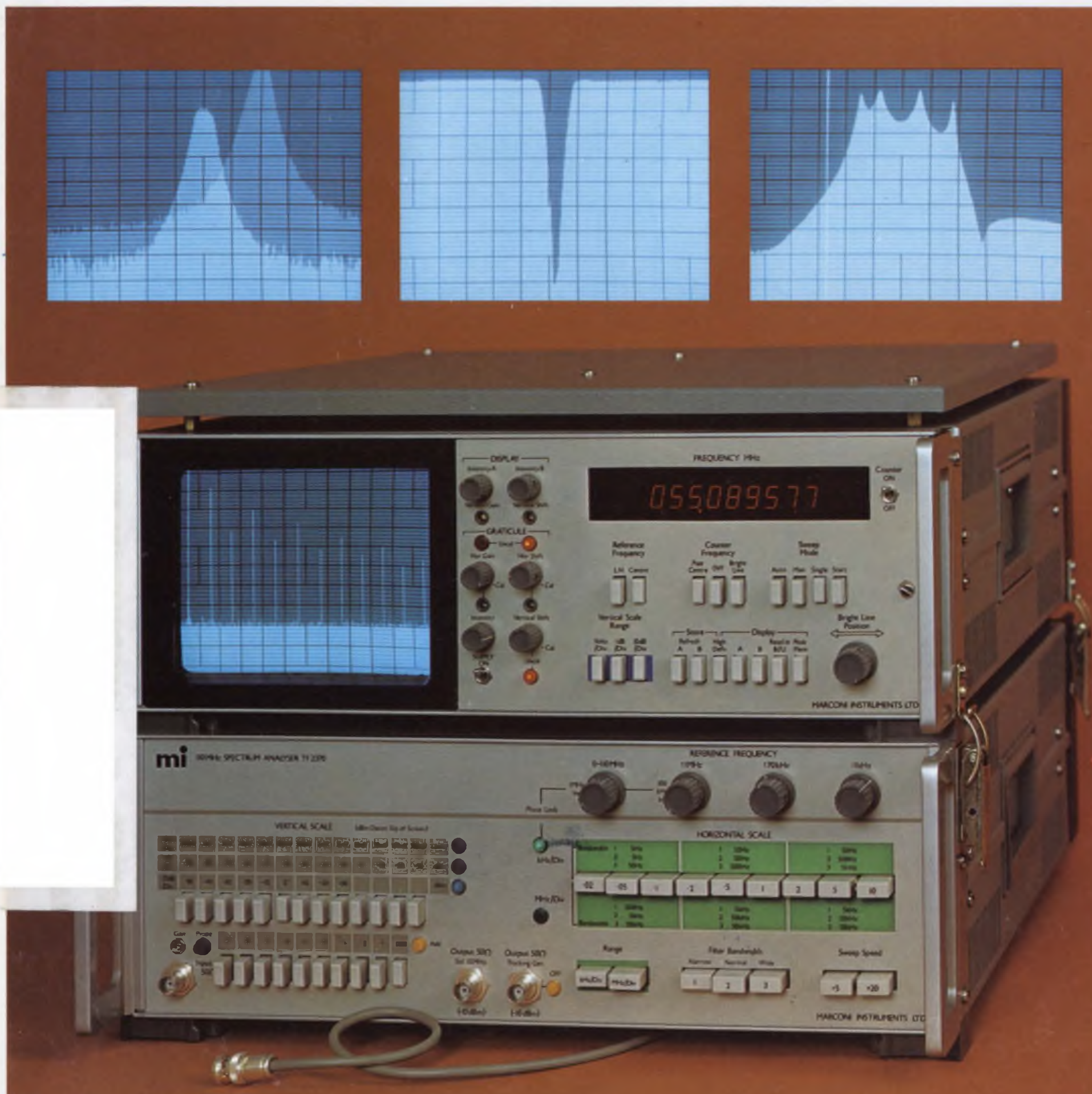
Electronic Design

VOL. 22 NO. 8

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 12, 1974

Watch spectra as never before. Set center frequency, sensitivity, sweep width and resolution, and a program automatically selects filter bandwidth, rf/i-f gain ratio and sweep speed. Digital storage gives infinite persistence on a vertically scanned TV display with projected reticle. A counter reads the frequencies. Page 137.



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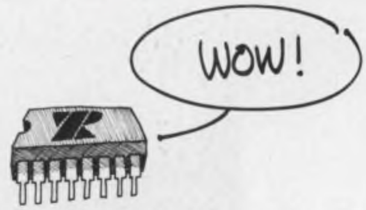
INFORMATION RETRIEVAL NUMBER 241

THE NEW XR-2207 IS A PRECISION VOLTAGE CONTROLLED OSCILLATOR WITH SIMULTANEOUS SQUARE AND TRIANGULAR WAVE OUTPUTS, EXCELLENT FREQUENCY STABILITY, SUPER-WIDE SWEEP RANGE, MINIMAL FREQUENCY DRIFT, AND ULTRA-LINEAR SWEEP DRIVE.

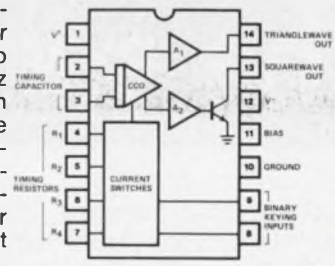


By providing 30 ppm/°C frequency stability, 3000:1 sweep range, and 0.15%/V frequency drift in the XR-2207, Exar produced a precision VCO that can easily do those tough FSK, FM generation jobs. With a minimum of external circuitry, you can use the XR-2207 in applications such as two-channel FSK generation for modems, as the VCO portion of phase-locked loop systems, and voltage to frequency conversion that formerly required crystal controlled oscillators.

With only one capacitor and four resistors, four discrete precision frequencies are generated; two TTL keying inputs enable selection between frequencies. You can also sweep your frequency over a wide 3000:1 range with the use of one extra resistor and a little voltage.

So, if you've been putting together lots of parts for tough waveform generation, the XR-2207 can save you time and money. It's the easy way to generate variable-frequency square and triangular waves (pulse and sawtooth too!) for every application.

The XR-2207 operates with either single or dual supplies from ±4V to ±13V over a 0.1 to 1 MHz frequency range. Seven device types are available in 14 pin ceramic and plastic packages for both commercial and military applications. Call or write for the XR-2207 data sheet and application notes.



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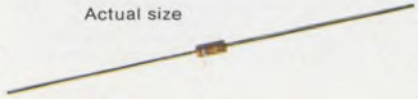
Actual size



INFORMATION RETRIEVAL NUMBER 3

A-B QUALITY

Allen-Bradley
Milwaukee, Wisconsin 53204

EC53

VOL. 22 NO.

Electronic Design 8

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 12, 1974

NEWS

TECHNOLOGY

PRODUCTS

Departments

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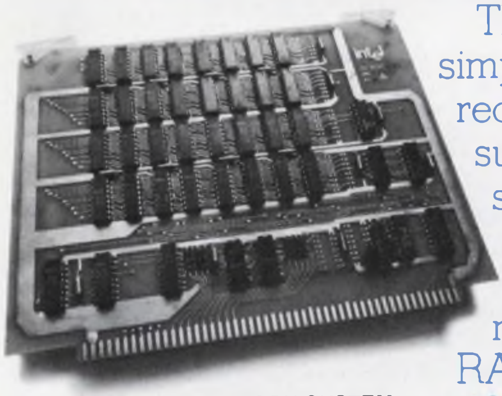
The 2102 to get as it is to

The Intel 2102 n-channel RAM is the most popular 1024 bit static memory available today. It is *the* general purpose RAM with more second sources than any other semiconductor memory component.



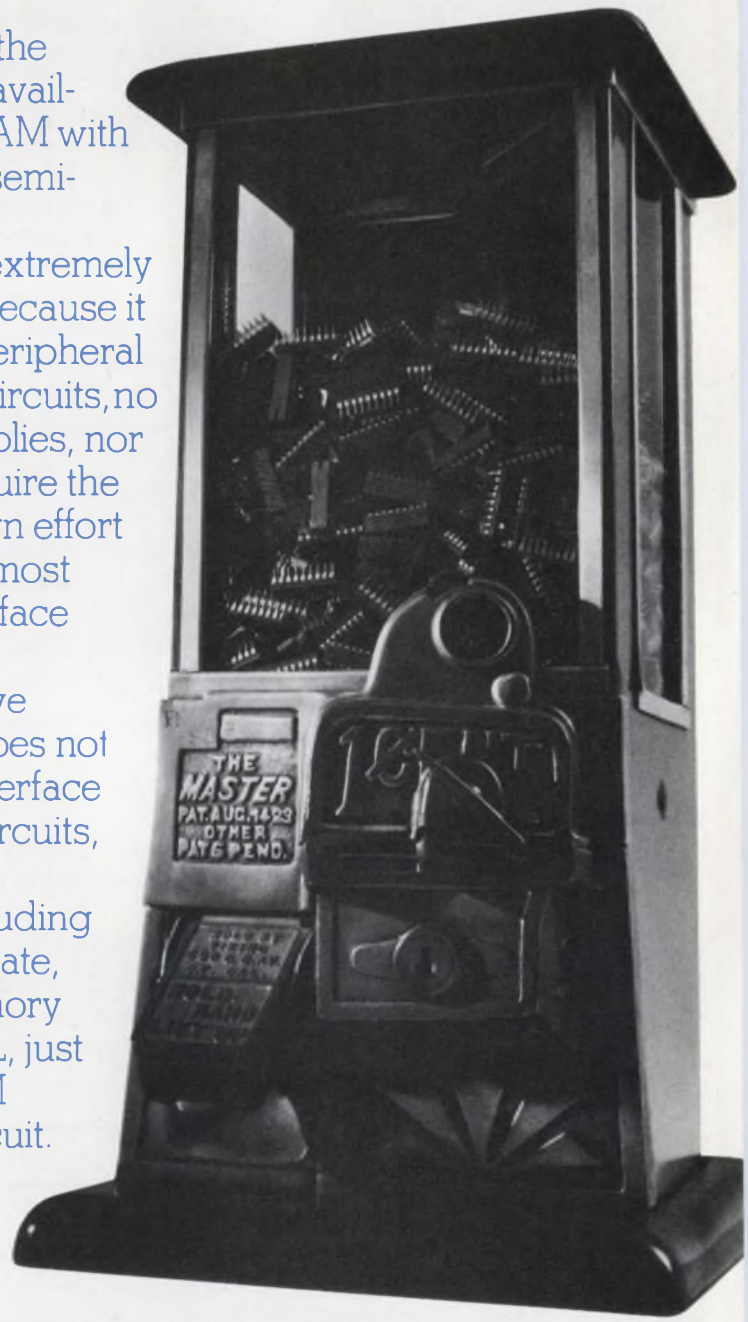
INTEL IN-26 MEMORY SYSTEM

The 2102 is extremely simple to use because it requires no peripheral supporting circuits, no special supplies, nor does it require the extra design effort needed by most RAMs to interface with TTL.

By using the 2102, you can achieve greater system economy because it does not require level shifters, MOS drivers, interface circuits, clocks, refresh and decode circuits, nor even pull-up resistors.

Every pin is TTL compatible, including the +5 volt V_{CC} supply and the three-state, OR-tie data output that simplifies memory expansion. To connect the 2102 to TTL, just add solder dots. In fact, the 2102 RAM performs exactly as if it were a TTL circuit.

The 2102 speed specs are efficient also. Guaranteed maximum access time is 1 microsecond, typical access time is 500 nanoseconds. Minimum read and write cycle time is also 1 microsecond.



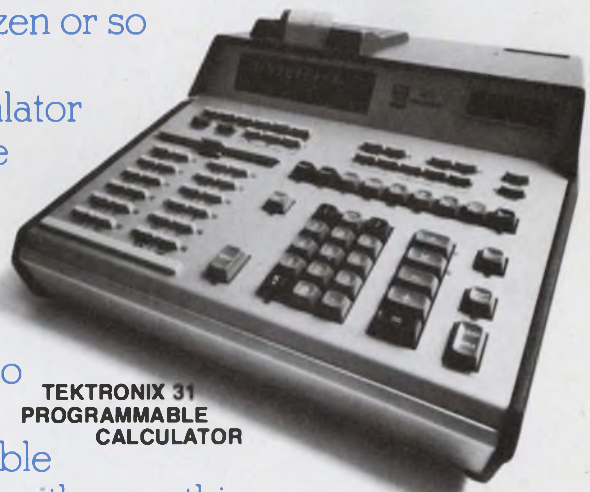
The 2102 costs less per bit in quantity than penny candy. And when you

RAM is as easy use.

N-CHANNEL

subtract what you don't spend on design time, other parts, special supplies, boards and labor, the 2102 is easily the most economical static RAM for a wide range of applications.

What's more, the Intel 2102 is easy to get. We have been producing it in volume since early 1972 with the industry's most mature n-channel silicon gate technology. Today, we ship more 2102's than the combined outputs of the dozen or so announced second sources.



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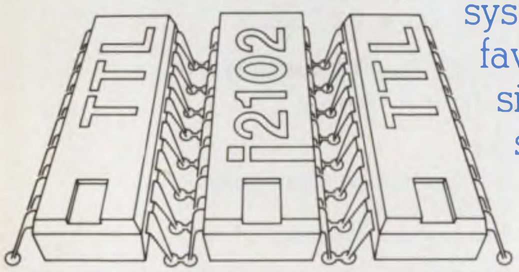
The Tektronix 31 Programmable Calculator uses the 2102 and millions of our 2102's are now being used in peripheral equipment, instrumentation and microcomputer systems. It's a favorite with designers who want to simulate buffer, refresh and variable length registers with something more convenient and less costly than custom MOS registers.



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The 2102 is only one of Intel's popular MOS RAMs available in volume and from distributor stock. Send for a full catalog of our products including RAMs, ROMs, PROMs, interface circuits and Microcomputers.

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INFORMATION RETRIEVAL NUMBER 4

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

Editor-in-Chief George Rostky

Managing Editors:
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Editorial Field Offices
East
Jim McDermott, Eastern Editor
P.O. Box 272
Easthampton, Mass. 01027
(413) 527-3632

West
David N. Kaye, Senior Western Editor
2930 West Imperial Highway
Inglewood, Calif. 90303
(213) 757-0183
Northe K. Osbrink, Western Editor
112 Coloma St.
Santa Cruz, Calif. 95060
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Washington
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2506 Eye St., N.W.
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across the desk

Wrong spec given for 'Idea' circuit

The Idea for Design "Digitally Programmable Oscillator Selects Frequency in Integer Units from One to 15" (ED No. 25, Dec. 6, 1973, p. 140) contains a fundamental error. This scheme is commonly known as "rate multiplication." The circuit shown is a very inefficient rate multiplier and could be implemented by three TTL circuits. The basic mistake, however, lies in the statement that "the circuit output will have equal spacing at any selected frequency."

The output will not have equal spacing between pulses unless the input frequency is increased to 360,360 times the lowest output frequency; for this is the smallest number that can be divided by all integers from one through 15. This method can therefore generate pure output frequencies up to only ~ 100 Hz. Higher-output frequencies require a phase-locked loop.

Peter Alfke
Manager, Digital Applications
Fairchild Semiconductor
464 Ellis St.
Mountain View, Calif. 94040

In "Digitally Programmable Oscillator Selects Frequency in Integer Units From One to 15," the fact that 256 is not evenly divisible by all integers from one to 15 implies that no simple generator yielding equal pulse spacing for all frequencies can be built.

The only simple way to remedy the situation is to increase the input-oscillator frequency by all prime factors up to the highest desired multiple (of the unit frequency) and to redesign the generator.

The Shakib design is, of course, quite a simple generator, with usefulness in, for example, the testing of digital circuits at various input rates. But the irregular spacing of the pulses destroys its usefulness in many audio-oscillator applications.

J. James Belonis 2d
3514 SW 110th St.
Seattle, Wash. 98146

The author replies

My apologies for the oversight. However, the signal out of this circuit is a periodic signal, and its period is equal to the time it takes the basic oscillator to generate 256 pulses. This time translates into a maximum of 15 cycles at the output of the circuit. The average frequency will be equal to the selected frequency.

As Mr. Belonis mentions, this oscillator is not desirable for many audio applications. However, it is quite useful for digital applications.

A rate multiplier is similar to the circuit I proposed, but it might be quite an oversight on Mr. Alfke's part to say it takes three TTL circuits to select one to 15 units of frequency.

John Shakib
IBM
P.O. Box 1328
Boca Raton, Fla. 33432

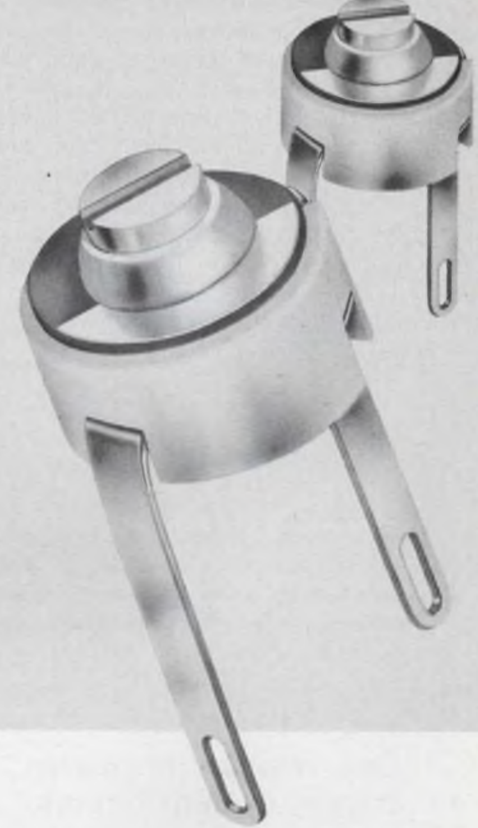
Rms or average power? It's just semantics

Many engineers talk about "rms power" when they really mean "average power." The problem is one of semantics.

When power calculations are made, voltage and current are measured in rms and the power

(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)

calculated from $I_{rms}E_{rms}$, E_{rms}^2/R, or I_{rms}^2R. Because rms values of voltage and current are used, it appears reasonable to call the resulting power calculation rms power.

However, derivation of both rms and average power reveals that average power $= I_{peak}E_{peak}/2 = E_{rms}I_{rms}$; and rms power equals $I_{peak}E_{peak}\ \sqrt{3/8}$. Thus the two aren't equivalent. With sinusoids, it's the average power that's really of interest.

R. Tolmei
Johns Hopkins University
Applied Physics Laboratory
Silver Spring, Md. 20910

Correction

The announcement of a new log amp from American Astrionics (ED No. 1 Jan. 4, 1974, p. 204) erroneously gives a lower dynamic range than that specified. The correct figure is 80 dB.

One resistor improves trigger-system circuit

The circuit in the Idea for Design "SCR Turn-off Problem Eliminated in Rapid-Fire Stroboscope Trigger" (ED No. 22, Oct. 25, 1973, p. 116) has two minor deficiencies. The rate of charge is proportional to H_{fe} and shows considerable variation. This affects the peak current drawn from the dc supply. Secondly, the power dissipation of the series-pass transistor is $1/2\ CE^2\ f$. With the values shown, at 1 kHz, the transistor dissipates 9 W. This is considerable dissipation for a small power transistor and necessitates an adequate heat sink.

By adding a single resistor in the collector circuit, we solve both problems. The resistor is chosen to be $H_{fe\ (min)}$ times smaller than the base resistor, so the transistor is allowed to saturate during the charging interval. Thus it dissipates virtually no power and does not require a heat sink. Instead the power is dissipated in the collector resistor. Since resistors can operate at much higher surface temperatures than transistors, the thermal design is simplified. In addition the capacitor's charging rate is now primarily determined by the collector resistor RC time constant.

S.E. Summer
2 Lark Place
Hauppage, N.Y. 11787.

The author replies

Mr. Summer is absolutely correct. His addition makes this circuit even more usable. The only precaution I would recommend would be to keep the resistor away from sensitive components and to provide a sink for the resistor's heat.

Dave Zinder
Senior Engineer
Motorola Semiconductor Products, Inc.
5005 E. McDowell Rd.
Phoenix, Ariz. 85008

Missing program line filled in by author

Please publish the following correction in the article "Multiple-Output NAND Networks," which appeared in the Nov. 8, 1973, issue of ELECTRONIC DESIGN:

On p. 104, left column, line 457 of the program should read

IUP = 1 + (NV-1)/IBIT.

This statement was missing due to a "system error."

Stephen Y. H. Su
Associate Professor
The City College
School of Engineering
Dept. of Electrical Engineering
New York, N.Y. 10031

A lusty cheer for the Wang 2200

For shame! In your Jan. 18 issue, you list all the minicomputers and such. But you left out my favorite: the Wang 2200 system.

I admit that the definition of a "minicomputer" is sometimes vague, and that Wang itself calls its 2200 a "programmable calculator." But I believe a serious look at the specs and features would let it be added to your listings.

I really enjoy your magazine and find it a great help in getting up-to-date data on changes in the industry.

A. K. Rosenhan, P.E.
Box 321
Racine, Wis. 53401

Reader agrees solvents can be a real peril

Jeremy Agnew's article "Choose Cleaning Solvents Carefully" (ED No. 5, March 1, 1974, p. 54) is both useful and necessary. My work has required the use of the photoresist process—making circuit boards and etched panels. I was casual with the materials until an amateur chemist informed me of a few of the hazards.

When I tried to learn about the safe handling of solvents, however, I found manufacturers' representatives unaware, uninformed or just plain shut-mouthed. Even the California Dept. of Public Health, while obliging, was short of information.

The best source I've yet discovered is Ethel Browning's "Toxic Solvents" (Edward Arnold Co., 1953). Her source is direct observation of industrial casualties in England. Since then, a few more solvents, including trichloroethylene, have been recognized as more than moderately hazardous. Another reference is Condensed Chemical Dictionary (Van Nostrand Reinhold).

The difficulty with solvent poisoning is its chronic nature. Twenty years might elapse before the physical damage is evident. A problem is human resistance to discovering and facing the facts, whether from an economic motive or because it's a dreary business all in all.

I think Mr. Agnew should have recommended the use of respirators and told us what gloves to use. Xylene dissolves rubber; polyethylene gloves are too thin—they tear easily.

It's not a safe world, but what excuses ignorance?

Peter Mundy
Alembia
60 Brady St.
San Francisco, Calif. 94103

(continued on page 19)

MEASUREMENT COMPUTATION NEWS

innovations from Hewlett-Packard

APRIL, 1974

in this issue

Another small miracle for engineers and scientists: the HP-65

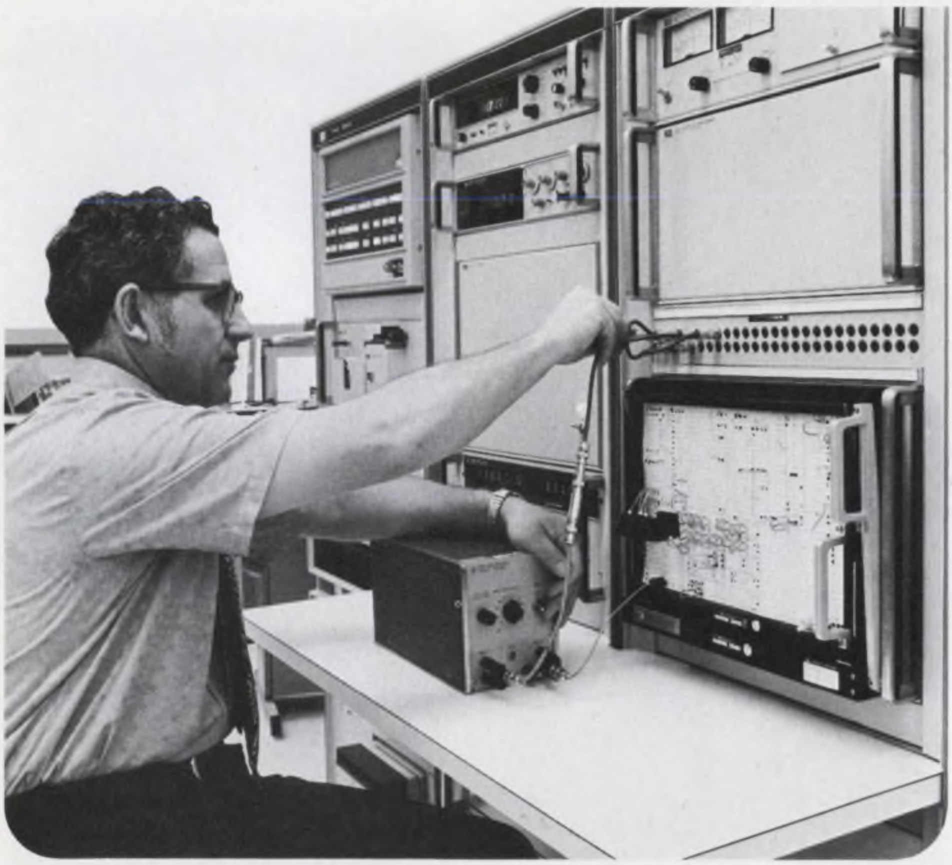
The HP-65: a new programmable pocket-sized computer-calculator. It accepts pre-programmed magnetic cards or you can write your own programs on blank cards.

Two years ago, the HP-35 provided scientists and engineers with a revolutionary mathematical tool. Now, for the first time, Hewlett-Packard offers full programming capability in a pocket calculator. No other machine of its size and price lets you prepare and edit your own programs, then store them on magnetic cards for later use. The unique HP-65 lets you perform branching, logic comparisons, and conditional skips—sophisticated, efficient programming—over lunch, in the field, or in your home study.

The calculator has five master keys (A-E) for storing and recalling user pro-

(continued on page 3)

Now, HP guarantees system specs at interface to unit-under-test



The 9510D automatic test system performs up to 400 complex tests in 4 or 5 minutes.

HP's new 9510D automatic test system is the first commercial test system *guaranteed* to meet specifications at the interface to the unit-under-test. Now you can match your requirements and pre-plan your testing facility with complete confidence; the 9510D performs each test with consistent repeatability to specified accuracy.

It's the only system with calibration initially traceable to the National Bureau of Standards. Standardization not only means reliability, but faster delivery and lower prices than custom-engineered systems.

The 9510D provides stimulus and measurement for voltage, resistance, frequency, distortion, phase, pulse digital and waveform analysis—plus RF stimulus and measurement of CW, AM and FM signals up to 500 MHz. It's designed to test electronic circuits and circuit functions, as well as sophisticated aircraft avionics, missile guidance and control, transceivers, TV receivers, satellites, navigation and communications equipment.

For specifications, check N on the HP Reply Card.

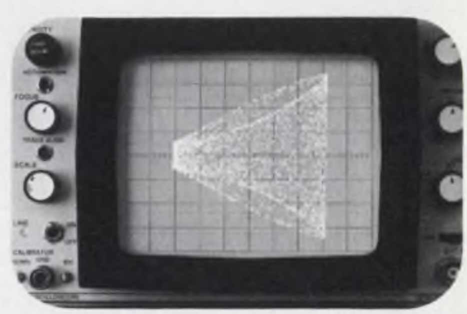
Sampling modules extend HP 180 scopes to 18 GHz

Dual-channel sampling modules for HP's 180 oscilloscopes offer qualitative and quantitative measurements of repetitive signals from dc to 18 GHz. The 1810A plug-in measures up to 1 GHz, while the 1811A module offers a choice of two sampling heads, 4 or 18 GHz. The remote sampling heads have feed-through design that allows measurements to be made using the system as a load, rather than an artificial termination in the system.

High-frequency applications include RF modulation testing, distortion and phase shift measurements up to 18 GHz. A sampling scope also displays the input vs. output of IF amplifiers to obtain gain and phase information. Fast sweep times are especially useful in nuclear laboratories for coincidence testing.

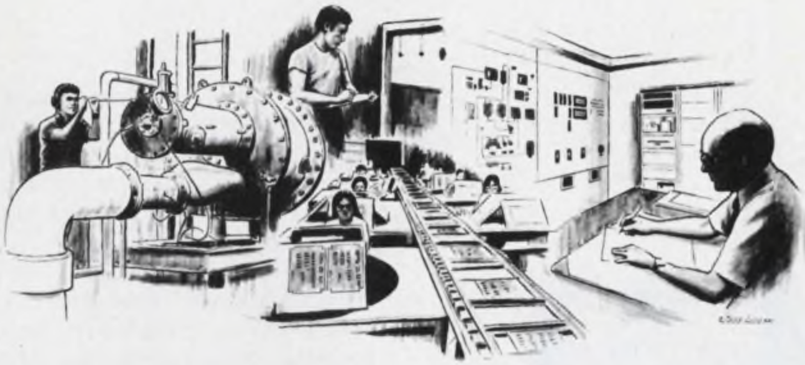
HP design improvements eliminate the need to trigger the sampling scope for modulation trapezoids. Now, you can make modulation trapezoid measurements on live transmission systems when triggering is impossible.

For details, check C on the HP Reply Card.



A non-triggered modulation trapezoid display of a 1 GHz carrier modulated with a 12 MHz sinewave.

New measurement/control system can improve productivity



Applications for the 9610 system include: material handling, process control, information networks, and quality control.

HP's new 9610 industrial measurement and control system helps manufacturers in three important ways: it will ensure your materials are on hand, when needed, in the right quantity; it can control the manufacturing process itself; and when the job's done, the 9610 can check the quality of the finished products automatically. The system also integrates easily into a plantwide information network for management reports and data processing.

Start with a small system (12 digital I/O channels and 16 analog inputs) and expand up to 540 I/O channels and 336 analog inputs. This can be done on location, with minimum down time. The high-speed analog subsystem has a 12-bit 45-kHz A/D converter with choice of high level and low level analog multiplexers.

Programming is done in simple HP BASIC or FORTRAN. Operating systems range from a low-cost interrupt-driven control system to a sophisticated disc-based real-time executive programmable in ALGOL and assembly language as well.

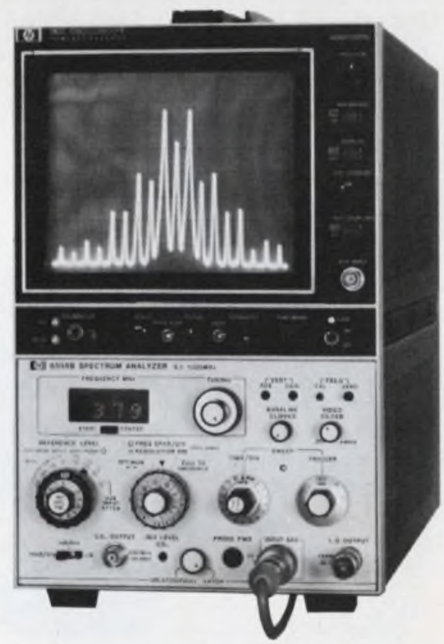
For more information, check O on the HP Reply Card.

Spectrum analysis plug-in adds to 180 scopes

HP's economical 1500-MHz spectrum analyzer, the 8558B plug-in for 180 series oscilloscopes, has performance and operating features ideal for lab, production and field applications.

- **Three-knob operation**—For most measurements, just tune the frequency (shown on LED digital readout), select frequency span width, and set the calibrated amplitude level control. The analyzer itself takes care of sweep time and resolution (1 kHz to 3 MHz).
- **Accuracy**—The 8558B offers ± 1 dB frequency response and ± 5 MHz frequency accuracy plus > 70 dB distortion-free dynamic range. This is comparable to what you'd find in analyzers costing up to twice the 8558's price.
- **Versatility**—Because the 8558B is part of the HP 180 scope family, you can combine its frequency-domain capabilities with the many time-domain plug-ins available.

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



Accurate measurements are made easily with the economical 8558B spectrum analyzer (shown here in a 182C oscilloscope).

(continued from page 1)

grams of up to 100 steps. The HP-65 can be programmed either from the keyboard or by inserting a tiny, prerecorded magnetic program card. Programs entered from the keyboard can be recorded on blank cards for future use. When you no longer need the program, erase the card and use it over again.

For your convenience, prerecorded programs are available from HP for statistical, mathematical, engineering, medical and surveying applications. Additional application pacs will be offered as they are developed. All HP-65 owners also receive a free one-year subscription to the HP-65 User's Library.

By itself, the HP-65 has 51 built-in functions: standard arithmetic operations plus logarithms, square and square root, exponential, factorial, reciprocal, and trigonometric functions. You can add and subtract in degrees, minutes and seconds format. You can choose any of three trigonometric modes—degrees, radians and grads— and convert octal-based numbers to decimal-based integers or vice versa.

There are 9 addressable memory registers that can be used for data storage or register arithmetic. The 4-register operational stack stores intermediate answers and automatically retrieves them when needed in a calculation. Answers appear on the 10-digit LED display.

Rechargeable batteries operate the 11 oz. (3 hg) calculator for approximately 3 hours. Included with the HP-65 are hard and soft carrying cases, a recharger-adapter, user's guides, and a standard application pac.

An impressive capability at a modest price.

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

New digital power sources for test systems

Designing a minicomputer or calculator-based test system? Then you'll need a programmable power source to generate stimulus, vary Vcc, or adjust bias potential—namely, HP's extensive line of digital voltage and current sources. More than simple D/A converters with extra power capability, the DVSs and DCSs satisfy all requirements for system use:

- Isolated digital inputs and outputs to eliminate ground loops.
- Flexible interface circuitry compatible with many programming sources.
- Internal storage of all digital input data to eliminate the need to refresh the supply.
- Programmable current or voltage limiting that protects supply and load.
- Feedback signals.
- External analog input to modulate the programmed output.

There are 5 digital voltage sources, programmable in 16-bit binary or 8421 BCD, covering an output range from ±10V to ±100V at currents up to 12.5A. Programming speed is 350 μs. Two digital current sources are available: model 6140A, programmable in 16-bit binary or BCD; and 6145A, programmable in BCD only.

For digital power source specifications, check J on the HP Reply Card.

The 6145A digital current source has 200 μs programming speed and 1 μA (X1 range) or 10 μA (X10 range) output accuracy.

Microwave power meter has new accuracy

The 435A power meter's internal RF power reference provides added confidence in overall measurement accuracy.

HP's thermocouple power meter (435A meter/8481A sensor) covers wide ranges—10 MHz to 18 GHz in frequency and 0.3 μW to 100 mW in power. It combines overall measurement accuracy with convenient operating features.

High accuracy results from the virtual elimination of mismatch uncertainties; the unique silicon-integrated thermocouple sensor has extremely low SWR (< 1.2 at 30 MHz to 12.4 GHz, < 1.3 from 12.4 GHz to 18 GHz). Overall system calibration can be verified anytime, anywhere, using the precise RF power reference that's built into the 435A meter.

Attractive optional features include an internal rechargeable battery pack and provision to operate the sensor up to 200 feet from the meter. The 435A/8481A accuracy can also work for you in field tests.

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

Now, prices reduced on IC troubleshooters

Now many IC troubleshooting instruments cost less, and the HP 10529A logic comparator has a new "no-cost" accessory. Price reductions affect the 10525E logic probe, 10528A logic clip, and the 5011T and 5015T kits.

The 10525E is the only logic probe with fast enough response for ECL logic. Even a 5 ns pulse causes the lamp in the probe tip to blink for 0.1 sec. The probe tip light indicates logic high, lows, open, and pulse trains.

The 10528A clips over 14 or 16-pin dual in-line DTL or TTL integrated circuits. The 16 LEDs on the clip indicate the instantaneous logic states of all the pins.

Always a low-cost way to buy IC troubleshooters, two HP kits are now even a better buy. The 5015T "mini" kit contains a logic probe, clip and pulser to stimulate your ICs in-circuit. The 5011T "maxi" kit contains the same three plus a logic comparator.

Along with each 10529A comparator, you now get a new plug-in reference board that has an IC socket and miniature switchs rather than hard wiring the reference IC. You still get 10 of the old reference boards, too, for testing a specific type of IC frequently.

The new board can be ordered as a spare part (10529-60014).

For more on these lower prices, check Q on the HP Reply Card.

New plug-in reference board sets up quickly and economically for infrequently used ICs.

Calculator-aided transformer design saves time and slashes costs

Simply input your specs (say, temperature rise, voltage and current requirements). The 9830 calculator automatically selects the fabrication parameters you need.

Designing power transformers involves using several charts, graphs and tables, plus your own intuitive feeling for each problem; selecting core material; calculating losses; determining temperature rise; and planning for the required regulation. Repeated guesstimates take time because they must be done carefully and accurately.

Now, there's a better way: add an HP 9830 programmable calculator and transformer design software to your staff. The 9830 is a powerful, computer-like calculator that is fast and easy to program in BASIC. At HP's Loveland facility, it's used for all new transformer design problems.

With the 9830 calculator and the HP-developed software, accurate transformer designing, quoting and specifying is performed with important reductions in time and cost. The software is user-tested: HP spent 5 years developing, using, then refining the programs.

The results? Designs that once took 4 hours (using manual techniques) now take only 15 minutes with calculator-aided design. Equally significant, only a third as many HP engineers are needed to do complex transformer designs. And turn-around time, from specification to prototype shipment, has decreased from an average 10 days to 3 days.

For more on calculator-aided design, check S on the HP Reply Card.

New OEM disc system is fastest in its price range

Add a disc subsystem to the HP 2100A computer via a dual-channel DMA board, and you've got the HP 2123A, the fastest disc-based minicomputer system an OEM can buy.

The 2100A CPU provides 16K words of memory, memory parity, memory protect, hardware multiply/divide, and power fail/restart. The 5-megabyte disc has 30-ms access time, making the HP 2123A the fastest system available in its price range.

There's another HP exclusive: add a printed circuit board, Writable Control Store, to the 2123A system; and you have the only OEM disc system that is user-microprogrammable.

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

The 2123A OEM disc-based system has a data transfer rate of over a million 16-bit words per second.

New pulse generator works well with several logic families

Now, test several different circuits over a full range with one easy-to-use pulse generator.

Our new 20-MHz pulse generator has simultaneous +10V and −10V outputs, ample for HTL, DTL, RTL, discrete and analog circuits. The new 8005B also has a separate TTL-compatible output for testing TTL circuitry. Compared to its predecessor, the 8005A, the new generator has twice the pulse rate, twice the output, and three simultaneous outlets—all for the same price.

The normal/complement switch lets you change conveniently from positive to negative logic without readjusting offset. The 8005B has selectable output source impedance (50Ω or current-source) and linear transition times from 10 ns to 2 sec. With a range from 0.3 Hz to 20 MHz, the pulse generator also features square-wave operation from 0.15 Hz to 10 MHz and a double-pulse mode to 10 MHz.

For the full story, check L on the HP Reply Card.

Now, the dmm probe becomes a five-function bench instrument

Four months ago, HP introduced the 970A digital multimeter—a handheld probe that measures ac and dc voltages from .001V to 500V with automatic polarity, and resistance from .001 kΩ to 10,000 kΩ.

Equally handy in the field or in the lab, the 970A takes the trouble out of troubleshooting.

Now, you can convert the portable 970A into a five-function bench instrument. A new optional current shunt/bench cradle adds five ranges of ac/dc current measurement capability. Simply select a current range of 0.1 mA, 1 mA, 10 mA, 0.1 A, and 1 A. The cradle binding posts add terminal versatility: it accepts wrap-around, screw-down, clip-on or banana plug terminations. All readouts still appear on the dmm's 3½ digit display.

For more on the probe and the new option, check P on the HP Reply Card.

New measurement techniques with storage and variable persistence

High-speed signals, single-shot events, or low frequency signals are difficult, sometimes impossible, to see on a conventional oscilloscope. However, the HP 1703A portable 35-MHz storage scope captures these elusive signals with ease. Storage and variable persistence can solve many varied measurement problems.

At Four Phase Systems, a California computer company, a 1703A scope is used to detect a single-shot 100-ns command signal. The stored trace verifies that the pulse occurred at the proper time.

When IBM's instrumentation classes analyze the contact bounce of switches, they view these nonrepetitive signals with a storage scope. Capturing real-time waveforms lets the computer trainees examine this prevalent source of trouble. Thanks to fast writing speed, the 1703A displays these high-speed, single-shot signals clearly.

At the Utah Power and Light Company, the 1703A interrogates 40 remote stations sequentially. The signal from any one remote station is equivalent to measuring a low rep rate signal. Using a 1703A scope with delayed sweep, a technician isolates the desired signal, then adjusts the variable persistence to display both the master signal and the remote response. By comparing the two traces, he can determine the validity of the returned data.

For details and more information on storage applications, check B on the HP Reply Card.

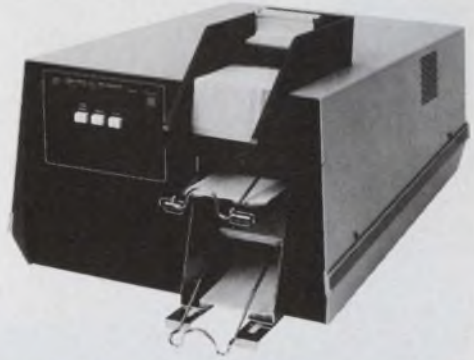
The portable 1703A scope on-site at Utah Power and Light Company.

Now, use source cards for data entry

Save data preparation time with HP's new 7261A parallel card reader. Designed for use directly with a computer or smart terminal, this optical mark card reader accepts source documents for data entry. Thus, your initial functional set of cards—the ones you mark with ordinary pencil—can be input directly. The intermediate step of keypunching is eliminated, as well as the possibility and probability of keypunch errors.

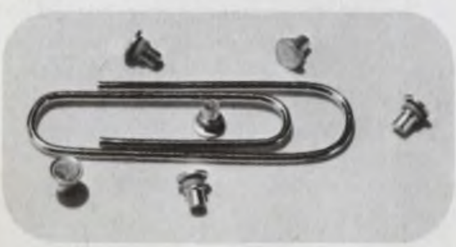
No special marking pencils are necessary; and yes, you can erase mistakes. You can even make notes; the card reader ignores areas used for handwritten messages. Yet, it will read marks, punched holes, and pre-printed data. Maximum feed rate is 300 cards per minute. An optional 500-card select hopper is available for operation under computer control.

For details, check K on the HP Reply Card.



HEWLETT-PACKARD COMPONENT NEWS

New high-efficiency high-power IMPATTs



These developmental diodes have operating voltages from 100 to 143V, with operating current from 50 to 900 mA, depending upon frequency and power output.

Two new developmental silicon IMPATT diodes are now available for microwave radar and communications applications. The two pulsed units deliver peak powers of 12W at 10 GHz and 10W at 16.5 GHz. Designed for X-band and Ku-band, these double-drift diodes offer higher power and efficiency, lower junction capacitance, and lower FM noise than single-drift IMPATTs.

Two developmental CW IMPATTs, capable of 1.3 and 2.3W at 11.2 GHz, are also available for X-band oscillators and amplifiers in telecommunications applications.

For details, check R on the HP Reply Card.

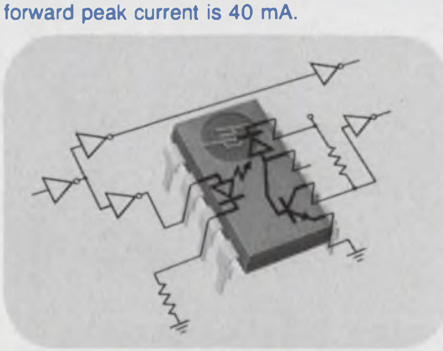
HP reduces prices of high-speed isolators

Now, you can save 22% to 40% on high-speed optically-coupled isolators. These devices combine an LED input optically-coupled with a P-N photo-diode driving a transistor. Isolation voltage is 2500V. Propagation time is only 225 ns, and bandwidth is 5 MHz. They can be direct-coupled to TTL loads at TTL speeds without additional buffers or triggers.

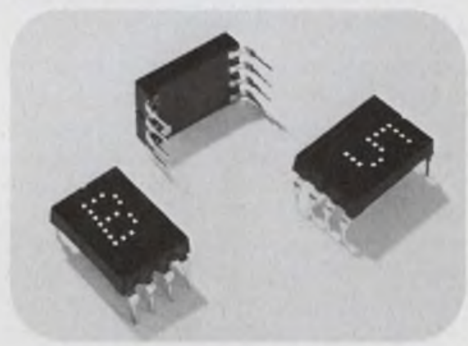
There are three isolators, designed for different applications. For general-purpose isolation, use the 5082-4350 with a typical dc current transfer ratio (CRT) of 11%. The 5082-4351 is a high gain device with CRT of 22% while the 5082-4352, with a CRT between 15% and 22%, is designed for critical gain control applications.

For prices and specs, check G on the HP Reply Card.

Maximum forward dc current is 20 mA; maximum forward peak current is 40 mA.



New lower prices for hexadecimal display



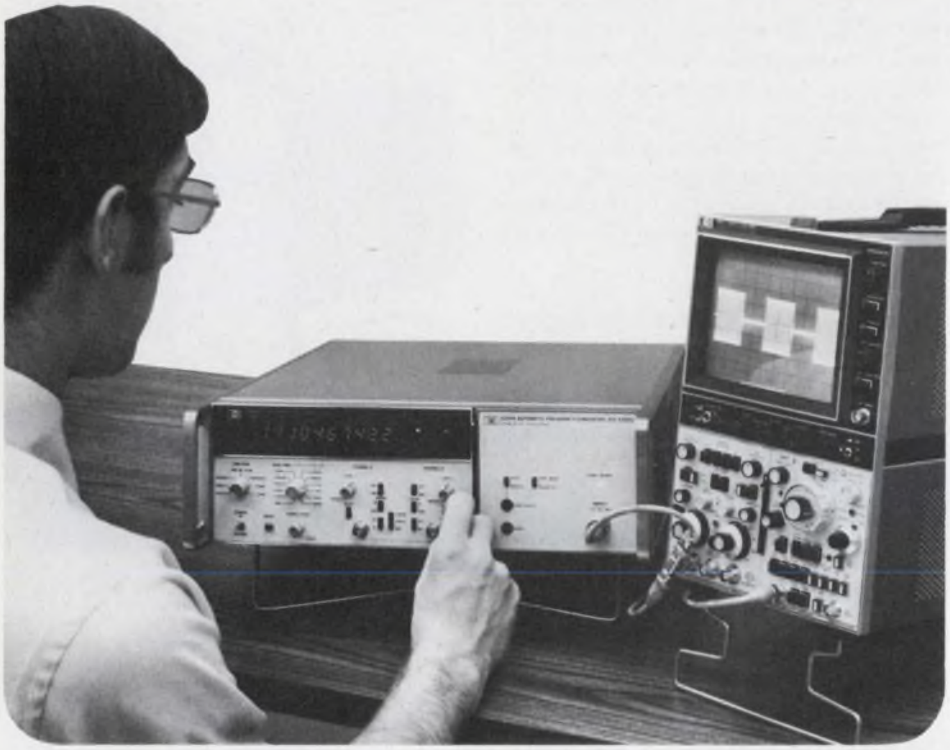
Display digits or letters with HP's low-cost hexadecimal indicators.

Now, you pay approximately 30% less for an LED display that converts binary logic to a base 16 numbering system and displays letter A-F, as well as digits 0-9. Used in computers and test instruments, this solid-state display is suitable wherever you need to show more than 10 states.

The 5082-7340 hexadecimal indicator has built-in decoder/driver and memory. The unique blanking control lets you turn off the display, and retain or change the data stored in the on-board memory. It's completely DTL and TTL compatible.

To learn more, check H on the HP Reply Card.

New "super-counter" provides higher speed, greater resolution, and unique frequency averaging



Pulsed RF and CW up to 4 GHz are measured automatically with a heterodyne converter plugged into the new counter.

Our new 5345A "super-counter" brings a quantum jump in measurement capabilities to general-purpose counters and opens new application areas.

This unique counter uses the period-measuring reciprocal-calculating technique for greater resolution in less time than conventional counters. For example, any frequency between 1 Hz and 500 MHz is displayed to 9 digits in just 1 second. Thus, for a desired resolution, you can make hundreds more measurements in the same amount of time.

Unique input amplifiers not only give 10 mV sensitivity with switchable impedances but are also direct-coupled. Thus, the counter isn't limited to CW signals but handles non-symmetrical waveforms, random events, pulses, pulsed carriers, and time intervals.

New HP-developed sub-nanosecond digital logic ensures the counter's accuracy to ± 1 clock pulse of the internal 500 MHz clock and allows gate times down to 50 ns.

