fort Washington, PA 19034. (215) 643-1300. From $140; 6 to 8 wk.

Two automatic/manual transfer stations are designed for use on manual process startup or for standby service if the control instrument is removed from service. One model is for use with current-proportioning controllers that have 4-to-20-mA outputs. The other unit is used with position-proportioning controllers to provide continuous indication of the operator position and to manually position the operator when in the manual mode. The auto/manual stations also can be used with controllers of other manufacturers, the color and size of the instruments, however, match the company's DialaTrol line. Both models have power-on lights and continue to operate in the manual mode if the controller is unplugged.

CIRCLE NO. 363

V/f converter covers 100 Hz to 5.05 MHz

Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, MA 02026. (617) 329-1600. $149; stock.

The 4707 voltage-to-frequency converter provides a 100-Hz-to-5.05-MHz pulse-train output that is a direct linear function of a +1 mV to +10 V dc input signal. The 4707 has a linearity of 0.004%, a drift of 44 ppm/°C and a differential linearity of 14 to 16 bits. The converter is housed in a 3 × 2 × 0.4 in. case and operates over 0 to 50 C. Derated operation is possible over −25 to +85 C.

CIRCLE NO. 364

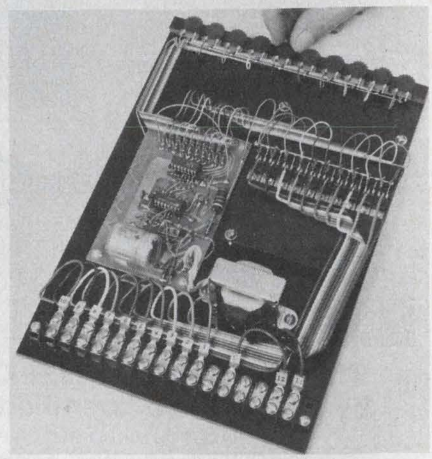
Wideband amplifier spans 5 to 500 MHz

Watkins-Johnson, 3333 Hillview Ave., Palo Alto, CA 94304. (415) 493-4141. $125 (1 to 9); stock.

The WJ-A9 is a high-dynamic-range rf amplifier designed to deliver 11 dB of gain over the frequency range of 5 to 500 MHz. The amplifier is assembled in a hermetic four-pin TO-8 package and operates with supply voltages from +15 to +24 V dc (the supply voltage is internally decoupled). At +24 V dc the third-order two-tone intercept point is typically +35 dBm, output power at 1 dB gain compression is +22 dBm and gain is 11 dB. Most performance parameters remain constant with changing supply voltages with the output power dropping to +21 dBm at 20 V and +18 dBm at 15 V.

CIRCLE NO. 365

Programmable timer controls 10 circuits

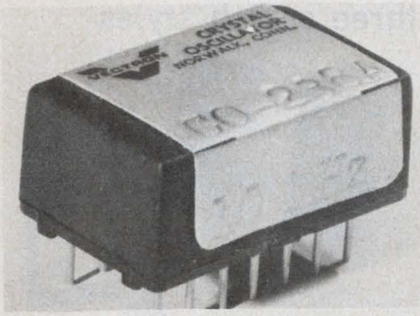


Bayside Timers, 43-69 162 St., Flushing, NY 11358. (212) 463-8935. $180 (uncased); 1 wk to 10 days.

The Varistep timer-stepper can control 10 circuits with each having a different ON period duration. Each ON period can be adjusted independently of the other nine. The Varistep timer-stepper also provides the user with the option of using only the number of circuits needed between two and the full 10 by moving a jumper from one terminal post to another. Each circuit has its own control potentiometer, providing a minimum-to-maximum time range of approximately 1 to 3000. Options include triacs for switching heavy loads (the standard model has 10-A triacs rated for 600-W tungsten filaments), a pushbutton for single-cycle operation, a toggle switch for single-cycle/repeat-cycle operation, and precision potentiometers for high accuracy and repeatability of time interval settings.

CIRCLE NO. 366

Crystal clocks operate at Schottky speeds



Vectron Laboratories, 121 Water St., Norwalk, CT 06854. (203) 853-4433. 4 to 6 wk.

The CO-238 DIP-compatible crystal oscillator is available at frequencies up to 100 MHz to drive Schottky TTL logic. The oscillator operates from 5 V dc, drives 10 TTL loads and plugs into a 14-pin DIP socket. The standard CO-238 provides stability of ±0.0025% over 0 to 70 C. Options include the MIL range CO-238-2 with stability of ±0.005% over −55 to +125 C and the high stability CO-238-3 with stability of ±0.0003% over 0 to 50 C.

Booth No. 2322 *Circle No. 367*

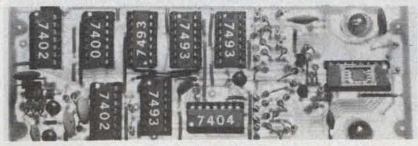
LVDT signal conditioner uses only two wires

Schaevitz Engineering, P.O. Box 505, Camden, NJ 08101. (609) 662-8000. $272.90; stock.

The CTM-401 is a fully encapsulated two-wire LVDT signal conditioning module which delivers a 4-to-20-mA dc signal. This signal is directly proportional to any change in LVDT core position. The CTM module does not require any additional external power since it operates on dc current from existing process controllers, recorders or readout devices. It delivers a nominal 1-V-rms excitation to an LVDT and converts the LVDT output to 4 to 20 mA dc with zero to full range change in LVDT core position. The CTM is an intrinsically safe design because the current can be limited to 50 mA even with accidental overvoltage or internal short-circuiting. Performance includes a frequency response of dc to 100 Hz (within ±1 dB), nonlinearity and hysteresis of less than 0.1% full scale and stability (after 15 min.) of 0.25% of full scale.