Pulsed carriers can now be measured automatically, even for very narrow single-shot pulses. High-speed gating, the reciprocal technique, and a new technique known as "frequency averaging" maintain accuracy and resolution on pulses narrower than 100 ns. And plug-in modules extend automatic measurements to 4 and 18 GHz. (If you already have an HP 5245L counter, you can use the same plug-ins in the 5345A.)

Outstanding time interval capability gives resolution to 2 ns single-shot; improved time interval averaging extends into the picosecond region. External gating allows jitter to be easily characterized between any two pulses in a bit stream. Ratio measurement is more versatile than ever because you can ratio any two signals from dc to 500 MHz with full sensitivity.

System designers benefit, too, because the new counter interfaces easily with HP calculators and 2100 series computers.

There's more. Check I on the HP Reply Card.

HEWLETT hp PACKARD

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00446

ACROSS THE DESK

(continued from page 8)

Help! He needs a clamp source

I need some clamps that must support a total of 12 oz. when fastened to the lead of an integrated circuit. The clamp should measure no more than 0.050 in. wide in reference to clamping surfaces, and 0.400 in. long, and it should not weigh more than 1/2 oz. The material is unimportant.

Can you help me locate a source?

Gary G. Lagier
Quality Assurance Manager
Viking Laboratories, Inc.
150 Wolfe Rd.
Sunnyvale, Calif. 94086

Air-cooling guide gets high rating

May we congratulate ELECTRONIC DESIGN and Dave Nevala of Digital Equipment Corp. for the fine article "A Guide to Good Air Cooling" (ED No. 4, Feb. 15, 1974, p. 76).

Rotron, Inc., a manufacturer of air-moving products, has worked in close association with Digital Equipment Corp. for the past several years. Mr. Nevala's knowledge of forced-air convection cooling has enabled DEC to achieve the desired packaging densities and system reliability typical of their products.

It is gratifying to hear the virtues of forced-air cooling being expounded by someone outside of our industry.

Gordon M. Taylor
Manager, Marketing Engineering
Rotron, Inc.
Woodstock, N.Y. 12498

Good-news cable

Though we've seen one of two messages from advertising agencies, advising us that their clients are doing nice things, we were rather charmed by a cable from Evenett & Desoutter in London,

(continued on page 23)

WANT A 16K BY 20 650 NSEC. MEMORY ON A SINGLE CARD?

YOU JUST FOUND IT

Not only do we have just the memory you're looking for, we have it in a thoroughly field-proven design. A design that has been accepted — even by our competitors — as the industry standard. Basically it is the same reliable 3 Wire, 3D design as our MICRO-MEMORY 3000. We doubled the capacity, but kept everything else the same.

It is the MICROMEMORY 3000DD. Consider its credentials. Cycle and access times of 650 nsec. and 300 nsec., respectively. Power requirements of ±15VDC and +5VDC. The complete system, including all necessary logic, drive and sense circuitry complete on one convenient plug-in circuit board. Standard configuration of 16K by 16, 18, or 20 bits, alterable to 32K by 8, 9, or 10. And it is interchangeable with the original MICROMEMORY 3000.

The MICROMEMORY 3000DD is also available as a pre-packaged, multi-card system, complete with power supply, self-test and interface cards, and various other features and options. And standard chassis are available to hold from one to 16 memory cards. Since both the original 8K MICROMEMORY 3000 and the new 16K MICROMEMORY 3000DD cards can be intermixed, this gives you new and greater growth flexibility from 8K to 256K.

Get complete information and technical details from your local EMM office, or call Commercial Memory Products Marketing Department at (213) 644-9881. Do it today.

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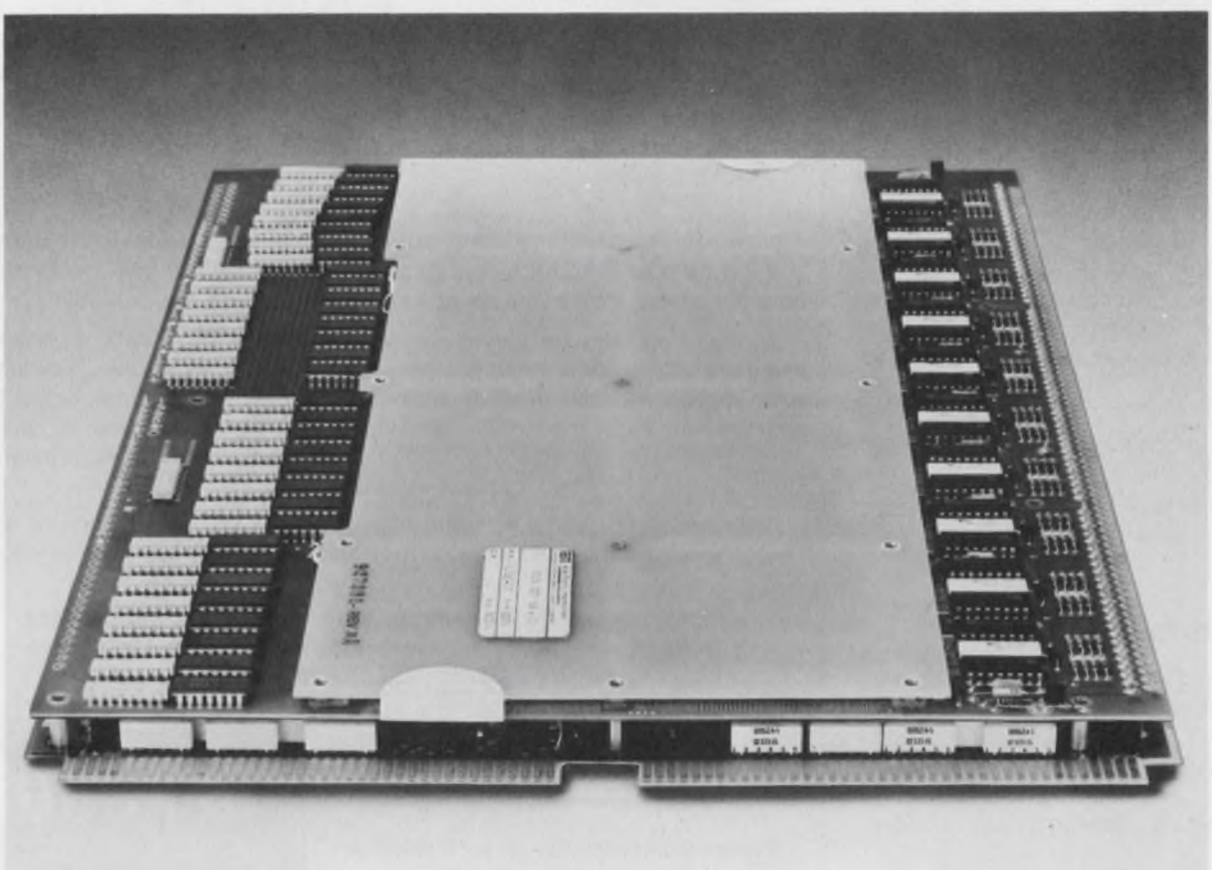
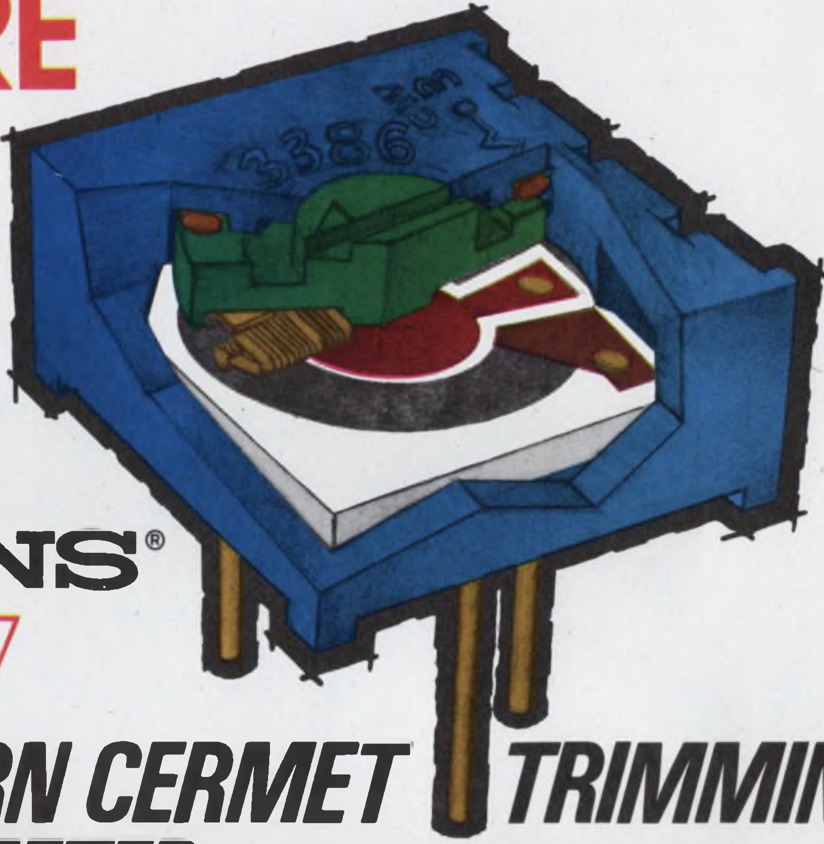


"See us at the NCC show in Chicago, Booth 671"

INFORMATION RETRIEVAL NUMBER 8

A LOT MORE FOR A LITTLE LESS



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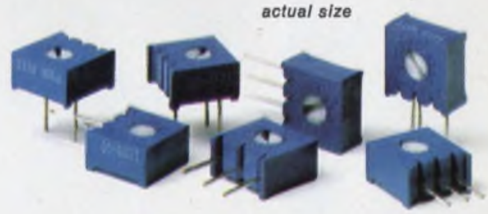

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• typical CRV less than 1%• infinite resolution • TC of ±100PPM/°C to 200K ohms • power of .5 watt at 85°C • thin ⅜″ square size

For complete details, contact your local Bourns representative or distributor, or the factory direct.

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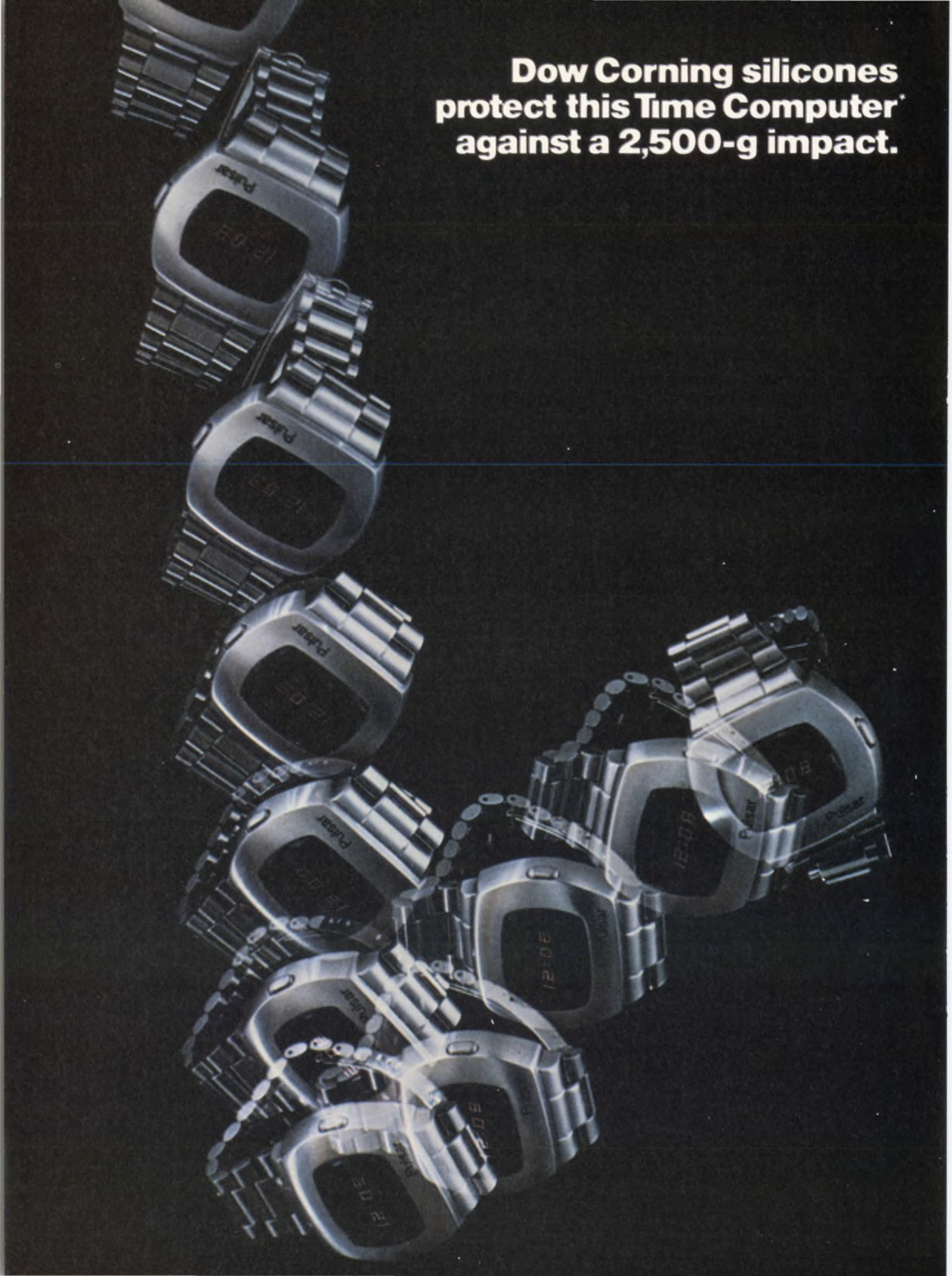
Dow Corning silicones protect this Time Computer* against a 2,500-g impact.
Pulsar

(continued from page 19)

the agency for Jermyn, Sevenoaks Kent (with U.S. headquarters in San Francisco). The cable read as follows:

"Don't believe all you read in papers. Britain not fallen in pit. Not all workers revolting. Not everyone on short time. Example: Jermyn has own generator working five-day week as usual. Satisfying worldwide demand as usual. Sun is shining. Spring is early."—John Evenett

A little 'bureaucracy' in us all, says V. P.

Your editorial "The Bureaucracy" (ED No. 3, Feb. 1, 1974, p. 51) certainly rings true. A little of this attitude fits all of us.

Certainly we can all relate to the man or woman who fits the bill. Not only did we have a name for such people in the Army, but the name also applies to some people in our profession. In short, if the shoe fits, wear it.

I enjoyed the editorial, and look forward to more of your clever wit.

Robert Shevlot
Vice President, Marketing
Texscan Corp.
2446 N. Shadeland Ave.
Indianapolis, Ind. 46219

Add the inflation factor

I feel that R. W. Wiegel overlooked a very important parameter in his plot of semiconductor storage-element price trends (see "The Memory Price Plot," ED No. 25, Dec. 6, 1973, p. 8). If an inflation factor were added, his plot would surely resemble more the amplitude-frequency response of a crystal filter—or any other bandpass filter viewed through a crystal ball.

C. Humphrey
Engineer
Raytheon Canada Ltd.
400 Phillip St.
Waterloo, Ontario,
Canada N2L 3X3

This is not an Augat board.

It's better.

The more creative your mind, the better you'll like our dual-in-line socket boards and cards. Because they give you more design freedom than Augat's.

For example, we put both 14- and 16-pin sockets on the same board. We build in a unique "wire wrappable" section for discrete components. Also a "universal" section to take unusual components. And power decoupling. And "wire wrappable" test points. And so on, and so on.

Everything to serve you better.

We're EECO. We'll see you through.

INFORMATION RETRIEVAL NUMBER 11

EECO

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Also from G. S. Marshall Company nationwide.

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We'll send it to you if you'll send us the information below.

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Now you have an alternate source for 2GHz & 3GHz microwave transistors

TRW's new 2GHz & 3GHz microwave amplifier parts are available right now, off-the-shelf, from any authorized TRW distributor. So, soon as you qualify these parts, you are no longer at the mercy of a single-source manufacturer!

And here's some more news: our transistors are **not** simply "just as good" as the originals; they're better! Gold metalized to last longer. Metal migration failure is virtually non-existent. The 2GHz parts can also withstand infinite VSWR and overdrive. Yet TRW's gold metalized parts cost the same as ordinary aluminum ones (maybe less!).

These are practically drop-in parts. You can use them right now, in your present amplifiers—and, of course, in future designs. That means instant improvement in the reliability of your amplifiers. Part for part:

	2GHz	PART NUMBERS	3GHz	
	Aluminum	**Gold**	**Aluminum**	**Gold**
1W	MSC2001	TRW2001	MSC3001	TRW3001
3W	MSC2003	TRW2003	MSC3003	TRW3003
5W	MSC2005	TRW2005	MSC3005	TRW3005
10W	MSC2010	TRW2010	—	—

For details, call Don Comm, (213) 679-4561.

Or write TRW Semiconductors, an Electronic Components Division of TRW Inc. 14520 Aviation Blvd., Lawndale, California 90260.

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INFORMATION RETRIEVAL NUMBER 13

news scope

APRIL 12, 1974

LSI finding a place in homes in multi-purpose alarms

Large-scale integrated circuits are starting to turn up in sophisticated security alarms for the home.

An LSI system introduced by Westinghouse Electric Corp., Pittsburgh, for use in high-rise apartment buildings has, in one system for the first time, all of these features:

- Alarm tones that distinguish fire and smoke conditions from intrusion and emergency conditions.
- Separate tones that distinguish line trouble from an actual alarm.
- A private code number for each apartment.
- Two-way voice communications between the central monitoring console and apartment units.
- An acknowledgement light that tells the resident that monitoring personnel have received the alarm.
- Adjustable arming and disarming time periods.

The all-in-one security system is based on a single, 40-pin LSI PMOS circuit. According to Douglas Drumheller, engineer in charge of the project, the original design was done with about 50 CMOS ICs. The switch to PMOS was made, he explains, when it was realized that power saved with CMOS was negligible compared with the high power required to drive the alarm speakers.

The chip is a random-logic, ion-depletion-mode device and is manufactured to MIL Spec 883 Level B, except for the burn-in requirement. The MIL spec was chosen to get very high reliability.

Smoke, heat and intrusion sensors are wired to a small master control panel in each apartment. This panel contains all of the alarm circuitry and is connected by a single cable to a central monitoring console, usually placed in the lobby of the building.

There are two distinct alarm sounds: an electronic gong for fire and smoke, and a siren for intruders and other emergencies. These signals are digitally generated on the chip. Other functions performed on the chip include fault and level detection, system testing and supervisory control.

In addition to the MOS chip, the system contains a 256-bit bipolar pROM that holds 3-to-6-digit user code, a communication board that contains a discrete-component power amplifier for the intercom, and a local power supply.

Drumheller points out that the communication board is a plug-in that can be changed for interfacing to a CATV network.

4-signal RCA system joins quadraphonic race

A quadraphonic FM stereo system that broadcasts four discrete audio signals was demonstrated by RCA at the National Association of Broadcasters Conference in Houston, Tex.

The system is competing with at least seven others for ultimate adoption by the Federal Communications Commission.

Gene Bidun, broadcast professional equipment product manager for RCA Government and Commercial Systems, Moorestown, N.J., says the new system is compatible with existing stereo and monophonic FM receivers. A key feature is two modes of operation.

In one mode four separate signals are broadcast, but the subcarrier frequency that is used for FM background music cannot be used. Since background music produces considerable revenue for FM stations, it can be retained in the second mode of operation, with only about 10 dB loss of channel separation, according to Bidun.

The RCA system will be evaluated by the Electronic Industry Association's National Quadraphonic Radio Committee this spring or summer. Not all of the systems under consideration by the EIA transmit four discrete channels. Some are matrix systems that use the existing two stereo channels and rely on phase-shifted audio components to produce a simulated four-channel effect.

With RCA's system, Bidun points out, four signals—M, X, Y and U—are combined for transmission in the same way as mono and stereo. The M channel contains all of the four-channel information, so it is compatible with existing receivers.

The standard 38-kHz stereo subcarrier is modulated by a double-sideband AM suppressed carrier to form the second, or X, channel. The third, or Y, channel is provided by a second 38-kHz subcarrier that is in quadrature with the first and similarly modulated. The fourth channel, which uses a 76-kHz subcarrier, is provided by the U signal, modulated like the X and Y channels.

All four audio signals can have a bandwidth of up to 15 kHz, and all of the information for four-channel sound is multiplexed onto the main FM carrier within a total bandwidth of 91 kHz.

Because the most significant information for four-channel sound is impressed on the three highest quality channels—M, X and Y—the fourth channel, U, may be dropped to use the FM signal channels in the 53-to-75-kHz band.

PC-board holes made with simpler technique

A photochemical process for making "through-holes" in printed-circuits boards is reported to be cheaper and simpler than the conventional mechanical technique.

According to the developer, Sandia Laboratories, Albuquerque, N.M., the technique cuts costs by eliminating a lot of machinery: numerically controlled or optical drilling machines, as well as the jigs and fixtures normally needed for reference holes and the registry of circuit art work. The processing time for finished boards is also reduced, and the technique allows complete automation of PC board manufacturing by reducing it to a batch process.

The key to the new process is a dielectric substrate containing preformed holes spaced on a 0.1-inch matrix. These 0.03-inch diameter holes conform to accepted drafting practices and match the lead patterns on such components as transistors and ICs, permitting components on both sides of the board to be connected.

The holes are punched, drilled or molded into the substrate during original manufacture, then covered on both surfaces of the board by standard copper cladding. A row of holes is left uncovered along one edge of the board for registration.

To open the proper holes in the substrate, the board is covered with a standard negative photoresist coating and exposed through a photo positive containing the hole diameters and locations for a circuit. Standard developing and etching open the holes on each side of the board.

The resulting hole pattern is then cleaned and plated through with existing techniques. Remaining steps follow the standard "panel plate" process. Larger holes for mounting, plotting and other purposes can be made with the technique, then drilled through with an inexpensive shop drill.

Satellites to give WU 30 times more capacity

With the launching this month of the first of three domestic communications satellites, Western Union is moving to increase by thirtyfold the capacity of its transcontinental microwave transmission system.

The two other satellites are to go up in June and October.

The satellites, called Westar, are almost identical to Telesat Canada's Anik. Both the American and Canadian systems were built by Hughes Aircraft.

The three Western Union relay stations will operate with five fixed earth stations and associated microwave relay links. There will also be a ground station for tracking, telemetry and the forwarding of commands to the satellites.

At the heart of each satellite is a communications repeater that consists essentially of 12 independent fixed-gain amplifiers, each with a bandwidth of 36 MHz. Common to all transponders is a wideband receiver that establishes the system noise temperature, translates 6-GHz receive carriers to 4 GHz for down transmission and amplifies the 4-GHz carriers to an intermediate power level prior to channelization.

A significant advance in technology over that incorporated in previous communications satellites is Westar's antenna de-spin system. De-spinning is necessary to keep an antenna oriented toward the earth while the body of the supporting satellite spins in orbit for stability.

Canada's Anik has a de-spin and antenna-pointing mechanism that uses an earth-generated control signal. This, however, "creates the possibility that signal—or power—failure at the control station could result in antenna misorientation and complete loss of communication, Western Union says.

To guard against this, Westar was provided two precautions: Highly accurate antenna spin control is provided by a pilot signal from the earth. And this is backed by a simple on-board de-spin system that takes over instantly and automatically if the pilot signal is interrupted.

Another difference is in the feed system. Anik's antenna pattern is generated by a three-horn, phased-feed system that creates an elliptical pattern over Canada. Westar uses a four-horn, phased-feed system that creates an elliptical pattern over the United States, a spot beam over Hawaii and provides a "back-porch" pattern covering Alaska and Puerto Rico.

A-power project to try new laser optic setup

A key element in a system that may ultimately produce unlimited electrical energy from isotopes of hydrogen in sea water is a new reflecting optical system for directing and focusing high-energy laser outputs.

Developed by the Raytheon Missile Systems Div., Bedford, Mass., for the University of California's Los Alamos Scientific Laboratory in New Mexico, the optical system is being used to determine the feasibility of using lasers to initiate controlled thermonuclear fusion. The program is part of the Atomic Energy Commission's effort to produce practical electric power with thermonuclear sources before the year 2000.

The Raytheon approach handles the laser beams at visible or infrared frequencies. Donald Banks, chief scientist at Raytheon, says the system has a much higher surface-to-aperture ratio than conventional systems do, thus reducing the power per unit area.

A proprietary material with very high dimensional stability is used. Problems with earlier systems have centered on the fact that many lens materials deteriorate because of the heat generated by the laser beam.

The new system uses highly polished geometric solids for the reflecting surfaces. A key element on which the laser energy is directed is a mirror-surfaced hyperbolic-shaped solid that resembles the nose cone of a missile. The energy is reflected from this surface to other surfaces in the focusing structure, and eventually to a target point, where the focused energy produces intense temperature and pressure.

Because the lasers can deliver large amounts of energy in short times and the beams can be focused on extremely small areas, they are potentially capable of providing compression and the intense heat of millions of degrees believed necessary to induce fusion in such materials as heavy isotopes of hydrogen. Once the nuclear reaction is initiated, the energy released—many times that put into the system—would be absorbed by liquid lithium and thermodynamically converted to electricity.

The Raytheon system will be used at the Los Alamos Laboratory to handle and focus high energy from carbon-dioxide laser chains.

The optical system was developed by Raytheon in a three-year program headed by Dr. Werner Rambauske.

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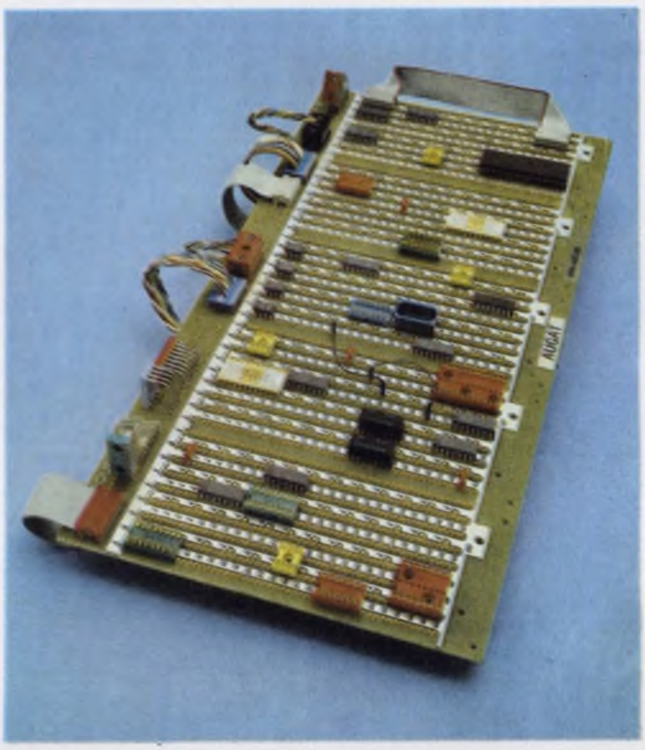
INFORMATION RETRIEVAL NUMBER 14

REPORT ON BREADBOARDS

From $2.50 to $1500, good systems can save you time in circuit design



Breadboard hardware, by Augat, is designed to accept either ICs or sockets into which ICs can be plugged. Interconnections are made with wrapped wire.

"With the right breadboarding system, I can turn out a fairly complex circuit design in a matter of hours. With the wrong kind, it may take all day, and even then, translating it to a prototype for production can be a pain in the neck."

This observation, made by an instrument designer, is echoed by engineers around the world. A good breadboarding kit is important. But what is good? And for whom?

There are all kinds to choose from. They cost anywhere from $2.50 to $1500, and there are advantages to all. They include these:

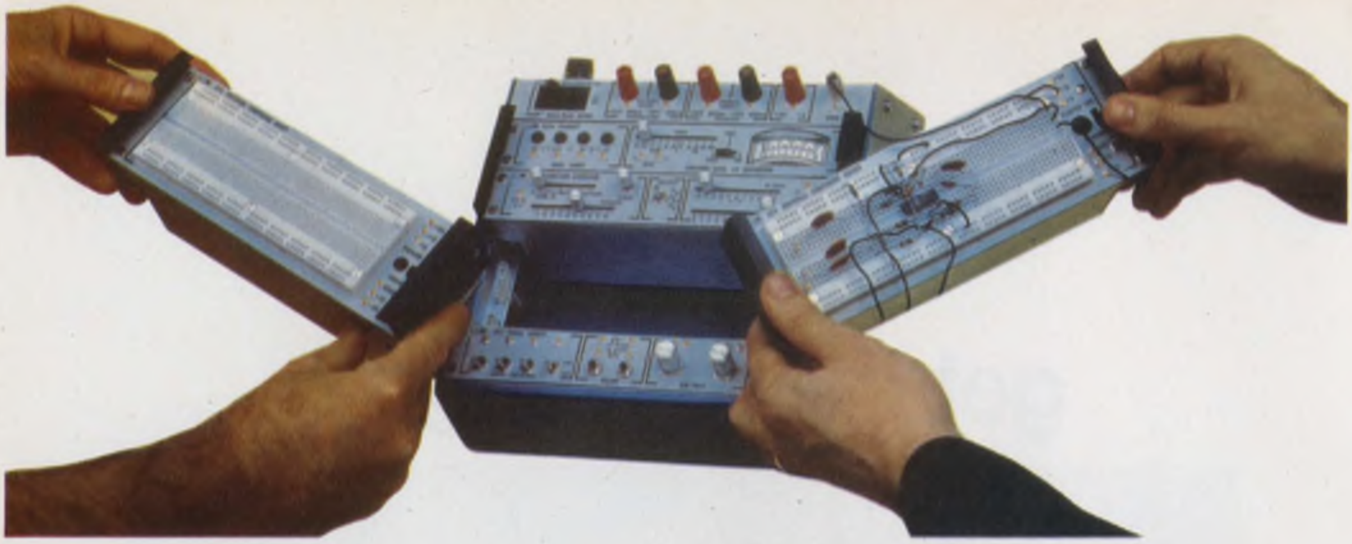
- *A plain board with punched holes*—the simplest form. Sometimes special pins for wired interconnections are provided. Components are mounted and connected to the pins.
- *Plug-in kits with interval bus bars.* These are slightly fancier. They require no soldering; circuits are formed by "push-in" wire connectors.
- *More complex plug-in kits*—with built-in power supply, system checks, switches and lamps. They can cost $1500.
- *Soldered-wire systems*—a building-block approach. Special component-mounting pads are interconnected with soldered wires.
- *Self-adhesive kits.* Similar to decals, the metalized wire layouts are mounted with self-adhesive backing. To lay out a circuit, you simply peel off the backing and press the pattern onto a circuit board.
- *Wrapped-wire panels.* They consist of rows of sockets that can be tied together by wrapped-wire solderless interconnects. Here, components are plugged in on one side of the board and interconnected from the other side with a simple wrapping tool.

John F. Mason
Associate Editor

What do you need?

Which advantage is important for you? You can't have them all in any one board. These are prime considerations:

- Simplicity or deluxe "laboratories"? What's the case for a plain board with punched holes vs the expensive systems that come equipped with their own power supplies, pulse generators and switches? The extras, called by some vendors "complete laboratories," run into money but can be worth it if they are used continuously by a large group of engineers whose designs are copied by technicians.
- Reusable socket boards. Reusability is important for schools and for engineering applications when the cost of components is a factor. You don't want to solder



Removable sockets are provided by Adam I, by E&L Instruments, so one engineer can use the system's power supply, pulse generator and other accessories, then remove his socket and let another engineer move in.

an expensive IC and later risk destroying it when you try to take it out. If the breadboard is going to become the prototype, of course, it's a one-shot deal anyway.

■ Ease of use and time saving. The time it takes to design a circuit is not necessarily proportional to the quality of the finished product. You can work all day and turn out a mess if you're using the wrong hardware. The important thing is to have a system that calls for a minimum of mechanical manipulation and lets you spend your time on the creative aspect of design.

■ Standardization. There's a strong trend toward building systems that will accommodate all kinds of components without need for adapters. It's important to be able to use what you've got on hand rather than having to go back to the factory.

■ Availability. It's important to buy from a company with an adequate continuing line of products.

■ Versatility. The breadboarding equipment should be able to handle simple components and advanced ICs. It should also be ready to accept new technology as it emerges. You may find that a board designed for 14 or 16-pin DIP ICs with rows on 300-mil centers may not be able to handle DIPs with 24 or 40 pins or DIPs with pins on 600-mil centers. It's also important to be able to add tie points and test points as a design progresses.

■ Reliability. The designer can lose time and his patience trying to figure out why an oscillator doesn't oscillate when all the time an internal bus bar is intermittent.

Tuned circuit can be mounted in less than four minutes on a GP-7 Mini-Mount, Christiansen Radio says. It's one of 14 patterns used in the company's no-hole, no-drilling, dc-to-GHz breadboard systems.

■ Convertibility. Easy transition from breadboard to prototype to production model is important.

■ Cost. It's wise not to overbuy or underbuy. For small projects, it's extravagant to use boards with elaborate jumper-terminal systems, installed sockets and power supplies. On the other hand, a lot of expensive time can be lost on a big job if special tools and connectors have to be fabricated.

Simple or deluxe?

When is a $3 board better than a $1500 system? This is not a set-up for a joke; it's an important question with important answers.

"A simple breadboard is good if the only goal is to get a simple circuit operating to demonstrate a counting frequency or to make product variance tests, or evaluate second-source devices," says Floyd L. Hill, vice president of marketing of Vector Electronic Co., Sylmar, Calif.

"A simple flip-flop circuit can be handled by a pair of Vector's new Klip-Bloks [miniature patchboards with 0.1-inch spaced multiple contacts] mounted on a piece of perforated board with a few adjacent terminals," Hill says. "A high-speed logic breadboard may require elaborate shielding, ground-plane construction, convenient, accessible three-level power buses and a wiring technique that keeps signal interconnections as short as possible."

Vector offers its Universal Logic Cards and specific accessories for these situations.

Another plug for simplicity: "The kind of board depends a lot on where in the production development cycle it's going to be used," says Richard David, vice president of Keystone Electronic Corp. in New York. "A cheap board is good for simple designs that can be used as the prototype itself. Also, if a breadboard must be kept throughout the product life as a means of updating or checking the design, a simple board can be used; it would be ex-

(continued on pg. 34)

Tic-Push-Toc-It's balanced!

New Honeywell signal conditioner with automatic 2 second bridge balance - saves time - saves money.

Strain gage excitation, automatic balance, amplification and complete signal control in this size plug-in module.

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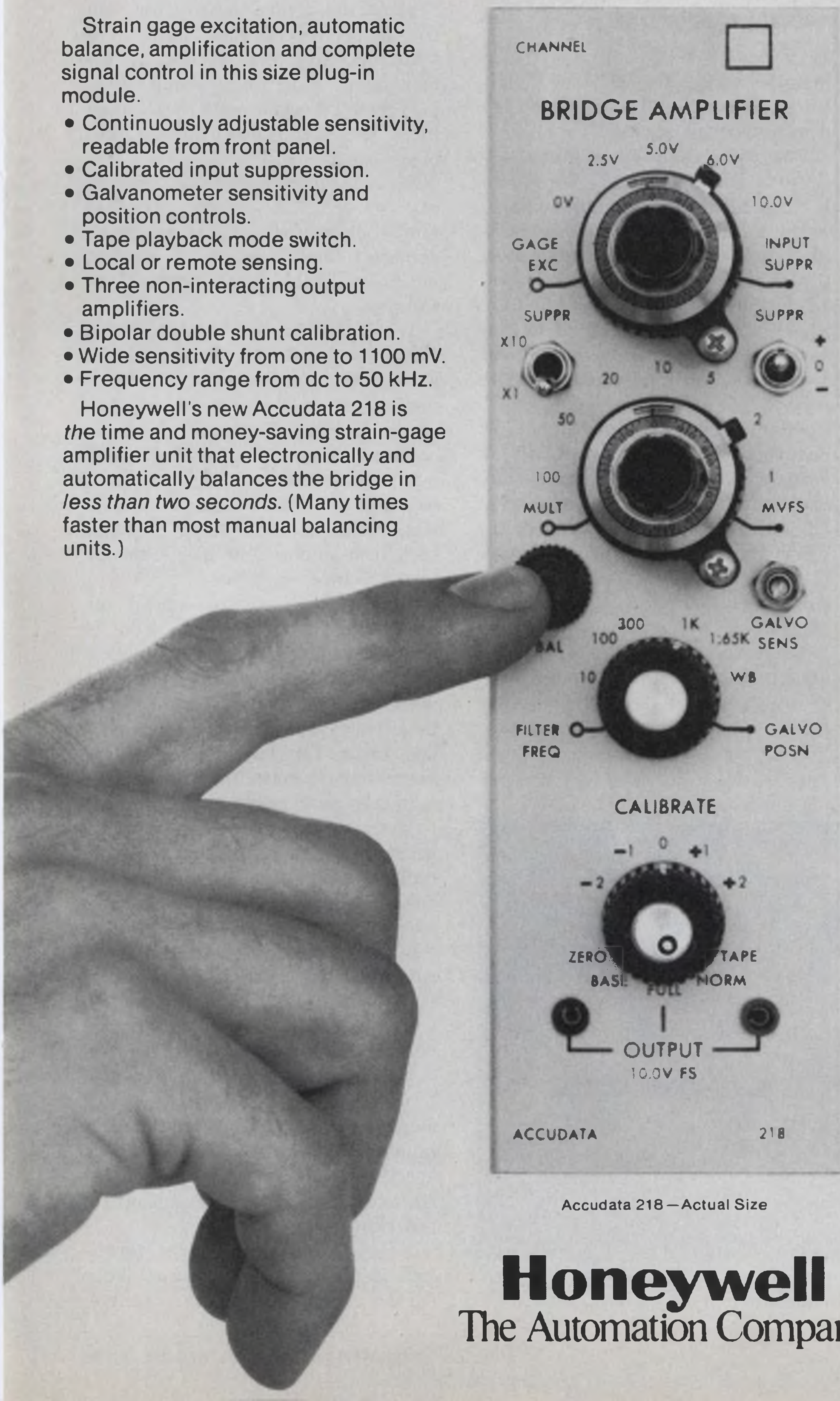
Honeywell's new Accudata 218 is *the* time and money-saving strain-gage amplifier unit that electronically and automatically balances the bridge in *less than two seconds*. (Many times faster than most manual balancing units.)



Accudata 218—Actual Size

Other time-saving features: direct reading sensitivity for rapid calibration—reduced set up time. Tape playback selector switch eliminates need to change signal input and recalibrate system sensitivity when switching from record to playback.

AND...full scale output switch mode that eliminates external recorder calibration techniques. Internal, calibrated input suppression that eliminates the need for external power supply and hook-up.

PLUS...three non-interacting outputs that provide insurance against loss of data in the event of shorts or overloads.

Below: Two more of Honeywell's fine family of Accudata signal conditioning units: The Accudata 122/123—solid state, wide band, wide gain range differential input dc amplifiers. And the Accudata 117—a direct coupled, single ended floating wide band amplifier of moderate gain for use as a general purpose signal conditioning instrument.

For a FREE short form catalog and specifications on the Accudata 218, write or call: Lloyd Moyer, Honeywell Test Instruments Division, P.O. Box 5227, Denver, Colorado 80217 (303) 771-4700.

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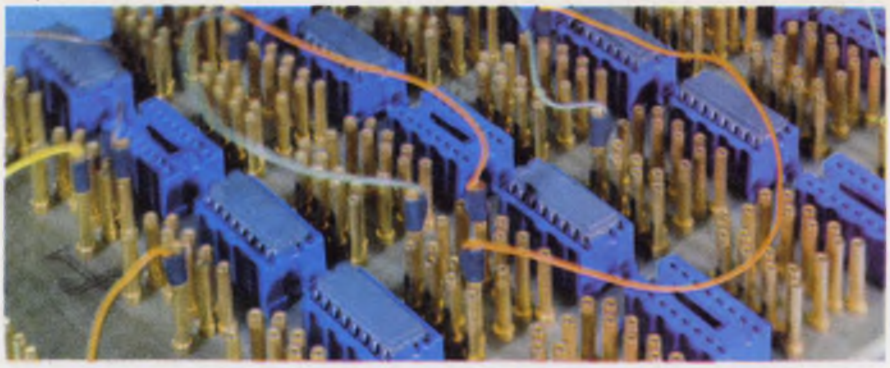


For breadboarding small quantities of ICs, this panel from Augat is handy, because interconnections are made with standard wire jumpers.

pensive to use a high-priced unit."

"One factor here," says Murray Gallant, president of E&L Instruments, Derby, Conn., "is whether you're working in a place that's already got the power supplies and pulse generators and other peripherals that you need for designing. A student, for example, doesn't need anything more than our SK-10, costing $17.25, because he has access to the university equipment."

He can design as many circuits as he wants, making solderless connections to and from circuits within the SK-10 simply by inserting stripped ends of common #22 solid wire into small holes in the top of the socket. He doesn't need built-in auxiliary equipment.

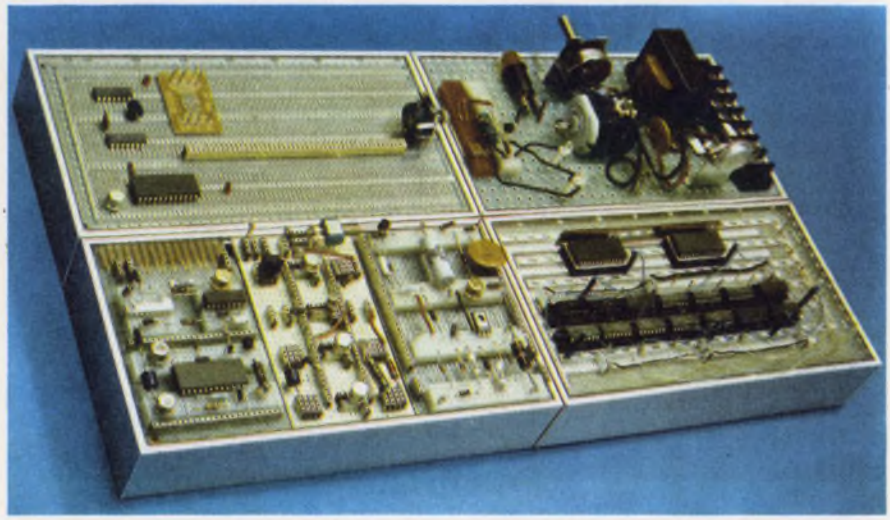
"But a $1500 deluxe model does pay off," Gallant continues, "when you are setting up a new operation where there are no power supplies, pulse generators or any of the other things you need for breadboarding. Under these conditions it may well be cheaper to buy the entire package."

For this, E&L Instruments offers its Elite series and its Adam I. The Elite 2, for example, provides a built-in function generator, dual-output pulse generator, three independent power supplies, 12 buffered monitor lamps, four SK-10 component sockets, isolated switch and pushbutton arrays and a variety of I/O connectors. It costs $1395.

Adam I goes a step further. It has the basic instrumentation of Elite 2 plus a socket board that can be removed, leaving space for an extra one to be slipped in. "Five or six engineers, each with his own socket, can use the same Adam mainframe," Gallant explains.

Later this year Adam II will be announced, offering a heavier power supply. Adam I costs $450, and Adam II, which will probably phase out Elite 2, will cost approximately $1500.

Hewlett-Packard is now offering a digital laboratory in a compact package that was developed originally as an educational tool. The unit, Model 5035T, sells for $650.



Multiconn breadboarding system, made by Vector, can accommodate almost any interconnection technique—wrapped, soldered or push-in wire.

Consider the components

Another factor in choosing a board is the kind of components you plan to use, says Vector's Hill: "Industrial applications often call for large components with non-standard lead and mounting dimensions." For these applications perforated boards with 0.093-inch holes on 0.265-inch centers are often used.

With large or heavy components, of course, the board, whether sinple or deluxe, should be thick enough to support them. If a board bends it could cause connections to open.

When trying out new ideas, a relatively simple pre-punched board and push-in terminals are more useful than a virgin board, advises Keystone's David. Various configurations can be tried without need to punch your own holes. Keystone's boards come with hole sizes ranging from 0.042 to 0.120 inch in diameter and spaced on 0.1 to 0.375-inch centers.

Virgin boards are cheap or expensive, depending on who is using them, says E&L Instruments' Gallant. "For a hobbyist whose time is free, a virgin board is a very inexpensive device. It's one thing for *him* to spend two hours boring holes and another for a highly paid engineer."

But virgin boards do have their uses, David says. They're good for limited production runs when the design is already set. When laying out a virgin board, however, the designer should give careful consideration to the various terminal types available.

"The circuit board should not become cluttered," David notes, "nor should a terminal have more wire connections than it was designed to carry. This is particularly important in military work, where specifications determine the method and number of connections to a terminal."

Keystone offers a line of terminals that include single or multiple turrets, tubular (hollow), double-

ended and split push-in types in a number of places.

Is reusability important?

In general, it's a good idea to buy a breadboard you can reuse, says Hill of Vector. But in any given case it depends on the nature of the circuit, what you're going to do with the breadboard and how tight money is.

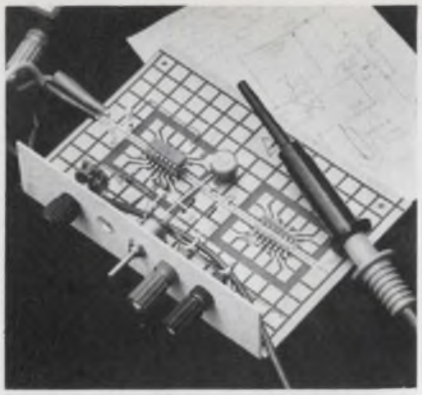
For schools, the whole idea is to learn and to reuse the board as long as possible. And even in some engineering applications the cost of components may be a factor—unsoldering an expensive component isn't always successful. But with cheap components, it may be cost-effective to solder parts that won't be changed anyway, Hill says.

All of Circuit-Stik's basic drilled-board material, sockets and connectors can be used many times, says Donald E. Harper, the company's director of marketing in Torrance, Calif. In the case of Circuit-Stik sub-elements, the basic board is built up with standard patterns, such as three-lead transistors, and 14-lead DIP sub-elements. The active components may be removed and new components soldered in, Harper says. If you want to change a three-lead to an eight-lead TO-5 sub-element pattern, it can be done easily by replacement of the pattern, he says, adding that the remainder of the board would possibly still be reusable without any changes.

A number of companies make plug-in boards that don't require soldering and unsoldering. Boards made by Cambion in Cambridge, Mass., provide jacks or sockets for components to plug into. Some of the patch cords are of the piggy-back type, allowing many connections to be made at one point.

E&L Instruments also builds plug-in boards. According to its president, Gallant, the company has steered clear of helical spring terminals because with them "intermittent conditions inevitably result, due to the single helical spring's inability to flex, its lack of wiping action when leads are inserted and the difficulty of mounting very thin leads which simply slip out."

Since prizes are never handed out for the way you design a circuit—but only for the merit of the finished product—the faster and easier you do it, the better off you are. Some companies attack the time and ease-of-use problem by building breadboards that require no adapters and no soldering. They build plug-in boards that are designed in a logical, visual way that's easy to understand. You don't have to reverse the board to translate it to a prototype. Makers of such systems say they provide a time saving of 3 to 1 over any kind of soldering system, and 2 to 1 over any solderless system that is designed around dual-in-line packages that are built in fixed configurations. This includes wrapped wire. When you have to work with these fixed configurations and put the ICs where the breadboard manufacturer wants you to—and use his special jumpers—it takes time, according to these manufacturers.



Instant Breadboard, by Instant Instruments, Glen Cove, N.Y., allows the engineer to assemble a circuit without inserting components. The circuit is soldered to pre-etched patterns of large, lift-resistant copper.

Quick and easy

Many manufacturers' designs are based on solderless construction with instant interchangeability, inexpensive interconnections with common jumper wire and a wide range of component sizes and shapes.

Components, both discrete and integrated, are inserted directly into the socket, with a secure spring contact to hold them in place. These springs are bifurcated, rather than helical, and are self-wiping on each insertion of components or leads. They are firmly embedded in a precision, plastic matrix and are exceptionally uniform in contact pressure over a wide range of component lead sizes.

Some designers prefer wrapped wire for both breadboard and prototype hardware. According to R. T. Hunter, product manager of Electronic Engineering Co. of California in Santa Ana, the technique is growing rapidly.

"A technician can wrap about 40 wires per hour, which really isn't too bad," Hunter says. "And a machine can wrap, using semi-automatic equipment, in excess of 240 wires per hour."

Wrapped-wire innterconnects work very well with IC socket-panel hardware, Hunter says, because when changes become necessary, they are easy to make.

"Changes of components, interconnection or circuit complexity can be made easily by hand at any time during the breadboarding or prototyping period," he says.

Other manufacturers see a disadvantage to wrapped wire—one that doesn't become apparent until you try to use it. All schematics or circuit diagrams for ICs are drawn as you look at the unit from the top, while wrapped wire is done from the reverse side of the IC. This is fine if you can get your mind to work 180 degrees out of phase, some manufacturers point out, but this takes practice.

Circuit-Stik helps the designer save time by providing pressure-sensitive circuit sub-elements as well as plug-in boards.

Holes are pre-drilled for easy insertion in the boards. And other connections, such as stripline and copper tape, are backed with adhesive. These are placed between the two points to be connected and a drop of solder is used at each end.

"The pressure sensitive adhesive holds the stripline and the tape firmly in place, but either one can be pulled free by using a sharp knife," says Harper, the company's marketing chief.

With the adhesive approach, you can easily modify sub-elements, he says, simply by slicing off one with a sharp knife and replacing it with another. A stripline can also be used to cross over other connections, because it is insulated. It can go on top of an existing de-

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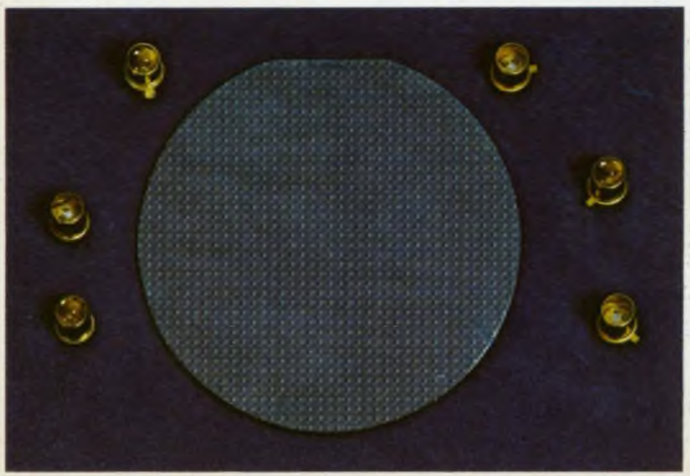
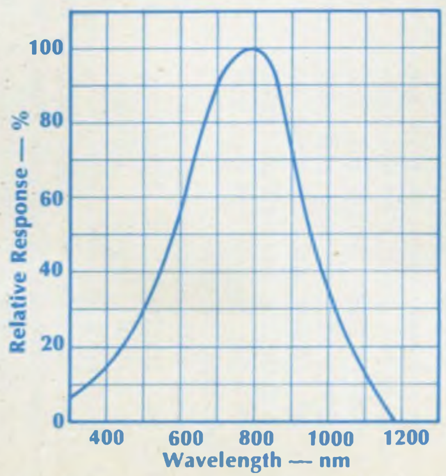
vactec phototransistors

VACTEC, INC.
2423 Northline Industrial Blvd.
Maryland Heights, Mo. 63043
Phone (314) 872-8300

Vactec npn epitaxial large chip, high sensitivity phototransistor. An enlarged section of the wafer forms the colorful background.





Standard Vactec phototransistors provide very high sensitivity and good blue response. Liberal design flexibility is also offered with trade-off for some characteristics, including: light current; response time; spectral sensitivity; and breakdown voltage. Selection of packages are TO-18, co-axial, pill, non-hermetic TO-18 size and special arrays on 50-mil or 25-mil centers.

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sign, if modification is necessary. Circuit-Stik GP boards can be used with wrapped-wire sockets, which you can modify by changing the wire.

Christiansen Radio of Laguna Beach, Calif., tries to make life easier for the designer by offering a decal-like, adhesive-backed, pre-etched circuit board, called Mini-Mount. It is designed to mount most existing electronic components on the top surface of the board.

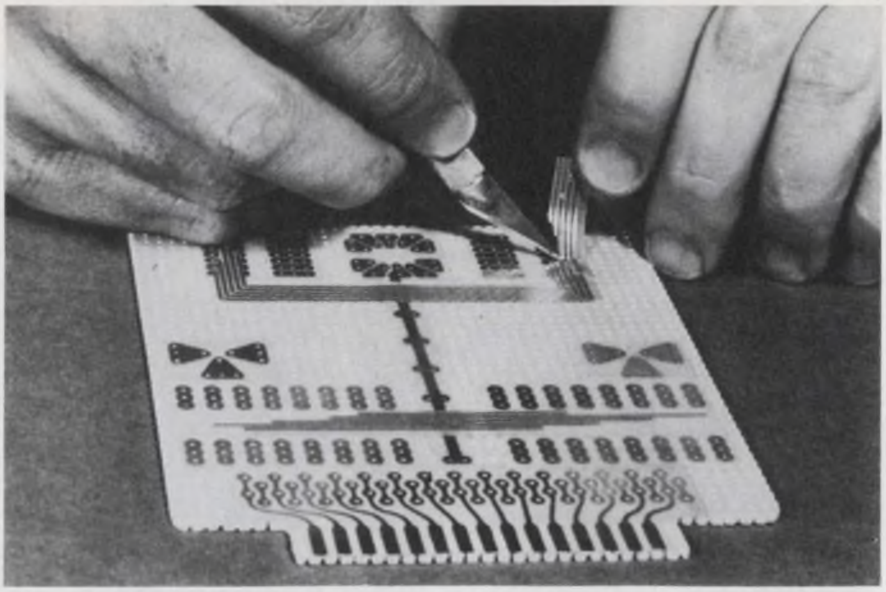
The base material is a G-10 glass epoxy, which provides good bond strength to copper patterns. All patterns are solder-coated for easier soldering and to protect the copper from oxidation.

With Mini-Mounts, you merely decide on a tentative layout on the ground plane, remove the backing paper from the mounts and place them, with light pressure, on the ground plane. Multi-lead devices can be soldered on the mounts first, if desired. Interconnecting wires and component arrays are then soldered directly to the pads. To remove any component, you melt the solder at both ends and lift off. There are no holes or wrapped joints to contend with. Mini-Mounts can be removed and repositioned at will.

In line with photographic reproduction methods of producing printed-circuit boards. Injectoral Electronics in Glen Cove, N.Y., supplies a line of copper-clad, sensitized boards in various sizes that enable the first prototype to be made quickly, with savings in materials, time and labor when additional boards must be reproduced. The company's boards are sprayed with photoresist and baked. The board is then exposed to an ultraviolet light for a few minutes and etched. The result is described as "a quality, professional board."

The great advantage of this method, according to the company's president, Everett Wollman, is that if additional boards are needed, they can be reproduced with a few minutes exposure to light.

A word of advice is offered by Keystone's David on the use of push-in and staked terminals when pre-punched boards are used. The push-in is preferred, he says, where speed of assembly is important and terminal replacement



Adhesive-backed circuit sub-elements, interconnecting materials and board materials that eliminate the need for wire, are provided by Circuit-Stik.

impossible. However, push-ins tend to become loose after a number of components have been added and removed, and they can't be subjected to severe mechanical stress. They are a good choice, he concedes, in the initial stages of prototyping, where changes are frequent in the design of compact packages.

"If a large number of component changes is anticipated during the design," he says, "or some longevity is required, the turret terminal is the best."

Generally the larger the number of reliable connections that can be made at one point, the more desirable the breadboarding system, says Hill of Vector.

According to Christiansen Radio, multiple connections to ground make up the biggest node in a system and potentially the largest single source of problems. If the circuit calls for many such grounding points at the node, the breadboard should be able to furnish it conveniently.

How important is versatility?

To provide versatility, Christiansen Radio offers breadboards that differ in pin count, heat dissipation, physical size and shape, profile, cost, radiation sensitivity and ruggedness. The breadboard system should be able to accommodate all.

For prototyping, a wide range of component types and sizes are available that can be mixed on one circuit board, including both discrete components and ICs. Several designs permit the mouting of any combination of DIPs, from eight leads up to 40 leads, while still permitting packaging densities as high as 49 14-lead DIPs on a card 4-1/2 by 6-1/2 inches.

Advice from several manufacturers: Ease of electrical testing is a major reason for making a breadboard. A positive feature to look for is a breadboard with a place to clip the scope probe on test points.

It must be reliable

Expensive engineering hours should not be spent tracing intermittent connections or other breadboard or prototype hardware problems.

Some companies offer drilled holes instead of punched holes for prototyping hardware because, as one puts it, they are "clean and accurate with no fractured edges." They are also free of contaminating glass fibers, and therefore don't have as much tendency to absorb moisture. Since the holes are cylindrical rather than partly crushed by a punching die, the cylindrical hole provides a rigid support for sockets, terminals and wrapped-wire pins.

"As a result of our quality drilling, our material offers a 65% increase in board strength over ordinary punched boards," one company official maintains.

Circuit-Stik builds its boards to last beyond the original functional workbench tests. Its prototype boards are similar to production boards made from high-quality FR4 epoxy glass material. They have heavy gold and nickel plating on connectors, and where adhesive sub-elements are used, they offer a stronger bond strength than is normally used in the manufacture of copper laminate materials.

As a result, the Circuit-Stik breadboard or prototype can be wave or flow-soldered and cleaned in ultrasonic cleaning tanks with Freon and triclorethylene. The company says its prototype boards have been subjected to high altitude and vibration and have been tested for nuclear radiation hardness, high and low temperatures and a vacuum environment with no loss in performance.

Making the next step easy

Conversion from breadboard to prototype to production model should be as painless and inexpensive as possible.

Many breadboards can be used as prototypes, but for those that will be subjected to harsh environmental conditions that they can't survive—such as heat— some companies build PC boards that are identical to the breadboards that they sell. When the designer is satisfied with his breadboard, a technician can transfer the components to the PC board in about 20 minutes, and he's got his prototype.

Sometimes breadboards are chosen for the material they are made of—designers want them to be as much like the prototype as possible.

"We like glass epoxy boards rather than paper, because glass is closer to the thing we're making —flight equipment," says Hugo Ritucci, a senior engineer at Grumman Aerospace in Bethpage, N.Y. "Laying out our breadboard as close to the final package layout as possible gives us better performance as far as straight capacity and interwiring pick-up is concerned. We don't want any surprises when we make our final layout."

In the same vein, the breadboard should not have better power-handling capabilities than the final model will have. And if heat sinks will be needed to dissipate heat in the production model, the breadboard model should use the same sinks.

"Mechanical changes in a production model to accommodate unexpected temperature problems are the most difficult and expensive to accomplish," one company says.

Augat believes that the use of wrapped wire saves the designer money. Even though its socket panels cost more than typical breadboards, the initial cost is justified as the board is phased into production and is capable of weathering design changes, the company says.

One manufacturer says: "Wire is a very inexpensive patching material, compared to soldering or to use of banana plugs or special molded pins."

Christiansen Radio's bid for economy is in the use of its stick-on Mini-Mounts. "These mounts are so cheap they make the idea of throw-away breadboards feasible—unless, of course, the components have to be saved," Christiansen says. ■■

Need more information?

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

A P Inc., 72 Corwin Dr., Painesville, Ohio 44077. (216) 357-2101. **Circle 410**

Alco Electronic Products Inc., 1551 Osgood St., North Andover, Mass. 01845. (617) 685-4371. **Circle 411**

Amphenol Barnes Div., 24 N. Lansdowne, Lansdowne, Pa. 19050. (215) 622-1525. **Circle 412**

Augat Inc., 33 Perry Ave., Attleboro, Mass. 02703. (617) 222-2202. (E. Redgate) **Circle 413**

Buckeye Stamping Co., 555 Marion Rd., Columbus, Ohio 43207. (614) 443-9458. (R. E. Osborne). **Circle 414**

By-Buk Co., 4326 W. Pico Blvd., Los Angeles, Calif. 90006. (213) 937-3511. **Circle 415**

Caddell-Burns Mfg. Co., Inc., 40 E. 2nd, Mineola, N.Y. 11501. (516) 746-2310. **Circle 416**

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138. (617) 491-5400. **Circle 417**

Centron Engineering, 24015 Garnier St., Torrance, Calif. 90510. (213) 530-4410. **Circle 418**

Christiansen Radio, 3034 Nestall, Laguna Beach, Calif. 92651. (714) 497-1506. (Allan Christiansen). **Circle 419**

Circon Corp., 749 Ward Dr., Santa Barbara, Calif. 93111. (805) 967-0404. **Circle 420**

Circuit-Stik, Inc., 24015 Garnier St., Torrance, Calif. 90510. (213) 530-5530. (D. Harper). **Circle 421**

Circuit Structures Lab, 3200 N. San Fernando, Burbank, Calif. 91504. (213) 849-6341. **Circle 422**

D-Cemco Inc., 3200 N. San Fernando, Burbank, Calif. 91504. (213) 849-6341. **Circle 423**

Di/An Controls, 944 Dorchester, Boston, Mass. 02125. (617) 288-7700. **Circle 424**

Dionics Inc., 65 Rushmore St., Westbury, N.Y. 11590. (516) 997-7474. **Circle 425**

Douglas Electronics, Inc., 718 Marina Blvd., San Leandro, Calif. 94577. (415) 483-8770. (Nancy Cain). **Circle 426**

E & L Instruments Inc., 61 First St., Derby, Conn. 06418. (203) 735-8774. (Richard Vuillequez). **Circle 427**

Electronic Engrg. Co., 1441 E. Chestnut Ave., Santa Ana, Calif. 92701. (714) 547-5651. (B. Fordiani). **Circle 428**

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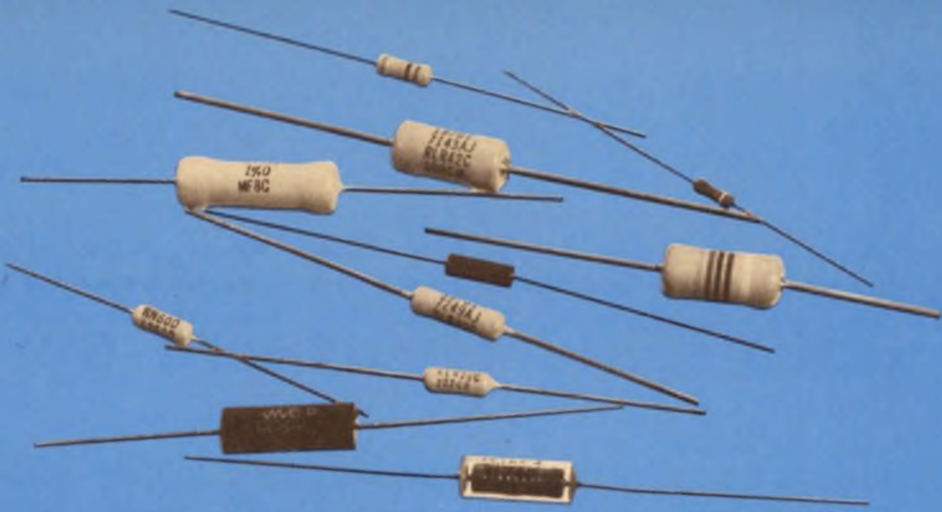

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IC specs available in 'seconds' with automatic microfilm system

An automatic microfilm information-retrievel system to help designers find IC data is said to "do in seconds what it used to take hours, days and even weeks to do before."

The system, made by Information Handling Services, Englewood, Colo., slashes the time required to look up data in manufacturers' catalogs. With the constant introduction of new integrated circuits —and the problems that arise with last-minute design changes if the ICs aren't available—engineers need all the help they can get, says Don Van Dyken, product manager for the new Integrated Circuit Parameter Retrieval System.

IC Parameter Retrieval System reduces the time engineers need to get data sheets.

Specs in seconds

When the system is used in conjunction with the company's Visual Search Microfilm service, Van Dyken says, the designer can move from his need for an IC circuit function—such as a flip-flop, memory or op amp—to the manufacturer's data sheet in one simple, fast operation. The complete sequence can take less than a minute, he reports.

An engineer can locate a particular IC by any one of three methods: by functional description, such as op amp or memory; by popular industry number, such as 1103 memory or 741 op amp; or by manufacturer's number, such as NS741 or μA709.

Once the device is located, the designer receives basic information that includes a description of the function performed by the IC, the technology used to produce it, the type of package it comes in, its temperature operating range, type number, original circuit number, supplier or source and where the manufacturer's data sheet can be found in the microfilm library. If a hard copy of the data sheet is required, the engineer merely pushes a button on a microfilm viewer, and the sheet is produced on the spot.

Van Dyken says that other systems give information either in tabular form, without data sheets, or classify ICs only by broad categories. The new system is timely, he continues, because with current paper shortages, some manufacturers are being forced to reduce their distribution of data sheets.

The cost of the IC information service starts at $1440 for an 8-mm system, which can be placed on one corner of the designer's desk. The system does not include data-sheet reprint capability. For that, the 16-mm system is necessary, and it costs $3000. Microfilms can be updated three times a year.

The system will be available for shipment in June, the company says. ■■

INTERFACE CIRCUITS LISTED BY FUNCTION

DESCRIPTION/ DEFINED FUNCTION	TECHNOLOGY PROC	TECHNOLOGY SCALE	TECHNOLOGY FAMILY	PACKAGING CHIP DIP FP HDR CASE CELL	RANGE TEMP	RANGE TEMP	SOURCE CIRCUIT TYPE NUMBER/SERIES	ORIGINAL CIRCUIT NUMBER	SUPPLIER/SOURCE	FILM CART- FRAME NUMBER
DECODER/DRVR BCD-DEC	MON	MSI	TTL		IND		N7441	7441	CGW-SIGNETICS	-
DECODER BCD-DEC	MON	MSI	TTL	A	IND		N7442	7442	CGW-SIGNETICS	-
DECODER EX3-DEC	MON	MSI	TTL	B	IND		N7443	7443	CGW-SIGNETICS	-
DECODER EXCESS 3-GRAY-DEC	MON	MSI	TTL	A,F	IND		N7444	7444	CGW-SIGNETICS	-
DEC/DRVR BCD-DEC OC HV	MON	MSI	TTL	B	IND		N7445	7445	CGW-SIGNETICS	-
DEC/DRVR BCD-7 SEGMENT	MON	MSI	TTL	A	IND		N7446	7446	CGW-SIGNETICS	-
DEC/DRVR BCD-7 SEGMENT	MON	MSI	TTL	A	IND		N7447	7447	CGW-SIGNETICS	-
	MON	MSI	TTL	B			N7448	7448		-
	MON	MSI	TTL							-
... HV	MON	MSI								

Sample output of the system lists ICs by circuit function. The output also indicates the technology and packaging used, temperature range, name of the supplier and where the manufacturer's data sheet can be found.

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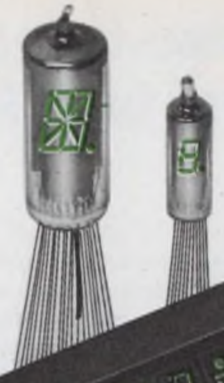

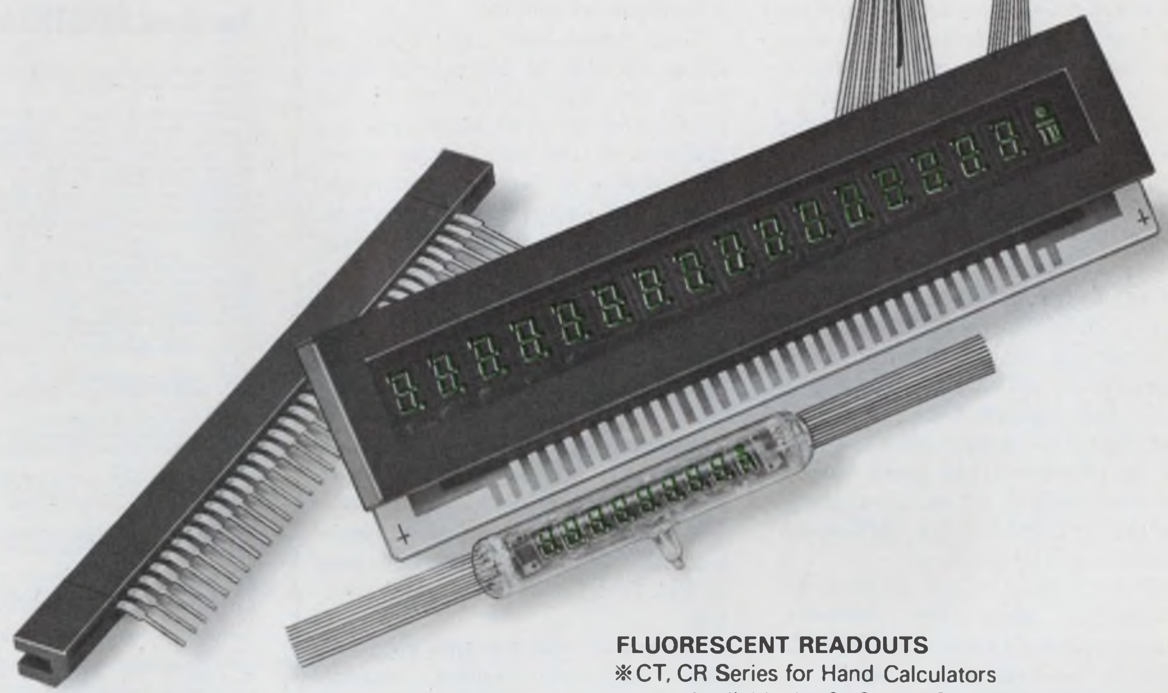

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INFORMATION RETRIEVAL NUMBER 21

Impulse-bonded wiring allows fast PC changes

A new method of impulse-bonded wiring is reported to reduce circuit-board fabrication costs substantially, permits rapid changes of wiring patterns during development and replaces multilayer boards—up to seven layers—with a two-sided PC board.

The bonding technique is automated. A tape-controlled machine routes the wires to the bonding points and produces accurate interconnection patterns in small areas.

Developed by the Bendix Navigation and Control Div., Teterboro, N.J., the concept was intended originally to solve circuit-board wiring problems that arose during the development of an all-weather landing system for the McDonnell Douglas DC-10 jetliner.

"During the DC-10 system development," says John Sobieski, manufacturing superintendent at Bendix, "we originally used multilayer boards. But to make developmental wiring changes required that the boards be drilled out where we didn't want circuitry between the layers. As a result, we wound up with a lot of expensive scrap and were also delayed in our development program."

To solve the problem, Bendix investigated conventional impulse-bonding wiring, because with this technique, changes can be made by rerouting wires along the surface of the board. However, that approach was not satisfactory, for a number of reasons.

Impulse-bonding system developed by Bendix uses Teflon-coated, nickel wire for PC board interconnections.

One reason was cost. With the usual method of impulse-bonding, holes are drilled in the circuit board, and stainless steel studs are inserted on the rear of the board. All bonding is done to these studs. With that approach a typical board costs about $65, Sobieski says.

"With our approach," he continues, "we've reduced the cost more than one-third by doing the bonding on the top, or component, side."

Bonding on the front side is advantageous because the board can be fabricated with standard methods of automatic component insertion and flow-soldering. The rear is left free for fault-isolation testing.

Also, with the top-side approach under numerical control, Sobieski points out, the wire can be routed between the ICs in a fairly uniform pattern on X and Y coordinates. From nine basic coordinate patterns, 80 to 90 different circuit boards can be developed, he says.

Standard PC boards are used

"We're the only ones using a standard PC board for impulsed-bonded wiring," Sobieski says. "Our system is basically a two-sided printed-circuit board with plated-through holes."

Bendix developed the bonding material—Teflon-coated nickel wire—and also modified conventional impulse-bonding equipment to obtain the performance required. An average of 50 feet of Teflon-coated nickel wiring is used to make some 500 bonds per board.

Two pressures are involved in making a bond. An initial pressure of about 9.5 pounds is applied to the nickel wiring to penetrate the Teflon coating and make the contact between the bonding electrode and the conductive PC pattern.

Wiring changes can be effected in 48 hours in contrast to several weeks for the multilayer boards, Sobieski says. ■■

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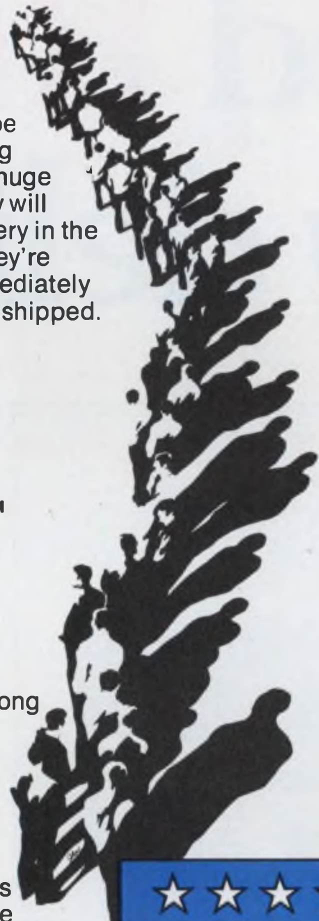

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INFORMATION RETRIEVAL NUMBER 23

washington report

Heather M. David
Washington Bureau

GAO scores Navy ASW sensor development

The General Accounting Office says the Navy erred in pushing the development of three aircraft antisubmarine warfare sensor systems even though testing indicated that there were problems with the systems. In one case an integrated magnetic airborne system that detects submarines by the change in the earth's magnetic field "will not satisfy its minimum performance requirements" until a new advanced processor is installed in several years, the GAO notes.

The agency also says that Congress might want to question whether the Defense Dept. is "putting appropriate emphasis on development of needed sensor capabilities," compared with the push it is putting on the production of new antisubmarine warfare aircraft. The Navy says it, too, is concerned about sensor development and is striving to meet the problem.

Army developing laser guidance for common projectiles

The Army is marrying some of its newest technology to some of its oldest, putting laser guidance on cannon-launched projectiles. The objective is to hit targets, such as tanks and armored personnel carriers, with the first round of fire before they can move to cover. At present the Army uses area-fire techniques or precision-fire methods, but is reported to get only marginal results. With the new weapon, a forward observer will illuminate the target with a narrow-beam laser when the projectile is approximately 10 seconds from the target. The projectile then homes in on the reflected laser energy. Two contractors are developing projectile models for competitive test-firing.

AWACS: A change in role and a new threat

Sen. Thomas Eagleton (D-Mo.) is mounting a new drive to keep the Air Force from putting the Airborne Warning and Control System (AWACS) aircraft into production as scheduled in fiscal 1975. General Accounting Office representatives have told the Senate Armed Services Committee that they have serious reservations about the program, particularly since Defense Secretary James Schlesinger has decided to use the huge aircraft for controlling tactical air operations rather than for detection and defense against Soviet bombers, for which it was originally intended. GAO says the tactical role will require considerable upgrading of the data-processing and communication capability of the system and will increase the unit price from $56.8-million to $73-million.

Eagleton also cites the GAO's conclusions that the aircraft may be extremely vulnerable in a hostile air theater, being subject both to enemy air action and to electronic countermeasures that might impair or black out its look-down radar system. The agency has recommended that the system be tested against the full spectrum of state-of-the-art electronic countermeasures to determine whether known counter-countermeasures are effective. The Air Force is asking $549.8-million for the first 12 planes plus another $220-million for continued research and development in fiscal 1975.

Nadar group challenges Government patent policy

Ralph Nader's Public Citizen, Inc., has sued in U.S. District Court for the District of Columbia in an effort to keep contractors from getting exclusive rights to any inventions they develop under Government R&D contracts. The suit is aimed at halting a new General Services Administration regulation that allows the granting of patents to such contractors. If the court rules for Public Citizen, it would affect aerospace and other military contracts. The National Aeronautics and Space Administration, however, would be unaffected; it has authority from Congress to waive rights to ownership and can grant exclusive rights to contractors.

FAA presses discrete-address beacon plans

The Federal Aviation Administration has begun briefing industry on the new discrete-address beacon system it wants developed to improve aircraft control in the next decade. The system, with ground sensors and airborne transponders, will make it possible for air-traffic controllers on the ground to interrogate and get a reply from one aircraft at a time instead of all in the zone of coverage. The FAA hopes thereby to eliminate problems of "synchronous garble," caused by the overlapping responses of several aircraft flying in close proximity. The agency says it will procure three engineering models of the system and a number of aircraft transponders.

Capital Capsules:

The Atomic Energy Commission's **program to make electricity from thermonuclear fusion has been stretched out three years,** making the new target date the late 1990s. The Office of Management and Budget has ordered the AEC to trim $140-million in the fusion research budget over the next five years, which will delay the program. . . . RCA has signed an agreement with the Alaska Pipeline Service Co. for two communications systems to support the Alaska pipeline. The first will be a $7-million interim system to be used during construction of the pipeline, the other a $23-million system to be ready when the pipeline goes into operation in 1977. . . . The Air Force's Home Air Development Center is asking industry **to submit its small-area radars for evaluation as possible sensors for protecting parked aircraft.** The radar must be able to detect intruders weighing 75 pounds or more. . . . The Commerce Dept. and the State Dept. are **considering negotiating an agreement with the Soviet Union that would protect U.S. patents prior to 1965.** They are now unprotected. A number of U.S. technology companies, interested in trade with the Soviet, have asked for the agreement. . . . The Senate has passed **a bill to establish an Office of Federal Procurement Policy.** It would establish uniform Government policies and regulations. . . . The FAA plans to develop a **prototype model of a new phased-array antenna** to upgrade present instrument landing systems at the nation's airports.

1000 cm/µsec stored writing speed, four storage modes, and more.

100 MHz oscilloscope
Tektronix 7633 oscilloscope gives you 100 MHz bandwidth and 1000 cm/μsec stored writing speed. So you can retain and view fast rise, low repetition rate, single shot or slow moving waveforms. All with one instrument. This allows you to solve problems in computer sciences, aerospace, ballistics, communications and various other applications.

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No special operating safeguards are necessary with the 7633's rugged, burn resistant CRT. This makes it a dependable unit for design bench, hospital laboratory, service facility or classroom. The large 8 x 10 div. CRT is easy to read in both cabinet and rackmount configurations. An alphanumeric readout, exclusive on Tektronix instruments, makes quick on-screen reference and easy interpretation of photographic records. Or, the instrument may be ordered without the readout for $400 less.

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Select from thirty different 7000 Series plug-ins. You can custom tailor your instrument to meet your immediate need. And expand its capabilities later as the need arises. A 7633 mainframe costs $3650. A typical configuration with dual trace vertical amplifier and delaying sweep timebase sells for $5,550. For rackmount add $100.

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Vertical System—Accepts all 7000 Series vertical amplifiers. Bandwidth determined by mainframe plug-in unit up to 100 MHz. Left, Alternate, Add, Chop, Right display modes. Chopped rate approximately 1 MHz.
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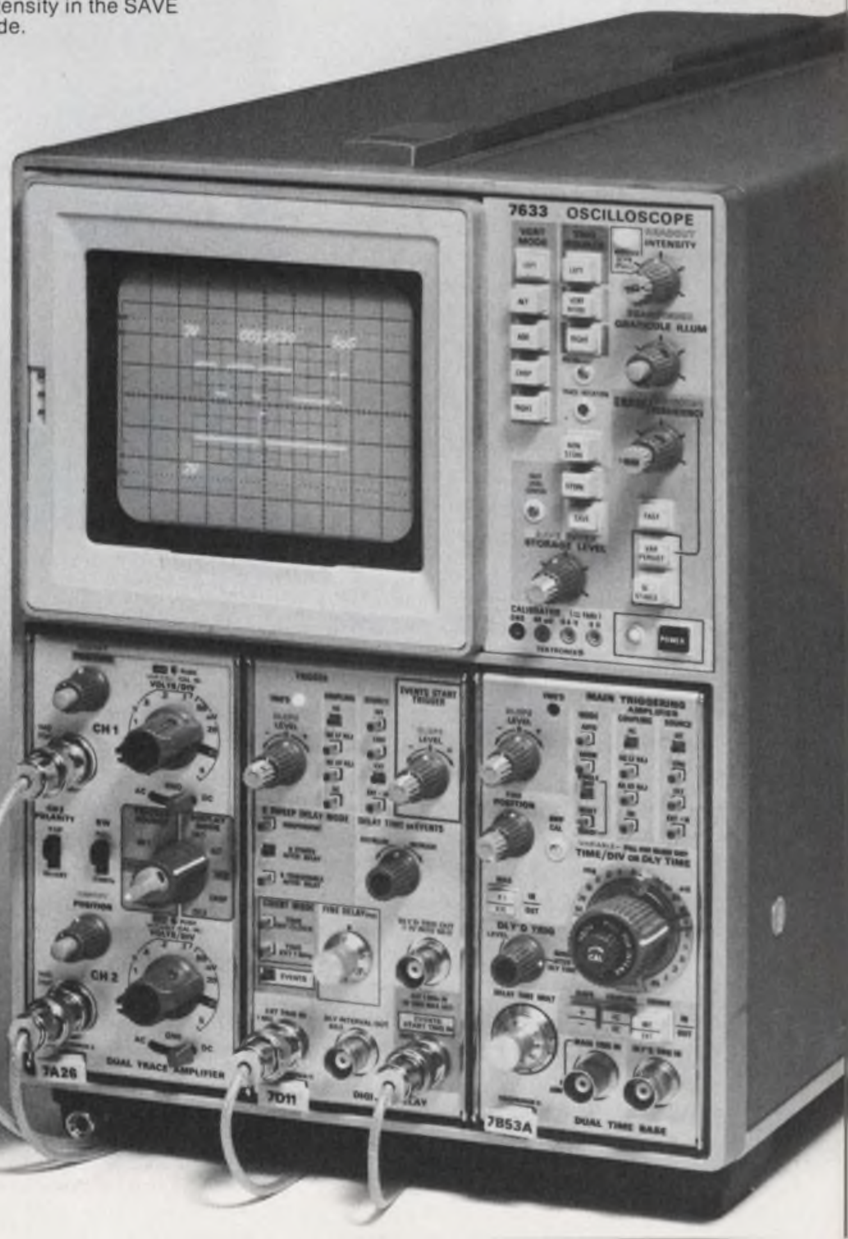

INFORMATION RETRIEVAL NUMBER 24
FOR DEMONSTRATION, CIRCLE 248

Centralab perspective:

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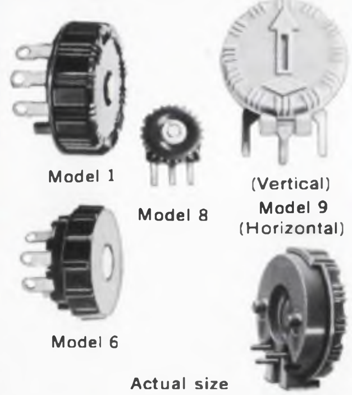

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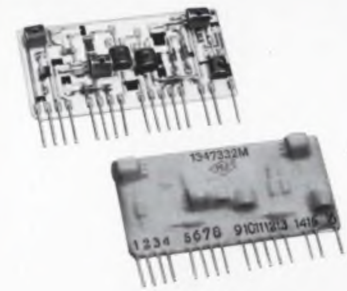

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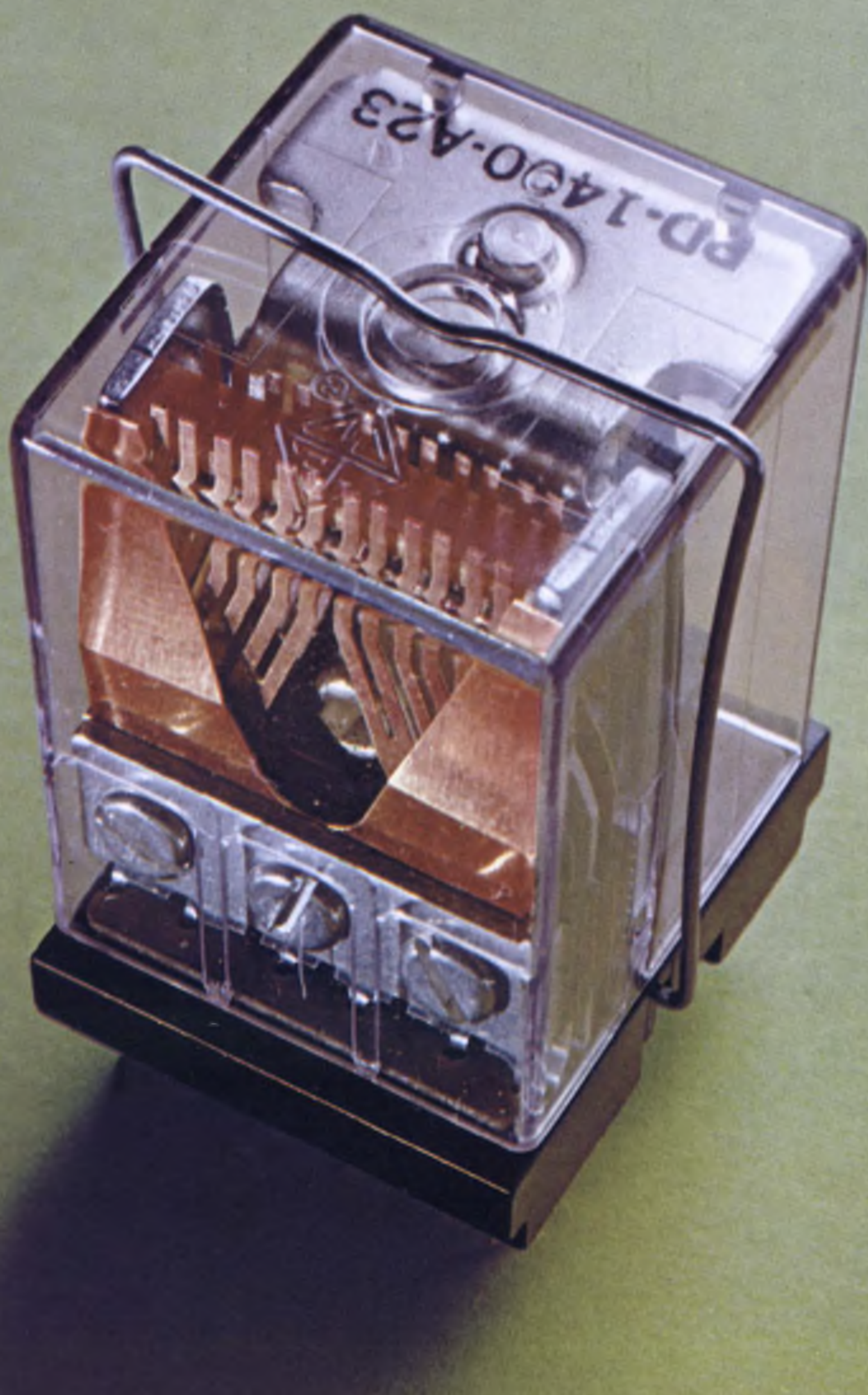
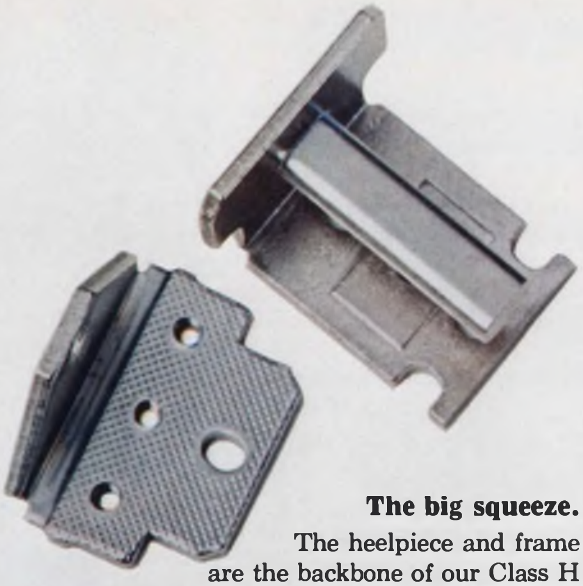
- Ratio Matching...............±1% minimum
- Capacitor Types..........Ceramic and tantalum
- Active Devices.......Diodes, transistors & IC's
- Operating Temp. Range... −55° C to +150° C

For Bulletin 1429H write A.R. Wartchow, Manager, Electroceramic Marketing. Outside U.S.A. contact J.H. Meunier, Manager, International Sales.

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.

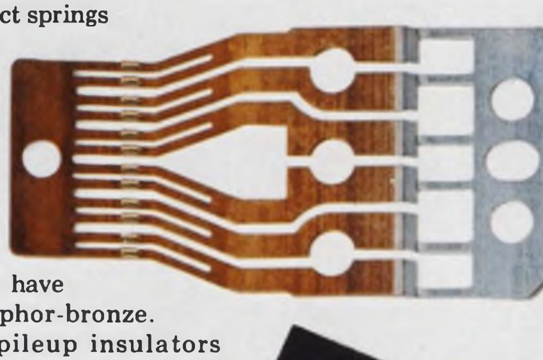
The heart of a relay is the coil. If ours looks different, it's because we build it around a glass-filled nylon bobbin. It costs us more, but you know how most plastic tends to chip and crack.

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.

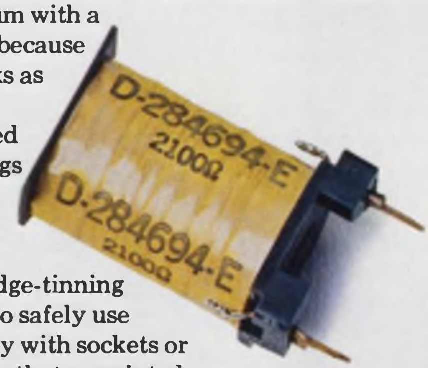
Other manufacturers just punch them out.

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 29

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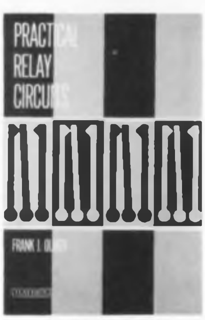

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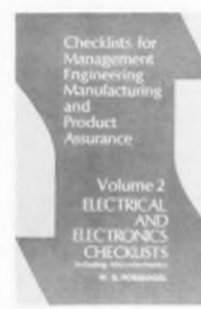

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Mr. Gordon Haley Manager, Systems Technology ICL Computer Development Div.	**Future Computer Technology**

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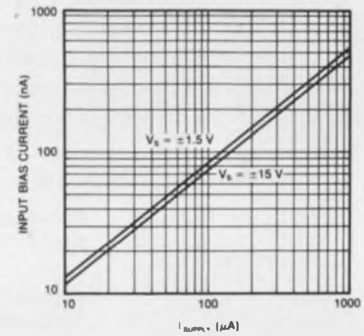

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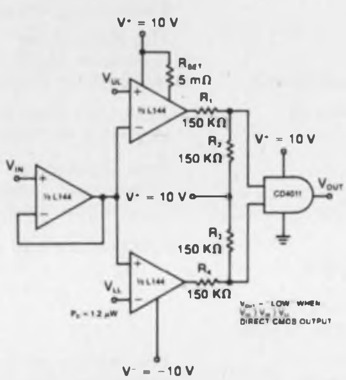

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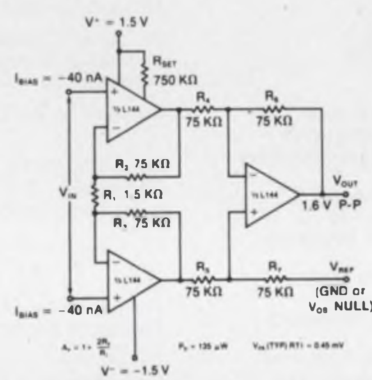

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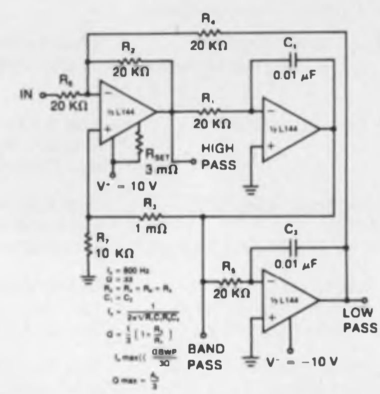

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INFORMATION RETRIEVAL NUMBER 30

editorial

We've changed.... haven't we?

Not too long ago the public's image of the typical electrical engineer was of a rather studious looking, crew-cut type who wore a white shirt, conservative bow tie, dark suit and white socks. He walked around the office with a rather dazed look, dreamily pondering the solution to some complex design problem, a slip stick in his hand, a fountain pen hanging from his belt. His perception of the world around him was generally limited to a quote or two from the local paper and discussions with his peer group. His political views were on the conservative side, his temperament mild.

An unflattering image, certainly. But perhaps containing enough truth so that this stereotyped image persisted for many years. Now we begin to see a change in the popular perception of the engineer. A lot has happened to our profession in the past decade. The engineer has been as much affected by the turbulent changes in recent years as has the public in general. Sideburns and collar-length haircuts have replaced the crew-cut. His mode of dress now includes Brooks Brothers and Bill Blass. The ballpoint pen has supplanted the fountain pen; the electronic calculator, the slide rule. But far more important than these outward trappings, the engineer today has become involved.

He finds that as a professional, he needs to keep up with current events as much as technology. He reads newspapers and magazines as avidly as the technical journals. He is concerned and is increasingly involved in politics, both on a national and local level. More and more he has begun to raise questions about company ethics and the by-products and end use of his designs. He has brought about considerable change—mostly for the better—in the professional societies. In short, the engineer of today is as different from his counterpart a decade ago as the microcomputer from the mainframe.

We don't claim that his expertise is necessarily any better than his predecessor's, but we think he's become a better engineer. Being involved has not only helped him as a person but has helped his profession as well.

Ralph Dobriner

RALPH DOBRINER
Managing Editor

Commercial Resistors Finding New Uses

Growing use in automotive, appliance and entertainment applications has prompted Dale Electronics, Inc., to expand production and shorten delivery of its entire commercial wirewound resistor line.

Dale currently manufactures low-cost uncoated wirewounds in axial and radial lead models as well as fireproof, potted versions of the same construction. Ratings up to 5 watts per inch are available in uncoated models. Potted styles are available in sizes from 2 to 10 watts and conform to EIA Standard RS 344.

For applications requiring tighter tolerances and/or environmental protection, Dale produces a complete line of industrial-grade wirewounds including solid core axial lead styles (CW) and tubular core lug and lead styles (HL). For complete information, contact Wirewound Division, Dale Electronics, Inc., Box 609, Columbus, Nebraska 68601.

CIRCLE 245

Wall Charts Aid Resistor Selection

Two comprehensive wall charts designed to aid in resistor selection have been published by Dale Electronics, Inc.

Divided into wirewound and metal film categories, the charts show a complete range of precision, industrial and commercial styles. Basic performance and dimensional specifications are shown for all models. Both charts are 17" x 24" and are available free of charge from Dale Electronics, Inc., Dept. 860, P.O. Box 609, Columbus, Nebraska 68601.

CIRCLE 246

High Value Metal Film Winning Design Favor; Delivery Shortened

For better resistor performance in upper value ranges formerly limited to carbon styles, many designers are specifying Dale Electronics' HMF metal film series.

These epoxy molded axial lead resistors are available with values up to 50 megohms and range in size from a subminiature 1/20 watt to 1 watt. They provide a standard tolerance of 1% plus controlled TC and excellent high frequency characteristics.

To respond to the demand for HMF styles, Dale has expanded its production facilities and is now offering shortened delivery times for popular models. Contact: Metal Film Division, Dale Electronics, Inc., Box 74, Norfolk, Nebraska 68701.

CIRCLE 247

Engineers disagree on cause of shortages,

spot check shows, but agree on how to work around missing parts and the more recent squeeze on energy and raw materials.

Dick Turmail, Associate Editor

Shortages are nothing new to producers and users of electronics. An ELECTRONIC DESIGN spot check shows that most designers and engineering managers have run into trouble getting components for well over two years now. They've been searching for substitutes, redesigning, dual-sourcing and delaying projects. As one engineer from California put it:

"Semiconductors and capacitors have been in short supply since the recession,. when the industry failed to stock up against a growing consumer demand."