CIRCLE NO. 368

Image sensing module uses 1024-element array

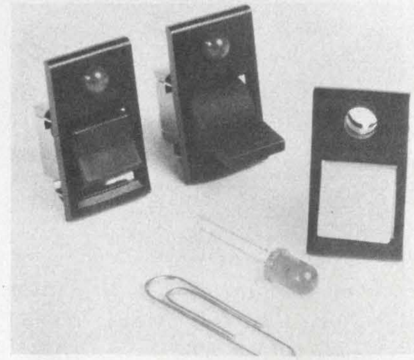


Cromemco, 26655 Laurel, Los Altos, CA 94022. (415) 497-2642. $90 (kit), $150 (assembled).

An image sensing module that uses a 1024-element IC array is designed for digital camera applications. The IC image sensor and support circuitry are contained on a single printed-circuit board that measures 5.5 × 2 in. Grey-scale information and position information are digitally encoded for complete compatibility with digital systems. Outputs are also provided to permit the direct display of a picture on an oscilloscope screen. Applications include pattern recognition systems, security systems and automated control systems.

CIRCLE NO. 369

LED lamps snap into three switch styles



C & K Components, Inc., 103 Morse St., Watertown, MA 02172. (617) 926-0800.

LED indicator lamp bezels have been added to three switches in C & K's family of products: 8100 Series snap-in-momentary push-button, J-50 snap-in rocker switch and J-60 snap-in paddle switch. The LED lamp can be snapped into the bezel either before or after the switch and bezel have been installed in the panel. The switches are normally supplied without LEDs, but they are designed to accommodate lamp models supplied by Monsanto, Texas Instruments, Chicago Miniature and others.

Booth No. 1315 Circle No. 332

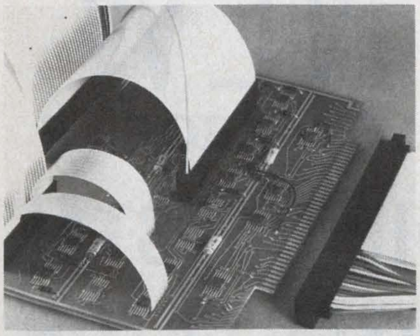
Selective plating saves gold

Dynatech Corp., 1255 E. Wakeham, P.O. Box 1019, Santa Clara, CA 92702. (714) 558-8755.

A new selective-plating technique called ZIP process for cantilever PC connector contacts is said to save gold use by 25 to 90% over tip-plated and welded gold-bead methods. Hard 24-K gold-plating is applied in thicknesses from 10 to 100 millionths of an inch only on the surfaces where it's needed. Also, the process eliminates underplate requirements, when the base material contains less than 88% copper. And since the deposit is of globular, rather than a columnar-grain type found in conventional processes, the plated area produces a dense, non-porous surface that has hardness levels of approximately 140 Knoop, despite purity levels near 24 K. Sample plated contacts are available free.

CIRCLE NO. 370

Flat cable terminated without preparation



Elco Corp., Willow Grove, PA 19090. (215) 659-7000.

Without preliminary cable preparation, such as stripping, plating, soldering, welding or indenting, the Flattac Series system can terminate up to 35 insulation-displacing contact crimps on flat-multiconductor cable, simultaneously, in one cycle of a semi-automatic applicator. The terminated cable snaps into the insulator to provide a completed cable assembly in seconds. The manufacturer can provide any combination of parts of the system—from a complete cable assembly to individual components for customer termination with leased application equipment.

CIRCLE NO. 394

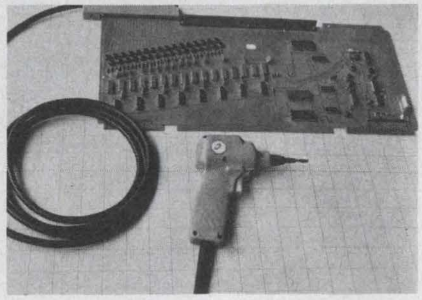
Ionized-air blower reduces static charges

3M Co., 3M Center, St. Paul, MN 55101. (617) 733-8830.

A tabletop ionized-air blower minimizes destructive static electricity during the manufacture and assembly stages of MOS/FET ICs. The 909 ionized-air blower increases production yields and reduces field rejects. Placed on a workbench, the unit continually bathes the area to continually discharge static buildup.

CIRCLE NO. 395

Screwdriver system operated by computer



Optimized Devices, Inc., 220 Marble Ave., Pleasantville, NY 10570. (914) 769-6100.

A computer-operated screwdriver acts as an automatic tool for fast, accurate setting of calibration pots, tuning screws, zero adjustments, phase alignments, etc., without operator judgment. Two modes are available. In the servo mode, the computer sets a reference value and a control unit drives the screwdriver until the circuit parameter is equal to the reference. In the iterative mode, the computer measures the circuit parameter, compares it with a reference value, and drives the screwdriver a computed increment to bring the circuit parameter close to the reference. The computer repeats this process a few times until balance is achieved. The screwdriver system is available with interface and software for PDP/8 computers.

CIRCLE NO. 371

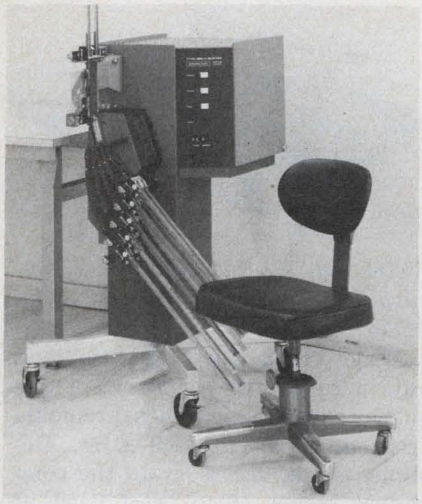
Teflon tubing shrinks 50% under low heat

Alpha Wire Corp., 711 Lidgerwood Ave., Elizabeth, NJ 07207. (201) 925-8000.