What is new perhaps is that now designers are trying to work around two additional shortages: energy and raw materials.

'Politics' attacked by some

With few exceptions, most engineers and companies are of the same mind when handling their shortage problems. They are trying familiar tactics: searching for or developing their own substitutes, establishing new product lines, improving yields, controlling manufacturing waste, cutting over-all inventories and double-ordering high volume parts, reducing lighting and heating, and driving less. But there is a great difference of opinion as to what "shortage" is.

Some respondents think that the term is a misnomer. The problem, they insist, is "politics." There will be genuine shortages, a Midwestern engineer comments, "unless we allow capitalistic free enterprise to make the infinitely complex adjustments necessary, free of all unconstitutional Government intervention."

An engineering manager from Utah says it more bluntly: "The best solution to shortages is to stop the Government from telling us how many of what kind of a thing we can make, what we can charge for it and what we can pay our employees to make it."

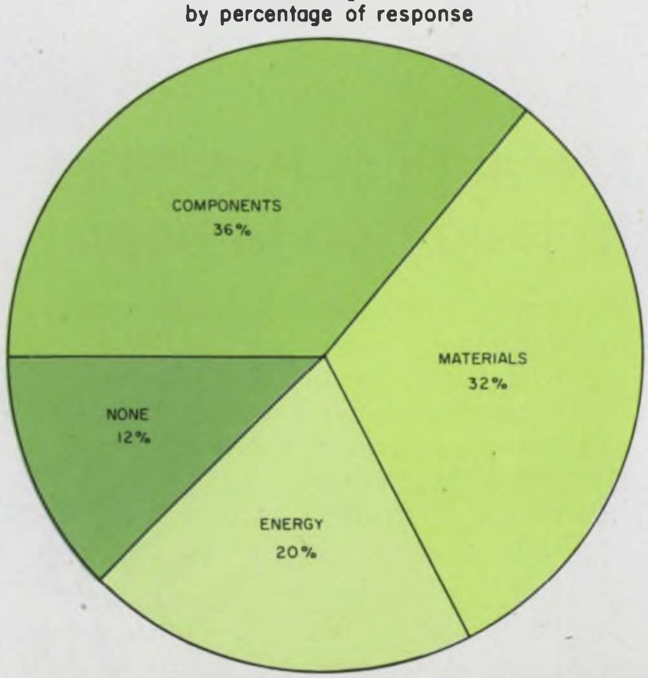
Another opinion from an engineer in Massachusetts is that "shortage does not require technological solutions but rather responsible Presidential and Congressional action to stop the huge outflowings of our basic resources and products."

Others think, as does one engineer from New Jersey, that "shortage is just another word for long delivery time and higher-than-usual prices." Still others believe that shortages are a design problem or a purchasing and inventory problem, and just as many respondents admit they don't know what to believe.

Some of the other more interesting findings of the spot check are these:

- Shortages are causing destructive side effects: fewer deliveries because of scarce gasoline supplies; bigger inventories that squeeze company cash flow; destruction of business in special products sold in small quantities at a quick turn-around.
- Though two of every three companies are looking for component substitutes, only one in 10 is actually developing its own.
- Few companies are laying off employees because of shortages.
- One of 10 respondents reports that his com-

Shortages
by percentage of response



pany has no shortages at all.

- In general, the larger the company the harder it is to maintain a normal supply of energy; the smaller the company, the harder it is to get components.

Shortages: What—and how long a wait?

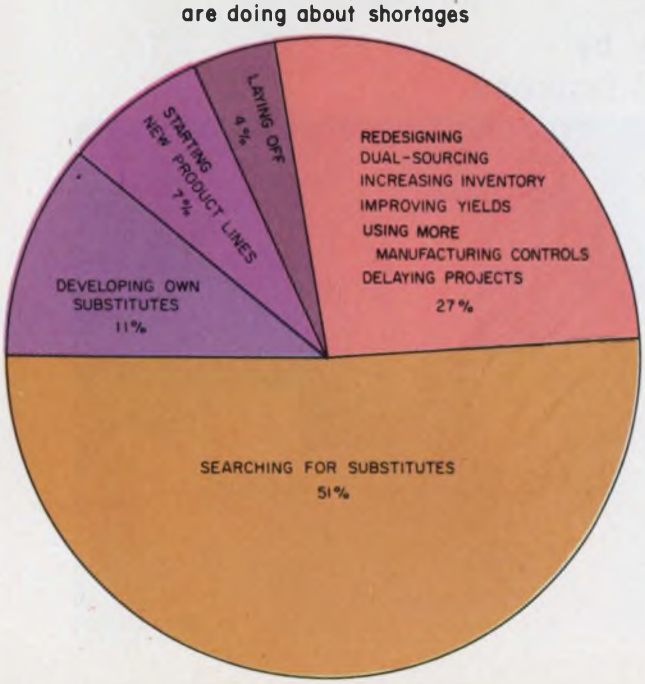
While the parts shortage is not limited to any one region of the country, the size of the company may make a difference. According to the ELECTRONIC DESIGN poll, nearly 60% of those companies grossing less than $24-million annually are having more trouble finding components than their larger competitors. Many respondents who work for young companies grossing less than $10-million say that because of their company's size, it's often impossible to compete with larger manufacturers on volume orders. And because the company is young, it is often low on the distributor's list of preferred clients.

However, the spot check found that larger companies were having shortage problems, too. About one-third of the companies that gross $100-million and more are having trouble getting enough electricity, fuel oil, gasoline and natural gas, probably because they use more than smaller companies.

What components are the hardest to get and when can you get delivery?

The components in shortest supply are ICs, transistors, electrolytic and ceramic capacitors and metal-film resistors. There's also a shortage of switches, relays, zeners and gold-plated connectors.

What companies are doing about shortages



Deliveries for most ICs are reported to take from two weeks to a year. It reportedly takes two weeks to six months to get most memories and military op amps, and deliveries for transistors—mostly small-signal (plastic), power and FETs—can take up to six months, with shorter lead times for small-signal, metal transistors.

Resistors are shipped a little sooner—usually in six to 20 weeks for fixed carbon types and fixed and variable wirewounds. But there are waiting periods of up to 45 weeks for fixed, metal film resistors.

The wait for capacitors can be from one month to a year if you want electrolytic, ceramic and tantalum types. If you prefer mica or film and paper capacitors, your wait is generally shorter—from one to five months.

Prescriptions for shortages

What do respondents suggest as a hedge against semiconductor and component shortages? One engineer from Ohio says: "Take two days to design instead of one, and spend the second day cutting your circuit in half."

An engineer from Florida suggests that it's helpful to "get vendors to quote honest deliveries so that the designer can design around known shortages."

Another engineer from Massachusetts offers an innovative material control system, with point-of-sale terminals at the stock room and an interactive, on-line management information system in purchasing. "But purchases must be made at just the right time," he advises.

A New Yorker suggests that large-quantity deliveries of components to single companies be reduced. Instead, he would set up smaller-quantity deliveries to a greater number of companies. His reasoning is that quantity requirements do not indicate immediate use—a large delivery may sit on the shelf when some small company may need only a small quantity to support its production requirement.

Raw materials that respondents have trouble getting are paper, ceramics, solvents and many metals, including copper, brass, steel, zinc alloys and especially aluminum. There's no apparent national shortage of aluminum, but it takes great amounts of electricity to make it, and there's a shortage of electric power in some areas. The U.S. imports 81% of its aluminum supply, but a rise in the price may encourage an increase in domestic production.

Petrochemicals are also high on the respondents' list of hard-to-get raw materials, including vinyl, nylon, polystyrene, polyethylene and particularly plastics used for circuit boards and many electronic components.

Some relief is in sight. Fewer new automobiles are being built, and they require about 150 pounds

Respondents' profile

ELECTRONIC DESIGN's spot check is based on responses to a questionnaire published on p. 42 in the Jan. 18 issue. Besides the categorizing questions of title, location, company size and industry, the questionnaire asked:

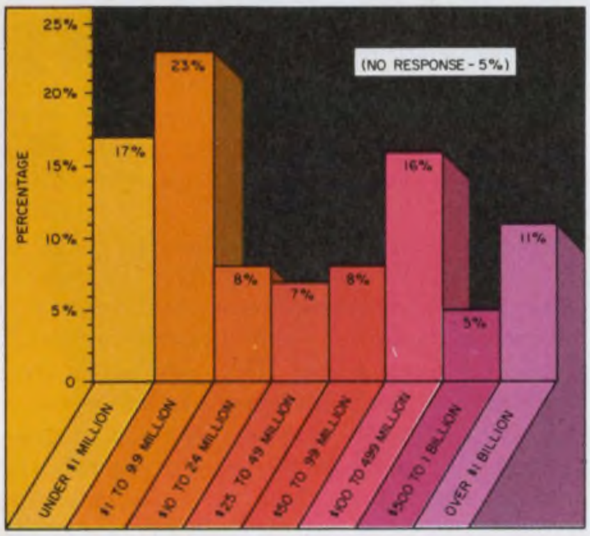
- Is your company experiencing shortages now? If yes, please specify.
- What is your company doing about its shortages?
- If your company is not currently experiencing shortages, does your management expect shortages in the future? If so, when?
- Please include technological solutions on how to deal with shortages.

Detailed replies came from 75 engineers and 25 managers in 32 states. Over half of the response was from California (14%), Massachusetts (13%), Texas and New Jersey (9% each), and New York (6%).

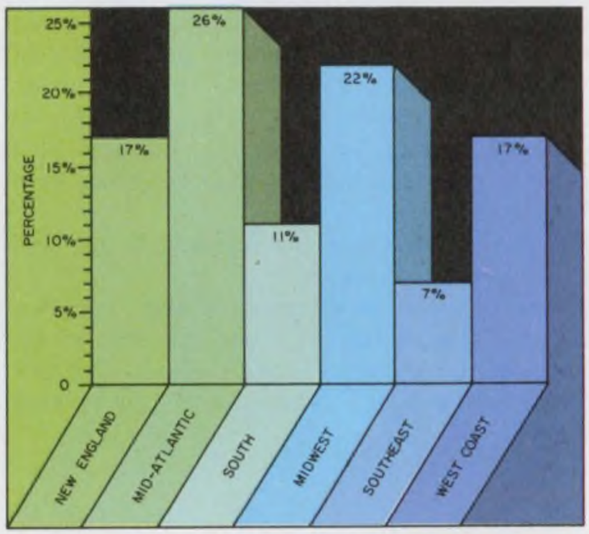
Two of every five respondents work for companies that gross under $10-million annually, and one of every three for a company that grosses $100-million or more.

Over half of the respondents work in communications, an industrial company, for the Government or in aircraft and/or aerospace. The remaining 45% are well spread in seven other electronic industry categories.

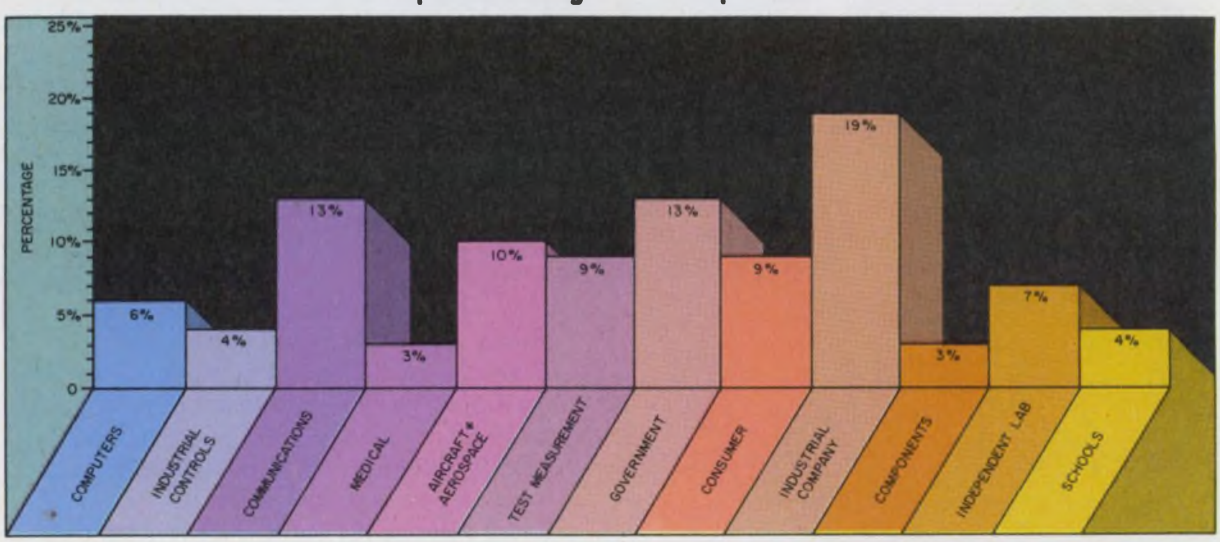
Company size by percentage of response



Location by percentage of response



Industry by percentage of response



Shortages by location

	NEW ENGLAND	MID-ATLANTIC	SOUTH	MIDWEST	SOUTHEAST	WEST COAST	SOUTHWEST
ENERGY	26%	21%	33%	13%	25%	14%	22%
COMPONENTS	37%	40%	27%	34%	50%	49%	22%
MATERIALS	30%	33%	40%	44%	25%	23%	34%
NONE	7%	6%	NO RESPONSE	9%	NO RESPONSE	14%	22%

Shortages by company size

	UNDER $1 MIL.	$1 TO 9.9 MIL.	$10 TO 24 MIL.	$25 TO 49 MIL.	$50 TO 99 MIL.	$100 TO 499 MIL.	$500 TO 1 BIL.	OVER $1 BIL.	GOV'T.
ENERGY	9%	14%	NO RESPONSE	16%	14%	32%	27%	32%	50%
COMPONENTS	49%	49%	58%	33%	28%	26%	37%	26%	17%
MATERIALS	27%	33%	42%	43%	35%	21%	27%	42%	33%
NONE	15%	4%	NO RESPONSE	8%	23%	21%	9%	NO RESPONSE	NO RESPONSE

of plastic for each car; this will free some petrochemicals for use in electronic components. Also, the Federal Cost of Living Council decided in February to exempt most petrochemical feedstocks from Phase IV price regulations. There won't be any immediate turn-around, but the action should free more materials over the long range. Prices will go up initially—about 10% to 15%, it's estimated—and then follow the price of oil.

Ideas on conservation

On energy conservation, some respondents have their own ideas. An engineer from Michigan says: "To reduce heating-oil use, we are circulating building air through the molding machine's cooling system; in summer, we'll exhaust this warm air."

Another engineer from Michigan suggests computer monitoring and control of the gas generator and furnaces for efficient operation. An Alabaman thinks that solar power and geothermal energy should be used where available—even windmills, he said, are a viable source of electrical energy in most parts of the country. One Texan submits his theory for a thermal energy converter:

"Make a large thermopile by bonding together strips of alternate dissimilar materials (perhaps carbon and silicon carbon) like the pleats of an accordion."

Another engineer from Texas suggests using street lighting that's activated only by passing auto headlights, and time-delay switches to turn off hotel passageway and office hallway lighting after use. Also, more use of fluorescent lights instead of incandescent is suggested. An engineer from Massachusetts advises using precipitators to clean coal smoke, so coal can be used more freely.

Many respondents suggest that saving fuel is basically a measurement and control problem; that electronic controls can be used for heating, lighting and air-conditioning, and that alternative energy systems, such as solar and geothermal, will require instrumentation and controls.

But which comes first? The component, the energy, the raw materials? Or the control and instrumentation? ■■

John Donohue's "blue line" turns out keyboard switches faster than you can say Oak.

John Donohue, Director of Manufacturing here at Oak, is mighty proud of his "blue line." He ought to be. It's the most sophisticated fully-automated keyboard switch assembly facility in the industry. It was designed with the customer in mind. We wanted to make sure we'd be able to meet his demands for huge quantities of our popular keyboard switches.

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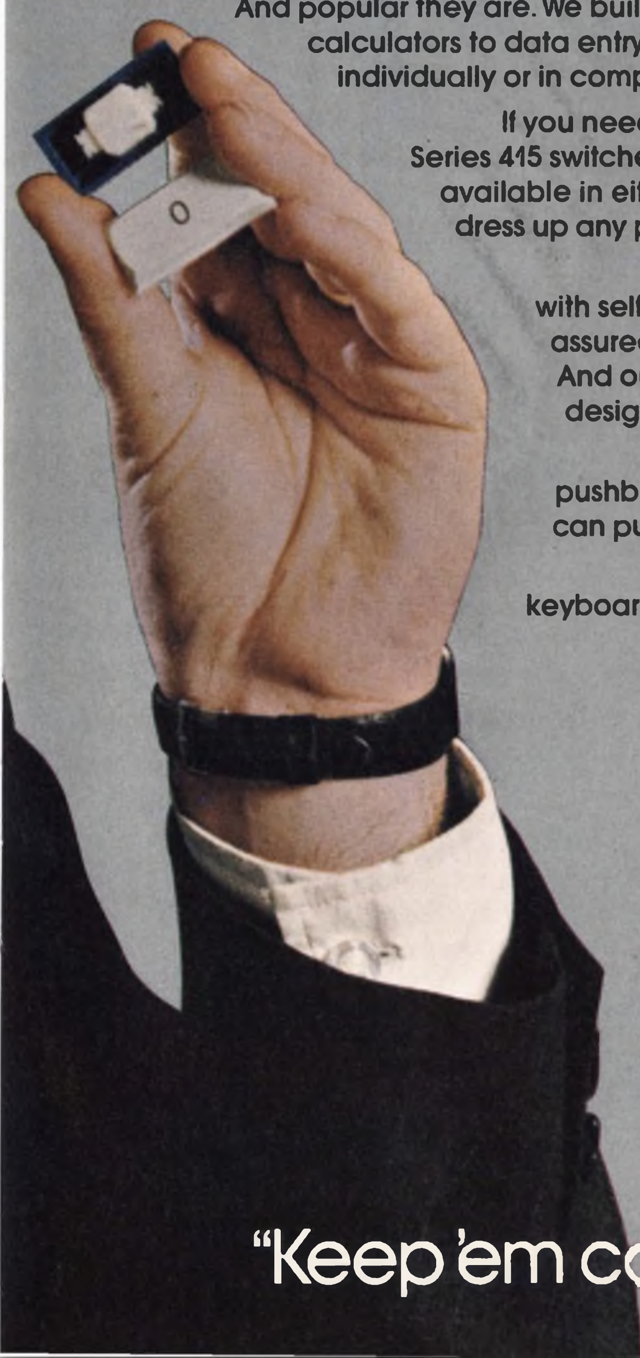

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"Keep 'em coming, John"

MOS/LSI microcomputer coding: It involves loaders, assemblers and even compilers. Use these and other tools to store algorithms in the system's memory.

Second of three articles

Engineers who incorporate MOS/LSI microcomputers in their designs face a critical need: conversion of system algorithms into instructions that can be loaded directly into the system's memory.

IC manufacturers are giving more and more attention to this phase of design, generally called coding, with improved tools and techniques to simplify the designer's task.

The basic tools available are these:

- Assemblers.
- Editors.
- Loaders.
- Compilers.
- Microprogramming.

Fig. 1 shows the primary function of the first four tools. In addition hardware or software simulators are available for program testing and error locating.

Assembly language: the most appropriate

An assembly language, the most common for microcomputer programming, has these features: symbolic operation codes; labels that refer to memory locations—instruction or data; and symbolic names for operands, such as registers, condition flip-flops and test conditions of conditional instructions (Fig. 2).

For example, in the Fairchild PPS-25 the instruction[1]

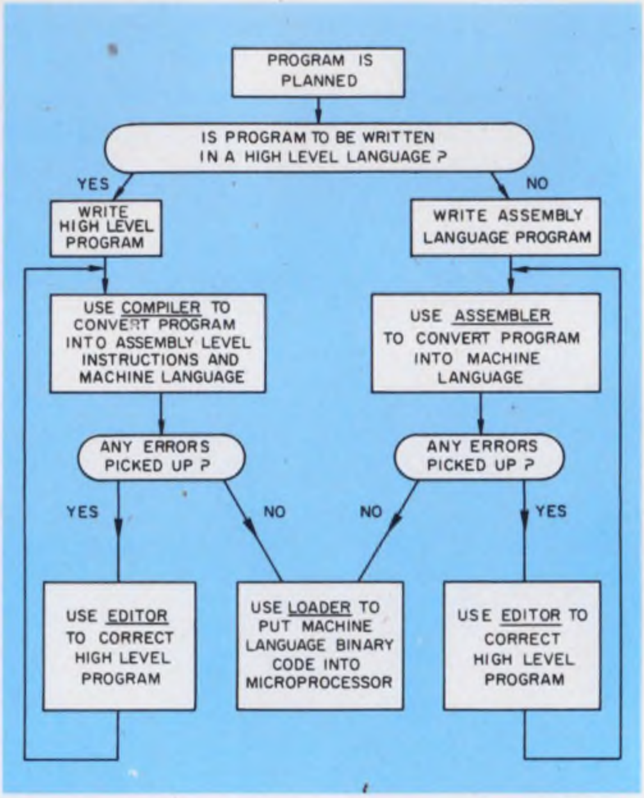
$$(R_{ij}) \leftarrow (A_j) + (R_{kj})$$

replaces the contents of register R_i with the sum of the contents of the accumulator and register R_k. However, only a designated field, j, in each register is involved in the addition. The Fairchild assembly-language equivalent reads

ADD Y, X, T.

Here Y represents the name of a destination register, X the name of a source register and T a previously selected code that represents the field over which addition is to take place. The

C. Dennis Weiss, Ph.D., Member of the Technical Staff, Bell Telephone Laboratories, Holmdel, N.J. 07733.



1. **Preparation of the binary code** to be placed in read-only memory can be simplified by use of a compiler or assembler and an editor and loader.

possible codes of T, with their meanings, include the following:

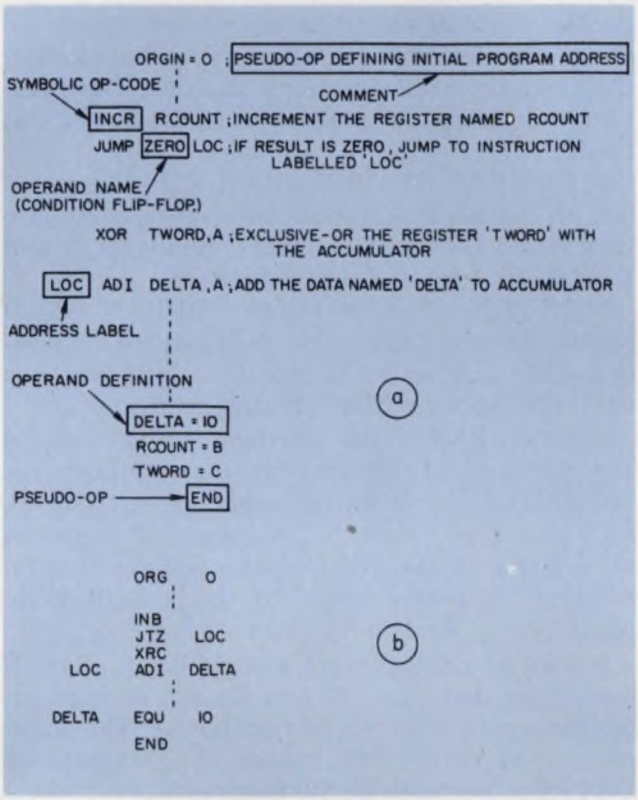
TOTAL:	Total field,
FRAC:	19 (left-most) digit fractional or mantissa field,
LSD:	Least significant digit,
PFIELD:	Digit selected by pointer register.

In the Intel 8008, consider this conditional CALL instruction: PC↓S and (PC) ← 14 bit immediate field, if condition holds; otherwise do next instruction. PC refers to the program counter and S represents a last-in, first-out stack.

Such an instruction in the Intel assembly language is written

CTX PLACE.

X refers to C, Z, P or S, which mean, respective-



2. **Part of an assembly-language program** (a) illustrates the basic language features. The same program segment appears in the Intel 8008 assembly language (b).

A line of source tape

`LD ACϕ ,@.+10`

This says LOAD register ACϕ indirectly, through the address given by adding 10 (octal) to the current value of the program counter (denoted by·)

A line of the list tape

`10 000 9109 LD ACϕ ,@.+10`

10 = line number in assembly language program (on source tape)
000 = location of the instruction
9109 = hexadecimal representation of the 16-bit machine language word
LD ACϕ, @ .+10 = assembly language statement written by programmer on source tape

A line of the object tape

`1001000100001001`

This is a 16-bit machine language equivalent of the instruction above.

3. **The assembler,—a program,—converts a source tape** to a list tape and absolute object tape in this example from the National IMP-16.

ly, Carry = 1, Result Zero, Parity Even and Sign Bit 1. PLACE is the label associated with any other instruction in the sequence being assembled.

Hence the statement

CTP STEP1

causes the microcomputer to call STEP1 conditionally. The processor saves the program counter and replaces it by the address labeled STEP1, if the parity of the register last operated upon was even. Otherwise the instruction that follows would be executed.

The sequence

```
INB
CFP  STEP1
JMP  STEP2
```

increments register B, calls to STEP1 if the parity of register B is odd or performs an unconditional JUMP to STEP2 if the parity is even.

The assembler can read a source tape or file with statements written in the symbolic assembly language (Fig. 3). Also, the assembler can construct various tables from the source file and produce an output object tape, or file, with binary numbers for the microcomputer.

For example, in the Fairchild PPS-25,

ADD B,C, FRAC

appears in the object code as

000100101010.

From left to right, 000 is the operation code for ADD; 100 is the Fairchild code for the B register; 101 is the code for the C register, and 010 represents the mask-programmed code to select the left-most 19-digit field of a register.

```
        NUMBERS OCTAL
        ORIGIN 0
ENTRY 1 LOAD R1, MEM 1
        LOAD R2, MEM 2
* * *   'LOAD' IS UNDEFINED OP-CODE * * *
ENTRY 1 COMPARE R1, R2
* * *   DUPLICATE ADDRESS LABEL * * *
        JCOND PLACE
* * *   'PLACE' is UNDEFINED ADDRESS
        LABEL * * *
* * *   OPERAND MISSING * * *
        JUMP FINISH
        STORE R1, MEM; if R1 > R2, EX-
        CHANGE
* * *   'MEM' UNDEFINED * * *
        STORE R2, MEM 1
FINISH  HLT
* * *   'HLT' IS UNDEFINED OPERATION * * *
MEM 1   = 1732
MEM 2   = 1840
* * *   NUMBER IS INVALID OCTAL * * *
          END
```

```
        NUMBERS OCTAL
        ORIGIN 0
ENTRY 1 LOAD R1, MEM 1
        LOAD R2, MEM 2
ENTRY 2 COMPARE R1, R2
        JCOND GREATER, PLACE
        JUMP FINISH
PLACE   STORE R1, MEM 2; if R1 > R2, EX-
        CHANGE
        STORE R2, MEM 1
FINISH  HALT
MEM 1   = 1732
MEM 2   = 2040
        END
```

4. **An assembler provides error messages** that start with "***" in a program with errors (top). The corrected program appears at the bottom.

For the Intel 8008,

CTP STEP1

appears as the 3-byte instruction,

01111010
00110000
xx001110.

STEP1 is assumed to be an instruction stored at binary location 00111000110000. The last two bytes give, respectively, the low 8 and high 6 bits of the address. The bits marked x are "don't cares" for the 8008. The assembler could substitute any bit pattern, since the machine ignores these locations.

The assembler—a program

The assembler is a program that must be run on some computer. One assembler program—from Intel—can be loaded into several pROM or ROM chips and executed by a microcomputer of the type for which it is assembling. These are called "hardware assemblers," because they run on the hardware itself.

A more common situation is one in which the assembler itself is written in Fortran. With minor modifications, the program can be run on any computer that compiles Fortran programs. Thus the designer prepares source programs, assembling them on some other computer, to obtain the object tape for the microcomputer. The Fortran-written assemblers are often made available to users through various national time-sharing, computer-service companies.

Assemblers contain pseudo-operations

Assemblers provide more sophisticated features. These are usually pseudo-operations, or assembler instructions, that do not assemble into microcomputer instructions directly but control the assembly of instructions that do. The more significant and common psuedo-ops are as follows:

- NUMBER SYSTEM (B,O,D). If B is written, all literals that appear in operand fields are interpreted as binary numbers. Similarly O and D establish octal and decimal modes.
- ORIGIN. The statement ORIGIN 256D causes the next instruction to be stored at location 256 (decimal). Consecutive locations are used until another ORIGIN statement appears.
- COMMENTS. It's common to intersperse English text in a source file that contains assembly language. With the selection of a symbol, such as "/" or ";" or ":", the assembler ignores all symbols to the right of the selected one on each line of source text. But the assembler reproduces the symbols in the final list file.
- EQUAL. A statement such as R1 = PLACE establishes that PLACE, and R1 can be used interchangeably as names of register R1. The statement DATA1 = 53D causes the contents of DATA1 to be taken as 53 (decimal).
- DATA GENERATING STATEMENT. A statement such as TABLE D 7, 53, 29 creates three data words stored in successive locations in memory. The first location is labeled TABLE.

Assemblers give error messages

The ability of assemblers to detect and point to a variety of errors in source statements is one of their most valuable features (Fig. 4). These errors are syntactic—they deal with misuse of the actual language. Assemblers normally cannot catch logic errors in the program, errors of intent or other subtle problems. A statement that contains an error is printed in the list file with a code letter—a flag—beside it. Or the entire error message may be printed.

Some common errors that can be detected include duplicate address label, undefined label and unrecognized instruction mnemonic (due perhaps to the misspelling of an operation code). Other detectable errors include undefined operand field names, wrong number of operands and an invalid number in the number system chosen. In addition an assembler could be made to detect the error of an address referred to the same ROM page, as in a short JUMP when a long JUMP is required.

Not all errors of syntax are flagged in current microprocessor assemblers. For example, when the labeled address for a JUMP or CALL instruction is not the start of an executable instruction, the error is not generally detected.

A macro facility—a deluxe feature in assemblers—is very useful when similar sections of code are used repeatedly but variations preclude the use of conventional subroutine techniques. A macro consists of a sequence of code or a routine that is defined with such parameters as data values, addresses, labels or even instructions. An expansion of a macro involves a specific copy of this sequence in which all parameters have assigned values.

For the assembler to produce an expansion of the macro, only a single statement need be written—if you assume that the macro definition has already been given to the assembler. This statement appears at the location at which the expansion is to begin, and it contains a list of the values to be assigned. The assembler creates the complete expansion where requested.

Editors make changes

Editors are interactive systems that allow designers to prepare a program, or text, and to make changes with simple commands. Time-sharing services, which provide remote access to microcomputer assemblers, have such editor systems. Hence designers can prepare assembly-language programs and correct them. They can add documentation and store, combine and retrieve programs. And they can output programs onto paper tape and printers with relative ease.

Once a program has been written, assembler-flagged errors corrected and a binary object tape, or file, created, the program must be loaded into the memory of the microcomputer system.

Assembled programs can be loaded into mask or field-programmable ROMs. They can also be loaded into RAMs, in which case a small bootstrap loader is required. The latter may be a minimal program loaded into several ROMs or pROMs. This bootstrap program has just enough capability to read an object tape of a complete loader program, which is placed on a tape reader under microprocessor control. More often, the bootstrap loader contains the entire loader program, and all RAM space is available to load the application program.

Application programs can be conveniently tested in RAM before they are committed to ROMs or pROMs. However, if they are to be used in RAMs in the final system, a startup or restart procedure is needed. The procedure permits bootstrapping of the microcomputer into operation. A permanent loader is required in read-only memory.

A PL/M statement

```
DECLARE (X,Y,Z) BYTE; IF X > Y THEN Z =
   X - Y + 2; ELSE Z = Y - X + 2
```

An equivalent set of assembly language statements for the Intel 8008

```
          ORG 4000
BEGIN     LLI LOW X
          LHI HIGH X
          LAM;          accumulator contains X
          LLI LOW Y
          LHI HIGH Y
          LBM;          B-register contains Y
          SUB;          Subtract B-register from
                        accumulator
          JTS LOC2;     if result negative, jump
                        to LOC2.
LOC 1     ADI 2;        add 2 to accumulator
          LLI LOW Z
          LHI HIGH Z
          LMA;          store answer in the loca-
                        tion for Z
          JMP FINISH
LOC 2     LCI 377
          XRC;          accumulator bits
          ADI 1:        complemented
                        2's complement of X-Y in
                        accumulator
          JMP LOC1
FINISH    HLT
LOW X     EQU 70;       word address of X
HIGH X    EQU 10;       page address of X
LOW Y     EQU 71
HIGH X    EQU 10
LOW Z     EQU 72
HIGH Z    EQU 10
          ORG 4070
LOC X     DEF 0;        X = 0 initially. Value as-
                            signed elsewhere
LOC Y     DEF 0;        Y = 0 initially
LOC Z     DEF 0;        Z = 0 initially
```

5. **A short, readable compiler statement** corresponds to many assembly-language statements.

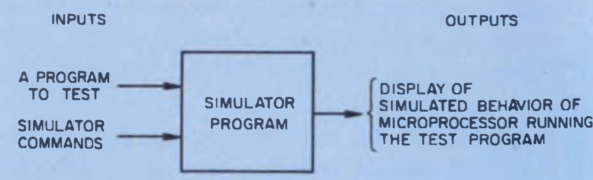
Advanced loader features

The most elementary binary loader simply reads successive words on the object tape and writes them into successive locations of RAM memory. The loader generally starts at a fixed origin. A relocating loader is more complex and not generally available. The reloading loader uses a special object tape and the desired origin data to automatically adjust the program addresses and load the resulting binary instructions.

With a basic binary loader, the same flexibility can be achieved by reassembly of the original source tape or file, but with a change of the ori-

- Errors in basic system design
  - difference between intended or desired operation and that achieved
- Errors in basic algorithms
  - incorrect algorithm
  - wrong strategy
  - algorithm takes too long to execute
  - arithmetic accuracy or precision unsatisfactory
- Errors in implementation
  - logic error
    - off by one count
    - conditions reversed
    - data stored in wrong order
    - microcomputer hangs up in a loop
    - data destroyed by overstore
    - wrong register used
  - coding errors
  - wrong instruction
- Errors in hardware
  - marginal operation
    - races
    - propagation delays too great
  - wiring error
  - interface signals incorrect
  - peripheral device operated improperly

6. **Many potential sources of error** exist in a microcomputer design.




```
EXAMPLE
  INPUT TO SIMULATOR
    The program itself (machine language in-
      structions produced by an assembler)
    A list of simulator commands
      SET PC = 0, REGISTERS R1 = 1, R2 = 1,
        R3 = 1
      SET MEMORY LOCATIONS MEM (100)
        TO MEM (150) = 0
      STOP SIMULATION AFTER 20 INSTRUC-
        TIONS
      DISPLAY REGISTERS R1, R2, R3
      DISPLAY MEM (100) TO M (103)
      DISPLAY OCTAL
      START
  OUTPUT OF SIMULATOR
      R1 = 5   R2 = 10   R3 = 73
      MEM (100) = 0
      MEM (101) = 377
      MEM (102) = 264
      MEM (103) = 113
```

7. **Commands to a simulator** allow designers to verify that a program is correct.

gin using a suitable ORIGIN pseudo-operation.

Another feature of more advanced loaders is linking capability. Here program segments or routines with undefined labels or names can be loaded. The loader supplies missing cross references between the separate routines. Again, this feature can be achieved by reassembly of the entire collection of programs.

Compilers translate languages

A compiler is a program that accepts as input data another program, written in a so-called source language. The compiler then outputs another program, written in what is called the target language. The latter can be either the assembly language or a machine language.

The source language is usually a high-level language, in which the instructions or commands are much more powerful than those of the target language. Examples of source languages are FORTRAN, COBOL, APL, ALGOL or PL/1.

Compilers make the programmer's job easier because they provide a language that requires fewer statements for an algorithm. Compilers eliminate the need to write detailed codes to control loops, to access complex data structures, or to program formulas and functions.

For example, a compiler from Intel has a subset of PL/1 instructions as its source language. The subset language is called PL/M.[2] An example from PL/M illustrates the powerful nature of the source-language instructions:

```
DECLARE (X,Y,Z) BYTE;
IF X > Y THEN Z = X – Y + 2;
ELSE Z = Y – X + 2.
```

The PL/M statements are converted by the compiler into a sequence of assembly-language instructions. The instructions compute Z after they test to see if $X > Y$. If X is bigger, then $Z = X - Y + 2$ is computed. If $X \leq Y$, then $Z = Y - X + 2$ is computed. X, Y and Z refer to the contents of three, single-byte locations established by the DECLARE statement.

Fig. 5 shows an equivalent sequence of instructions written directly in the assembly language of the Intel 8008. Notice how much more difficult the instructions are to understand, despite the comments. And notice the increased amount of writing required, even without comments.

The use of higher-level languages has its limitations. Although errors may be reduced because of the lessened detail, new problems can be caused by failure to understand all the conventions built into the compiler. There is also invariably some loss in efficiency in compiler-generated code.

If you rely too heavily on a compiler, your mode of thinking may be too far removed from the actual microcomputer capabilities. While programs are compact, easy to read and much easier to write, the net result may be excessive storage space and slower execution.

One solution is to write routines that are typical for an application in both the compiler's source and assembly languages. The comparison helps to determine any loss of efficiency and how significant the loss may be.

A compiler that produces assembly-language code—and not simply machine-language words—permits the use of an assembly listing for tests and verification. Also, such a compiler lets the designer eliminate redundant data movement.

Microprogramming tailors designs

Some microcomputers—the National GPC/P,[3] for example—can be tailored to design requirements through use of a mask-programmed control ROM. In effect, the designer can choose, within limits, the basic machine-language instruction set if he writes the microprogram.

This flexibility simplifies use of a microcomputer as an emulator of another computer. The instruction set of the other computer is microprogrammed into the microcomputer control ROM. Execution of a program instruction corresponds to selection of the equivalent microroutine.

Microprogramming can also be used for critical, short routines in applications where speed is of the essence. The routines can be executed faster when written in the basic control language of the microcomputer. A single machine-language instruction triggers the routine.

The microprogram instructions are more elemental than the usual machine-language instructions. Each instruction controls limited, simple operations in the microcomputer. A sequence of instructions is required for most machine-language instructions. Hence many instructions are required for an entire computational routine.

Simulator tests programs

Many potential sources of error exist in a microcomputer program of even modest complexity (Fig. 6). A software simulator provides one of the most useful tools for testing programs.

Input data to the simulator consist of an assembled program, or object file, written for the microcomputer. In addition various commands are available to control the simulated execution of the program (Fig. 7).

The simulator output contains representations of the contents of various registers, flags and memory locations. These are shown as they would appear inside the microcomputer. The simulator commands allow designers to obtain selected outputs at simulated instants. A listing of simulator commands similar to those for the Intel 4004 and 8008[1,5] appears in Fig. 8.

As with all computer systems, microcomputer program libraries are beginning to form, with contributions from vendors and users. A brief listing of frequently used programs appears in Fig. 9. ■■

- Start simulation.
- Stop simulation after a given number of cycles of simulated instructions.
- Stop simulation when the processor reaches a specified instruction or memory location.
- Stop simulation when the contents of a specified memory location are altered.
- Display any registers, flags, program counter, stack contents, I/O ports, or memory locations specified in a command and range-list.
- Trace the simulated microprocessor by displaying elements such as registers whenever an instruction is fetched from the memory region specified in a range-list.
- Display the number of instruction states used by the microprocessor since the last simulator initialization.
- Set specified memory locations, registers and I/O ports to specific values to initialize a run.
- Interrupt the simulated microprocessor and force a CALL instruction.

8. **A variety of simulator commands** is available to test microcomputer programs.

- Hardware exercisers
- Test programs for RAMs
- Logic subroutines for microcomputers which do not have basic logic type instructions
- Decimal arithmetic routines
- Transcendental function routines
- Data format conversion routines
- Teletype or tape drive interface programs

9. **Program libraries** contain frequently used programs.

The first article in the series appeared in the April 1 issue, and dealt with microprocessor instruction sets. The concluding article will discuss an application example.

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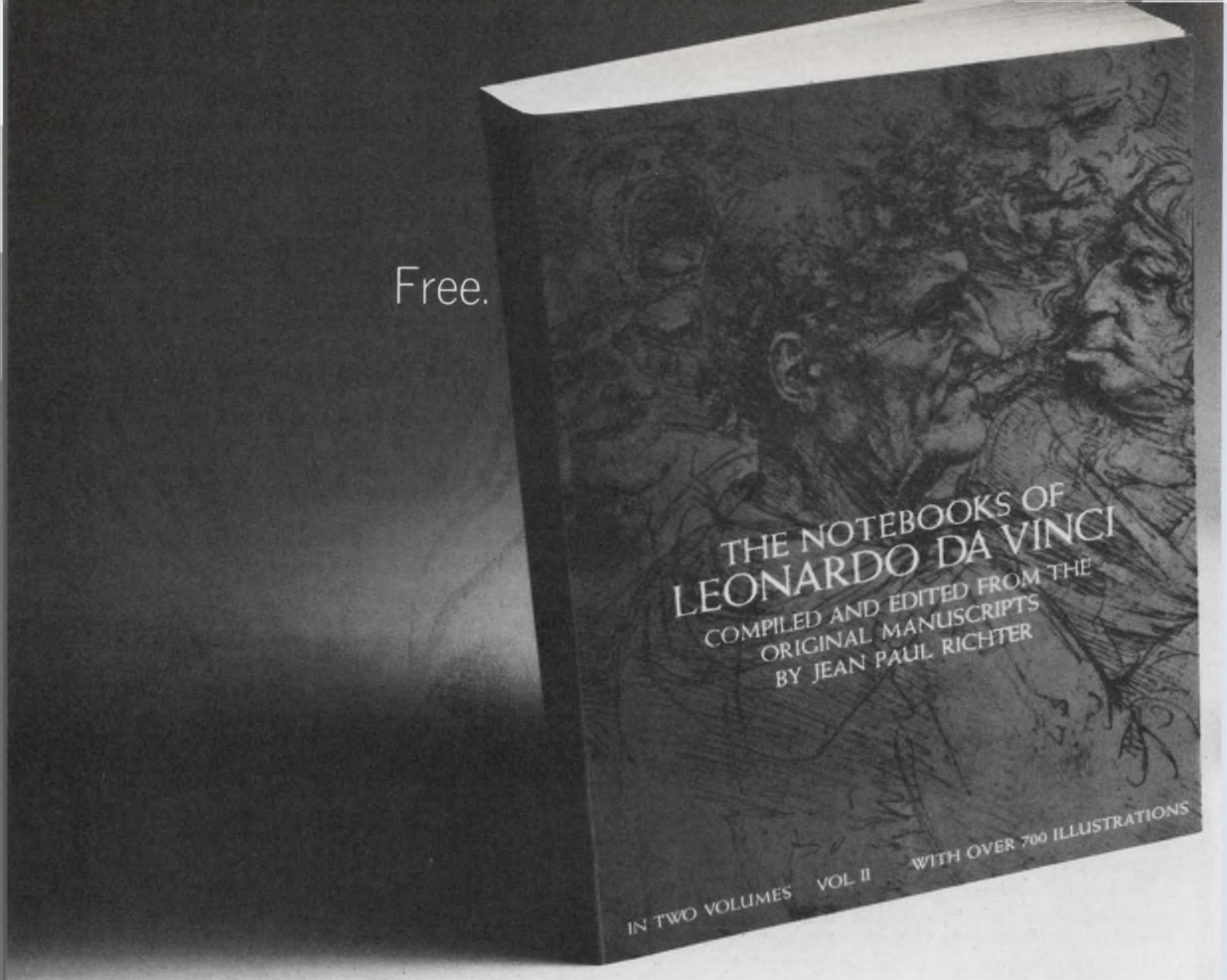

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The case for using ceramics: High thermal conductivity and insulation resistance plus superior strength make this material hard to beat for microelectronic packaging.

With today's pressure for increased circuit density, engineers are hard-pressed to find reliable insulating materials for new designs. One material family stands out above the others: Ceramics.

Ceramics have two major advantages over plastics as a packaging or substrate material. The thermal conductivity is 25 to 100 times higher, allowing the ceramic to act as a heat sink. In addition, because ceramics can form hermetic seals, ceramic packages can protect semiconductor devices from atmospheric contamination.

Here are other reasons for using ceramics:

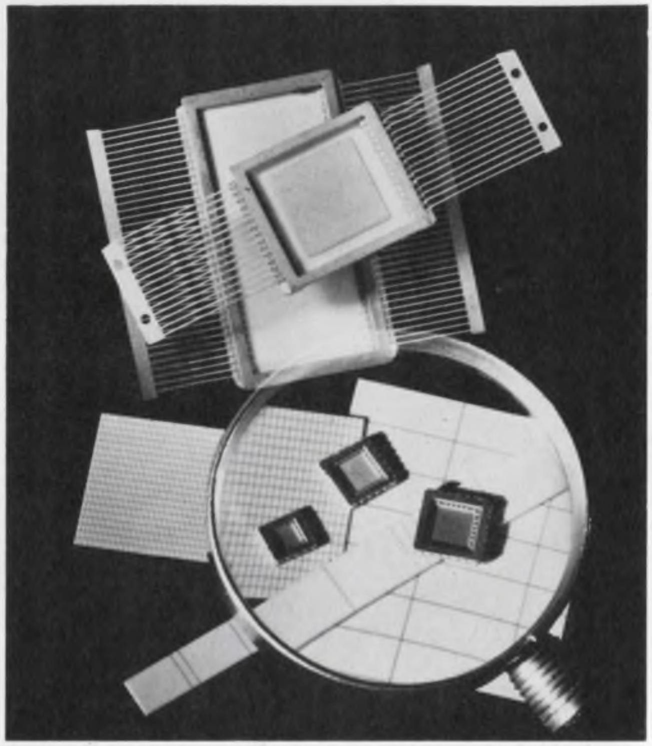
- The thermal expansion can be matched to that of other commonly used materials to allow for hermetic sealing with those materials.
- A wide range of dielectric constants is available, as are low dielectric losses and high dielectric strengths.
- Surface finishes with a smoothness of just a few microinches are obtained directly from the firing process. These surfaces can also be polished or glazed.
- Opaqueness is available, when needed, in light-sensitive applications.
- The materials have good mechanical properties—high strength, hardness and impact resistance. Ceramics can be molded, metalized and machined by grinding or lapping.

A ceramic is an inorganic, nonmetallic material. It may be a crystalline, polycrystalline or amorphous—for example, glass.

Alumina: many desirable properties

Today, ceramics like beryllia, steatite, forsterite, alumina (75 to 99.7% pure Al_2O_3), zircon, titanate and barium titanate are being used. Each has advantages and disadvantages, and the designer must consider them carefully before making a final selection. Some typical properties of the more commonly used ceramics are compared in Table 1.

J.T. Bailey, Research Manager, American Lava Corp., Chattanooga, Tenn. 37405.

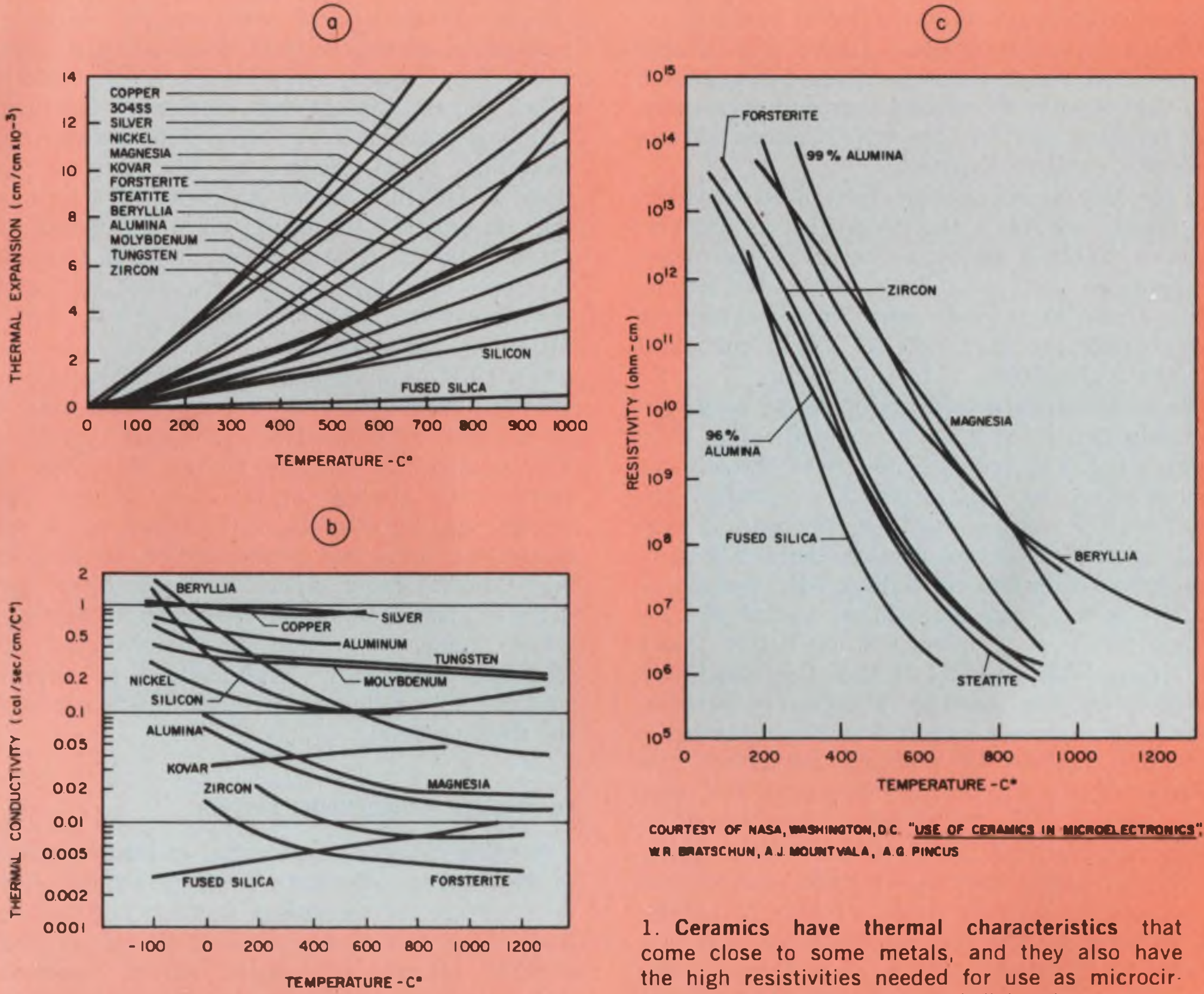


Hybrid-circuit packages (top) with 30 and 75 leads and chip carriers that seal hermetically (under magnifying glass) are made from alumina ceramic. Laser scored ceramic substrates facilitate the separation of individual circuits after processing has been completed.

The aluminas are probably the ceramic most widely used in electronics. They possess many desirable—and only a few undesirable—properties for substrate applications. Thick-film or thin-film processes can be applied to alumina, and it is the most popular, commercially available substrate for microcircuits. Its cost is moderate.

Typical thermal expansion characteristics of alumina are compared with metals and other ceramics in Fig. 1a. Alumina's compatibility with Kovar is one of its principal advantages in metal-ceramic assemblies.

Although most alumina ceramics (85 to 98% Al_2O_3) contain entrapped porosity, it is possible to fabricate pore-free grades. They are made from high-purity oxides, and they are chemically modified to permit sintering to full density. Densification and grain growth during processing



1. **Ceramics have thermal characteristics** that come close to some metals, and they also have the high resistivities needed for use as microcircuit substrates, insulators and dielectrics.

Table 1. Some representative properties of ceramic substrates

Material property	Unit	Steatite	Forsterite	Zircon	Alumina (99.5% pure)	Beryllia
Water absorption	%	Impervious	Impervious	Impervious	Impervious	Impervious
Hardness	Moh's scale	7.5	7.5	8	9	9
Thermal expansion	25 to 900 C cm/cm/°C	8.5×10^{-6}	11.7×10^{-6}	4.9×10^{-6}	7.7×10^{-6}	8.7×10^{-6}
Dielectric strength (60 Hz ac, 1/4" test discs)	Volts/mil	220	240	220	220	230
Dielectric constant 1 MHz		5.3	6.2	8.8	9.9	6.9
Dissipation factor 1 MHz		0.0026	0.0004	0.0010	0.0001	0.0002
Loss factor 1 MHz		0.014	0.002	0.009	0.0011	0.0014

are controlled, so that gas atoms in the pores can diffuse along grain boundaries to the surface.

Alumina's disadvantages? High temperatures are required for processing. When fabricated in large plates (over 2 × 2 in.), warping may occur. And grinding can be expensive, because of the material's extreme hardness.

In the last 30 years there have been considerable improvements in the properties of alumina ceramics. Table 2 shows the progress. Hardness, for instance, has gone from 69 to 90 R45N; purity from 85 to well over 99.9% aluminum oxide; densities from 3.40 to 3.96 g/cm^3; and strength from 35,000 to 100,000 lb/in^2.

The surface characteristics of alumina become especially important when a conductive film is to be deposited. The required degree of smoothness depends upon the application. For thin-film applications, the surface should be smooth and free of all imperfections and contaminants. The performance of thin-film capacitors, for instance, is sensitive to substrate smoothness and requires a surface finish of 1 microinch or better. Most thin-film resistor circuits, on the other hand, can satisfactorily use as-fired alumina substrates, which have a smoothness of 5 to 8 microinches.

Surface finishes on alumina substrates are available from about 40 microinches to less than 0.5 microinch. The 92 to 96% aluminas have finishes ranging from about 15 to 40 microinches. The finish depends upon the ceramic composition, the method of forming (tape process or press) and whether or not the substrate was tumble-polished after firing. A 99.5% pure alumina substrate, when formed by the tape process, can have an as-fired finish as fine as 5 to 8 microinches.

Glazing can provide an extremely smooth surface—less than 1 microinch. But it has drawbacks: It lowers thermal conductivity and the maximum service temperature, and has less resistance to mechanical and chemical stress.

Alumina substrates are available in sizes up to about 6-in. square in thicknesses of 0.005 to about 0.1 in. Almost any outside configuration and hole pattern is available. The standard dimensional tolerances are ±1/2% plus not less than ±0.003 in. Camber is 0.004 in/in. plus not less than 0.002 in. on as-fired substrates. At present the standard as-fired thickness tolerance is ±10%. However, there is a good indication that this will soon be reduced to ±5%. With a little extra care; a tolerance of ±7% is possible today with standard manufacturing processes.

These tolerances and properties will improve as alumina raw-material technology improves. The smaller the particle of raw material, the smaller the average crystal size of the fired ceramic and the smoother the surface of the substrate—an important consideration in thin-film applications. Purer materials reduce the incidence of stray iron, cobalt or chromium particles, which change color and alter mechanical and electrical properties. Minimization of organic contaminants reduces voids and surface pits in the fired ceramic.

For thermal conductivity: beryllia

Beryllia ceramics are similar in many respects to the aluminas, especially in surface smoothness, but they are not as strong. Beryllia powders are toxic; thus their cost tends to be higher than alumina because of needed safety measures. Beryllia raw-material costs are also much higher.

But beryllia has exceptionally high thermal conductivity (Fig. 1b). When used primarily as an insulator, beryllia's low dielectric constant helps to reduce crosstalk between conductors and

Table 2. Evolution of alumina ceramics

	1940's	1950's	1960's	1970's
Per cent Al_2O_3	85	96	99.5	99.95+
Density (gm/cm^3)	3.40	3.70	3.87	3.96
Hardness (R45N)	69	78	82	90
Tensile strength (psi)	20,000	25,000	30,000	60,000
Compressive strength (psi)	275,000	375,000	400,000	600,000
Flexural strength (psi)	35,000	46,000	60,000	100,000
Raw Materials				
Purity (% AL_2O_3)	95.5	99.7	99.7	99.99+
Particle size (Microns)	44	4	1 to 2	0.3
Surface area (m^2/gm)	—	1	2 to 5	10-12

Table 3. Typical properties of various alumina substrates

Properties	Units	Per cent Al_2O_3		
		96	99.5	99.7
Alumina's X particle size	microns	2.9	1.5	0.6
Density	cms/cc	3.70	3.89	3.86
Thermal expansion linear coefficient cm/cm × 10^{-6} per °C.	25-300 C. 25-700 C. 25-900 C.	6.4 7.5 7.9	6.6 7.4 7.7	6.5 7.4 7.7
Flexural strength specimen 0.025" T × 0.070" W, 0.500 L	lb/in²	60,000	70,000	85,000
Dielectric constant @ 1 MHz, 25 C.		9.3	10.5	10.3
Dissipation factor @ 1 MHz, 25 C.		0.0003	0.0001	0.0002
Average crystal size	microns	4.0	3.0	1.5
Surface finish	microinches	25	8	4

to allow high signal-speed propagation.

Another ceramic family that is used primarily as an insulator is steatite porcelain. The steatites are an improvement over the traditional clay-feldspar-quartz electrical porcelains; they have lower losses in the megacycle range and are relatively easy to machine. But they also have relatively low thermal-shock resistance and low strength when compared with alumina. Steatite ceramics can, however, be made economically for use as general-purpose insulators.

Forsterite ceramics are a further improvement over steatite. They have higher resistivity, higher strength, lower losses at microwave frequencies and can be used at higher temperatures. Their higher thermal-expansion coefficient matches that of many metals, but this property can cause thermal-shock problems. Two forsterite families are finding wide use. One matches the thermal expansion of certain chrome-iron alloys; and the other, titanium.

The volume resistivities of various ceramics are shown in Fig. 1c. Note the superior high-temperature resistivity of forsterite over steatite and even 96% alumina.

Cordierite ceramics, on the other hand, are outstanding for thermal-shock resistance. Porous cordierite ceramics are widely used for heating-wire supports. They are also available as dense ceramics. Since metals have higher thermal expansion than cordierite, it's difficult to seal to.

Zircon and magnesia ceramics are not widely used in electronics. However, a special property may justify occasional application.

Magnesia is used as insulation in electrical heating elements, special thermocouples and leads for high-temperature instrumentation, because of its high electrical resistivity, relatively good thermal conductivity and ease of fabrication.

And sapphire—since it is cut from a single crystal and has no porosity or grain boundaries finds use as a substrate for the epitaxial growth of single-crystal films of materials with similar lattice dimensions. Single-crystal spinel, beryllia and quartz are also used as substrates for epitaxial films.

Even diamond crystals are sometimes used for substrates and heat sinks. Other ceramics, such as boron nitride and thoria—also find occasional use as insulators, where their unique properties fit specialized applications. But, of course, their cost is usually higher.

Raw-material control essential

No matter what the ceramic, tight control of the raw-material mixture is a constant necessity. Modify a mix to meet tighter tolerances on one set of characteristics and you change other important properties. For example, addition of binders causes higher shrinkage in firing, and this, in turn, makes dimensional control difficult. And careful control of temperature during the firing is mandatory. Each composition must be fired at a specified temperature to obtain certain properties. A change in firing temperature will change the properties and also the shrinkage.

Thus alumina has a considerable range of controllable properties (Table 3). A relatively new property is opaqueness. Standard white aluminas have proved ineffective for packaging LEDs and light-sensitive devices, because they transmit too much light. A new black 94% alumina has the necessary opacity, yet it retains all of the qualities of equivalent white aluminas. A piece of this new ceramic 10 mils thick will absorb 99.99% of the incident light. No incident light can penetrate a standard 20-mil-thick package. ■■

New! Program Optimum

Now you can design linears your way. Our new single and dual programmable op amps offer greater economy and design flexibility, let you set your own parameter specifi-cations, and minimize power consumption at the same time.

All it takes to tailor the characteristics of our new HA-2720/2730 is one external resistor. This provides a master bias setting which will establish the desired current-flow through the devices.

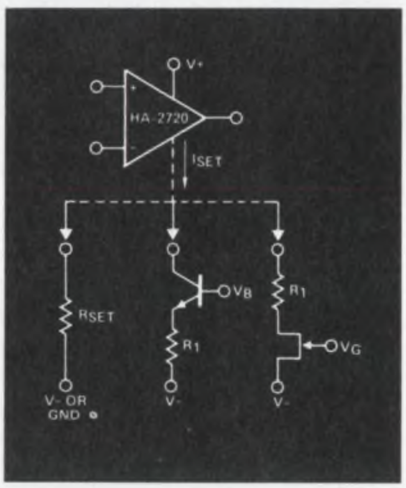
As a result, critical parameters such as bias currents, supply currents, bandwidth, slew rate, input noise, and others can be optimized to meet your particular needs. And because the devices have such a wide power supply range (± 1.2V to ± 18V) they can be used in an almost unlimited variety of linear designs.

A single programmable op amp, the HA-2720 is a direct replacement for many currently available op amps, yet it offers superior performance features over all of them. Among these are a wider range of programming, higher slew rate and bandwidth at low power levels, superior output current, and lower noise current. The HA-2730 is a dual monolithic version of the HA-2720 with identical perfor-mance features.

For the user these devices offer substantial benefits. First, they are highly reliable because they are short-circuit protected and have internal compensation with classical frequency response. They also provide you with considerable economy because the wide range of programming possible allows you to standardize your op amp inventory and change parameters as needed. Finally, by modulating the set current terminal you can minimize systems components and obtain such applications as VCO's, Wien bridge oscillators, and waveform generators.

Among other applications are low power instrumentation, portable battery operated instruments, active filters, and hearing aids. For details see your Harris distributor or representative.

Typical Biasing Circuits



HA-2720/30 Programming

	SLEW RATE	BANDWIDTH	INPUT VOLTAGE NOISE	INPUT CURRENT NOISE	OPTIMUM SOURCE RESISTANCE	BIAS CURRENT	POWER DISSIPATION	OPEN LOOP VOLTAGE GAIN
ISET ↑	↑	↑	↓	↑	↓	↑	↑	↕
POWER SUPPLY VOLTAGE ↑	↑	↑	↔	↔	↔	↔	↑	↑

↕ BELL-SHAPED
↓ DECREASE
↔ NO CHANGE
↑ INCREASE

Features

Wide range A.C. programming

Slew rate	0.06 to 6V/μs
Gain x Bandwidth	5KHz to 10MHz

Wide range D.C. programming

- Power supply range ± 1.2V to ± 18V
- Supply current 1μA to 1.5mA
- Input bias current 0.4 to 50nA
- Output current up to 15mA

Suitable for direct replacement of:

Fairchild μA776, Solitron UC 4250, National LM 4250, Intersil ICL-8021 } HA-2720

100-999 units

HA-2725	0°C	to	+75°C	$ 3.30
HA-2720	-55°C	to	+125°C	$ 8.80

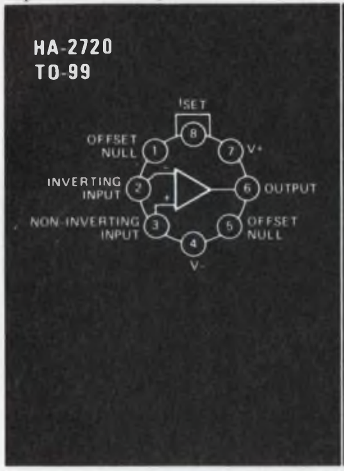
Supplied TO-99

HA-2735	0°C	to	+75°C	$ 7.15
HA-2730	-55°C	to	+125°C	$16.50

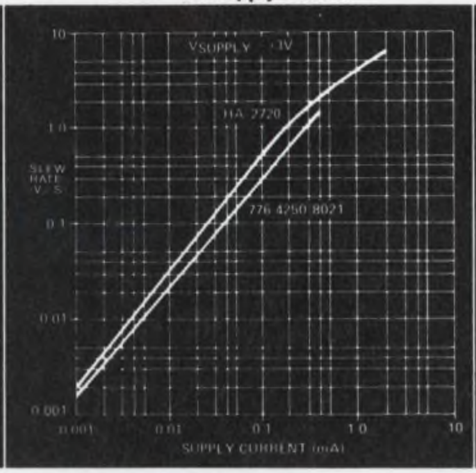
Supplied TO-116

mable Op Amps for Solutions

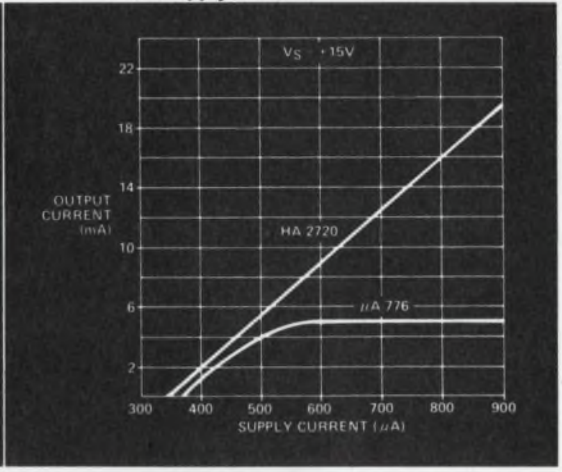
HA-2720 Single Programmable Operational Amplifier



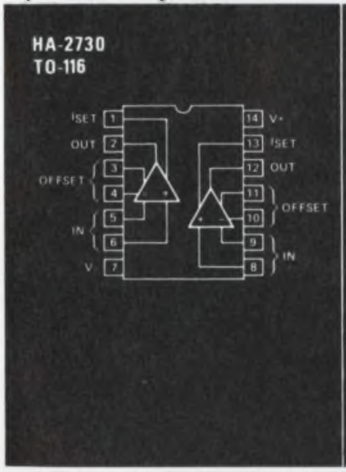
Slew Rate vs. Supply Current



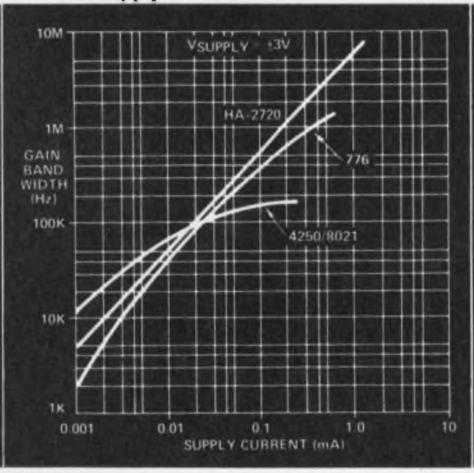
Output Current vs. Supply Current



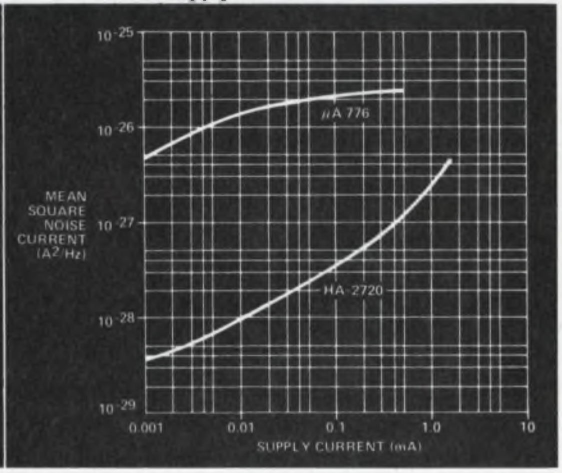
HA-2730 Dual Programmable Operational Amplifier



Gain Bandwidth Product vs. Supply Current



Input Noise Current vs. Supply Current



Above comparative data curves were experimentally derived or extrapolated from published data sheets where available.

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INFORMATION RETRIEVAL NUMBER 33

Don't lean on a/d specs when you work with high encode rates. Specs that characterize low-speed encoders may fall short when you go above 1 MHz.

The ancient Latin warning of caveat emptor may be especially applicable to high-speed analog-to-digital (a/d) converters—that is, those with word rates of 1 MHz and higher. That's because specs suitable for a/d's that operate at encode rates below 1 MHz often are not adequate for high-speed units.

Take accuracy, for example. Almost universally, a/d accuracy is spelled out as a dc spec. But dc accuracy can be interpreted in several ways, depending on how it's specified. And no matter which interpretation a potential user prefers, he'll inevitably wind up lacking valuable information.

For example, he may infer that the dc spec gives the accuracy over a wide frequency band. Unfortunately it doesn't. And, in fact, this isn't even a practical requirement.

Consider frequency response roll-off: The input circuit and track/hold circuits of an a/d don't have infinite bandwidth—any more than any circuit does. Even if the bandwidth is very wide, there inevitably will be some roll-off in the band of interest, thereby making the dc spec invalid at high signal frequencies.

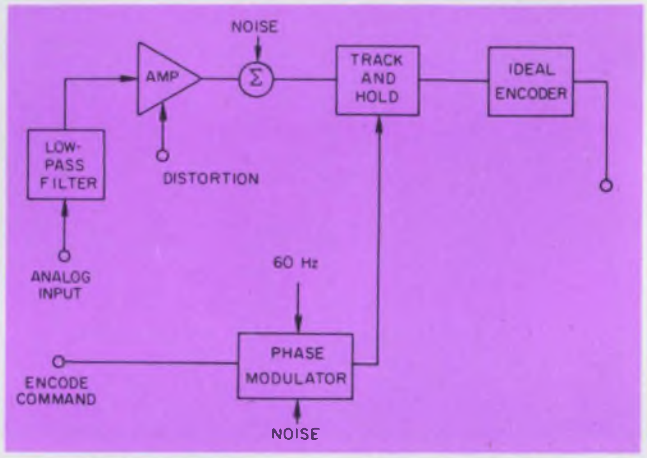
On the other hand, a specifier may infer that the listed dc accuracy is an interpretation of linearity at high frequencies. It is not. He should reconsider that idea carefully also. Nonlinearities invariably become worse at high frequencies—especially at frequencies close to half the encode rate.

There's yet another interpretation of a dc accuracy spec—one that assumes a certain naiveté on the part of a potential user. The user is led to believe that a dc spec includes aperture error. This is simply not true.

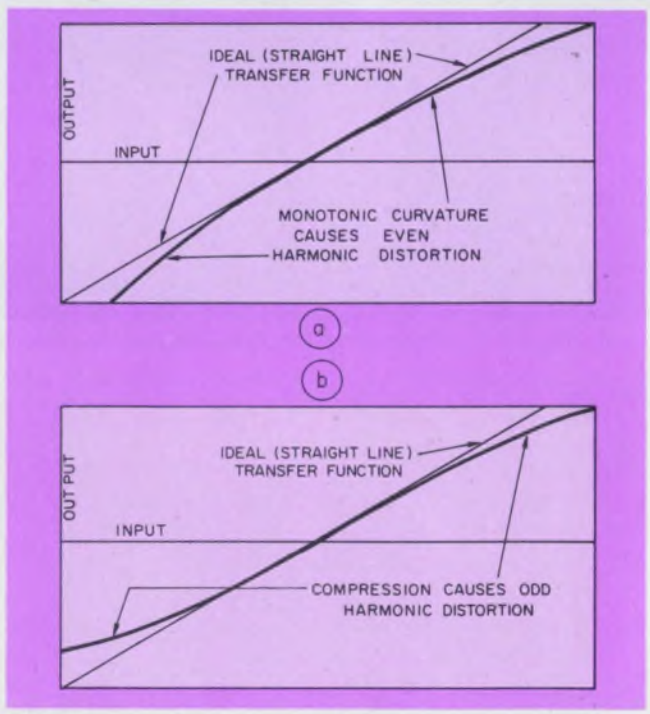
Other specs are needed

Obviously the fidelity of translation from analog to digital is the criterion for good performance. And since the analog input is often a wide-band video signal, the dc accuracy spec is only a small part of the story.

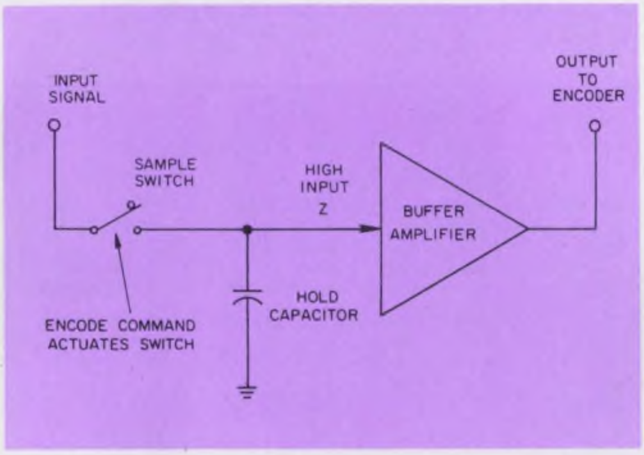
William J. Pratt, Senior Engineer, Computer Labs, 1109 S. Chapman St., Greensboro, N.C. 27403.



1. **All a/d converters fall short of the ideal.** The factors that contribute to the less than ideal performance can be accounted for if you think of the converter as ideal and treat individual error sources as additional inputs. The low-pass filter accounts for front-end roll-off.



2. **High-frequency rolloff** of an a/d's input circuits results in departures from an ideal transfer function. Monotonic curvature of the transfer function causes even harmonic distortion (a), while compression at ± full scale results in odd harmonics (b).



3. **In the classic representation of a sample-and-hold circuit,** the switch has zero resistance when closed, and opens instantly on receipt of an encode command. In practice, the sampling switch transits from a low to high resistance over some finite time interval.

The limiting input frequency of an a/d is generally that which satisfies the Nyquist sampling theorem for signal reproducibility. In some cases, however, the maximum frequency can go even higher. A converter user who recognizes this will therefore want to pin down the specs that call out the frequency-response roll-off, nonlinearity, aperture time and transient response—as well as some others. Here's why:

Frequency-response roll-off should be included in an a/d spec sheet simply because an a/d's buffer amplifier and track/hold circuits have finite bandwidth. Thus you can visualize any practical a/d as an ideal converter with a low-pass filter in its front end (Fig. 1).

The filter causes some loss in sensitivity as frequency is increased, causes the rise time of input pulses to deteriorate and also contributes lag errors, which show up as an apparent time shift of the sampling point.

A conscientious a/d manufacturer will estimate and verify the flatness of the response. The estimate is usually based on the known 3-dB point of the converter front end. The manufacturer then uses the theoretical roll-off characteristics to interpolate back to the maximum expected Nyquist frequency.

If a video filter is used ahead of the a/d—a matched filter for certain pulse waveforms, for example—the filter must be designed as part of a composite filter, which consists of the actual filter network in series with the a/d equivalent-input filter.

Typically, an a/d's input roll-off characteristic is that of a single pole with a 6-dB/octave slope. The 3-dB bandwidth of the input roll-off should be at least three times the Nyquist frequency. A lower bandwidth results in excessive attenuation at Nyquist and phase nonlinearity in the passband, and it makes video filter design difficult.

Occasionally a spec sheet lists the higher, small-signal bandwidth simply to make the a/d look better. When small-signal bandwidth is given, a slew-rate spec must be included to know the real capabilities of the a/d.

Circuits that roll off the input bandwidth can distort high-frequency inputs, no matter how linear the circuits appear at dc. When this occurs, watch for monotonic curvature of the transfer function—which causes even harmonics—and symmetrical compression near plus and minus full scale—which results in odd harmonics (Fig. 2).

Since nonlinearity errors of this type can lead to intermodulation products within the converter, a high-frequency linearity spec is almost universally needed to evaluate system performance. Unfortunately this spec is almost universally absent from the spec sheet—and from documented test requirements as well.

Intermodulation products have particular significance when the a/d is used for digital spectrum analysis. If two or more sinusoidal signals are applied to the input of the a/d, the products can limit the dynamic range of the system.

Aperture time: What does it really mean?

Mention aperture time and what it is, and you have a guaranteed argument at any engineers' coffee break. The original concept of aperture time was based on the conclusion that an error occurs when that famous (or infamous, if you prefer) a/d sampling switch opens (Fig. 3).

According to the concept, an error occurs because the input signal tends to be averaged over the finite time interval required for opening the switch.

The sampled voltage, therefore—the argument continues—does not exactly correspond to the voltage at the instant the switch starts to open. The time required to open the switch is called aperture time, and the equation that gives the error is

$$E_a = T_a \, dV/dt,$$

where E_a is the aperture error, T_a is aperture time and dV/dt is the rate at which the signal changes.

The fact is that no real error exists for such a switch. As long as the switch opens in a repeatable fashion, there is an effective sampling time—which can be regarded as the time an ideal, or zero-opening-time, switch remains closed. This sampling interval may differ from the time needed for the switch to open, but it is a constant time offset.

Effective sampling time is related to the arrival of the encode command via a fixed time interval. Neither of these fixed time delays constitutes an error. Only variable time delays can be called genuine errors.

Two types of aperture errors are commonly encountered: that of phase modulation of the hold command to the track-and-hold circuit, and systemic errors caused by the a/d's inability to encode rapidly varying inputs accurately.

In the first case, the encode signal is phase-modulated by random noise, the 60-Hz power-line frequency or some other source (Fig. 1). The magnitude of the error is proportional to dV/dt and thus qualifies as a valid aperture error.

With the systemic aperture error, the parameter of interest is the aperture time of the complete a/d system—not just the aperture time of the track-and-hold circuit.

This error generally results because the encoder portion of the system can't settle adequately to each new held value of the track-and-hold output. The higher the input slew rate, the more the encoder must gyrate to encode each new sample properly.

An encoder that uses d/a's, op amps, delay cables or other circuits that may not settle adequately will normally have larger systemic aperture errors than parallel comparator converters.

Since aperture error is a function of the analog input signal, and not the encode rate, an a/d converter can conceivably digitize both dc and low-frequency ac at an extremely high rate. But the unit may fail to digitize high frequencies—even at modest encode rates.

To know what errors to expect from a given aperture-time spec, a specifier must know the slew rate at which the measurement was made. This is because the systemic aperture time can vary unfavorably with input slew rate.

What's the slew rate?

If a vendor measures aperture time at a slew rate of 1 V/μs, for example, a potential user might incorrectly assume a certain level of performance at a slew rate of, say, 2 V/μs. In this case, he might expect the aperture error to be twice as great as the specification predicts. The actual performance may be far worse.

INPUT VOLTAGE	IDEAL CODE	INPUT VOLTAGE	ACTUAL CODE
	10000010		10000010
+16 mV		+16 mV	
	10000001		10000001
+8 mV		+8 mV	
	10000000		10000000 (ELONGATED CODE)
0 mV			
	01111111	(20 mV)	(SKIPPED CODE)
−8 mV			
	01111110	−12 mV	
−16 mV		(4 mV) −16 mV	0111110 (SHORT CODE)
	01111101		01111101

4. **Typical code skip near the most significant bit** for an 8-bit a/d with an input range of ±1.024 mV.

Thus the slew rate used for specification purposes should be at least that of a full-scale sine wave at the Nyquist frequency. In some converters the aperture error at this frequency is small—much less than 1 LSB. Consequently these converters can encode frequencies higher than Nyquist, provided signal aliasing is permitted. Or such converters can provide very accurate conversion of signals with frequencies that are less than Nyquist.

Some converters—those that are properly specified and that have very good aperture times—can operate on analog frequencies several times the encode rate. With others, if the aperture-time spec results in an error of 1 LSB at the Nyquist frequency, you can expect code skipping, loss of resolution at higher signal frequencies and reasonable performance only at frequencies below Nyquist.

If the aperture error is worse than 1 LSB at Nyquist, the usefulness of the instrument at its maximum encode rate is limited. Consider a converter with a 100-MHz maximum rate, a resolution of 8 bits and an aperture time of 2 ns.

With a 50-MHz input (the expected Nyquist for a 100-MHz encode rate), the aperture error is 30% of full scale; in effect, this makes the 8-bit machine a 2-bit a/d (no pun intended). Or, from another point of view, the maximum input bandwidth to maintain 8-bit accuracy would be less than 1 MHz.

Still another spec that must be carefully appraised is transient response. Let's take a look at it.

Settling time: Another evasive spec

The transient response of a converter becomes important in pulse-amplitude measurements, or when two or more channels of analog data are being time-multiplexed through the same a/d.

Under either of these conditions both the input circuits and the track-and-hold must settle fast enough to ensure that the encoded voltage is accurate to at least 1 LSB. Settling time is thus defined as the minimum elapsed time—between the application of a full-scale step at the input and the application of an encode command—that ensures accuracy within 1 LSB.

A vendor can spell out transient response by measuring the settling time of the input circuits, which are usually proprietary designs to optimize transient response and other parameters. But once the circuits are interconnected within the a/d, it's difficult to break out the performance of individual circuits.

Sometimes a vendor hangs on this difficulty as a rationale for not including a transient spec. But the spec may be deliberately left out because of poor performance. Or it may be "inadvertently" omitted because the vendor just doesn't understand its importance.

Regardless of the reason for its absence, don't be lulled into a false sense of security; transient behavior is important. Transient response is also an indirect indicator of other parameters important to front-end performance.

And response time becomes exceedingly important when the user wants to digitize pulse signals. A meaningful transient-response spec tells the user how long he must wait after the step-function input is applied to realize the converter's rated accuracy.

Other a/d specs may have to be known, depending on the application. For example, differential gain and phase specs are important to engineers who need to convert TV video signals.

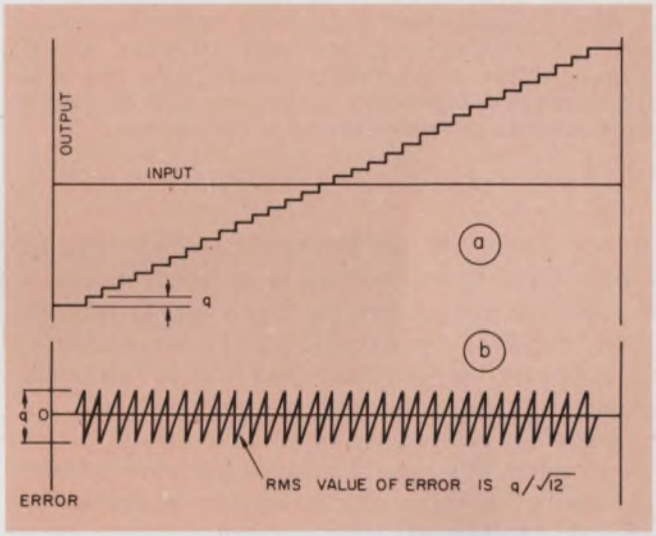
More important specs

As one might expect, the differential gain of an a/d converter is similar to that of an amplifier. It's defined as the percentage difference between the ratios of output to input amplitude (gains) for a small-signal, high-frequency sine wave at two stated levels of dc bias at the input.

Differential phase is the difference in output phase for a small-signal, high-frequency sine wave at two stated levels of dc input bias. Distortion-free conversion of a color TV signal requires that neither the amplitude nor the phase of the chrominance signal be altered as a function of the level of the associated luminance signal. And the luminance-signal phase and gain must be unaffected by the signal level.

In an a/d converter any differential gain error causes undesirable variations in the purity of the reproduced colors as a function of luminance level. Similarly differential phase other than zero causes undesirable variations in the dominant color as a function of luminance level.

Two other common errors—code skipping and



5. **In an ideal, 5-bit a/d**—one with no local aberrations in the transfer function (a)—the error takes the form of a sawtooth with a peak-to-peak amplitude of 1 LSB (b) and an rms value of $q/\sqrt{12}$.

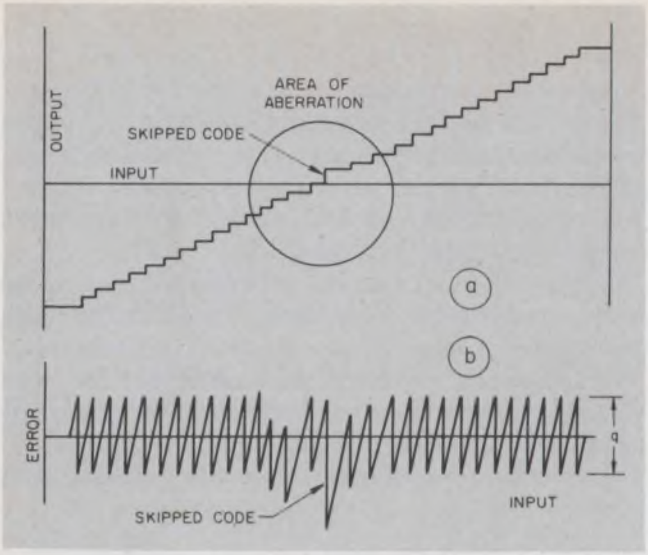
code elongation—are special cases of nonlinearity. Code skips are generally found adjacent to elongated codes, while surrounding codes are accurate. The problem usually shows up during fast input slewing and near major-bit transitions.

Fig. 4 shows the form of a typical code skip near the most significant bit (MSB). The figure is based on an 8-bit converter with a bipolar input range of ± 1.024 V—which means each quantum level or LSB change is equal to 8 mV.

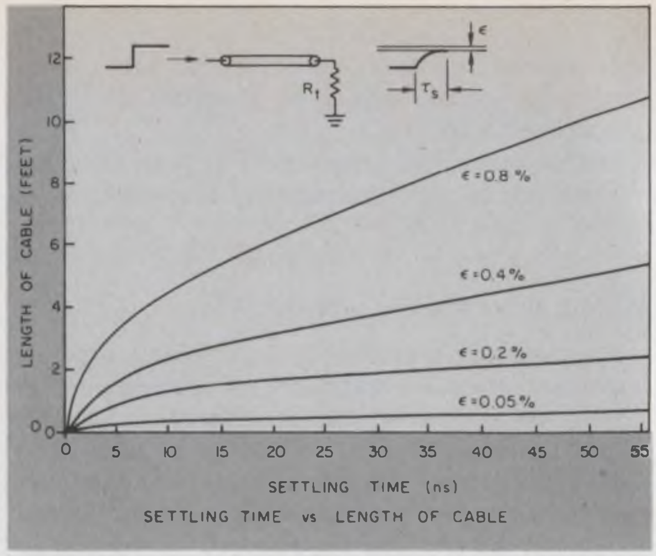
In the figure, the dotted horizontal lines opposite the voltage values represent the transition points from one level to another; the digital numbers represent the value of digital output present between those levels.

As illustrated, an elongated code is one in which the digital number represents two or more quantum levels, instead of the 1-LSB change expected in a normal code. This type of nonlinearity is often classified as a "localized aberration" in the transfer function.

In many cases, skipping and elongation errors



6. **In a nonideal, 5-bit a/d,** a local aberration appears near mid-scale (a) and the error increases (b). No formula exists to determine the additional rms noise for all possible aberrations. Each case must be handled individually to determine the noise contribution.



7. **Settling times of RG58/U coaxial cable** for a step input and for various error bands expressed as a percentage of step amplitude. Miniature cable takes longer to settle, while larger, low-loss cable takes somewhat less time than RG58/U.

do not appear (or are negligibly small) when the input signal is confined to dc or low frequencies, and appear only when the input signal contains high-frequency components. Thus it's necessary to measure the transfer function at high frequencies to pinpoint such errors.

Although code skipping of this sort is an obvious error, it's really quite inoffensive in comparison with other nonlinearities, provided the number of skipped codes is small.

Code skipping does not cause much harmonic or intermodulation distortion; its worst effects are increased noise levels and a loss of resolution in the area of the code skips. Note that, in general, the s/n ratio of code-skipping a/d converters is usually much worse than the theoretical rms sine-wave-to-noise ratio of 6 n + 1.8 dB, where n = the number of bits.

In the ideal case, with no local aberrations, the error takes the form of a sawtooth and the peak-to-peak error is 1 LSB (Fig. 5). Since the sample-to-sample error has an equal probability of assuming any value from −1 LSB to +1 LSB, the effect is similar to that of additive noise, with an rms value of 1 LSB (in volts) divided by the square root of 12 ($q/\sqrt{12}$).

In the nonideal case, where local aberrations are present, the noise worsens (Fig. 6). Since the aberrations can take many forms, no formula can be used to determine the increase in noise level, and each case must be analyzed individually to determine the additional rms noise.

All of the comments with regard to the important a/d parameters apply equally to the converter's external drive circuits. Since it's difficult to design good transient response into, say, a video interface, the system designer should avoid circuits and connections that limit transient response, rather than seeking ways to enhance the response.

Some converters require inputs of as much as 5 V into 50 Ω. Maintaining 60 dB or more of dynamic range with these units is no easy trick. Consequently the drive circuits become difficult to design and should be carefully thought out.

If a low-distortion system is required, a converter with high sensitivity or high input impedance is desirable, and a short coaxial interface is almost mandatory.

Ideally, the coaxial interface will be source-terminated. The high-impedance load allows the source driver to be fairly distortion free, and the short cable assures that reflections from the unterminated end will damp out rapidly. Ground noise and crosstalk problems are also minimized by short interface cables.

VSWR and skin effect, as well, tend to prohibit long cables (Fig. 7). Skin effect in coaxial cables prevents settling in the cables to a high degree of accuracy, even though the bandwidth and 10-to-90% rise time seem more than adequate. For example, a coaxial cable with a bandwidth in excess of 16 MHz may take microseconds to settle to 10 bits of accuracy.

High-speed analog multiplexers are particularly troublesome and should be used only when there is no alternative. If an analog multiplexer is necessary, better performance can be achieved if the multiplexer is built into the converter.

External multiplexers can normally be used in systems that need accuracies of about 1% (7 bits, or less, resolution). This accuracy is limited primarily by crosstalk introduced by an a/d input that doesn't settle fast enough. ■■

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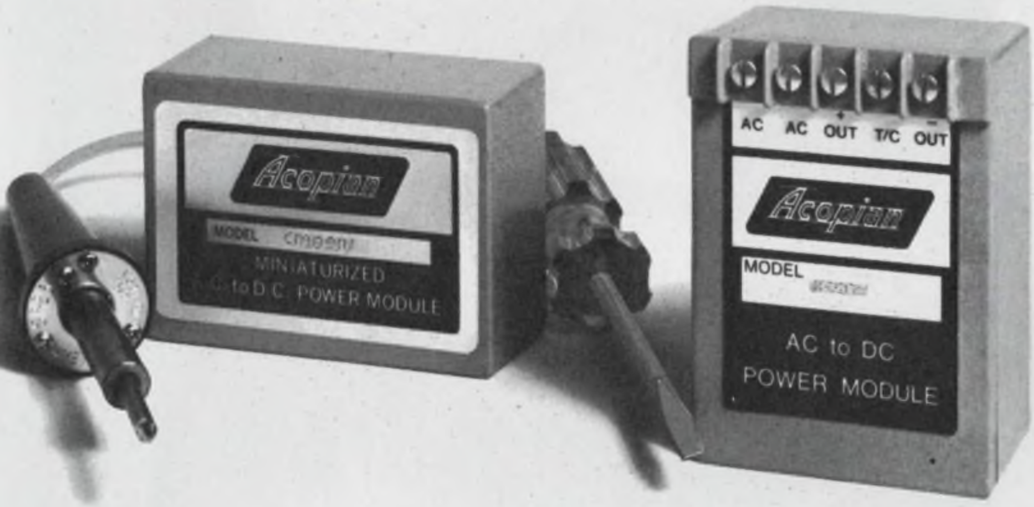

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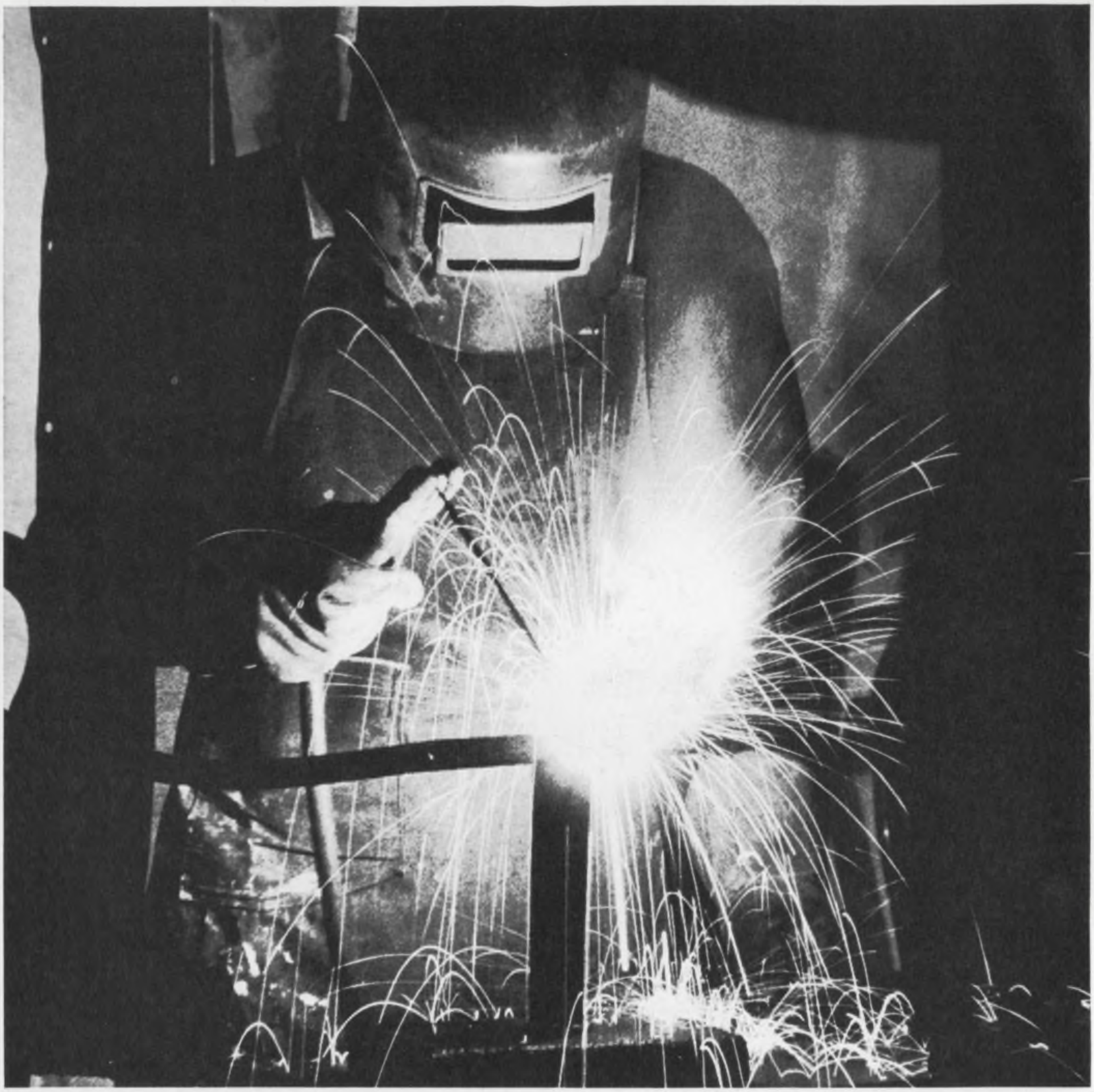


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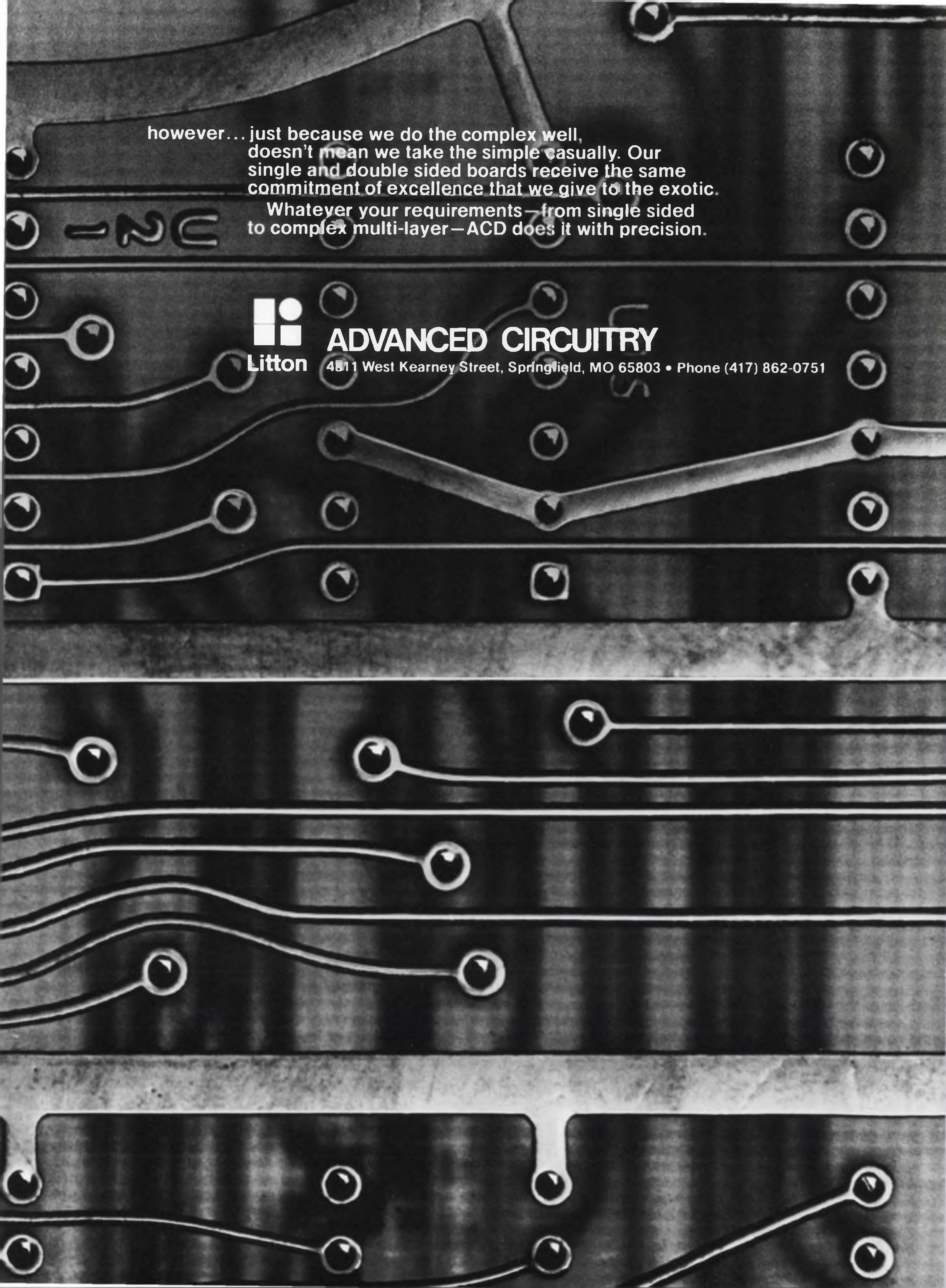
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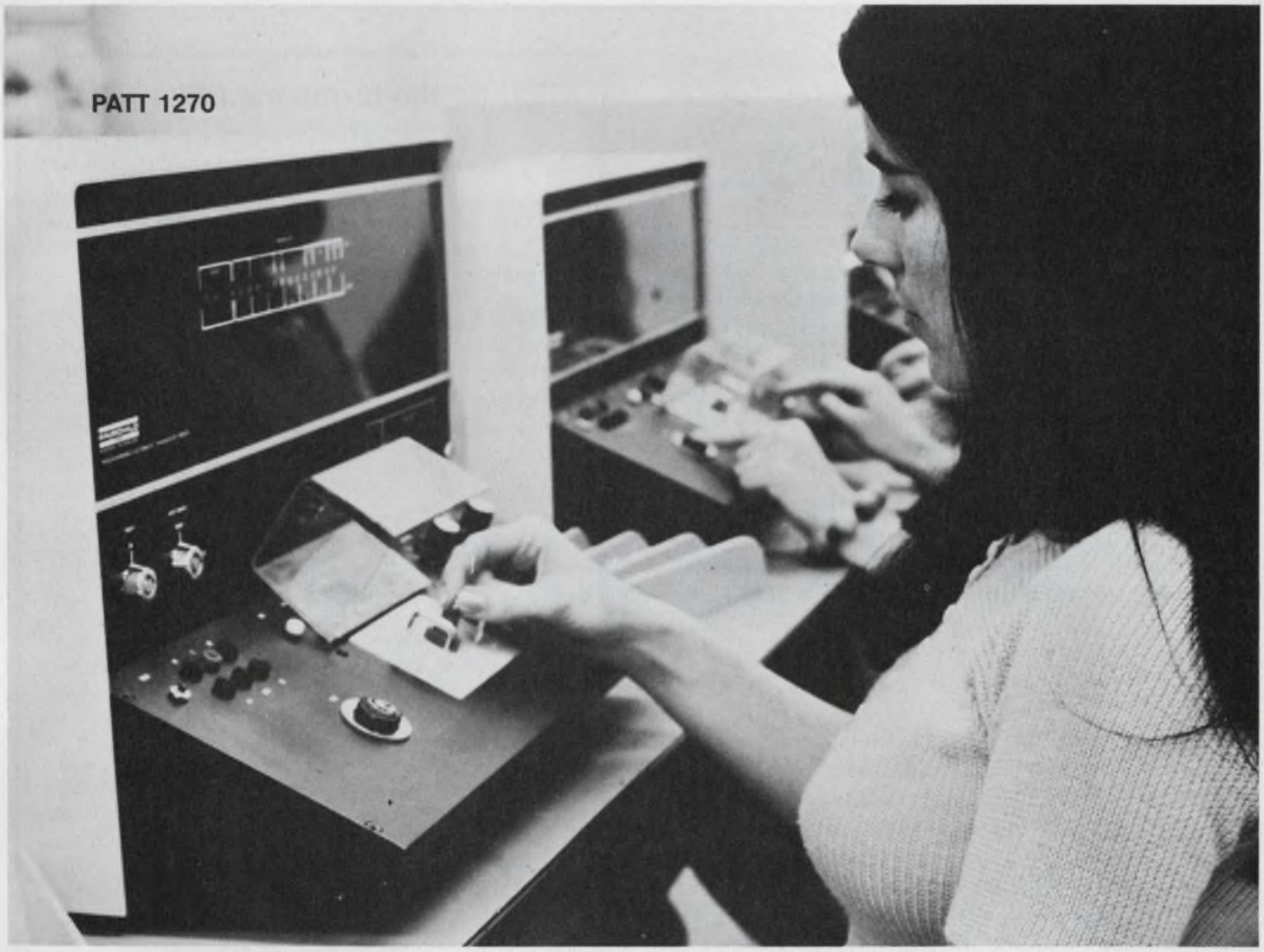

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INFORMATION RETRIEVAL NUMBER 37

There's more to thermal drift than just tempco. Three measurements help pin down the effects of some often-forgotten op-amp thermal gradients.