A new heat-shrinkable tubing combines the properties of Teflon with low shrinkage temperature. For application to heat-sensitive components. FIT-400 FEP Teflon-tubing shrinks at a 2 to 1 ratio at only 200 to 350 F and has a 400-C operating temperature. The tubing features all of the outstanding electrical, chemical and mechanical advantages of Teflon. The tubing is available in 18 sizes from 0 to 24 AWG, and in packaged assortments of 6-in. lengths.

CIRCLE NO. 372

DIP test handler adapts easily to changes



Daymarc Corp., 301 Second Ave., Waltham, MA 02154. (617) 890-2345.

Type 952/3 provides automatic DIP test handling from stick to stick for 6-to-22-pin DIPs. Test rate is 6000/h with 100 ms test time. Input station and all output stations are fitted with tandem stick holders so that operation continues during stick change. Tested devices are stored on output track during stick change. Change of stick types is easily accomplished. Also adaptation to different IC body dimensions is easily done with convenient thumbscrew adjustments.

Booth No. 2333 Circle No. 329

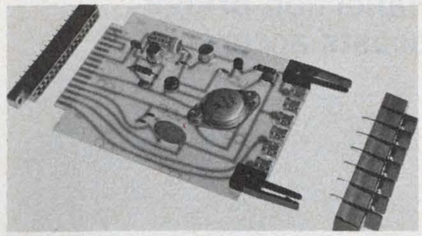
Chamber shields against magnetic environment

Ad-Vance Magnetics Inc., 226 E. Seventh St., Rochester, IN 46975. (219) 223-3158. 30-60 days.

A new, large, movable multilayer cylindrical AD-MU shielding system, Model MEC-125, provides a repeatable controlled magnetic environment for determining response characteristics, sensitivity, and orientation direction of magnetic sensor devices. Such devices are used for signature recognition proximity sensing, etc., in industrial, military and commercial applications. Dimensions of 36 OD × 34 ID × 40 L in. are sufficient to avoid severe anomaly distortions caused by proximity of the shielding structure. Other shields can be constructed in accordance with any specific dimensional requirements.

CIRCLE NO. 375

Terminal strips unplug from PC boards

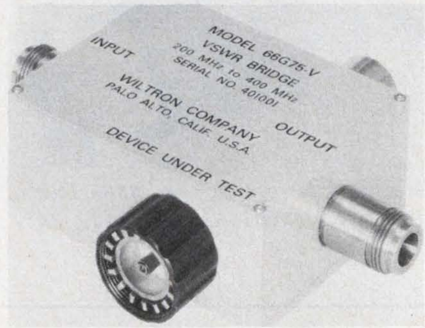


Magnum Electric Corp., 6385 Dixie Hwy., Erie, MI 48133. (313) 848-2555.

Magnum's new RS 100 line of single-row terminal strips allows the removal of all field wiring from a circuit board by simply unplugging the complete strip. The strips are rated at 120 A, 300 V. They have 3/8 and 7/16-in. center spacing and up to 30 contact positions. Plastic guide posts provide strip alignment during insertion and removal. Spring locking fingers in the guide posts hold strips when fully inserted.

CIRCLE NO. 376

Reflection bridge boosts accuracy

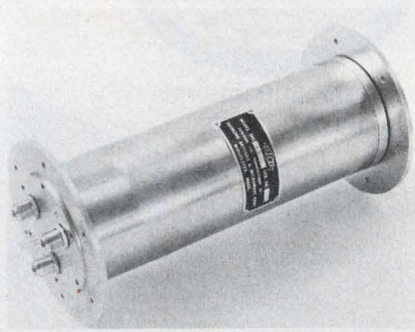


Wiltron Co., 930 E. Meadow Dr., Palo Alto, CA 94303. (415) 321-7428.

A line of 75-Ω reflection bridges—the 66G75 series—covers the 5-to-2000-MHz frequency range with directivity of 60 dB. The bridges make it possible to measure SWRs as low as 1.006 with increased accuracies. For example, a typical SWR of 1.02 can be measured with a total uncertainty of ±0.002. This accuracy is made possible by the special GR900 precision connector on the test port, the internal balance of the bridge and the termination.

Booth No. 2618-2620 Circle No. 377

Rotary joints provide several channels



Diamond Antenna & Microwave Corp., 35 River St., Winchester, MA 01890. (617) 729-5500.

A series of multichannel IFF rotary joints is available in dual, three or four-channel configurations with a choice of coaxial connectors. Typical specifications are a VSWR of 1.2:1 maximum, isolation of 50 dB, peak power of 5 kW and phase tracking between channels of ±5.0 degrees. Encoder drive shafts for azimuth pulse generators are also available.

Booth No. 1125-1127 Circle No. 378

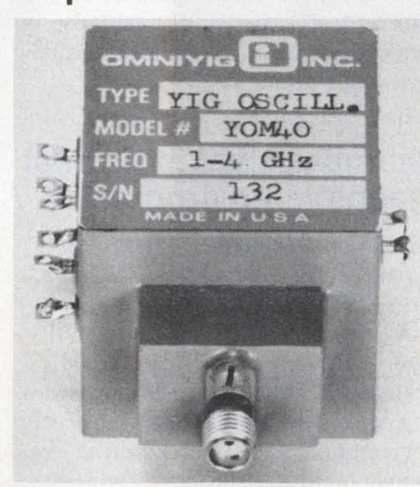
Unit tests insertion loss

Weinschel Engineering, Gaithersburg, MD 20760. (301) 948-3434. $2175 to $2495.