Thermal drift is probably the No. 1 enemy of high-accuracy analog circuits. In differential op amps, for instance, tempco is a must-know spec. So tempco is usually listed somewhere on the data sheet. But other thermal effects can be vital to op amp performance.

For example, signal changes can cause an op amp's internal power dissipation to change. When this happens, do thermal gradients arise that feed back into the differential input pair? If the op amp's case temperature suddenly changes, is the performance affected? And what happens to the gradients when you first turn the unit on? Any—or all—of these effects can be important.

But where do you find these on the spec sheet? In most cases, you don't. Fortunately each can be measured and subsequently used to pinpoint circuit performance more accurately. Let's see how.

Input stage blues

In differential amplifiers thermal unbalance of the input stage—due to internal or external heat sources—is the primary offender, and gradients show up as changes in the offset voltage, E_{os}.

By monitoring offset in each of three tests—the initial drift test, the initial step-transient test and the thermal step-transient test—you can characterize the thermal-gradient effects.

The first test, E_{os} initial drift, is a dynamic measurement performed at room temperature with no input signal. Measured here are warm-up drift and time. These, in effect, tell you the amplifier's immunity to internally generated gradients and the time the amplifier needs to reach thermal equilibrium.

Initial step transient, the second test, yields the internal-power-step coefficient of offset voltage. Though it has a "stop-and-think" definition (it's the ratio of a change in a difference), this coefficient actually spells out the effects of internal power-dissipation changes on E_{os} for step inputs within an op amp's linear output region.

Finally, the thermal step-transient test measures the excursion of E_{os} when an external temperature step is applied to an op amp's case. This excursion can be greater than that given by the tempco of offset. However, with some

What do the terms mean?

Initial E_{os} mean reference level: The thermally and electrically balanced initial E_{os} mean-reference level, referred to an amplifier's input and at some specified case temperature. This level is one of the two reference points used in the tests.

Final E_{os} mean reference level: The thermally stabilized, final, mean-reference level at a specified case temperature. This level may be offset from zero volts due to temperature coefficients, signal levels, etc., as required by the specific test.

Internal power step coefficient: This is defined by:

$$\frac{\Delta E_1 - \Delta E_2}{\Delta P_1 - P\Delta_2} = E_{os}/\text{watt (internal)}$$

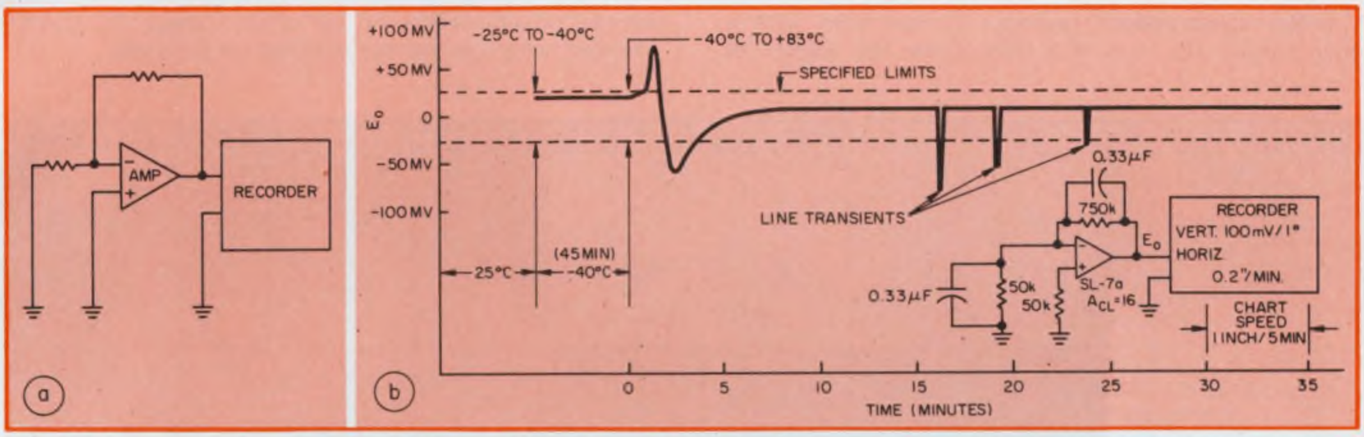
where $\Delta E_1 = E_{os}\,(\text{ref})_1 - \text{step level}_1$
$\Delta E_2 = E_{os}\,(\text{ref})_2 - \text{step level}_2$
$\Delta P_1 = P\,(\text{internal})_1 - P\,(\text{internal})_2$
$\Delta P_2 = P\,(\text{external})_1 - P\,(\text{external})_2$
where $P(\text{external})$ = power delivered to load (R_f and R_L)
$E_{os}(\text{ref})$ = mean reference level.

E_{os} thermal step-transient response: The ratio of the maximum peak excursion (ΔE_{os}) of an amplifier (with respect to its final E_{os} mean reference level) to the step temperature change applied to the case:

$$V/^\circ C = \frac{\text{Max. peak } \Delta E_{os}}{T_{A2} - T_{A1}}$$

E_{os} thermal step-transient recovery time: The elapsed period for an amplifier to return to within a specified percentage of the final E_{os} mean reference level, with respect to the point at which the step temperature change occurred.

Dan Sheehan, Chief Applications Engineer, Cal Tek Engineering, 29 Pemberton Rd., Wayland, Mass. 01778.



1. Simplified test setup to monitor the magnitude and settling time of the warmup drift of a differential op amp (a). The results of actual circuit (beneath trace) are recorded (b) on a strip-chart recorder.

units the tempco of offset approaches the peak transient so closely that the transient appears relatively small. In other op amps the input sections track so well that the peak transient offset is almost nonexistent.

In each of these tests a reasonable number of units of one model should be tested under reproducible conditions. For example, the case temperature change for the thermal step-transient test is critical and must be reproduced.

In the initial step-transient test, both the loading and the step level are critical if you are to reproduce internal thermal gradients accurately. Here, the worst-case level and load should be determined by trial-and-error tests on a reasonable number of units. Note that in this test (which uses a sensitive strip-chart recorder), you can set the amplifier to any dc level within its output range, and then buck out the dc level to monitor small excursions around the higher level.

Another precaution: Rise and fall times of the equipment used in the initial step test should be at least three orders of magnitude faster than the thermal response times of the differential amplifier under test.

The feedback-resistor values used in the tests should be optimized for small I_{bias} errors and low noise current as well as for output loading. Generally feedback resistors will fall into the range of 10 to 20 kΩ.

Here are the steps for the first test, E_{os} initial drift (Fig. 1):

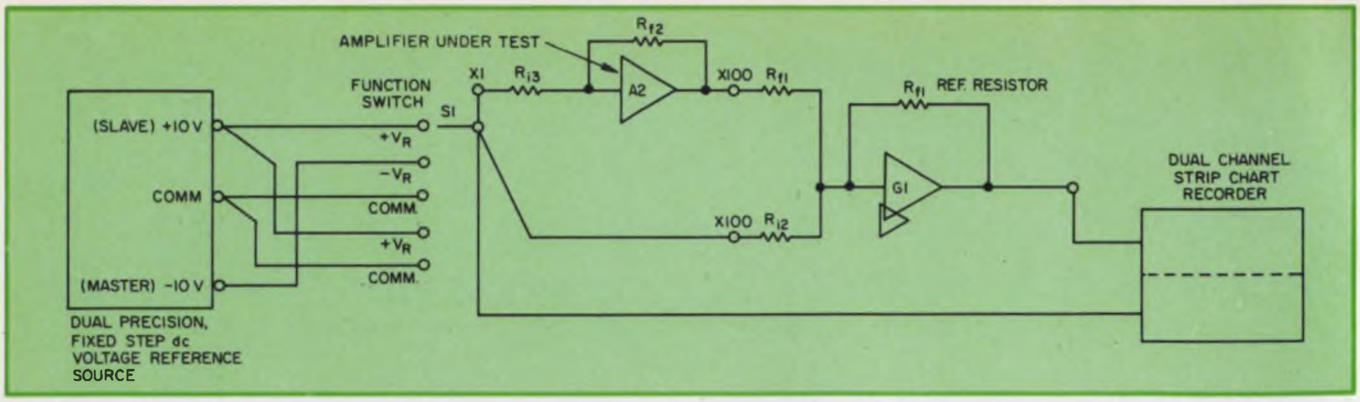
1. Set the sensitivity of a Houston 6520 strip-chart recorder (or equivalent) to 100 mV/inch and the chart drive rate to 0.5 inches/minute.
2. Try to arrange the total graph sensitivity so the maximum peak E_{os} is approximately half the available peak chart amplitude:

$$\text{Total graph sensitivity} = \frac{\text{Recorder Sensitivity}}{\text{Gain of amplifier under test } (A_{cl})}.$$

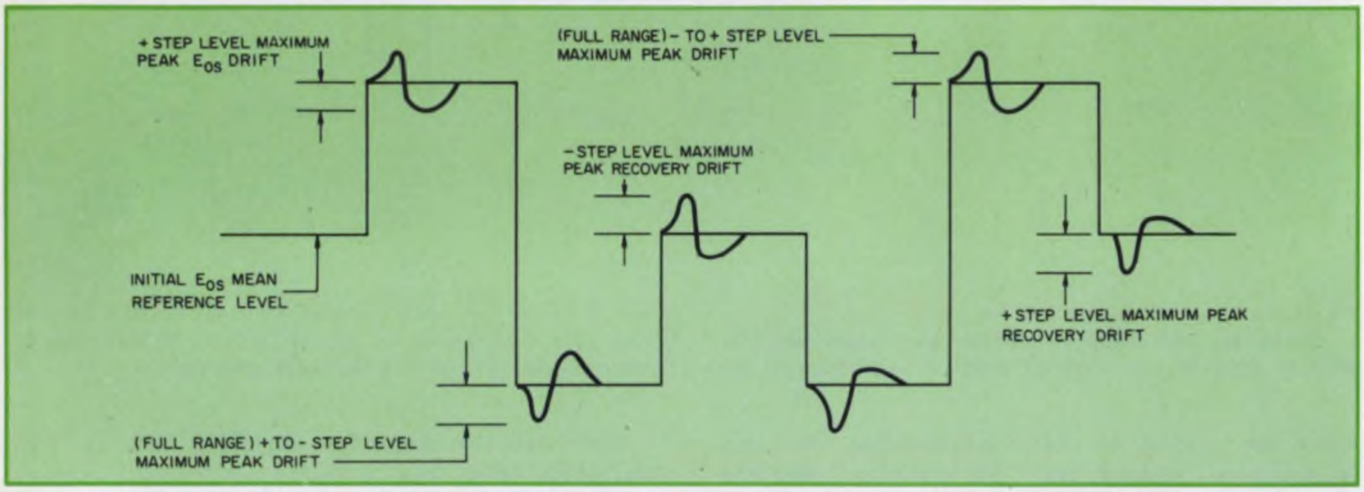
3. Set the gain (A_{cl}) of the amplifier with that value of feedback that minimizes the error contributed by I_{bias}:

$$I_{bias} \text{ error} = \frac{(I_{bias})(R_f)}{A_{cl}}.$$

4. Short the strip-chart recorder input and adjust a midscale zero reference line for the scale sensitivity to be used. Decrease recorder sensitivity, look for amplifier output to balance to zero volts and increase sensitivity accordingly. Allow the amplifier to stabilize and then recheck the balance.
5. Look at the amplifier output with an oscilloscope to confirm output stability.
6. Record the initial reference level (zero volts) for approximately two minutes. Stop the chart drive, lift the pen and reduce sensitivity a few orders of magnitude.
7. Remove amplifier power for the period of



2. **Initial step-transient response** is measured with a fairly simple rig. The test determines the effects of internal power changes on the offset voltage, E_{os}. Such changes occur via thermal feedback to the input.



3. **Various step input levels are selected** by trial and error to pin down the maximum step-transient criteria.

time required for cool-off and thermally restabilize (20 minutes minimum).

8. Increase recorder sensitivity, turn amplifier power on and *immediately start the chart drive.*

The E_{os} initial drift recovery time is the total elapsed period, from the point the power-supply transient (if any) returns to the initial E_{os} reference level, until the amplifier recovers to some specified percentage of the initial E_{os} mean reference level (for example a $\pm 10\%$ error band when $E_o < 1$ mV).

The step-transient test

The E_{os} initial step-transient test setup is illustrated in Fig. 2. This test generates internal thermal gradients in a reproducible manner. The input step-level signal and loading criteria should be determined (and specified) for worst-case results.

A number of errors can crop up in this test. Keep an eye out for these primary ones:

- Ratio and stability errors plus the step load regulation of the dual-reference supply.
- Accuracy, ratio and stability errors of A_2's loop networks.
- Ratio and stability errors of A_1 and those of A_1's gain-setting resistors (R_{f1}/R_{i1}).
- Stability of the recorder.

The test procedure follows:

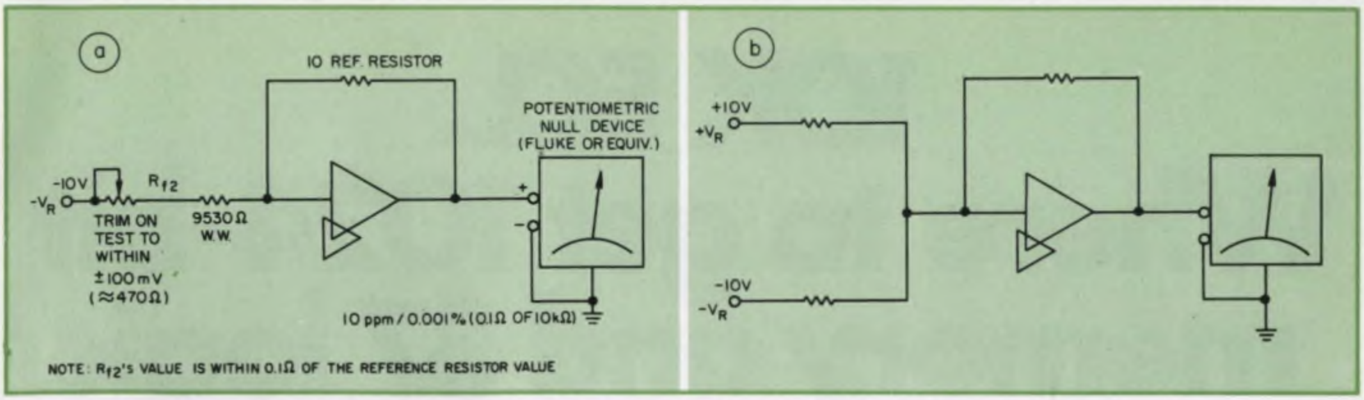
1. With an accurate potentiometric nulling device, adjust the master reference (V_R) to -10.00 V and the slave to $+10.00$ V. All amplifiers should be balanced and the corresponding precision wirewound loop-resistor networks matched. Another chopper-stabilized amplifier, such as the type used in the A_1 slot, can be substituted in the A_2 slot to check out the over-all test circuit for transients and instability.

2. To check out the test circuit, set the function switch to Common after the recorder has stabilized, and monitor the test-circuit output for a reasonable period of time.

3. Set the function switch to $+V_R$ and monitor transients and drift, if any.

4. Set the function switch to $-V_R$ and repeat, then set the function switch to Common and repeat again.

5. Remove A_2 chopper amplifier and insert the differential amplifier to be tested. Allow to stabilize, then rebalance back to the recorder's previous zero-reference line.



4. **To match the two input resistors** in the initial step-transient test, first balance the positive and negative reference voltages (a). Then use the setup in "b" to keep the gain ratio as accurate as possible.

6. After the amplifier under test has stabilized, record an initial E_{os} mean reference level for approximately 2 minutes. Then set the function switch to $+V_R$.

7. After the drift transient has stabilized, set the function switch to $-V_R$.

8. Allow stabilization, then return to Common and, again, wait until the amplifier has stabilized.

9. Set the function switch to $+V_R$, allow to stabilize and then set to Common.

Steps 8 and 9 give the E_{os} initial step transient and the E_{os} initial step-transient recovery time. Steps 6 and 7 provide the initial step-transient drift information—both magnitude and time.

Match resistors for ratio accuracy

To match the resistor ratios for the E_{os} initial step-response test, first use an accurate potentiometric nulling device and balance both the −10-V master reference supply and the +10-V slave (Fig. 4).

Although ratio accuracy—rather than absolute accuracy—is of primary importance, assume that you've got one accurate reference resistor and one accurate summing resistor for A_1. This assumption will allow you to match both the ratio and absolute accuracy of the other resistors in the circuit.

Perform the match with the previously adjusted −10-V master voltage reference as the input; with one of the chopper stabilized amplifiers; and with the accurate reference resistor as the feedback element. Use a fixed trim—less than 5% of the total input resistor value—to adjust the input resistor for unity gain at the output.

Add another resistor, similar to R_{f2} in Fig. 4, and use the positive section of the matched reference supply as the input (Fig. 4b). Adjust the fixed trim so the output is within ±100 mV of zero. Record the error, V_1, then swap the input resistors and record the error, V_2. The algebraic difference between V_1 and V_2 should be < 100 mV (10 ppm).

The two input resistors now provide an input and feedback pair—matched to ±10 ppm—for A_2's gain ratio. Repeat the matching procedure for R_{i1} and R_{i2}. The test sensitivity will now increase by × 100 (1 ppm).

Note that these steps also provide part of the information needed for the E_{os} internal power-step coefficient.

For the final test, the E_{os} thermal step transient, proceed as follows:

1. Remotely connect the external amplifier circuitry so the amplifier under test can be inserted into test chambers or oil baths without loop networks, loads, etc. These components should be kept in a stable room-temperature environment so network tempco errors won't contribute to the resulting measurement.

2. Connect the amplifier loops and recorder as described in the initial drift test procedure. Allow the amplifier to stabilize at the initial (T_{A1}) case temperature. Record the initial E_{os} mean reference level for three minutes or more. Stop the strip-chart recorder drive.

3. Remove the amplifier from the first temperature bath and instantaneously insert the unit into a second bath at temperature T_{A2}. At the same time start the chart drive and record for the next 10 minutes or more.

4. The maximum peak ΔE_{os} is referred to the final E_{os} mean reference level, and the thermal step-transient coefficient is:

$$\Delta E_{os}(\theta\ V/^\circ C) = \frac{\Delta E_{os}}{\Delta T_A} = \frac{\text{Max. peak } \Delta E_{os}}{T_{A2} - T_{A1}}.$$

The thermal transient-response recovery time is the total elapsed period from the time the case temperature-step change occurs until the final maximum peak excursion is within a specified percentage (error band) of the final E_{os} mean reference level. This information is derived from the thermal step-transient test data. ■■

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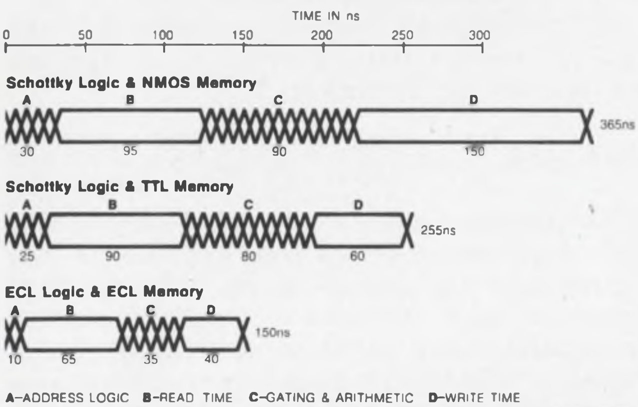

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INFORMATION RETRIEVAL NUMBER 38

Boost audio-amplifier efficiencies

in portable communications or audio equipment. To slash the power consumption, try the class-D approach.

If you design battery-driven communication or portable audio equipment and have to squeeze more performance from a circuit powered by an already overworked energy source, consider replacing the audio-output amplifier with a more efficient design.

The typical output stage, usually biased for class AB operation, is only about 60% efficient. But in consumer electronics equipment the audio-output stage usually places the greatest demand on the battery. Only the capstan drive motor or dial-scale lamp, if used, draw more power.

The biggest problem with increasing class AB amplifier circuit efficiency, however, is that output distortion is boosted simultaneously—a dilemma caused in part by output-transistor bias-current requirements.

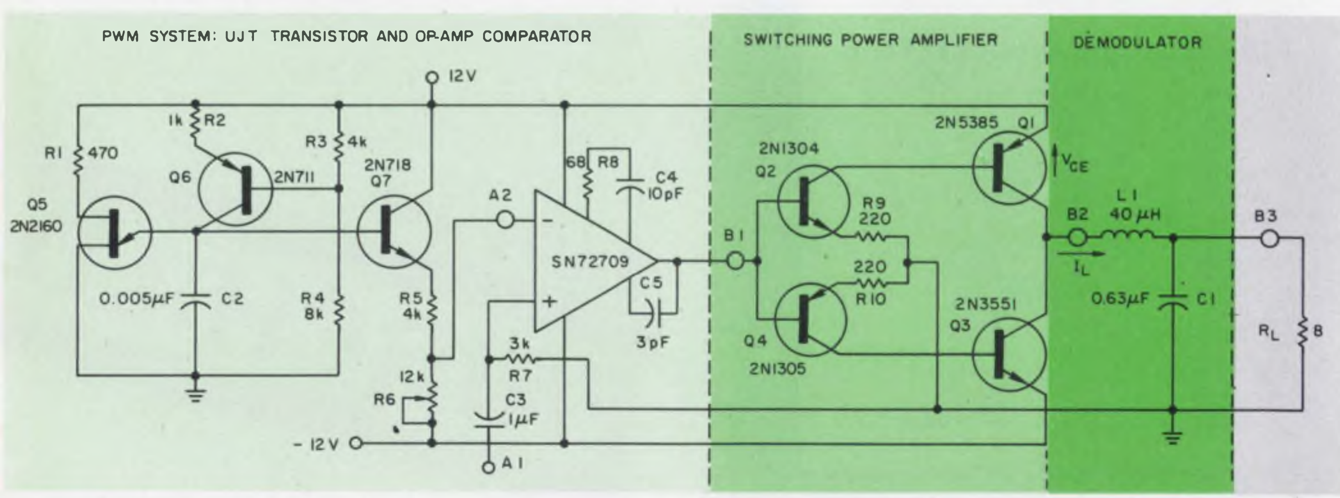
The solution? Use a switching-power amplifier —a design introduced about a decade ago but then rarely used. Its practical circuit efficiency is almost 90%. Besides improving the total efficiency of the system, the switching-power amplifier, sometimes termed class D, has other features:

- Less need for exact output-transistor electrical characteristics or thermal matching.
- A power dissipation rating that may be only one-fourth that of a class AB design for the same output power.
- No dc bias requirements for output transistors.

The schematic diagram of a practical switching power amplifier is shown in Fig. 1. It consists of a modulator, switching power amplifier, demodulator and load. Low-frequency audio, fed into the amplifier at point A_1, modulates a high-frequency square-wave carrier signal to produce pulse-width modulation. Pulse width varies as a function of the audio amplitude. Power amplification of the square wave takes place in the switching-power amplifier. The square wave varies about virtual dc ground at point B_2, where it is fed to the demodulator. This stage strips the high-frequency carrier from the signal and energizes a resistive or reactive load connected across point B_3.

One of the basic reasons why the class-D amplifier initially failed to gain acceptance was the problem of building a simple, yet stable modu-

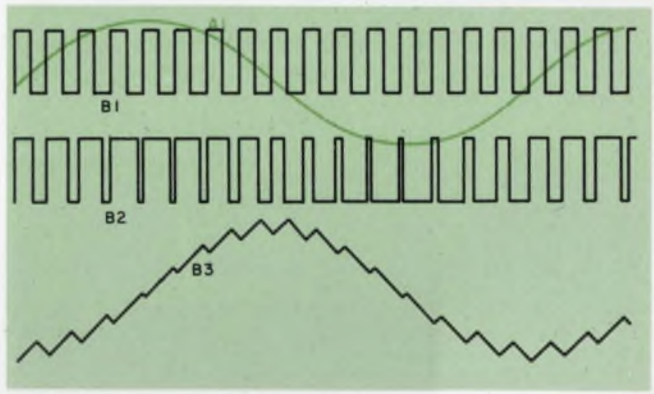
W.V. Subbarao, Assistant Professor, North Dakota State University, College of Engineering and Architecture, Fargo, N.D. 58102.



1. **The circuit uses a combination** of analog and digital techniques, so efficiency of the switching power amplifier approaches the theoretical 100% limit. The value of L_1 is not critical, but the core material affects amplifier efficiency. Power output with an air-core coil is 8.6 W. With a magnetic core, P_{out} drops to 8.3 W.

lator. If the modulator square-wave duty cycle varied when no modulating signal was present (an early problem), an error signal would be produced in the demodulator. In our updated design, a unijunction-transistor sawtooth generator feeds an emitter follower, which couples the carrier signal into the inverting input of a comparator. The modulating (audio) signal is fed into the comparator's noninverting terminal. The result, seen at point B_1, is a pulse-width modulated current waveform.

Both germanium and silicon power transistors were used in the power-amplifier stage. In either case, equal power output was obtained. Experimental amplifier efficiency was about 85%, somewhat less than the 90% calculated. This additional efficiency loss was caused by losses in the demodulator inductor. However, as we will see, this loss can be minimized by proper inductor selection.



2. **Waveforms at various points in Fig. 1.** The sinusoidal input signal (point A_1) provides a modulation frequency f_s at the comparator's noninverting terminal. Without the input signal, f_c consists of a 50% duty cycle square wave (point B_2). The presence of f_s modulates f_c, and varies the duty cycle. The signal at B_3 consists of an amplified pulse-width-modulated carrier, integrated in a low-pass LC filter.

A theoretical analysis

The updated switching-power amplifier was designed with the following simplified analysis:

The demodulator consists of a low-pass LC filter. At the signal frequency f_s:

$$X_L << R_L;\ X_C >> R_L. \quad (1)$$

where X_L is the inductive reactance, and X_C is the capacitive reactance. At the carrier frequency f_c:

$$X_L >> R_L;\ X_C << R_L. \quad (2)$$

If Eqs. 1 and 2 are combined, R_L is the geometric mean:

$$R_L = \sqrt{X_{L(fs)}\ X_{L(fc)}} = \sqrt{X_{C(fs)}\ X_{C(fc)}}. \quad (3)$$

To find supply voltage V_{cc}, first determine output power into load R_L:

$$P_{out} = \frac{V_m^2}{2R_L}, \quad (4)$$

where V_m = the peak value of V_o. At f_s:

$$V_{B2} = jI_L \cdot X_L + V_m. \quad (5)$$

Output-stage power losses and efficiency are determined next. Since the square-wave driver current has a 50% duty cycle, total power dissipated can be measured in Q_1 or Q_3:

$$P_{diss} = 1/2|V_{ec\ (sat)}| \cdot |I_L| \quad (6)$$

Turn-on and turn-off losses are determined if we assume that $V_{ec(sat)} = 0$ V:

$$V_{ec} = V_{cc}\left[1 - \frac{t}{t_{on}}\right]$$

$$V_{B2} = V_{cc}\frac{t}{t_{on}}. \quad (7)$$

The average power dissipated in Q_1 during turn-on is

$$P_{on} = \frac{V_{cc}^2\ t_{on}^2}{12\ LT}, \quad (8)$$

where T is the period of the carrier.

Turn-on and turn-off characteristics measured for Q_1 are almost identical. The total power dissipated in Q_1 during on and off periods is

$$P_{on-off} = 2\ P_{on} = \frac{V_{cc}^2 \cdot t_{on}^2}{6\ LT} \quad (9)$$

The total efficiency of the output stage may be measured next:

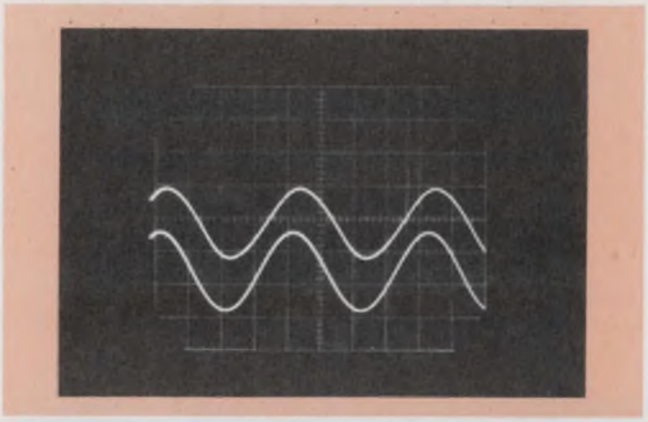
$$P_{loss} = 2\ P_{diss} + 2\ P_{on-off}, \quad (10)$$

$$\text{where efficiency} = \frac{P_{out}}{P_{out} + P_{loss}}. \quad (11)$$

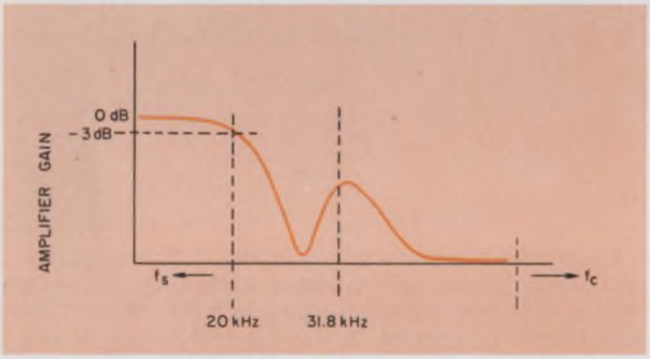
The complete switching-power amplifier of Fig. 1 is powered by a 24-V bipolar supply capable of 1.6-A output.

So much for theory. Now let's consider the practical aspects.

Solving Eq. 3, we get L = 40 μH and C_1 =



3. **Phase shift of the class-D amplifier** varies according to input frequency. The top sinusoid (signal at B_3) lags the input (A_1) by 19°.



4. **Frequency response of the amplifier** attenuates and boosts input f_s at two points. The −3 dB point shown corresponds to amplifier bandwidth. The second peak in the curve, which has a center frequency of 31.8 kHz, corresponds to the resonant frequency of the demodulator components.

0.63 μF. (Frequency f_s was arbitrarily chosen to be 10 kHz, with f_c equaling 100 kHz. More about this ratio later.)

The output power (Eq. 4) was solved for $R_L = 8\ \Omega$. Output P_{out} therefore equals 9 W when $V_m = 12$ V. Allowing 0.5 V_{ec} for Q_1 (or Q_3) and 11.5 V at point B_2, we get $V_{cc} = 12$ V.

Output load current I_L (Eq. 5) equals 1.6 A.

The power dissipated in Q_1 or Q_3 (Eq. 6) pinpoints one of the class-D amplifier's main features: $P_{diss} = 0.4$ W.

An increase in the carrier frequency may yield a closer approximation to the original modulating signal, but the tradeoff increases P_{on-off} losses in Q_1 or Q_3. Since t_{on} is a fixed parameter of the output transistors used, t_{on}/T increases if T is reduced. Although there is no ideal ratio for t_{on}/T, best results are obtained when this ratio approaches zero. If we restrict the total power loss for both output transistors to less than 2% of output power, the t_{on}/T ratio is 0.1. With the transistors used in the prototype amplifier, $t_{on} = 1\ \mu$s; therefore $T = 10\ \mu$s. Solving Eq. 9, we get $P_{on-off} = 0.06$ W.

The total power loss of the output stage (Eq. 10) yields 0.92 W. Efficiency (Eq. 11) $\simeq 90\%$. Power loss in the resistive component of inductor L greatly affects over-all power loss, and therefore the efficiency of the amplifier. The prototype used a 40-μH air-core inductor, thereby eliminating core and magnetization current losses. A typical air-core coil having a Q = 100 has a dc resistance of 0.025 Ω. If space is not a primary design goal, choose an air-core coil. If space is important, a magnetic-core coil may be used; the magnetic-core coil is about 4% less efficient than the air-core version at Q = 100.

From Eq. 10, the power rating of the output transistor is 0.46 W. The current rating of either Q_1 or $Q_3 \geqq 1.6$ A. The only other important transistor rating, V_{CEB}, equals $2V_{cc}$, or 24 V.

Simple pulse-width modulator

While this updated version of the amplifier uses a unijunction transistor sawtooth generator and monolithic comparator, a readily available multifunction generator or monolithic timing integrated circuit could also have been used—but at greater cost.

The unijunction transistor chosen has the following characteristics when $V_{cc} = 12$ V: $\eta = 0.6$; $V\gamma = 0.6$ V, $V_P = 7.8$ V; $V_V = 1.6$ V. The combination of R_5 and pot R_6 is adjusted so that V_{A2} has an average value of zero volts. This parallel combination also must be an order of magnitude less than the input resistance of the inverting terminal of the comparator; V_{A2} therefore can appear to be a voltage source to the integrated circuit.

Any of the textbooks treating the UJT can be used to find component values for a particular carrier frequency. But remember that f_c helps determine final amplifier efficiency. The upper limit of f_c (and therefore the ratio between it and f_s) is determined by the amount of distortion caused by high-frequency power. The 10:1 ratio set for f_c and f_s gives a final distortion of 2% at full power.

The comparator chosen has an upper frequency cutoff that is one order of magnitude greater than f_c. It is capable of ±10 V output from a ±12-V supply; I_{out} is ±2 mA. ■■

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The four-function 'scientific' calculator.

By simplifying equations and pushing the keys a few extra times you turn an inexpensive machine into a scientific tool.

The simple four-function calculator (Fig. 1) offers the engineer almost as much versatility as much more expensive scientific units. By altering the order in which some computations are performed, and by adding some extra steps, you can use the basic calculator to do operations like squaring, square-rooting, summing of products, summing of quotients, trig ratios and exponents.

But usually before you can do this, you must simplify the complex engineering formulas. The reduction simply eliminates some factors in the equation that would not affect the result by more than a few percent.

Once the formulas are reduced there are many areas where the four-function calculator can be used to predict the design trend quickly without lengthy analysis. Areas where this applies include power-supply filter design, signal filter design and rms signal calculations.

Overcoming calculator limitations

The square-root operation is one of the more common math operations that is not available directly on a low-cost calculator. To perform this operation with a calculator, start with the first-order approximation for the square root:

$$\sqrt{N} = 1/2(N/A + A).$$

N is any number whose square root is to be determined, and A is the approximate square root of N. As an example let N = 86, then let A = 9, and you get:

$$\sqrt{86} = 1/2(9.5555555 + 9) = 1/2(18.555555)$$
$$= 9.2777775.$$

If you need better than 5% accuracy, repeat the process with A = 9.2777775. The result is 9.273619. As a check, $(9.273619)^2 = 86.000009$.

This procedure for finding the square root can be expanded to find the nth root of a number N. The new formula for the nth root is:

$$\sqrt[n]{N} = \left[\frac{N}{X^{n-1}} + (n-1)X\right]\frac{1}{n}.$$

John Ayer, Manager, Calculator Operations, Bowmar Canada Ltd., 1257 Algoma Rd., Ottawa, Ontario, Canada.

In this case, N is the number whose root is to be determined, n is the order of the root and X is the approximate value of the nth order root of N.

Let's try a problem: Find $\sqrt[4]{28211}$.

Let X = 13. Then $(28211)^{1/4} =$

$$\left[\frac{28211}{13^3} + 3(13)\right] \times (1/4) = 12.96.$$

To do mixed calculations, such as a sum of products, just follow the simple steps outlined in this example:

$$N = (35 \times 7) + (75 \times 13) + (31 \times 9).$$

Keyboard	Display
Enter 35	35
Touch ×	35
Enter 7	7
Touch =	245
Touch +	245
Enter 75	75
Touch + (13 times)	1220
Enter 31	31
Touch + (9 times)	1449

For the sum of quotients, the fractions must first be converted to a sum of products over a common denominator. For example,

$$N = 36/5 + 21/8 + 81/6$$

is converted to

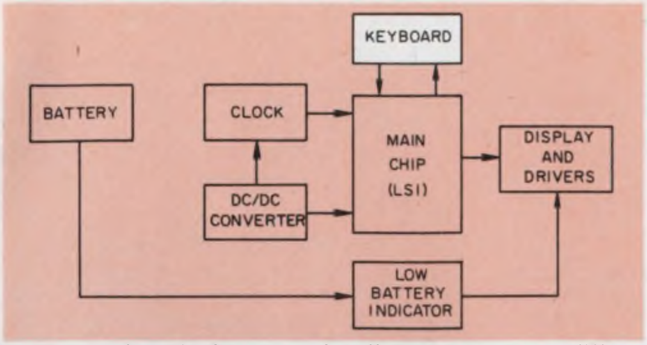
$$N = \frac{36(8 \times 6) + 21(5 \times 6) + 81(5 \times 8)}{5 \times 8 \times 6}.$$

This expression can be simplified further before you use the calculator:

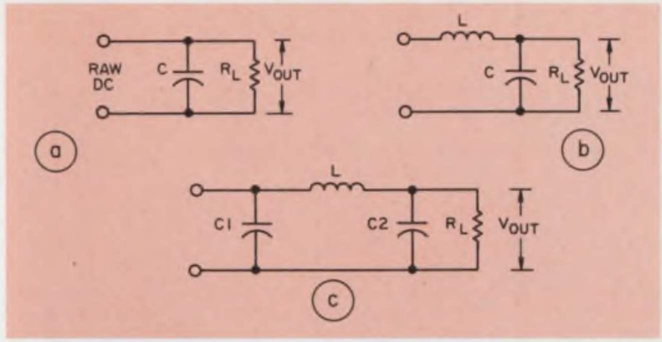
$$N = \frac{36 \times 48 + 210 \times 3 + 810 \times 4}{240}.$$

You can now proceed as in the sum-of-products procedure. The answer for this example is 23.325.

In cases like these, perform the multiplication or division before addition or subtraction. For numbers with decimals, convert the multiplier to a whole number before you use the sum-of-prod-



1. **The basic calculator can be divided** into many different functional sections that together do the computations and display the result.



2. **The simplest power supply filter** (a) is a lone capacitor across the raw supply. Further filtering results if an inductor is added (b) or a π filter is used (c).

The electronic calculator: Some definitions

With the large upswing in the use of portable electronic calculators, new terms have come into the engineer's vocabulary. Here are some of the more common ones:

Automatic or manual constant: This calculator feature simplifies reciprocal and squaring computations. Usually, a switch controls the constant, which is locked in the logic store and used when required.

Omni constant: The calculator can add consecutively in any steps of any predetermined size, raise the power of any number in consecutive steps.

Significant figures: This is the result displayed after automatic machine roundoff. For example, when an eight-digit calculator computes 45689 × 98745, it will display [45115603, although the actual result is 4511560305. The last two digits, 0 and 5, are not displayed, since the machine is limited to eight digits; only the eight most significant ones are displayed. The symbol to the left of the result indicates that the number is larger than the display can handle (i.e. overflow sign).

Overflow indicator: When the calculator's computing capacity is exceeded, the display will usually produce the answer with some special symbol and only the N most significant digits displayed. (This assumes that the calculator can display only N digits).

Zero suppression: Internal circuits prevent the zeros that preceed whole numbers from being displayed—thus an uncluttered number is shown.

Arithmetic logic: Most calculators use this mode of operation (since the circuitry is simpler). This logic cannot directly multiply two negative numbers and give a positive answer. Also, addition and subtraction operations are not done in the same sequence as written in the original equation.

Algebraic logic: This calculator mode permits all calculations to be done in the order in which they are written.

Underflow: When the calculator's capacity is exceeded, some of the least significant digits are discarded and the resulting display is sometimes zero.

True credit balance: When the answer is negative, the minus sign automatically appears in the display.

Fixed decimal point: Location of the decimal point in the display is chosen by a selector switch. For example, if the switch is set to position six on an eight-digit machine, the numbers between 99 and 0.001 can be used. In some machines no selector is provided, and a calculation like 123/456 yields the answer 0.28 instead of 0.2697368.

Floating decimal point: In this case each entry may contain the decimal point in any position. The number and decimal point will be properly positioned automatically when displayed.

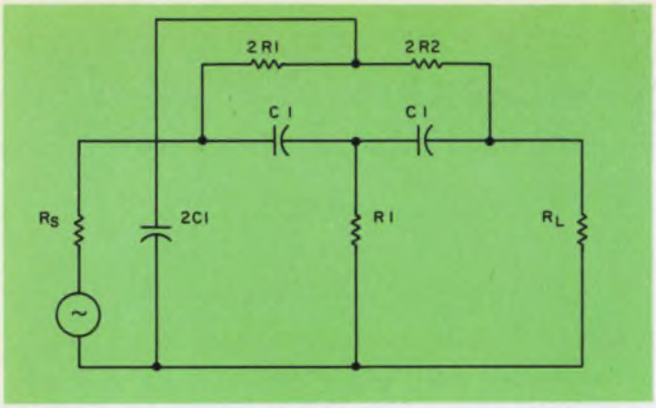
Memory: This gives the machine the capability to store information during chain calculations and to recall it when required. The memory eases the calculation of sums and differences of products and quotients.

Other features of many new calculators include a key that permits an eight-digit calculator to display 16 digits, an indicator that tells when the batteries are low, and a battery-saver circuit that cuts off the display after about 15 seconds to prevent excessive battery drain (the display is restored when any key is pushed).

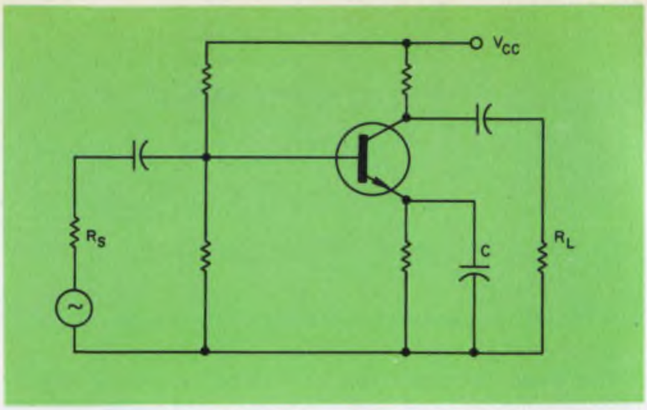
ucts procedure discussed earlier.