Model 1872 insertion-loss test unit permits fixed and swept-frequency insertion-loss measurements from 50 MHz to 18.0 GHz. Designed as an accessory to the company's Model 1810A stabilized rf ratio meter, the test unit incorporates two tracking and low VSWR square-law detectors and a precision 50-Ω resistive power splitter. The Model 1872 has an insertion point VSWR of less than 1.07 to 2 GHz and less than 1.15 to 18 GHz (source and load). Dynamic range exceeds 30 dB when used with a 10-mW output source.

Booth No. 2329-31 Circle No. 379

1-to-4-GHz YIG osc outputs 85 mW



Omniyig Inc., 2325 De La Cruz Blvd., Santa Clara, CA 95050. (408) 241-1226. $1145; 45 days.

The YOM40 1-to-4-GHz fundamental YIG oscillator permits a continuous sweep over its band with spurious responses at least −60-dB. The oscillator occupies a 1.4-in. cube. It has a typical output range of 40 to 85 mW, operating temperature range of 0 to −55 C and tuning sensitivity of 11 MHz per mA.

CIRCLE NO. 380

Filters keep distortion low

Allen Avionics Inc., 224 E. 2nd St., Mineola, NY 11501. (516) 248-8080. 3 days (prototypes).

Gaussian-type linear phase band-pass filters, offering fast cut-off and low delay-variation characteristics, are available in the frequency range from 1 kHz to 25 MHz with impedances from 50 to 10-kΩ in 30%-to-70% bandwidths. Maximum phase distortion over 3-dB passband is ±3°, with typical delay variation of 5%. The filters are epoxy encapsulated or sealed in metal cans, in sizes ranging from 2 × 1-5/8 × 1-1/8 in. to 4-1/2 × 2-1/2 × 1-3/8 in.

Booth No. 1115 Circle No. 381

Mate or unmate connectors fast

Sealectro Corp., Mamaroneck, NY 10543. (914) 698-5600.

A line of Kwick-Konnect rf coaxial connectors combines fast connect and disconnect with a VSWR of less than 1.30:1. These units can be used over the frequency spectrum of dc to 18 GHz, and they can replace BNC types in front panels.

Booth No. 1215-1221 Circle No. 382

Sig gen spans 6.95 to 12.2 GHz

Polarad Electronic Instruments, 5 Delaware Dr., Lake Success, NY 11040. (516) 328-1100. $3720; 30 to 45 days.

The Model 1108A-C compact wideband microwave signal generator has a single frequency range of 6.95 to 12.20 GHz (optionally to 12.40 GHz). The expanded coverage of the unit includes the 10.7-to-11.7-GHz communications common-carrier band and the 11.1-to-12.2-GHz broadcast, mobile and satellite communications bands. Previously, two generators were required because available X-band modular signal generators have had an 11.0-GHz upper limit. Frequencies are read directly on a four-digit readout with 0.5% accuracy. Output levels are calibrated directly from at least 0 dBm down to −127 dBm.

Booth No. 2316 Circle No. 383

Electronic Design's

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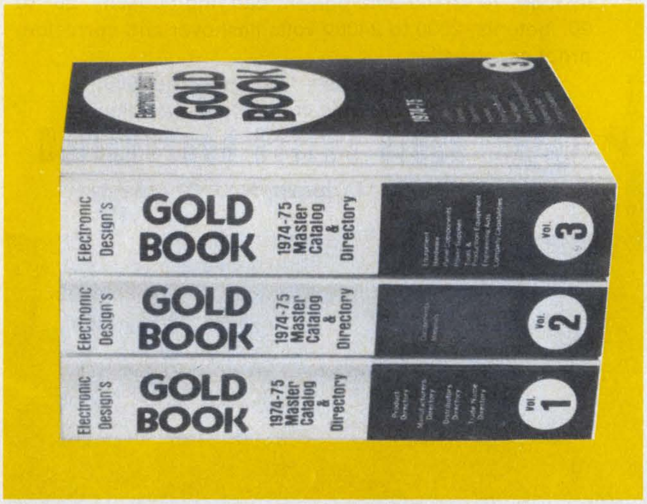

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TELEX	**NUMBER OF EMPLOYEES**
CABLE ADDRESS	**DOLLAR VOLUME**
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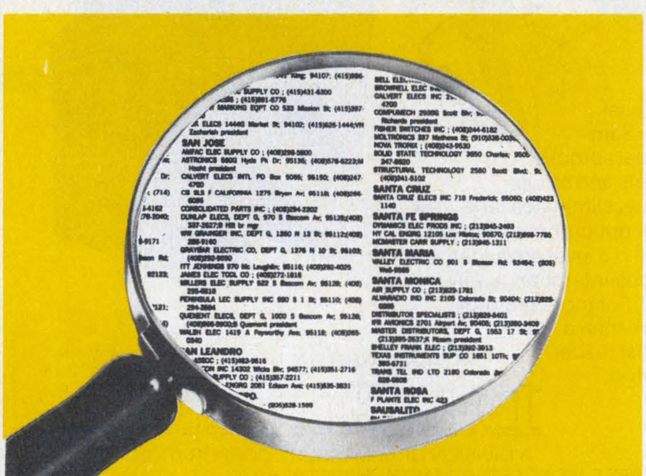

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application notes

Temperature measurement

"1975 Temperature Measurement Handbook and Catalog" lists over 6000 temperature measurement products. Over 25% of its 160 pages are devoted to basic temperature measurement data, including the latest NBS tables for thermocouples in 1° increments, in both C and F. Omega Engineering, Stamford, CT

CIRCLE NO. 384

Acoustic coupling

Application ideas for performing automatic polling and message exchange, computer time sharing, terminal-to-terminal and terminal-to-computer communications using an automatic acoustic coupler are outlined in a four-page brochure. Omnitec, Phoenix, AZ

CIRCLE NO. 385

Voltage testing

"Basic Facts About Voltage Testing" covers the whys and hows of high voltage testing, as well as information on leakage testing. Slaughter Co., Ardmore, OK

CIRCLE NO. 386

SCRs

Parameters, specifications, ratings and characteristics of SCRs are discussed in an application note. International Rectifier, Semiconductor Div., El Segundo, CA

CIRCLE NO. 387

Characterize logic circuits

Newly developed digital simulation software for the Model 9830A desktop calculator reduces the time it takes an engineer to verify logic behavior. This digital simulation pac is described in a six-page brochure. Each pac includes magnetic cassettes of ready-to-use prerecorded programs, a keyboard template and an instruction manual. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 388

new literature

Panel meters

Specifications, photos and schematics highlight a four-page panel meter catalog. Imtronics, Ronkonkoma, NY

CIRCLE NO. 389

110 & 125-A-rms SCRs

A series of 110 and 125-A-rms silicon controlled rectifiers is described in a data sheet. The literature contains 27 graphs, two dimensional drawings and a photograph. Ratings and specifications are provided. International Rectifier, El Segundo, CA

CIRCLE NO. 390

Motors and gearmotors

Fractional horsepower motors and gearmotors are covered in a 36-page catalog. Detailed rating tables, performance curves, specifications, application data, dimensional drawings and ordering information are provided. Howard Industries, Milford, IL

CIRCLE NO. 391

pH instruments

A 28-page illustrated catalog includes two recently introduced products—the Model 119 digital pH meter with pushbutton calibration and a low-cost laboratory reference electrode. Divided into four sections, the catalog provides physical and performance specifications for 11 pH meters and 77 electrodes. Five strip chart recorders and accessories for pH meters, electrodes and recorders are described. Corning Glass Works, Corning, NY

CIRCLE NO. 392

Charge-coupled devices

Basic operation and uses of the CD100, a 100-element linear CCD, are featured in a 12-page booklet and supplemental data sheets. Schematic diagrams accompany the text. Prices are included. GEC Semiconductors, Middlesex, England

CIRCLE NO. 393

Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card
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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

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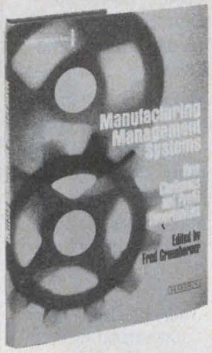

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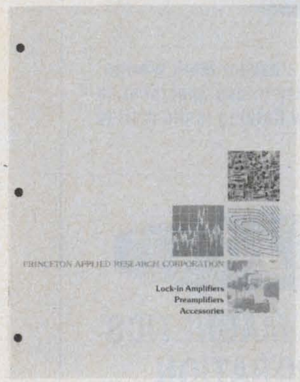

The Princeton Applied Research Model 129A Two Phase Lock-in/Vector Voltmeter permits simultaneous measurement of magnitude and phase angle even if the signal is masked by background noise. Flip a switch and measure the I and Q components of the vector; independent output expansion, offsetting, and filtering of each component are also provided. Full scale sensitivity ranges from 1 microvolt to 0.25 volts and is extendable to 25 volts with the optional compensated attenuator. Model 186/41. The Model 129A reference channel has fully automatic reference tracking capability and is phase matched to the signal channel over the operating range 0.5 Hz to 100 kHz. Complete specifications are contained in our Lock-in Amplifier Catalog No. T218.

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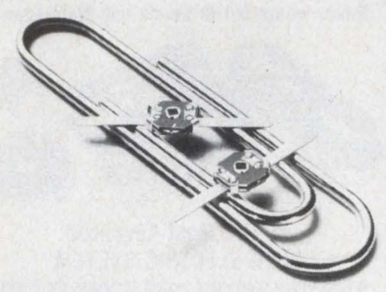

Thin-Trim variable capacitors provide a reliable means of adjusting capacitance without abrasive trimming or interchange of fixed capacitors. Series 9401 has high Q's and a range of capacitance values from 0.2-0.6 pf to 3.0-12.0 pf and 250 WVDC working voltage. Johanson Manufacturing Corporation, Boonton, New Jersey (201) 334-2676.

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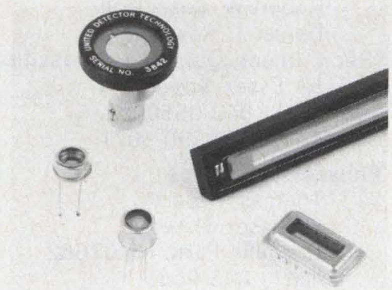

UDT offers a complete line of silicon photodiodes. Schottky for large area and enhanced UV responsivity, planar diffused for low noise and extended responsivity, photops (detector/amplifier combinations), special arrays and detectors to customer specifications. United Detector Technology, 2644 30th St., Santa Monica, Ca. 90405 (213) 396-3175.