Powers of e can also be calculated. To get them, though, you must approximate e as 2.7183, and the exponent must be a whole number—either positive or negative. There are two possible procedures: one for calculators that have a constant key (K), and one for those that don't (i.e. automatic). For the calculators with the automatic constant, the procedure is as follows:

For a positive exponent—for example, e^4:



3. **Design of the twin-T notch filter** can be simplified if a calculator performs modified notch computations.



4. **By simplifying the design equations** for the decoupling capacitor, you can use a calculator to get the answer.

Keyboard	Display
Enter 2.7183	2.7183
Touch × (four times)	54.599607

For a negative exponent—for example, e^{-3}:

Keyboard	Display
Enter 2.7183	2.7183
Touch ÷ (five times)	0.049786

Note: For negative exponents, the divide key should be pressed two times more than the absolute value of the exponent.

When the calculator has a constant switch, use the following procedure after setting the switch to K:
For a positive exponent (e^4):

Keyboard	Display
Enter 2.7183	2.7183
Touch ×	2.7183
Enter 2.7183	2.7183
Touch += (three times)	54.599607

For a negative exponent (e^{-3}):

Keyboard	Display
Enter 2.7183	2.7183
Touch ÷	2.7183
Enter 2.7183	2.7183
Touch += (four times)	0.049786

Note: For negative exponents, add one to the absolute value of the exponent to determine the number of times the += key should be pressed.

Even trigonometric functions and ratios can be computed on the four-function calculator. The only restriction is the maximum angle—for 5% accuracy, the angle is limited to 30°. To find sin x where x is in degrees, multiply x by 0.0174. For tan x, do the same but use 0.0175. The cos x is simply the ratio of sin x to tan x.

To go the reverse route and get the angle from trig value, just divide the sin or tan value by the respective multiplying factors used before. The inverse cosine is the inverse sine of 90° − x.

Applying the solutions

These calculator shortcuts can be applied to designs. Consider a power-supply filter. For the basic C, LC or π filters (Fig. 2), output voltage or ripple can be calculated from some simple formulas. The circuit of Fig. 2a represents the simplest filter. Its output equation[1] is:

$$V_{out} = 1.4\,(V_{in\ rms}) - 0.0042I_{dc}/C.$$

In this case V_{out} is dc', I_{dc} is in amps, C is in farads and R_L is in ohms. The ripple factor r, (R/X_c) can also be computed from the equation

$$r = 0.0024CR_L.$$

If the LC filter is used (Fig. 2b), the output voltage can be calculated from

$$V_{out} = 0.9V_{in\ rms},$$

while the ripple factor becomes

$$r = 0.0000008/CL,$$

where L is in henries.

In the last case (Fig. 2c) the π filter has an output equation identical to the simple filter of Fig. 2a. However, the ripple factor changes to account for the extra components. The new equation is

$$r = \frac{33}{10^8(C_1C_2LR_L)}.$$

The twin-T notch filter can also be designed with the calculator. The circuit of Fig. 3 provides good selectivity and will exhibit attenuation at the notch frequency, f_o, determined by R_1 and C_1. If the design requires that only f_o be rejected, then the value of either R_1 or C_1 is arbitrary. When gain has to be constant from dc to high frequencies, then

$$(R_1)^2 = R_GR_L/2,$$

and the notch frequency

$$f_o = 0.08/C_1R_1,$$

where C is in farads and R is in ohms.

Calculations for audio circuits are also possible. For example, if you want to convert 15 dB back to the power ratio it came from, raise 2 to

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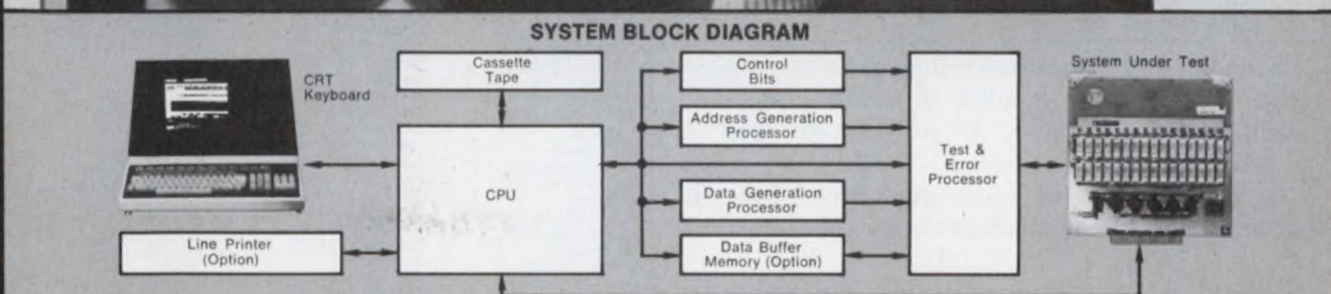

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$$15 \text{ dB} = 2^{15/3} = 2^5 = 32 \text{ times.}$$

For a voltage or current ratio from dB, do the same thing, but then take the square root of the ratio. Example:

Convert 13 dB to its voltage ratio

$$13 = 2^{13/3} = 2^{4\ 1/3} = 16 + 16 \times 1/3^* = 21.$$

$$21 = \frac{1}{2}\left(\frac{21}{A} + A\right) \quad \cdots \text{ see square root procedure}$$

$$= 4.48 \text{ times.}$$

The effective value (rms), arithmetic mean value (amv) and form factor (ff) of any waveform can be approximated by the following three formulas and multiplicative constants:

$$1.\ V_{rms} = \sqrt{\frac{1}{T}\int_0^T V^2 dt.}$$

where T is the period in seconds.

$$2.\ V_{amv} = \frac{1}{T}\int_0^T |V| dt.$$

$$3.\ ff = V_{rms}/V_{amv}.$$

These three formulas[2] can help tabulate the effective value, mean value and form factor for any desired waveform. The table shows a few examples that are applicable either for voltage or current.

Waveform	Rms	Mean	Form Factor
Triangular	0.578 (V_{peak})	0.5 (V_{pk})	1.16
Sine wave	0.707 (V_{pk})	0.636 (V_{pk})	1.11
Trapezoidal	0.746 (V_{pk})	0.667 (V_{pk})	1.12
Square	V_{pk}	V_{pk}	1.00
Rectified half-wave sine wave	0.5 (V_{pk})	0.318 (V_{pk})	1.57
Rectified full-wave sine wave	0.707 (V_{pk})	0.636 (V_{pk})	1.11

Finally, amplifier decoupling capacitor values (Fig. 3) can be computed if a few reasonable assumptions are made.[3] If you assume that R_s is much less than h_{ie} and $g_m = 38I_c/10^3$, where I_c is in amps and g_m is in amps/volt. Now, the capacitance can be calculated from the following:

$$C = 6I_c/\text{Hz},$$

where C is in microfarads and the frequency represents the lowest frequency the amplifier is expected to pass. ■■

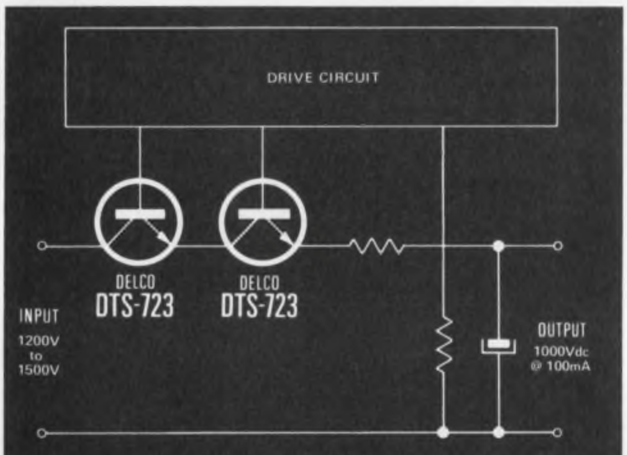
*Note: As in the previous example, if the fractional remainder of the exponent is 1/3 or 2/3 after division by 3, it is multiplied by the base raised to the integer part of the exponent and added to the base raised to the integer part of the exponent.

References

1. Filter formulas are available from several standard reference manuals.
2. Reiche, H., "Waveform Values and Factors," *Electronics and Communications*, Aug., 1967.
3. Engstrom, P., "The Decoupling Capacitor," *Wireless World*, Dec., 1971.

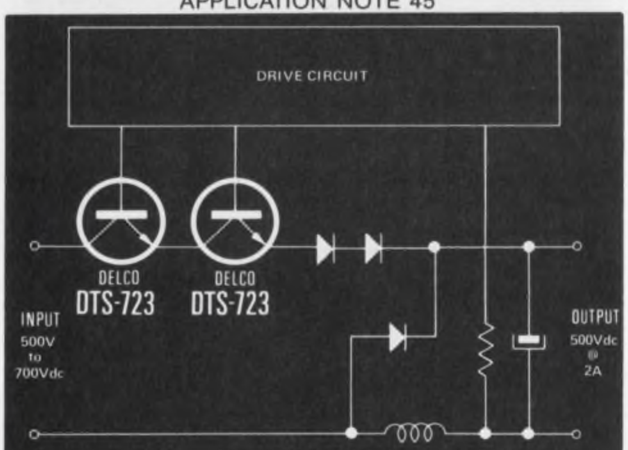
NEW VALUES HIGH ENERGY

TYPE	I_C(max.)	V_{CEO}	V_{CEV}	$V_{CEO\,(sus.)}$	$V_{CE\,(sat.)}$ @ I_C, I_B	Power Dissipation (max.)	h_{FE} min./max. @ I_C, V_{CE}
DTS-701	1.0 A	800V	—	600V	—	50W	20/— @ 150mA, 5V
DTS-708	3.0 A	900V	900V	600V	2.0V max. @ 1.0A, 250mA	50W	—
DTS-709	3.0 A	900V	900V	600V	1.0V max. @ 2.0A, 800mA	50W	—
DTS-710	3.0 A	900V	—	600V	—	50W	10/50 @ 150mA, 5V
DTS-712	3.0 A	900V	1200V	700V	—	50W	2.5/— @ 2.0A, 5V
DTS-714	3.0 A	900V	1400V	700V	—	50W	2.5/— @ 2.0A, 5V
DTS-723	3.0 A	1000V	1200V	750V	0.8V max. @ 1.0A, 250mA	50W	10/— @ 500mA, 5V
DTS-801	2.0 A	800V	—	700V	—	100W	20/— @ 200mA, 5V
DTS-812	5.0 A	900V	1200V	700V	—	100W	2.2/— @ 3.5A, 5V
DTS-814	5.0 A	900V	1400V	700V	—	100W	2.2/— @ 3.5A, 5V



1000 VOLT LINEAR DC REGULATOR

APPLICATION NOTE 45



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APPLICATION NOTE 46

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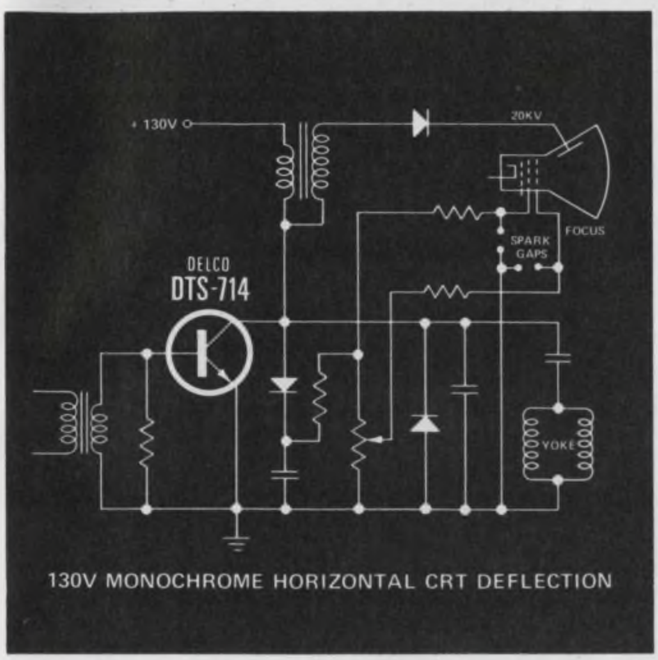

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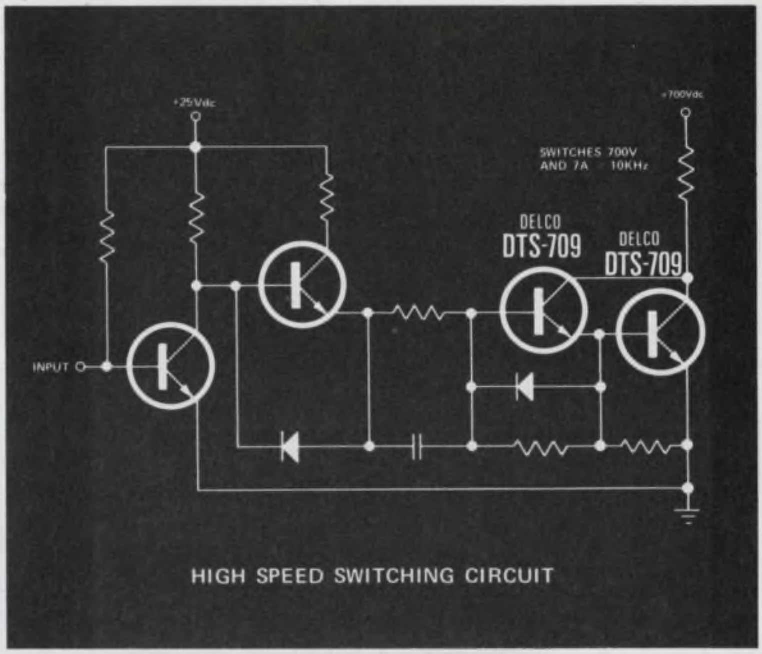

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INFORMATION RETRIEVAL NUMBER 45

Modified data-transmission module can handle ASCII and BCD

By adding full 8-bit control and sequencing to the Analog Devices serial-transmission module (STX 1003), you can adapt the unit to accept both the full ASCII character set and BCD.

The module and controller can be wired to transmit a sign bit (+ or −), four BCD characters and space for nine more cycles. And on the tenth cycle, the space character is replaced by the carriage return and line feed. When used in a 20-mA current loop with a teletypewriter or some other asynchronous terminal, the system operates as an automated data logger and instrument controller for virtually any instrument that has BCD output.

The STX 1003 module converts BCD to ASCII and transmits the characters in an asynchronous mode. In the BCD-to-ASCII conversion, the four most significant bits (MSB) of the ASCII character do not change from 1011_2. For transmission of characters other than numbers, these bits must be changed.

The circuit (see p. 112) controls the MSBs shown—the module inputs D16, D17, D20 and D13. Only bits 6 and 5 are controlled for the transmission of space, carriage return, line feed and the sign. In other applications, bits 7 and 8 can be controlled in the same manner.

The sequence starts when you load the module-input shift register with the BCD data and the four least-significant bits (LSB) of all other characters to be transmitted for the data point. The sequencers are at zero at this time. The BCD digits are loaded directly into shift-register positions 2 and 5. To get a plus sign (an ASCII plus is represented by 10101011), the four LSBs of the sign are loaded into the first character position; the four LSBs of the space (space = 10100000_2) are loaded into position 6 by G_4, and the transmitter stop character (1111_2) into position by G_5. The transmitter register now contains eight parallel bits for a full ASCII character. Therefore the four MSBs must now be externally controlled.

The first character (sign), 1010_2 is loaded into the four MSB positions under the control of sequencer 1. At the same time, the four LSBs (1011_2) are loaded from the module's internal shift register.

During transmission the D_{21} output goes low, and a shift pulse is produced at A_3. This advances sequencer 1 to position 1 and internally shifts the first BCD character into position. With the subsequent transmission of the four BCD digits, sequencer 1 advances to 5. Gate G_3 controls the loading of the four MSBs of the sixth character (space) into the transmitter buffer.

This cycle repeats nine times and, by the tenth cycle, sequencer 2 has advanced to 9. Now G_5 loads the four LSBs of the carriage return into shift-register position 6, and the line feed bits into position 7. Gates G_1 and G_2 load the proper bits into the four MSB positions of the transmitter buffer (the same as for the ASCII space bits). However, the stop character is also loaded into position 8 of the shift register.

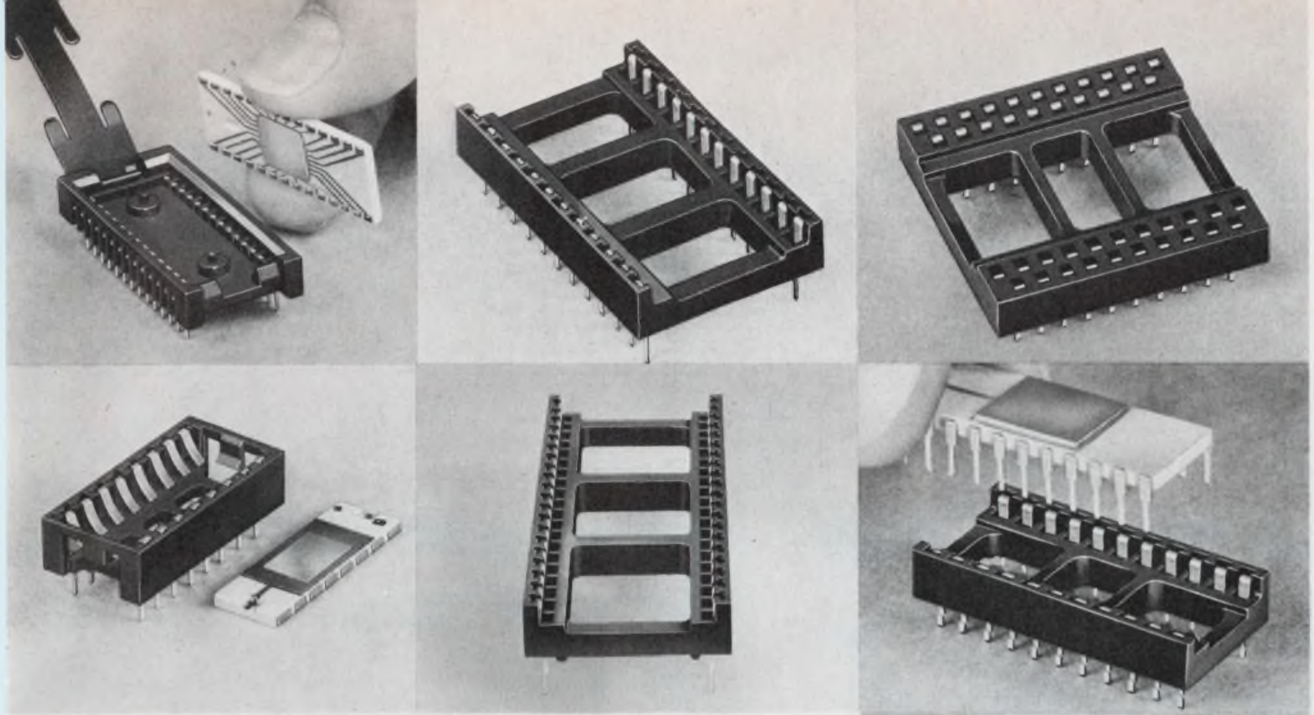
The receiver portion of the module is in the current loop. Thus any characters transmitted are received, and the available control functions can be used for control of the BCD instrument or sequencer at the other end. The circuit is set up so that when the $ key of the connected ASCII keyboard is struck, sequencer 2 will reset (it sequences from 9 to 0 automatically).

These sequencers can enable any array of ASCII characters by proper hardware programming of the system. For instance, when more than one digital instrument sends data, an identification code, sign and decimal point can be sent by each instrument. The characters—or their sequence—are limited only by the user's ability to wire a few OR gates and diodes to the sequencer's outputs.

David Larsen, Instructor, Chemistry Dept., Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

CIRCLE NO. 311

(continued on pg. 112)



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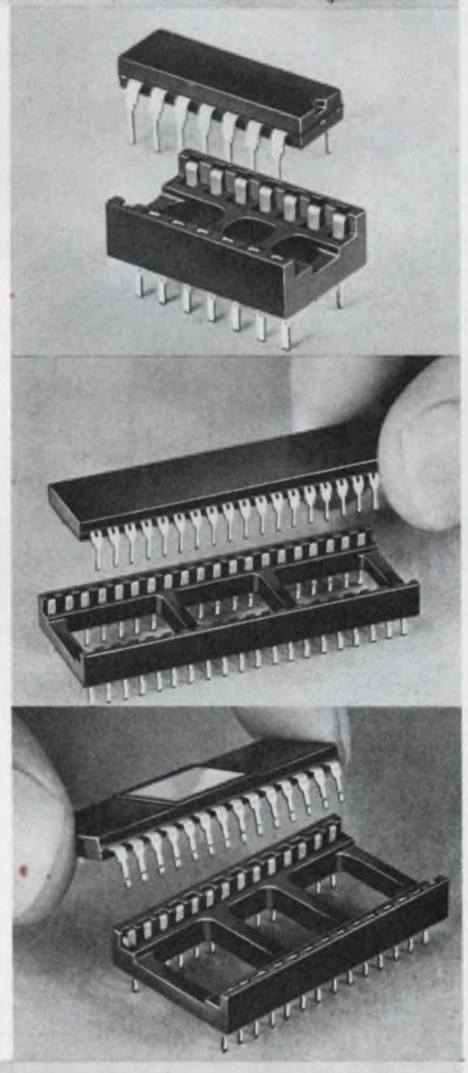

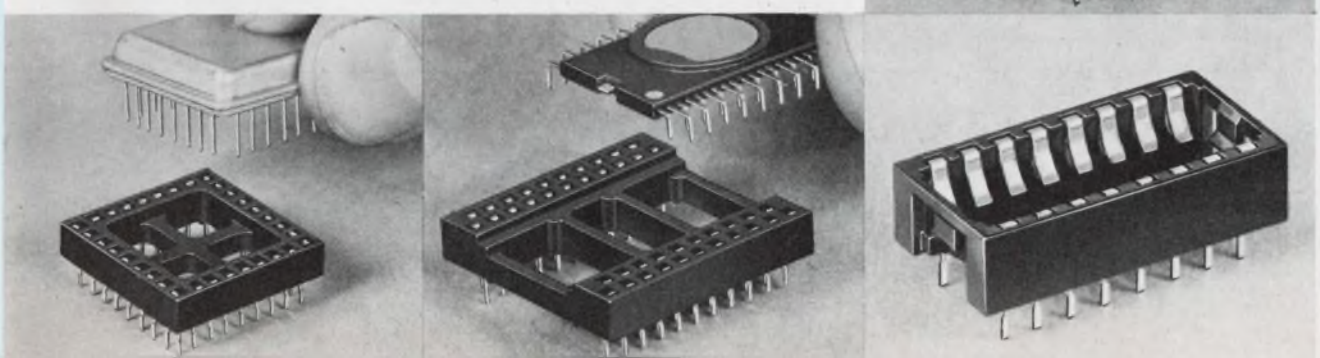

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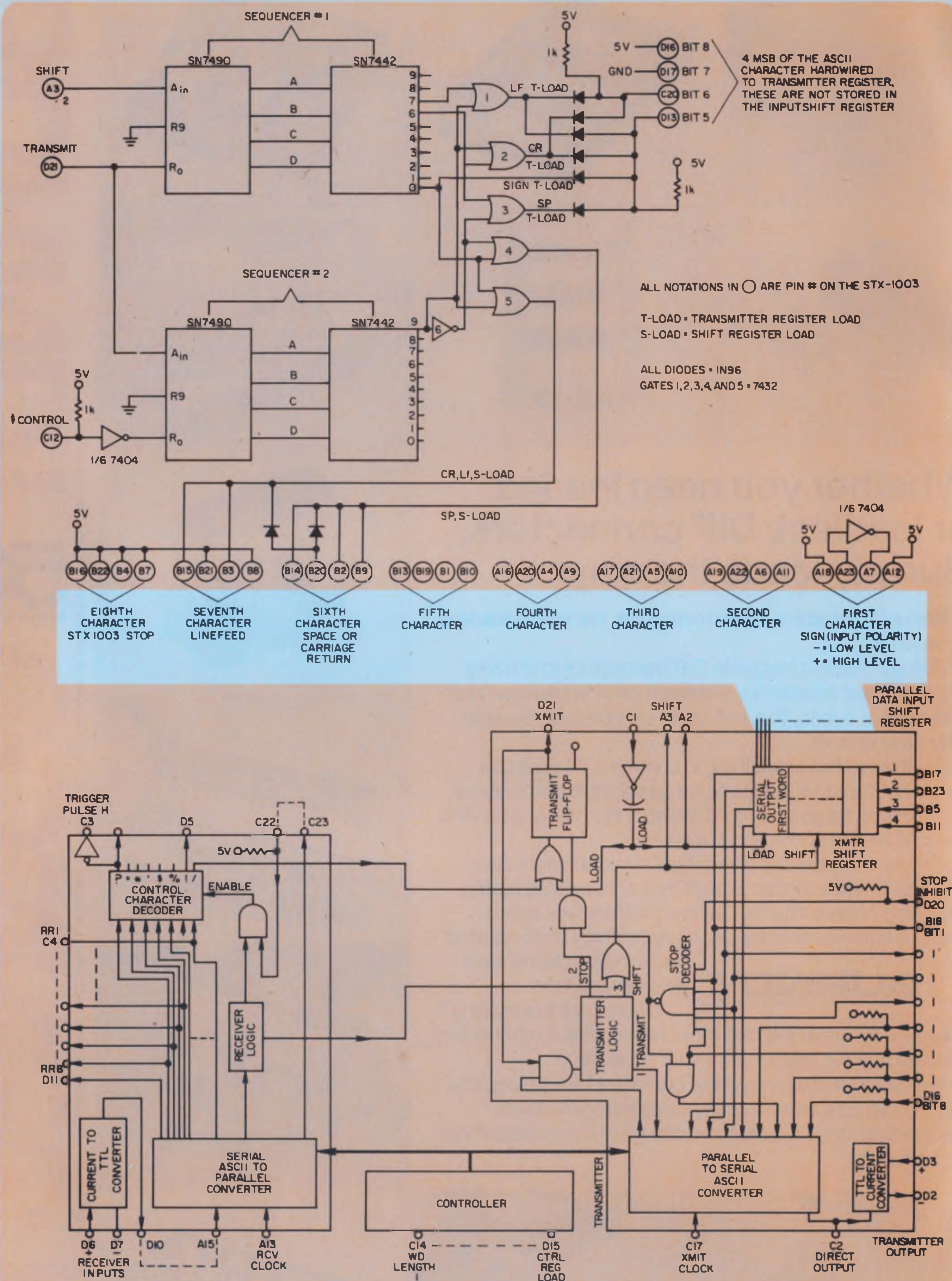

An external 8-bit controller-sequencer circuit is used to modify the STX-1003 inputs so that the module can accept the full ASCII character set in addition to BCD.

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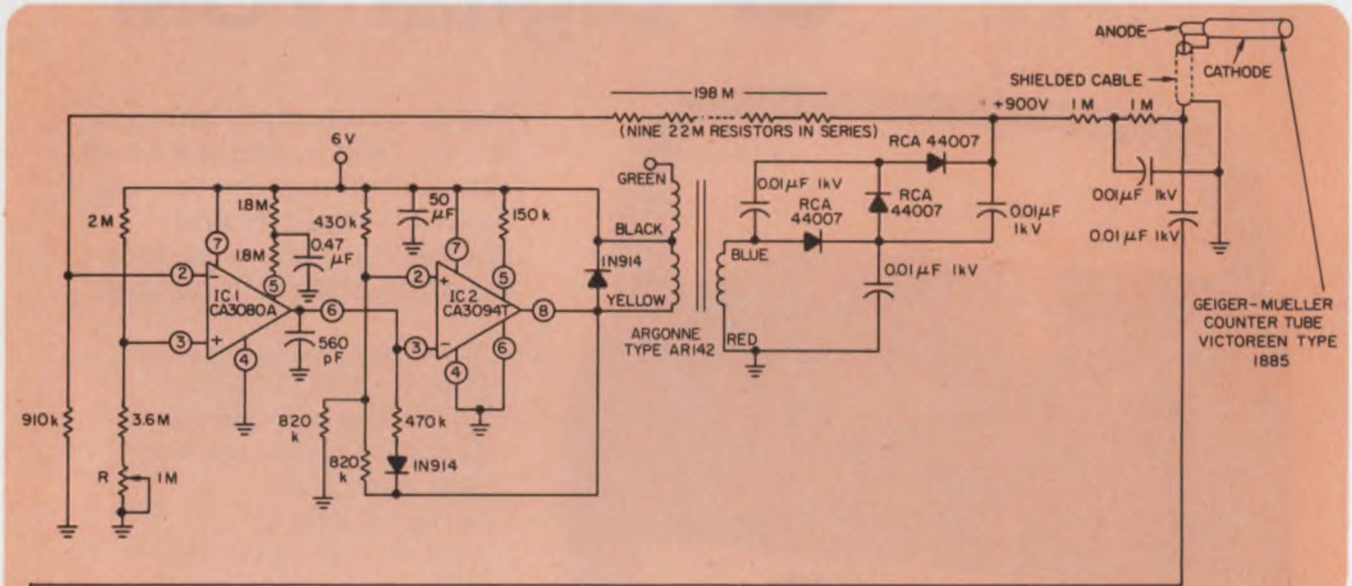
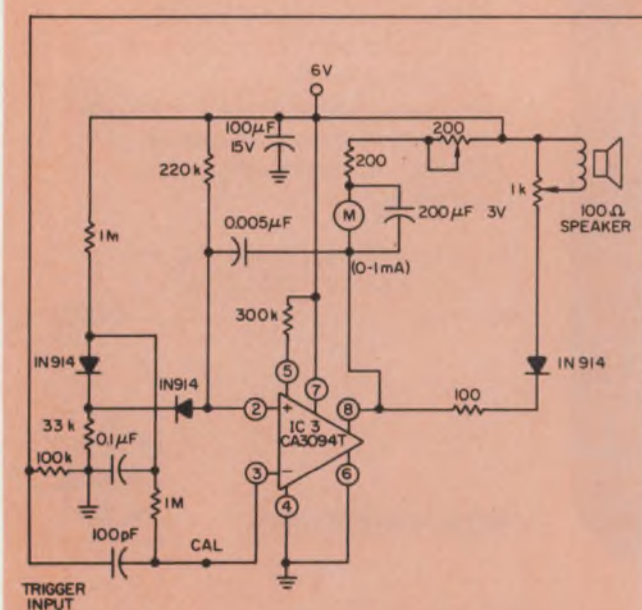
INFORMATION RETRIEVAL NUMBER 47

Pocket-sized Geiger counter built with three micropower ICs

Three micropower ICs allow a Geiger counter the size of a cigarette pack to idle with milliwatt power consumption, yet provide the necessary peak power to the counter tube when radiation is detected. A single 6.75-V mercury battery powers the counter, which features a 1-mA count-rate meter as well as an aural output.

A regulated 900-V supply provides stable operation of the counter tube. A multivibrator, built around differential power amplifier IC_2, drives the step-up transformer. Comparator IC_1 varies the multivibrator duty cycle to provide a constant 900 V. The entire regulated supply draws less than 2 mA.





A single 6.75-V mercury battery runs this micropower Geiger counter. Full-scale meter deflection is 5000 counts/min and the entire circuit draws less than 2 mA in the absence of ionizing radiation.

A one-shot multivibrator, built with IC_3, provides output pulses that have constant width and amplitude. Thus the average current through the meter is directly proportional to the pulse-rate output from the counter tube. And the constant-width pulses also drive the speaker.

Full-scale meter deflection (1 mA) represents 5000 counts/min, or 83.3 pulses/s. A convenient calibration checkpoint can be provided on the meter scale for 3600 ppm (60 pulses/s).

You can introduce the input externally if you touch a small contact on the case. The contact is wired to the CAL point shown on the schematic. The entire circuit uses 1.6 mA when no radiation is present and 3.1 mA at 83.3 pps. Sensitivity is adequate to monitor luminous clocks, watches or other potentially hazardous sources of ionizing radiation.

John Tilicsek and Hal A. Wittlinger, RCA Solid State Div., Route 202, Somerville, N.J. 08876.

CIRCLE NO. 312

TYPE - 256 x 1 Static SOS/CMOS Ram
NUMBER - INS4200
READ CYCLE TIME - 180 nS
WRITE CYCLE TIME - 140 nS
QUIESCENT POWER DISSIPATION - 40 μW @ 10 V
INPUT CAPACITANCE - 6.5 pF
SUPPLY VOLTAGES - 5 to 15 volts
OUTPUT - Three-state TTL compatible, full address decoding and bipolar compatible pin-outs.
PACKAGE - 16 pin dual-in-line
PRICE - Mil Range (100-999) $38.00
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INFORMATION RETRIEVAL NUMBER 48

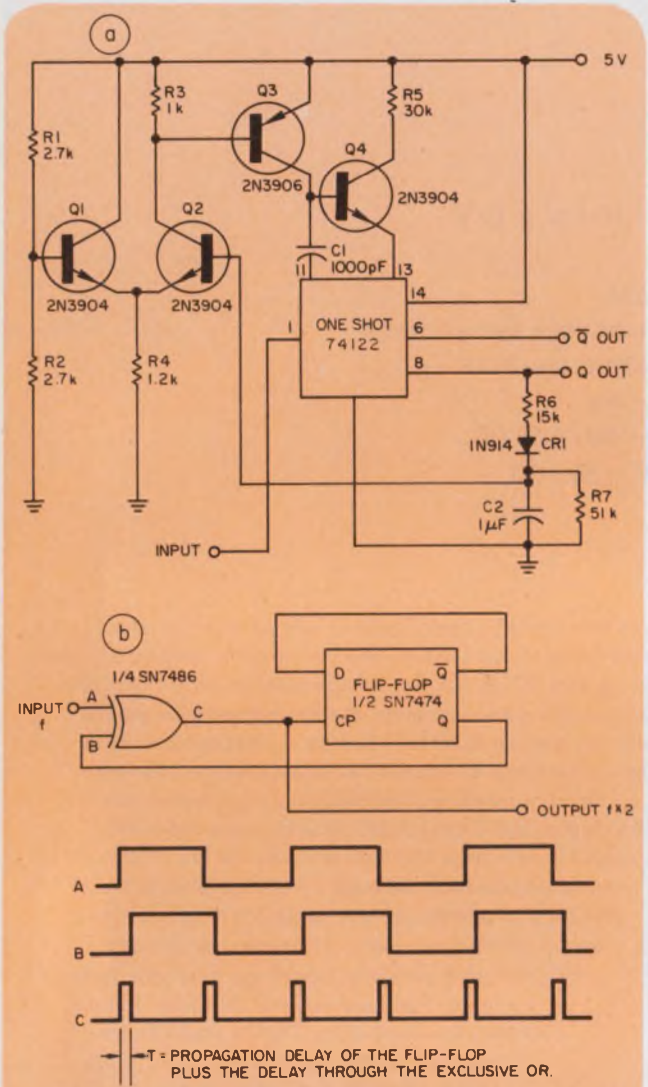
Wide-range pulse-shaping circuit gives square waves with 50% duty cycle

The shaping circuit of Fig. 1a automatically converts a periodic pulse train to a symmetrical square wave of the same frequency. It operates from 10 Hz to 1 MHz. The resulting square wave provides a suitable trigger source for other logic circuits such as frequency multipliers.

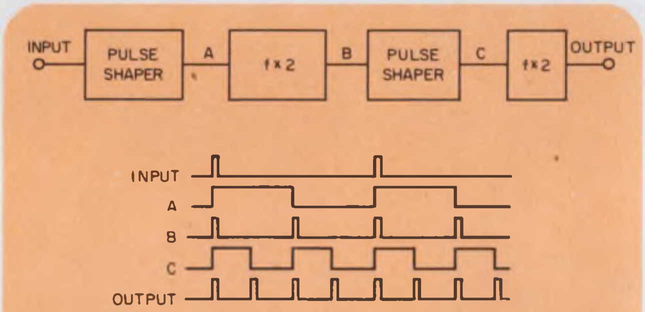
In the pulse-shaping circuit, transistors Q_1 to Q_4 form a voltage-controlled capacitance multiplier. As the voltage across C_2 rises, Q_2 and Q_3 are forced deeper into conduction and thus charge C_1 faster. This decreases the width of the output pulse from the 74122. And, in turn, it lowers the voltage at the output of the integrator formed by C_2, CR_1, R_6 and R_7.

If this shaping circuit is cascaded with the frequency-doubling circuit of Fig. 1b, symmetrical square waves of almost any multiple of the original clock frequency can be generated. For example, Fig. 2 combines two shaping circuits and two doubler circuits to quadruple the input frequency.

R. M. Stitt and R. L. Morrison, Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706. CIRCLE NO. 313



1. **A 74122 retriggerable one-shot** and a few components form a shaping circuit (a) that changes a repetitive pulse train into a 50% duty-cycle square wave. If you combine an exclusive-OR gate and a flip-flop (b) you can double the frequency of an input signal.



2. **If the pulse shaping circuit** of Fig. 1a is cascaded with the frequency-doubling network of Fig. 1b, almost any multiple of the input-signal frequency can be obtained.

IFD Winner of Dec. 6, 1973

John Shakib, Design Engineer, IBM General Systems Div., 2000 51st St., Boca Raton, Fla. 33432. His idea "Digitally Programmable Oscillator Selects Frequency in Integer Units from One to 15" has been voted the Most Valuable of Issue Award.

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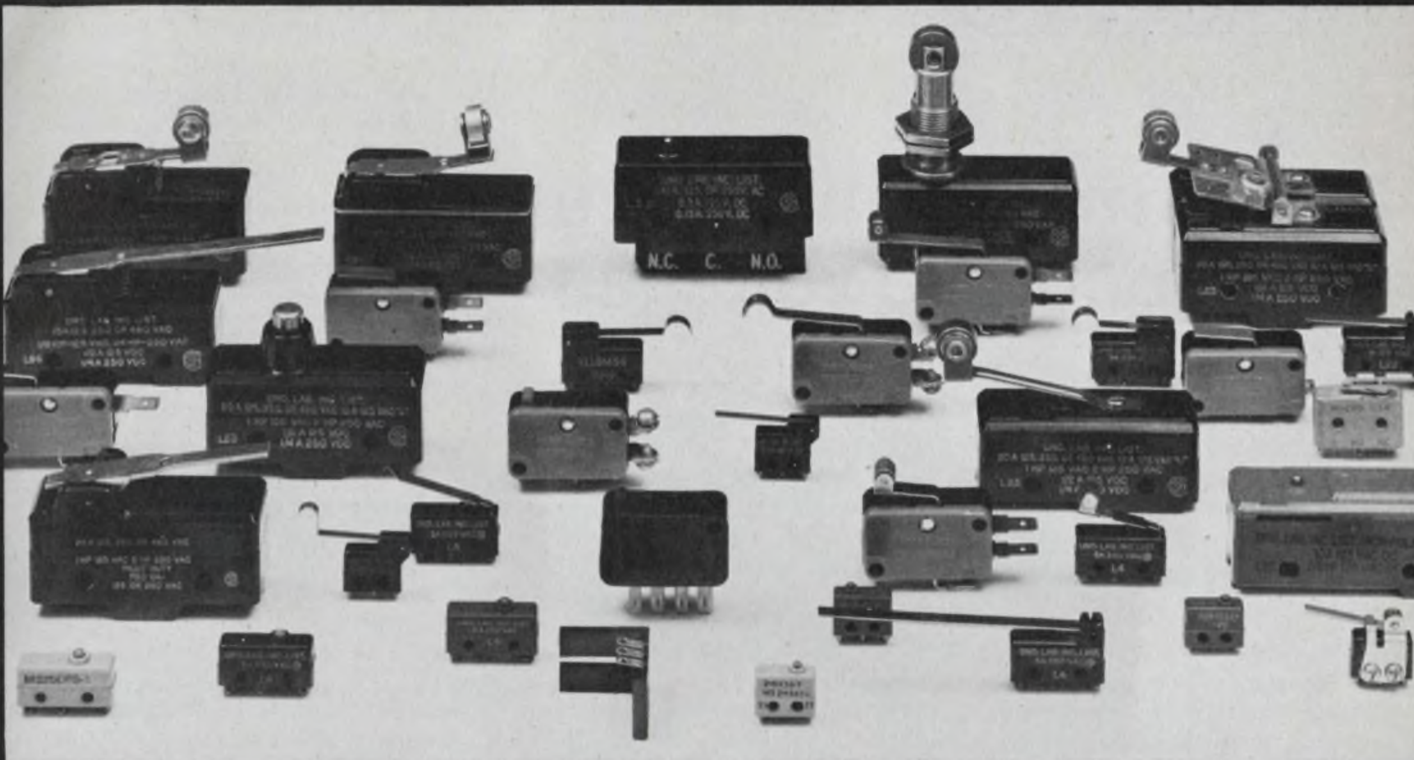

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Digital method linearizes thermocouple voltages

The inherently nonlinear output voltages of thermocouples have been linearized by use of digital techniques. The system, developed by Elektronska Industrija, in Belgrade, Yugoslavia, consists of a thermocouple, a conversion amplifier, a digital voltmeter and a linearizer.

The method is designed so that the thermocouple output and the indicated voltage are directly proportional over the range of temperature measured.

The thermocouple output is amplified and transformed in the a/d converter of the DVM to a train of pulses. In the linearizer, the pulses are counted by four counting decades and a flip-flop. The counter counts pulses in groups, and from each group an inhibit gate eliminates one pulse. The lengths of the pulse groups are adjusted to compensate for the nonlinear output of the thermocouple and its permitted error.

The count of the pulses passed is displayed as the measured temperature. The pulse-group counter is a modulo-N counter, with N adjustable between 2 and 20. A decade counter similar to the SN 7490 and resettable to zero is used.

The digital linearizer can also work on the outputs of other sensors, such as those that measure pressure, flow and humidity.

Microcomputer to warn of marine-engine trouble

A programmable microcomputer that costs about one-fifth that of a comparable minicomputer has been developed by Soren T. Lyngso of Copenhagen. It will be used by the Technical University of Denmark for diesel-engine monitoring and predictive maintenance.

The microcomputer will collect data from the engine and, based on past information and present engine status, will warn of potential breakdowns. The computer program is stored in a read-only memory and cannot be inadvertently modified or erased. Hardware failures in the central processing unit will not influence the program.

CIRCLE NO. 319

Charge-transfer hangup is reported overcome

Incomplete charge transfer—which limits the frequency response and the number of stages of bucket-brigade devices—is reported to have been overcome by researchers at AEG-Telefunken in West Germany. One transistor and one resistor per cell are added.

The additional transistor supplies a subsidiary clock voltage to the gate of the main-cell FET. The resistor is in series with the capacitor between the gate and the drain of the FET.

The extra transistor does not conduct until the voltage from the preceding cell exceeds a certain threshold value. When the threshold voltage is reached and the controlling transistor conducts, the main-cell FET gate potential decreases rapidly. The result is a faster, more complete charge transfer through the FET than that in previous bucket-brigade devices. Lower signal losses also result.

Printer reproduces details down to 0.1 mm

An electrostatic printing process that can reproduce a full range of shades of gray between black and white has been developed at the Philips Research Laboratory in Hamburg, West Germany. Details of approximately 0.1 mm can be reproduced.

In the new process, a spark discharge is generated in air, and negative ions are attracted by the positive voltage on a control electrode to the insulating surface of an image carrier. The ions pass through a cylindrical hole in an insulating plate fitted beneath the spark electrodes. This ensures that the charge on the image carrier is restricted to a small, well-defined spot.

Contactless printing makes it easy to move the image carrier to a point where the charge pattern is converted into printable copy with the aid of a toner. Wear and pollution of the charge carrier are eliminated.

The quantity of charge applied to the image carrier by the spark electrodes per current pulse—hence the density of the final print—can be varied within wide limits by adjustment of the voltage on the control electrode.

Copies can be made with a single set of spark electrodes if the image carrier underneath the electrodes is moved—but the printing rate is low. For fast printing, a row of several hundred spark electrodes, working in parallel, would be used. ■■

Electronic Design presents the 'top-ten' winners

The following pages display advertisements of companies who won our "TOP TEN" contest with outstanding ads in the January 4 issue. The contest attracted thousands of readers who attempted to match their ratings of the 10 most memorable advertisements with the "recall-seen" scores from ELECTRONIC DESIGN's regular Reader-Recall survey.

Winning advertisements combine attractive colors, tasteful design and well-written copy. The result: impact. Here are the winning companies in order of highest Reader-Recall score received:

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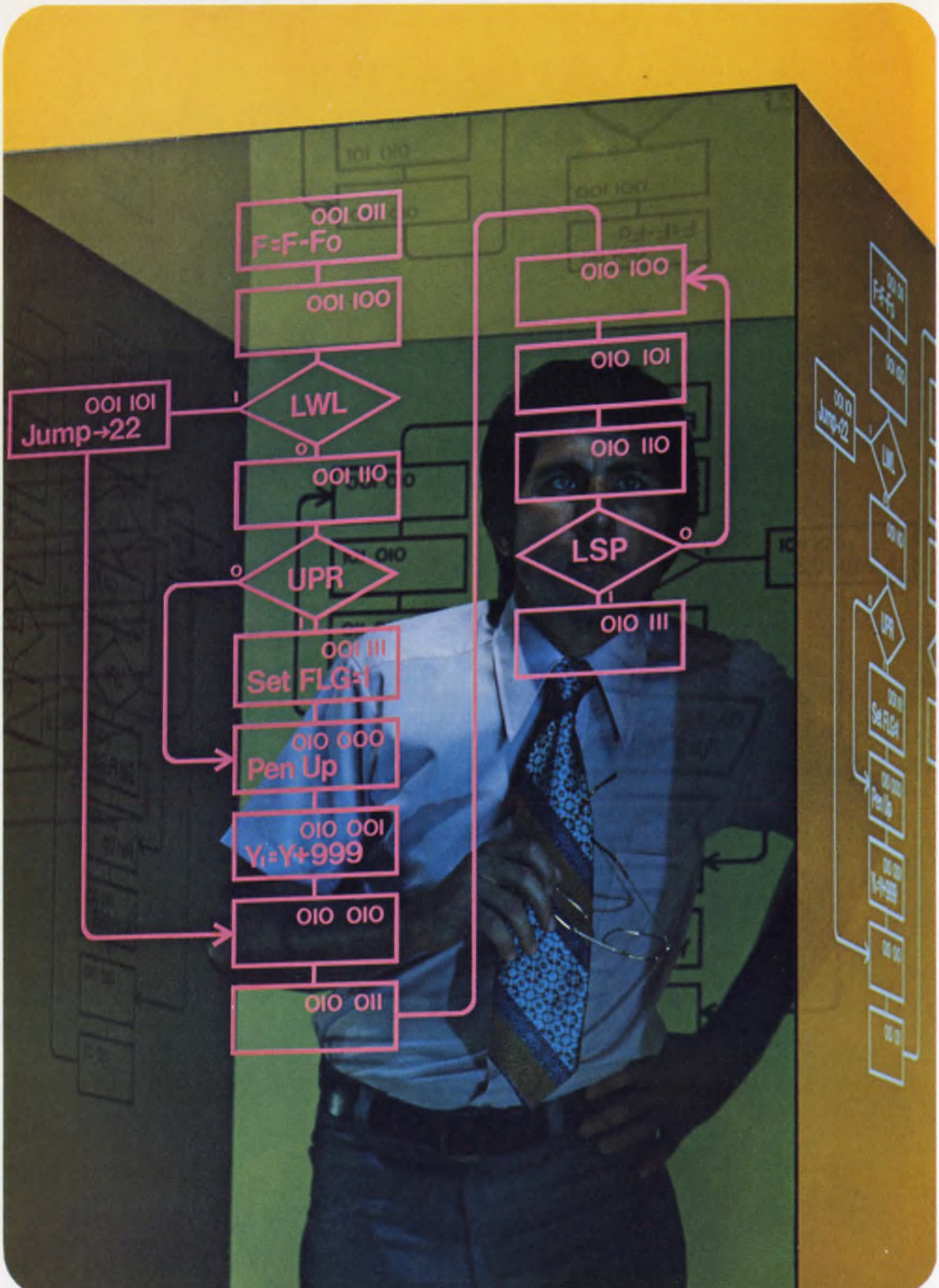
2. Guardian Electric Manufacturing Co.
3. Tektronix, Inc.
4. Computer Design Corp.
5. Hewlett-Packard
6. Hewlett-Packard
7. Corning Glass Works
8. Delta Products, Inc.
9. Hewlett-Packard
10. Signetics Corp.