INFORMATION RETRIEVAL NUMBER 604

Atomic Frequency Standard Model FRT for Lab/Field. Output 10-5-1 0.1 MHz, Short Term Stability $< 1x10^{-11}$ $\tau = 1s$, $< 1x10^{-12}$ $\tau = 100s$. Drift typ $1x10^{-11}$/M. Coupled with Receiver-Controller EFR. Sync to Standard Freq absolute freq parts in 10^{12}. Efratom Calif., Inc., 3303 Harbor Blvd., E1, Costa Mesa, Ca. 92626 (714-556-1620)

INFORMATION RETRIEVAL NUMBER 607

Unique New Programmable Generator features multiple function capability. Program as digital pulse or word generator. Programmable time from 50ns to .999 sec. External trigger, 8 or 16 output channels, ROM option, computer interface, expandable memory. Interface Technology, 627 Fremont Ave, South Pasadena, CA 91030 (213) 682-3705

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Introduction To Defense Radar Systems Engineering. Excellent introduction and practical reference to radar systems design and applications. #9194, 260 pp., $22.95. Circle the Info Retrieval No. to order 15-day exam copy. When billed, remit or return book with no obligation. Hayden Book Co. 50 Essex St. Rochelle Park, N.J. 07662

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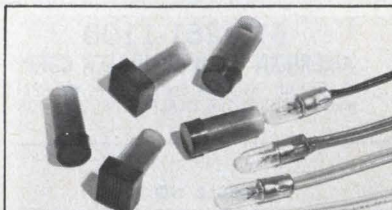

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- Wide Range of Voltage and Current
- Incandescent and Neon
- No Tools Required for Installation
- Lens Press Fits in Panel
- Lenses in Full Range of Colors
- Tamper Proof Housings

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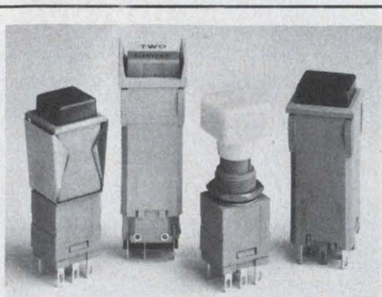

S190/S410 Switchlights. Low cost 2 Form C Mom. & Alt. action; Dual wiping contacts. Rating 100,000 cycles @ 2 amp res., 0.5 amp ind., 30 VDC & 125 VAC. Quick connect & solder terminals. Snap-in & rear panel mount. 10-amp power switch UL listed. Varied lens shapes. Clare-Pendar Co., Box 785, Post Falls, ID (208) 773-4541

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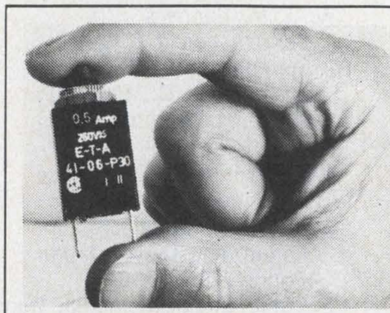

Overcurrent Protector, manual reset eliminates fuse replacement. Convenient panel mounting. 15 fractional ratings from 0.1 to 3 amp. Other models up to 400 amp. Trip-free and fool-proof, UL and CSA approved. High quality, low cost $1.29 ea. in 1000 lots. E-T-A Products Co. of America, 7400 N. Croname Rd., Chicago, Ill. 60648. Tel: (312) 647-8303. Telex: 253780.

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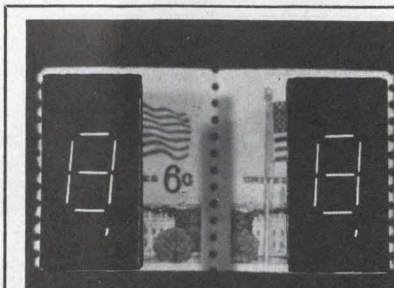

The Proven Incandescent Readout Standard 16 Pin DIP Flat Pack. All units 5 Volt 100,000 hrs. plus
3015F-BM 08ma/seg 700 ft/lam
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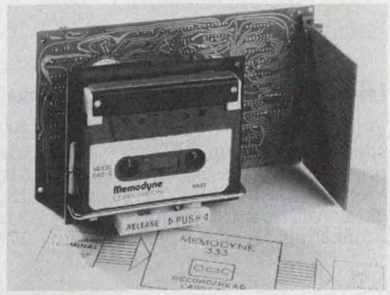
Field tested over 4 years in many applications. READOUTS, INC. P.O. Box 149, Del Mar, Ca. 92014 Tel. 714-755-2641 Telex 69-7992.

INFORMATION RETRIEVAL NUMBER 609

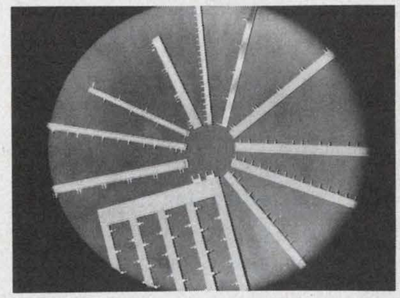
Contact United States Crystal Corporation for our new quartz crystal catalogue. It gives you the most up to date specifications on military CR numbers and information for designing and specifying crystals. Free engineering assistance on your crystal requirements. 3605 McCart St., Fort Worth, Texas 76110. (817) 921-3014.

INFORMATION RETRIEVAL NUMBER 610



MEMODYNE Incremental Digital Cassette recorders read, write, store alpha-numeric data at 50 cps in ASCII or 8-bit parallel. 72,000 character capacity. Low power (CMOS) for data logging, off-line terminals, microprocessors. Interfaces w/wide variety. Lit. avail. Memodyne Corporation, 369 Elliot St. Newton, Mass. 02164 617/527-6600 telex 922537

INFORMATION RETRIEVAL NUMBER 613



Mini/Bus® Evaluation Kit, $25, in stock. Lets you try Rogers' low-cost, noise attenuating, high packaging density power distribution system for PC boards. Millions in use. Standard parts on 2 weeks delivery, or less! Customer parts 4 to 6 weeks delivery. Rogers Corporation, Chandler, Ariz. 85224. Phone (602) 963-4584

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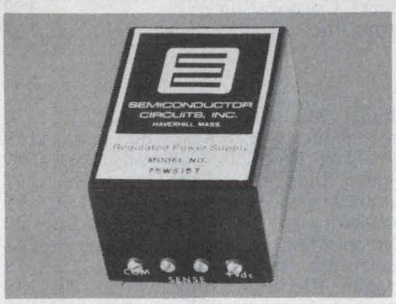

The "75WS15T" provides ±15Vdc @ 150mA and an isolated 15Vdc @ 200mA with rem. sense. Sense current 200 μA; Tempco 0.002%/°C; 1500V isolation; current foldback on all outputs, O.V.P. on X-Ducer supply; Price $196.00; Del 2 wks. Other models avail—contact Semiconductor Circuits, Inc., 306 River Street, Haverhill, MA 01830, (617) 373-9104

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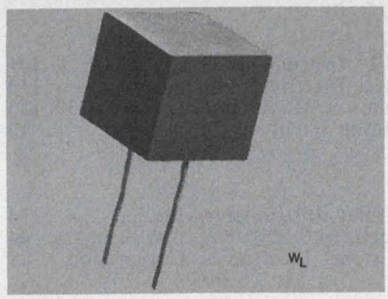

THE WL 451-T IS A HIGHLY LINEAR THERMISTOR. Using special semiconductor construction, the positive coefficient unit changes +4.93 Ω/C°. Special features include 1% tolerance, linearity ±1% from −25 to +150°C. Epoxy-cast in a .435" cube. $9.50 (1-9) Western Laboratories 728 S. Marengo, Pasadena, CA 91106 213-793-0148

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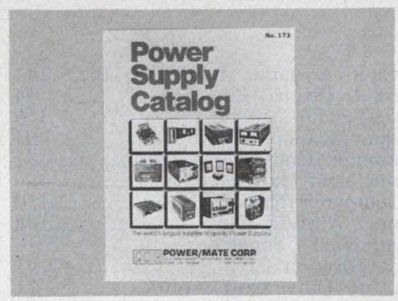

Free catalog of 34,500 power supplies from the worlds largest manufacturer of quality Power Supplies. New '74 catalog covers over 34,500 D.C. Power Supplies for every application. All units are UL approved, and meet most military and commercial specs for industrial and computer uses. Power Mate Corp. (201) 343-6294.

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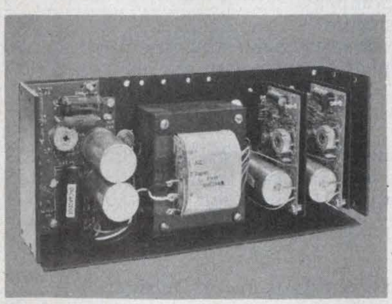

OPEN FRAME POWER SUPPLIES in single, dual or triple output feature IC control, copper shield in transformer, teflon wiring, and computer grade electrolytics. Options include 230 vac input, remote sense, and built-in OV protection. Dynage, Inc., 1331 Blue Hills Avenue, Bloomfield, Conn. 06002 203-243-0315

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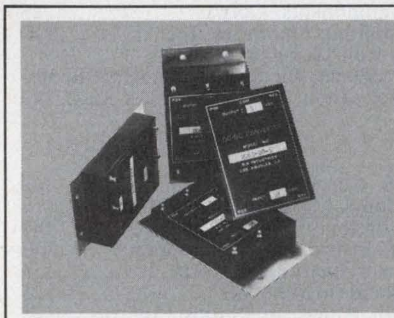

MODULAR DC/DC CONVERTERS offer 5 and 10 W dual output and 15 W single output with eff. from 55 to 68%. Regulation is 5 mv. Dual units allow rated power from one output. L/C filtering on both input and output for low noise. (1-9) from $78.60. B. H. INDUSTRIES, 5784 Venice Bl., Los Angeles, CA 90019 (213) 937-4763

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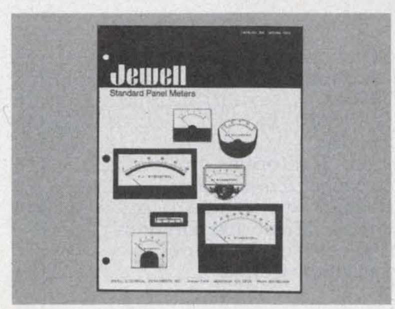

FREE PANEL METER CATALOG. Panel meters, stock or special. Available in a variety of sizes, 1-1/2" to 6", and styles . . . round, square, rectangular and edgewise. Special application meters also featured: Elapsed Time, VU Meters and Null Indicators. Jewell Electrical Instruments, Inc., Manchester, NH 03105, (603) 669-6400.

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advertiser's index

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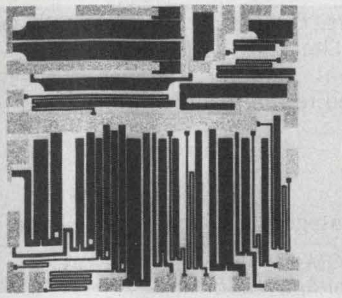
quick ads

New and current products for the electronic designer presented by their manufacturers.



Complete Functions Offered on a Chip. High density monolithic thin film processing offers exceptional resistive performance for hybrid assembly. 250 standard variations available to .01% accuracy, tracking to 0.5ppm/°C. Analog Devices, Inc., Route 1 Industrial Park, P.O. Box 280, Norwood, Massachusetts 02062. Telephone: 617/329-4700.

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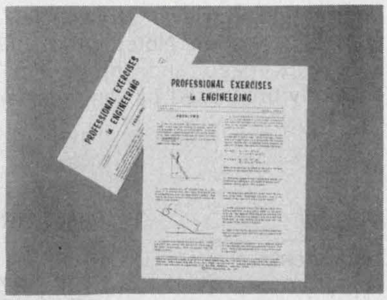

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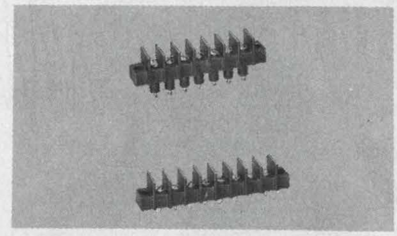

Compact Curtis Terminal Blocks of Unbreakable Thermo-Setting Plastic feature ultrasonically welded terminal inserts and full mechanical thread system. High-barrier CB/CFT blocks are rated 15 amp/300 volt with 5,500 volt breakdown. Feed-thru and surface-mount designs available. Curtis Industries, Inc., 8000 West Tower Avenue, Milwaukee, Wisconsin 53223, (414) 354-1500 or toll free (800) 645-9200 — New York call collect (516) 294-0990.

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Custom made cases, cabinets and enclosures. Exceptionally rugged construction, laminated Formica-wood-Formica. Internally reinforced corners. Attractive wood grain or solid color exteriors. Superb workmanship, competitive prices, small or quantity lots. W. A. Miller Co., Inc., 306 Mingo Loop, Oquossoc, Maine 04964. Telephone: 207/864-3344.

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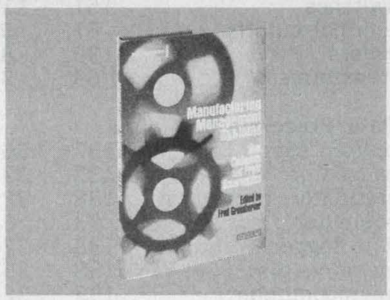

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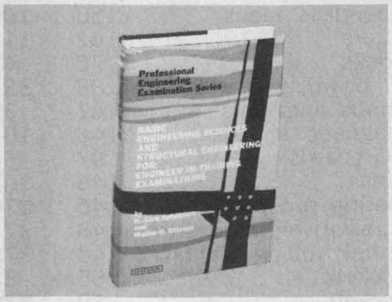

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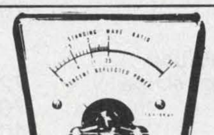

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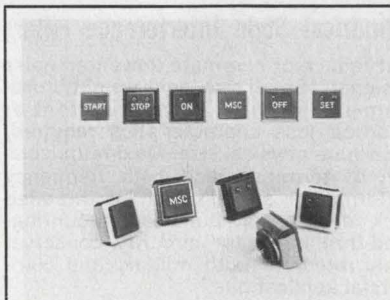

Touch Activators for solid-state switch circuits eliminate pushing, pulling, or flipping of switches. No moving parts; high reliability. A mere touch of finger activates switch circuit. Interface with CMOS, TTL, DTL, and HTL. Snap-in panel mounting. Lighted or unlighted. Master Specialties, 1640 Monrovia, Costa Mesa, Calif. 92627.

INFORMATION RETRIEVAL NUMBER 627

product index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

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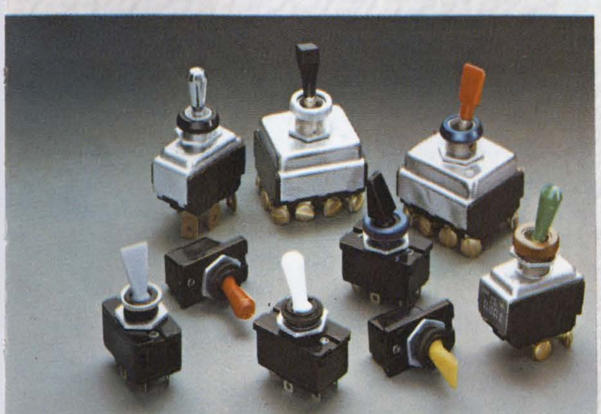
Introducing our new heavy-duty Designer Line switches with up to 20 amp, 2 hp, A-c and D-c ratings. Now you can color-code almost any function or simply use color to improve overall equipment appearance.

Select from nine distinctive lever styles, nine standard colors, two bushing lengths, as well as eleven color-coordinated decorator facenuts in two types.

You also choose from five switch bases, screw or plug-in terminals, single and double poles, plus a variety of circuit configurations.

The first color-capped industrial toggle switch gives you the new colorful choice for your heavy-duty applications. Contact your Cutler-Hammer Sales Office or Switch Distributor.



Designer Line—the broadest line of commercial toggle switches, ratings up to 8 amps, A-c and D-c, and 15 amps A-c. A rainbow of colors! Virtually unlimited combinations of toggle styles, circuits, colors.

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So anyone involved with aerospace, military and critical industrial applications can take advantage of this major breakthrough.

Because of the CMOS output stage, a voltage swing to within 10 millivolts of either rail on a single power supply is now possible for the first time. Other principal features are: high open loop voltage gain: 110dB; low input offset voltage: 8mV; low input current: 5pA; very high input impedance: 1.5 TΩ ($1.5 \times 10^{12}\Omega$); high slew rate: 10V/μs; 2.5mW at 5V supply voltage; 22mA output.

The speed with which RCA converted this breakthrough technology into a High-Rel device illustrates our commitment to High-Rel Linear ICs. Further evidence of this is the separate organization devoted exclusively to High-Reliability ICs; by our MIL-M-38510 approved production facility in Findlay, Ohio; by the full Class A, B and C processing to MIL-M-38510 and MIL STD. 883.

For the CA3130 High-Rel 8-page spec sheet, and a High-Reliability IC brochure, call your 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.

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