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F=F-Fo
001 100
001 101
Jump→22
LWL
001 110
UPR
001 111
Set FLG=1
010 000
Pen Up
010 001
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010 010
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010 100
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Now—Put Yourself Inside Your Designs.
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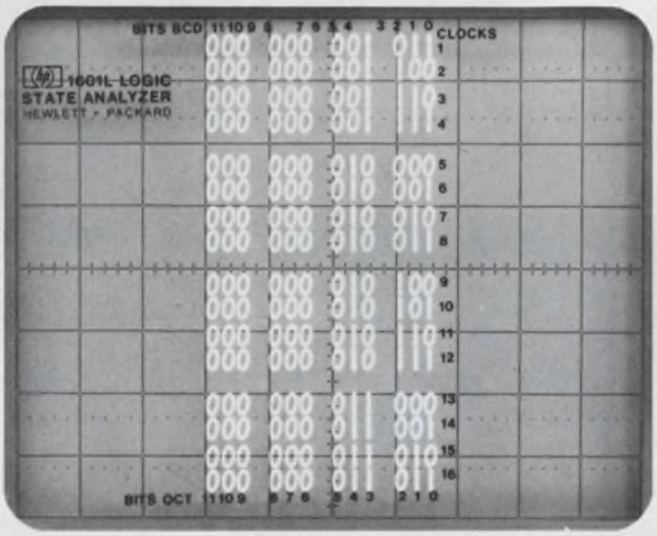

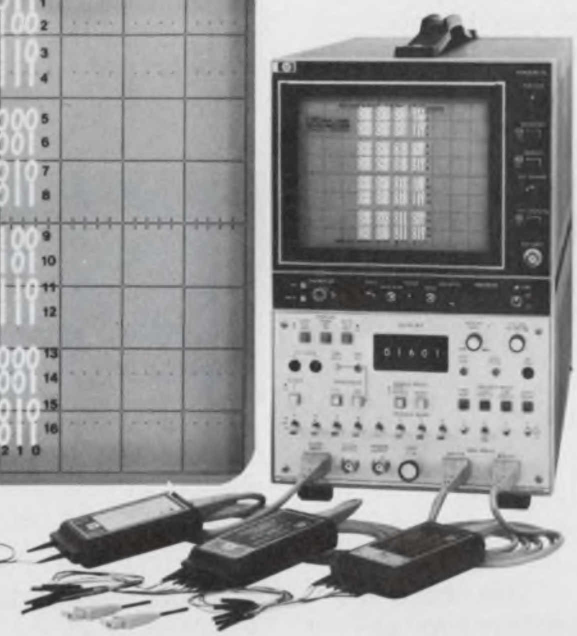

Breakthrough... The HP 1601L Logic Analyzer...

Here's a functional tester that can make a world of difference in helping you solve your digital design or test problems. With HP's 1601L you actually see each word displayed in "1's" and "0's", as shown here. Sixteen words at a time, each twelve bits wide.

Now see what's really happening. See each sequential step of your design, or of the equipment you're analyzing for problems. Display your digital words in "1's" and "0's," in hexadecimal, BCD or octal format. Select positive or negative logic corresponding to the type of circuitry you're working with, and adjust threshold over the ± 10V range provided. Think of all the time you'll save in design and troubleshooting.

See your logic in action. "Step inside" your design and watch it pace through its sequences. If a "glitch" should occur, end your display and look back in time to see what events lead up to the problem. Diagnostics couldn't be easier.

See dynamic data flow, negative time, much more. The 1601L displays an action portrait. Dynamically timed by your strobe signal (up to 10 MHz), you can delay the start of display up to 10^5 bits and really track your system's performance. If a problem develops, look back from the problem word (negative time) at least 15 words. Your oscilloscope will help you find the component or circuit at fault; the 1601L provides a trigger for your scope making fault isolation even easier.

See things you've never seen before. See those digital events you've always wanted to see. For all this capability the 1601L is priced at only $2650*. Or, consider the 5000A, a unit with LED display, two channels, thirty-two bits. It sells for only $1900*. Your local HP field engineer will be happy to arrange a "hands-on" demonstration in your office or lab.

*Domestic U.S. prices only.

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INFORMATION RETRIEVAL NUMBER 52

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Actual size

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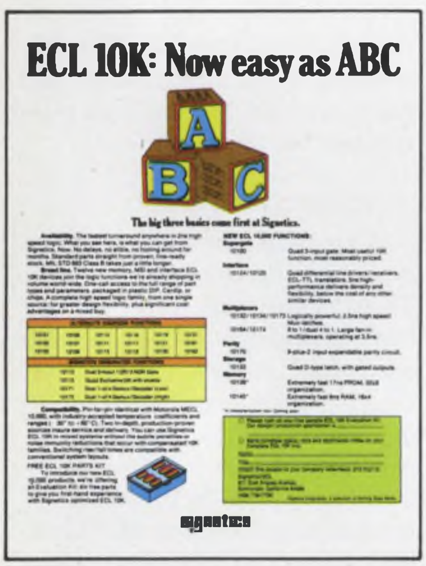

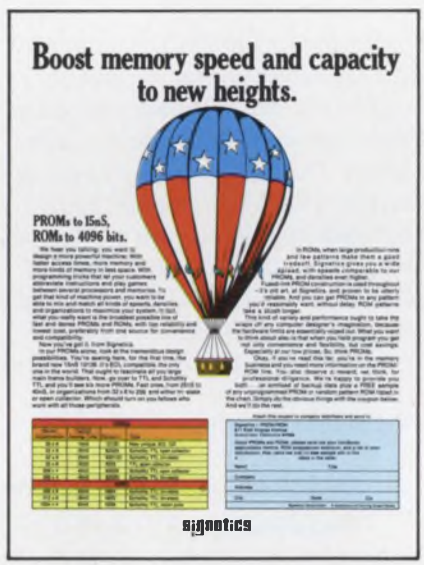

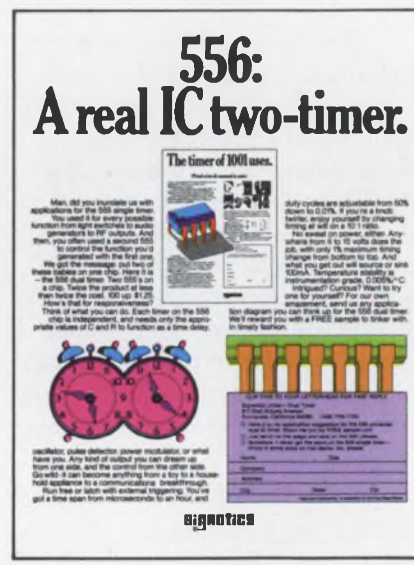

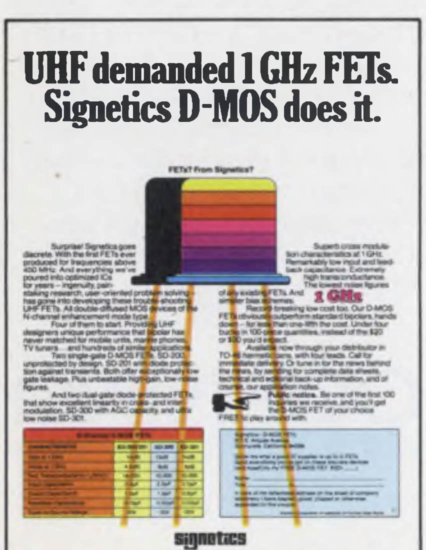

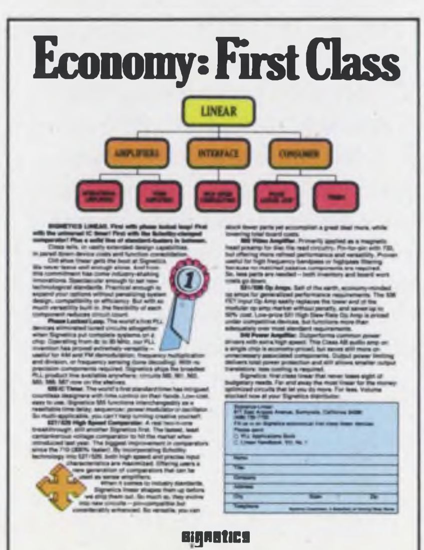

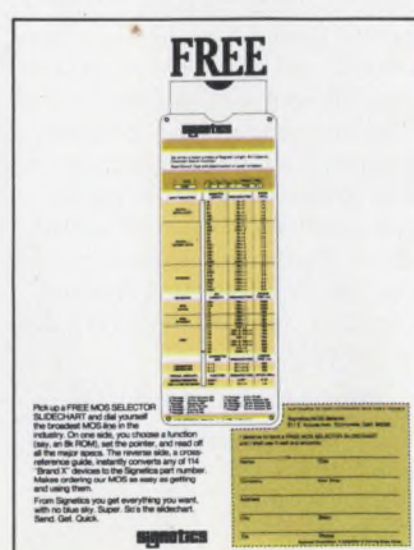

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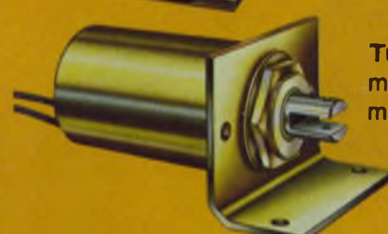

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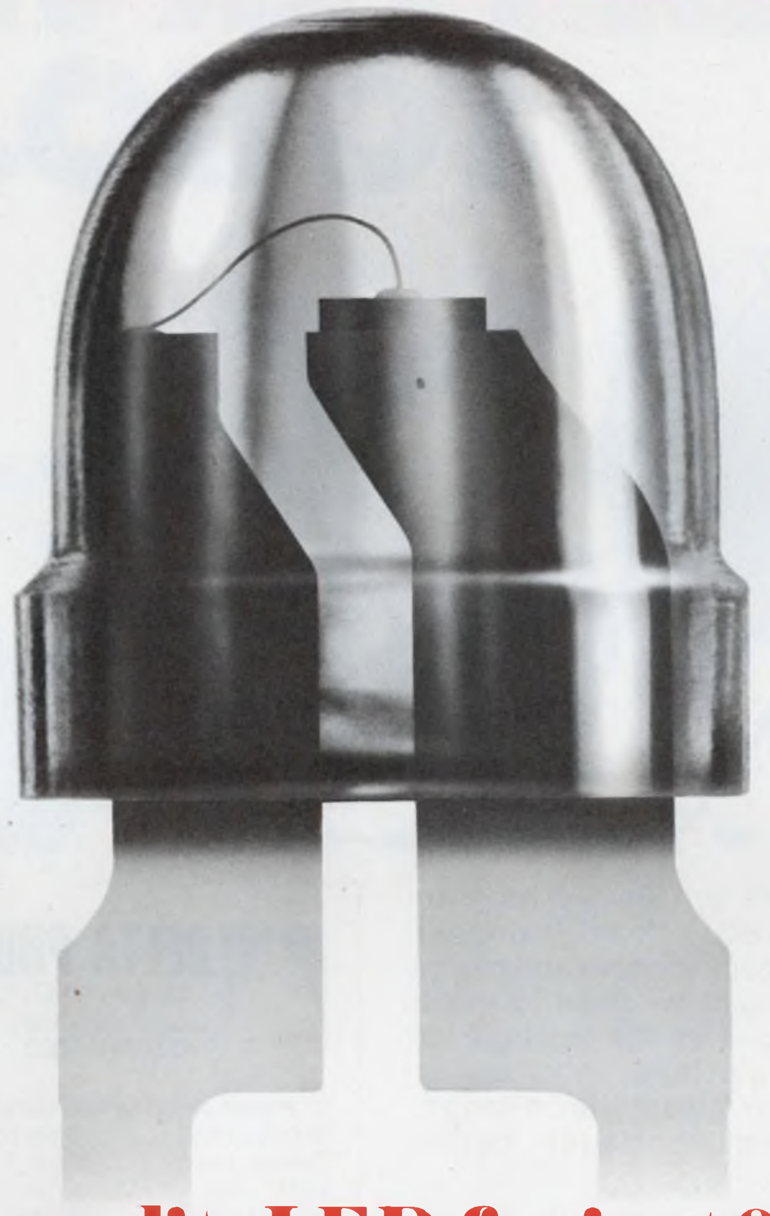

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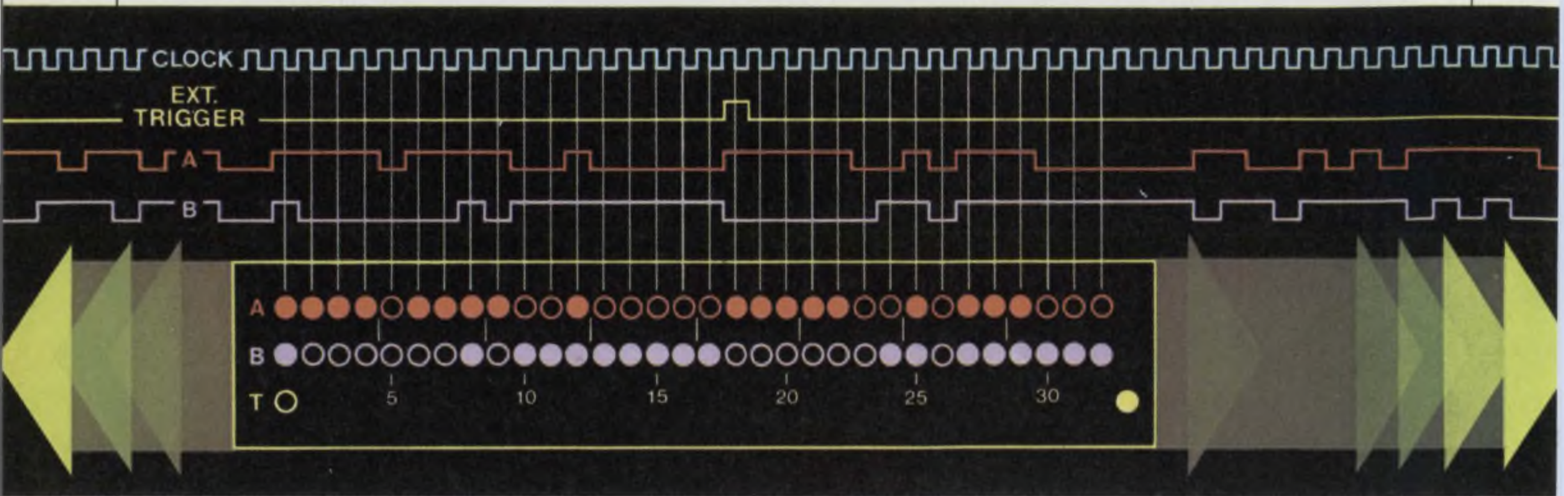

The ordinary way of looking at digital bit streams has become obsolete.

- **Diagnose Tough Digital Problems!**
- **See 10 ns. spikes in slow data!**
- **See 64 bits preceding that intermittent failure!**
- **See the one millionth bit after trigger!**

Introducing the HP 5000A Logic Analyzer. A fast, simple, easy — and above all — accurate way to look at digital signal streams. Highs and lows are displayed by "on" and "off" states of LED's that make intuitive sense when you're working with truth-tables or timing diagrams.

Now you can look *backwards* as well as forwards in time from a trigger event. Plus, fast, easy-to-use waveform storage that lets you conveniently capture single-shot or transient bit streams. Add to this straightforward, almost self-explanatory controls and you have an ease of operation and display interpretation unmatched by any other method of monitoring digital bit streams.

The unique trigger circuits of the 5000A will help you extract invaluable information from your circuit. Use "CLOCKED" triggering to prevent faulty triggering in the presence of data spikes. Use "ASYNC" triggering on that intermittent pulse from your decoder, for example, and expose its cause. Or, select a combination of any three inputs from your system for the trigger word. After triggering, the 5000A can either display the bit stream or automatically detect and display only those elusive spikes or glitches that may occur but once a day.

The HP 5000A has a capture rate of up to 10 Megabits/sec., adjustable threshold, and 1 megohm impedance. Use it with any existing logic family. Precise digital delay makes algorithm-checking and accessing of particular data in long streams incredibly easy. Timing and display are keyed to your clock signal so absolute repeatability is assured.
HP 5000A, $1900.*

If you need to display a series of parallel words, consider HP's 1601L Logic State Analyzer with a CRT display of 1's and 0's, $2650.*

To arrange for a demonstration, call your local HP field engineer today. Or write us for complete specifications.

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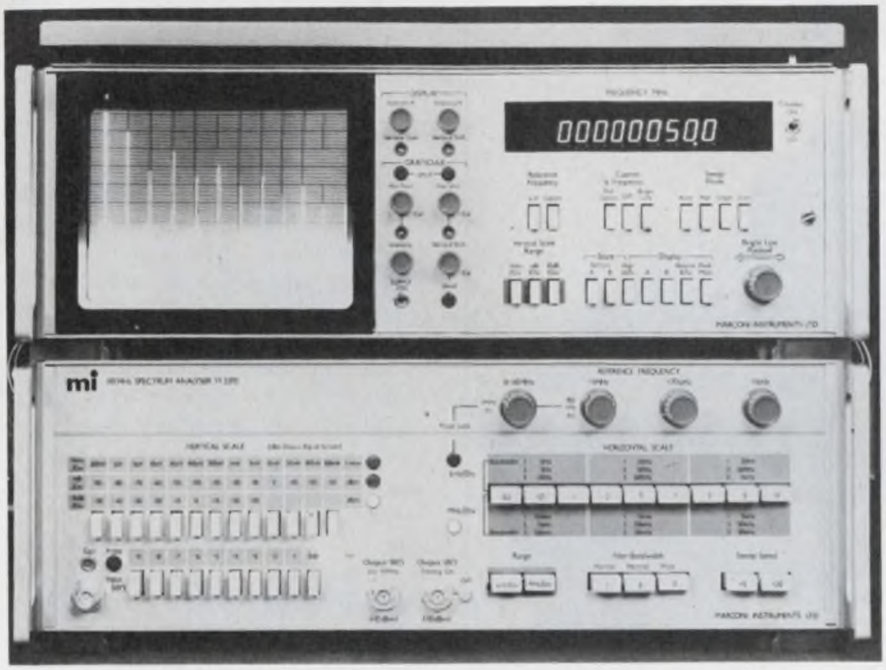

Marconi Instruments, 111 Cedar Lane, Englewood, N. J. 07631. (201) 567-0607. P&A: See text.

Marconi's 110-MHz spectrum analyzer, the TF 2370, not only brings a fresh approach to this class of instrument but also zooms ahead of all others in performance in at least seven key areas. Here's what the TF 2370 offers:

- 5-MHz minimum filter bandwidth—the narrowest available in its class by a factor of 2.
- −159-dBm minimum input (or sensitivity)—the lowest by 19 dBm.
- +25-dBm maximum input—the highest by 12 dBm.
- 100-dB displayed dynamic range—highest by 30 dB.
- 3-dB bandwidth of 30 Hz to 110-MHz—the widest of its class.
- 10 to 1, or better, i-f filter factor for all resolution settings (ratio of 60-dB to 3-dB bandwidths)—the best of its class.
- 9-digit frequency readout—highest by two digits.

And if these aren't enough to establish the TF 2370 as the leader of its frequency class, the unit also has smaller input VSWR (< 1.2), a larger display (10 × 12 cm) and a pack of features—like a brighter display, internal memory and automatic controls—not to be found on any competing spectrum analyzer.

Of course, such performance isn't cheap. The TF 2370—which also has a built-in tracking generator—sells for $14,750. Delivery takes 90 days.

New features? How about this one: The user sets the center frequency, sensitivity and sweep width, and the Marconi unit automatically computes and sets the optimum sweep rate, filter bandwidth and rf/i-f gain ratio. Improper settings that can destroy valid results are automatically avoided.

Also unique is the TF 2370's use of an internal a/d converter, MOS memory and TV-type display to give an infinite-persistence, flicker-free image. The need for long-persistence CRTs or storage tubes has been eliminated, along with problems of fading, blooming and burning.

Stored data are displayed at a 76-Hz rate and vertically scanned by a 513-line interlaced raster. The brightness modulation of the lines—to a height that represents the input amplitudes—conveys the spectral information.

Superimposed on the display is a projected, electronic graticule that can be moved vertically and horizontally by ±1 division, and a bright-line cursor that can be moved and set on any spectral line.

Thus the graticule can be shifted to fit selected spectra for parallax-free readout, and the cursor —which is coupled to a 9-digit counter—can be plunked on any line to display the line's frequency automatically on the counter.

The counter works in any of three modes: It can display the center frequency, the frequency that corresponds to the cursor position or the difference between these two frequencies. But for maximum sensitivity, the counter must be shut off to avoid leakage.

Digital storage lets the TF 2370 do several things: First, the image stays sharp, clean and bright indefinitely. Second, once contrast is set, it stays set; no continuous tweaking is needed to get the best compromise between brightness and persistence. Third, renewed data can be displayed at a higher brightness than existing data, since the brightness can be changed *after* a sweep. Finally, the memory can be split to superimpose two images for comparison tests. And not only can one image be dimmed relative to the other, either image can be kept indefinitely while the other is refreshed.

The TF 2370's closest competitor is a Hewlettt-Packard analyzer. With the HP 141T display, 8553B tuning section, 8552B i-f section and optional 8443A tracking generator/7-digit counter, the complete HP analyzer comes to

(continued on page 138)

INSTRUMENTATION

(continued from page 137)

$10,625—a good $4000 less than the Marconi unit.

But the HP analyzer doesn't have the Marconi's storage or display features, though it does have a parallax-free, internal graticule. And, of course, the TF 2370 leads in a number of important performance areas.

Strangely missing from the TF 2370's data sheet, though—and HP's catalog data—is another important spec: frequency stability.

Since it's hard to design filters with a narrow 3-dB bandwidth and a low 60-dB/3-dB ratio, it's understandable that a manufacturer will brag when he's done it. But a narrow filter doesn't guarantee outstanding frequency resolution in an analyzer. If the analyzer's residual FM causes frequency variations of greater than the 3-dB bandwidth, you can forget that hard-won filter spec.

Both analyzers, however, list a spec for frequency resolution. With the Marconi TF 2370 in the manual mode, with 5-Hz filter bandwidth and 20 Hz/div sweep, noise sidebands limit to 100 Hz the resolution of what the manufacturer calls "small" signals—that is, signals of 70 dB and down.

With the HP combo, the spec reads: "10-Hz resolution to see 60-Hz sidebands 60-dB down." To determine exactly what resolution you'll get for your particular set of inputs, ask Marconi or HP.

Two other important analyzer specs are the accuracies of the frequency and amplitude readouts.

With counter readouts, frequency accuracy is given by ±1 count ±time-base accuracy, and time-base accuracy depends on aging rate, tempco and line-voltage effects, if any. To get these specs, ask the vendor.

As for amplitude accuracy, HP's is listed as "to" ±0.8 dB absolute accuracy, while Marconi's is "broken down" into quantization error, bandwidth/dispersion switching accuracy, volts/div linearity on the linear scales and log accuracies on the log scales. To get absolute accuracy, put it all together—somehow.

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INFORMATION RETRIEVAL NUMBER 63

Memory tester handles 16 million addresses

Macrodata, 6203 Variel Ave., Woodland Hills, Calif. 91364. (213) 887-5550. See text; 6 to 8 wk.

With capabilities of testers twice its price, the Macrodata MD-107 memory-system analyzer can test, at 10 MHz, units with up to 16-million addresses.

The analyzer consists of a CPU, two cassette drives, a CRT terminal, an address-generation processor and a test-and-error processor. The basic system costs less than $50,000, and it tests plated wire, core and semiconductor memories with word lengths from 1 to 160 bits. The analyzer's system stimulus levels can be programmed to match ECL, TTL or MOS logic families.

Cycle time, data strobe and write-command leading and trailing edge position can all be set with 1-ns resolution. Test programs are written with an in-house developed language called TECOL. The language allows for CRT display manipulation, and it has executive, interpretive and editor software.

Memory systems under test receive stimulation from the test-and-error processor. Outputs from the memory system are fed back through the error processor for analysis. Inputs for the system under test are generated from four sections of the test set.

The data-generation processor stores one test word. This word, in turn, is controlled by the test-pattern processor. Another section, the address-generation processor, generates all possible input combinations for word lengths up to 24 bits. The last section manipulates the 11 control bits, which typically control the write, clear, strobe and data lines.

All four sections operate independently and can be changed on a cycle-by-cycle basis. Seven programmable clocks and three independently programmable cycle times are also available for the test system.

Pattern-processor software is available in microprogram form from Macrodata. The analyzer also has supportive diagnostic software routines that can test all sections of the MD-107.

The analyzer does a strictly functional test of memory systems to determine defects such as shorts, opens, incorrect components and interaction between components.

Options available with the MD-107 include a data-buffer memory and a line printer.

CIRCLE NO. 252

3-1/2-digit DMM costs just $219

United Systems, 918 Woodley Rd., Dayton, Ohio 45403. (513) 254-6251. $219; stock.

The 2110 Digital Multimeter is the latest instrument in the company's HT Series (High Technology). The unit offers 3-1/2 digits, is bipolar and portable. A built-in automatic recharger maintains the batteries at full charge as long as the instrument is connected to the power line. Fifteen ranges include dc which extends from 199.9 mV to 1000 V fs with a basic accuracy of 0.1% of reading; ac from 1.999 to 500 V fs with an accuracy of 0.5% of reading; and ohms from 199.9 Ω to 19.99 MΩ fs.

CIRCLE NO. 256

3 kg frequency counter covers 10 Hz to 512 MHz

Marconi Instruments, Ltd., Longacres, St. Albans, Herts, England.

The frequency counter, Model TF2424A, weighs only 6-1/2 lb (3 kg) and has a frequency range of 10 Hz to 512 MHz. Two switch selectable input channels are provided. One is a high impedance input with 30-mV sensitivity that accepts frequencies from 10 Hz to 10 MHz, and the other is a 50-Ω input with 10 mV sensitivity, covering 10 to 512 MHz. Resolution is 10 Hz up to 500 MHz. The frequency readout is displayed on a four-digit LED panel with an overflow lamp indicating when the count of 9999 is exceeded. An effective readout of eight digits is achieved by means of front-panel switches giving 10 Hz resolution with reading time of only 3.2 seconds. A 10 MHz internal crystal oscillator is operated in a constant temperature enclosure, ensuring a frequency stability of $\pm 1 \times 10^{-7}$ over a wide temperature range. Warm-up time is four minutes from switch on to a stability of 2×10^{-7}. The counter may be powered by an internal NiCad battery pack or from a 110 V ac source.

CIRCLE NO. 257

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TCΔVos - 0.3μV/°C
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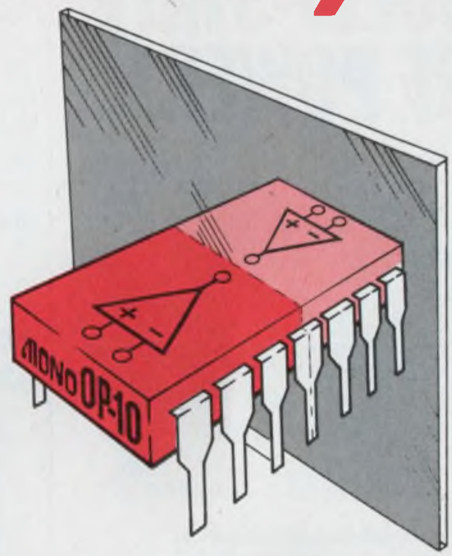
ΔCMRR - 123dB
14 Pin DIP Package



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Δ Vos (Vos_1-Vos_2)	180	500	500	—	μV
TC Δ Vos	0.8	1.2	0.9	—	μV/°C
Δ CMRR	114	106	106	—	dB
Input Bias Current	3.0	3.0	4.0	7.0	nA
Noise (0.1 Hz to 10 Hz)	0.6	0.6	0.6	0.65	μV, pk-to-pk
Long Term Drift*	0.2	0.2	0.2	0.3	μV/Month
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* Typical long term drift trend, averaged over a 12 month period (per amplifier)

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INFORMATION RETRIEVAL NUMBER 64

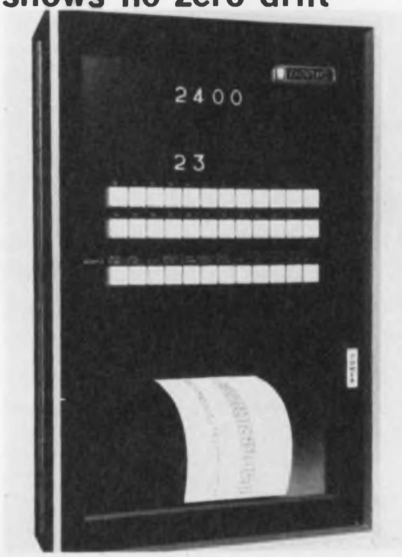
Microvoltmeter offers four bandwidths

Rohde & Schwarz, 111 Lexington Ave., Passaic, N.J. 07055. (201) 773-8010. $14,815.

Type USH 1 is a Selective Microvoltmeter that operates from 10 kHz to 60 MHz. The unit uses frequency synthesizer techniques in the local oscillator to achieve a resolution of approximately 2 Hz. Special features include: measurement range of 0.3 μV to 3 V (pk-pk and rms); linear and logarithmic (80 dB) indication; four selectable bandwidths of 200 Hz to 20 kHz; automatic tuning (sweep) to ±100 kHz max; and selectable input impedance of 50, 60, 75, 150 Ω, and dc coupling probe.

CIRCLE NO. 258

Multipoint recorder shows no zero drift

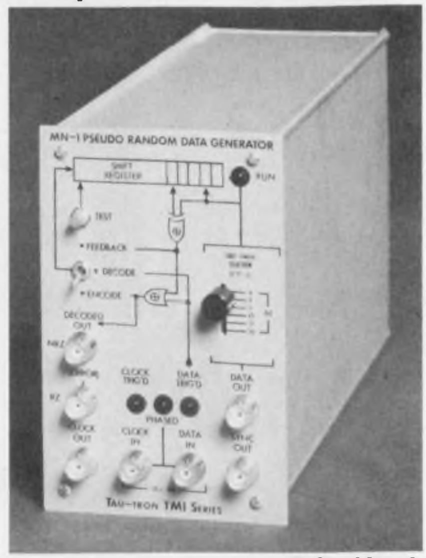


Doric Scientific, 3883 Ruffin Rd., San Diego, Calif. 92123. (714) 565-4415. $1575; stock to 90 days.

Digitrend 200 is a ruggedized, digital multipoint recorder designed for industrial environments. The unit will scan, display, log and alarm outputs from thermocouples, transducers, transmitters, strain gauges, or millivolt sources. Included are: a 6-point screw terminal input panel, cold-junction compensation, choice of solid state or electromechanical scanning, a/d converter, digital display in engineering units, printout on a strip printer and a built-in electronic timer to initiate periodic logging cycles.

CIRCLE NO. 259

Tester reads error rate at up to 75 Mb/s



Tau-Tron, 11 Esquire Rd., North Billerica, Mass. 01862. (617) 667-3874. MN-1: $1000; MB-1: $1800; 2 wk.

This Bit Error Rate Test Set operates from 1 b/s to 75 Mb/s and provides bit error and block error measurements along with a burst error indicator. The transmitter is the MN-1 Pseudo-Random Data Generator, which creates pseudo-random codes, from 63 to over 1 million bits per period. There are six codes in all. The receiver is the MB-1, PCM BERT. It automatically synchronizes its local code generator to the received sequence independent of path propagation delay. After link-up, it provides bit error rate and block error rate measurements on a four-digit LED display.

CIRCLE NO. 260

Computerized PC tester fits in a suitcase

Data Test, 2450 Whitman Rd., Concord, Calif. 94518. (415) 689-3583. Less than $7000; 30 days.

Weighing only 40 lb, the Datatester 2400 is said to be the first computerized test system to fit into a suitcase. Basic features include self-contained programmable power supplies, fixed program generators, matrix pin programming, family test module and fault diagnostic probe. A built-in microprocessor executes a powerful flexible instruction set, permitting real time functional testing, simulation and exercising.

CIRCLE NO. 261

Thermocouple indicator gives 0.1° linearity

Consolidated Controls Corp., 15 Durant Ave., Bethel, Conn. 06801. (203) 743-6712. $895; 10-12 wk.

Known as the MK III, this new line of digital instrumentation is designed to measure, display, monitor and record such physical parameters as temperature, pressure, load, torque, strain, flow, rpm, volts, amperes and combinations thereof. First unit in the MK III line is the Model 50GS1 digital thermocouple indicator which includes as standard, automatic zero to overcome drift with temperature variation, internal calibration, automatic polarity indication, five-digit display, isolated BCD output, plug-in circuitry construction, and rf line filters.

CIRCLE NO. 262

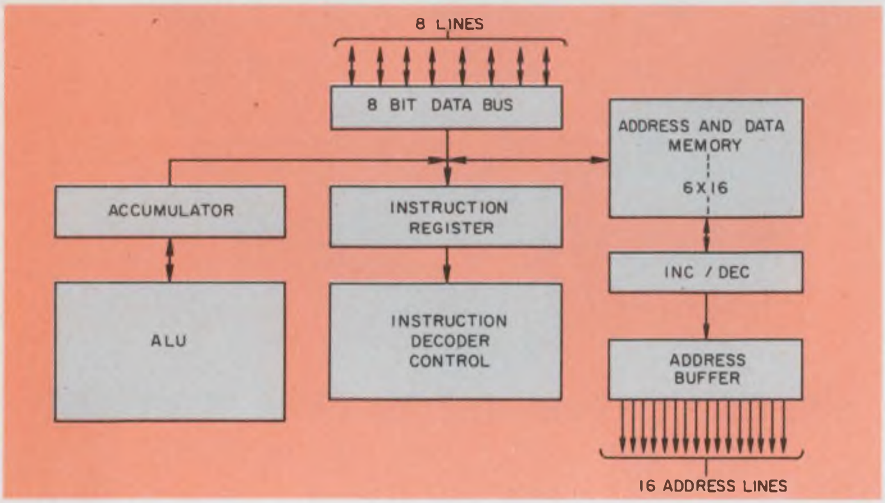
Impulse generator gives 150-ps pulse

IKOR, Inc., Second Ave., Burlington, Mass. 01803. (617) 272-4400. $1495; 60 days.

Model R100 IMP generator is a high-voltage source said to produce 100 times more power over a wideband output than any impulse generator previously available. Specs include: spectral output of 120 ±2 dBμV/MHz from 1 MHz to 1 GHz; a peak amplitude of 1000 V nominal; an amplitude stability of ±0.2 dB; a rise time of less than 100 ps; −3-dB pulse width of 150 ps max.; and a rep rate of 250 Hz.

CIRCLE NO. 263

NMOS microprocessor boosts speed, instruction-set power



Intel, 3035 Bowers Ave., Santa Clara, Calif. 95051. (408) 246-7501. P&A: See below.

The first n-channel MOS microprocessor—Intel's long-awaited 8080—sets the pace for increased speed and improved instructions. The 8-bit NMOS silicon-gate processor has a 2-μs instruction cycle and 74 basic instructions that include the 48 instructions of Intel's earlier 8-bit PMOS processor, the 8008.

The NMOS 8080 is an advanced design based on the PMOS 8008. The additional 30 instructions—including double-precision capability—and a 6:1 faster execution rate provide up to a 10:1 speed advantage over the 8008. Moreover the improved performance of the 8080 is obtained with a typical power dissipation of only 600 mW, the same as that of the 8008.

The 8080 can address up to 65-k bytes of memory without the need for an external address register. This compares with 16-k bytes of memory and an external register for the 8008. For a TTL I/O interface, the new processor requires six ICs, as contrasted to the 20 needed with the 8008. The NMOS 8080 comes in a 40-pin package and operates from +12 and ±5-V supplies.

Several architectural differences account for the improved performance of the 8080. For example, it contains a 16-bit stack pointer and a 16-bit program counter, instead of an address storage stack with eight 14-bit locations. A portion of the external memory can be used as a last-in/first-out (LIFO) pushdown stack, addressed by the stack pointer upon the execution of a CALL, RETURN or RESTART instruction.

Most significantly, not only the program counter but also the data registers, the accumulator and the flags can be saved in the external pushdown stack. As a result, multiple interrupts can be handled more easily with the 8080.

In another difference, the NMOS 8080 doesn't use time-multiplexing of the data bus for data and addresses, as the 8008 does. The 8080 contains a separate 16-bit, three-state address line and an 8-bit bidirectional data bus, both with separate control lines. Status information is sent out at the beginning of each machine cycle. Neither control signals nor status information require decoding. Thus interface circuitry is simplified.

The address bus provides, directly, the address to memory, or, it denotes an I/O device number. The data bus provides bidirectional communication between memory or I/O devices for instructions and data transfers. The 8080 can handle up to 256 input ports and a similar range of outputs.

Communication on address and data lines can be interlocked by use of a Hold pin. The processor becomes suspended and address and data lines are forced into a floating state. This feature permits "OR-tying" the address and data busses with other processors for a direct-memory access (DMA) mode, or the sharing of the memory by several processors.

The 8080 can perform BCD and binary arithmetic. It also has capability for double-precision arithmetic involving two 16-bit numbers.

Intel offers an extensive line of hardware and software design aids for the 8080. The software aids include assemblers, editors and simulators, which are available on time-share systems.

Currently available through distributors, the 8080 is priced at $360 in quantities of 1 to 24.

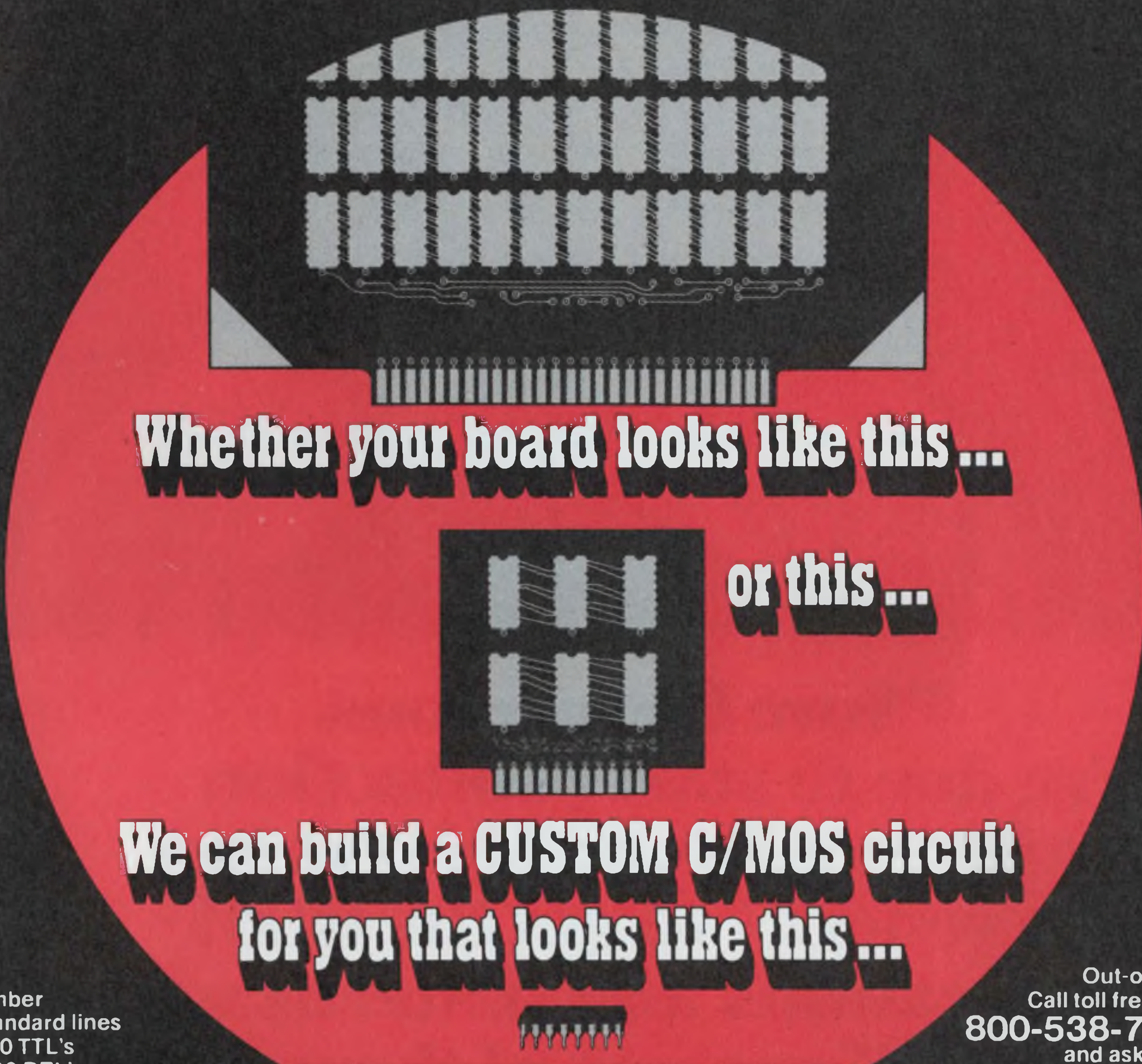
CIRCLE NO. 255

COS/MOS SR contains 200 stages

RCA Solid State Div., Route 202, Somerville, N.J. 08876. (201) 722-3200. $6 (1000).

A COS/MOS 200-stage dynamic shift register, the CD4062A, is the longest shift register available in low-power COS/MOS technology. It provides both single-phase and two-phase clocking options. The single-phase option permits operation to 1 MHz with noncritical rise and fall times. Clock input capacitance is less than 5 pF. Two-phase clock signals permit operation to 5 MHz, and further reduce clock rise and fall-time requirements at low speeds. The minimum operating speed is 1 kHz.

CIRCLE NO. 264



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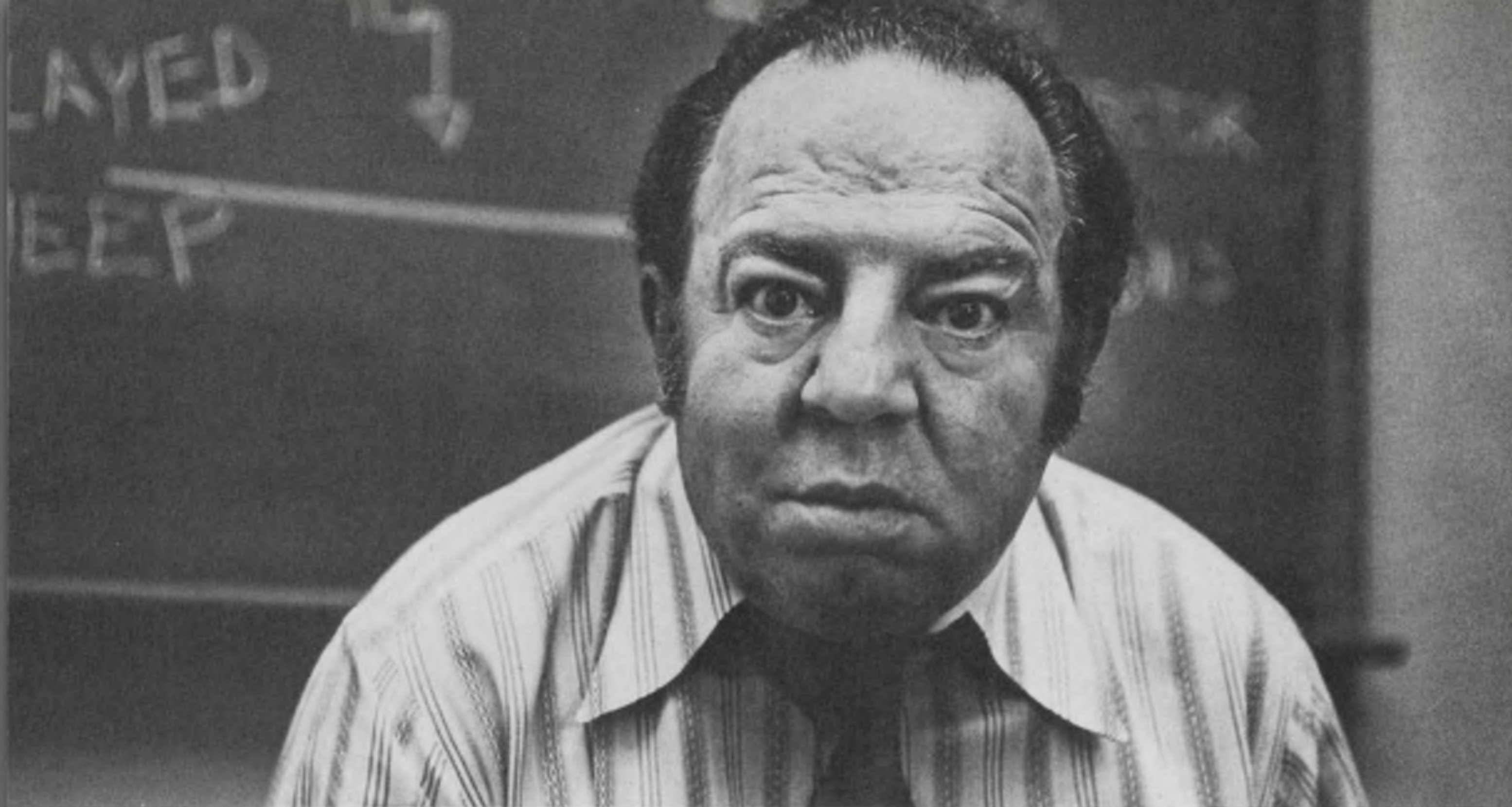

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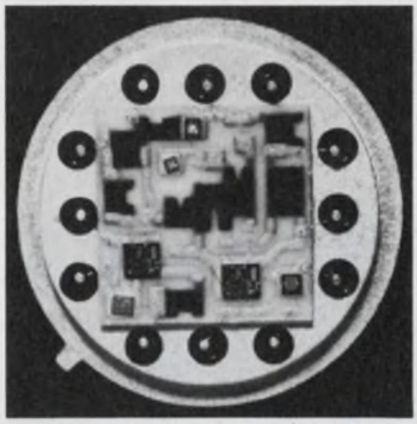
INFORMATION RETRIEVAL NUMBER 69

Hybrid ICs provide dual regulation

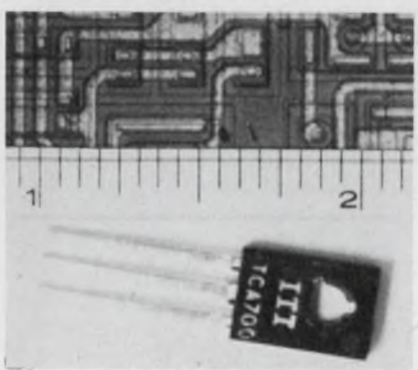


Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif. 92634. (714) 871-4848. $20 (1-9).

The Series 843 voltage regulators are dual-tracking hybrid units with output voltages preset to ±12 or ±15 V (±0.5%). The negative regulator output tracks the plus output within ±10 ppm/°C over the —55-C-to-125-C temperature range. Line regulation is ±0.005%/V and load regulation is ±0.005% (no load to full load of 300 mA). The unit's TO-8 package meets MIL-STD-883 specs.

CIRCLE NO. 265

10-V regulator outputs 200 mA

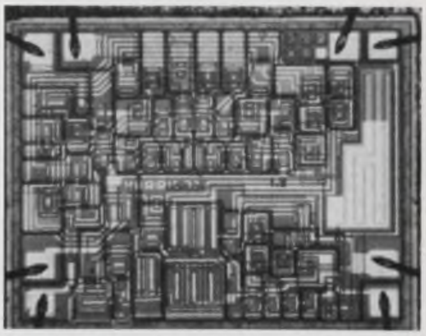


ITT Semiconductors, 3301 Electronics Way, West Palm Beach, Fla. 33407. (305) 842-2411. $2.05 (100-999).

A compact voltage regulator, the TCA 700, features internal short-circuit and thermal-overload protection. With an input voltage of 12 to 16 V, the regulator provides a 10-V output within 1/4 V. With heat sinking, the TCA 700 can provide 200 mA at 85 C. The regulator comes on a SOT-32 package.

CIRCLE NO. 266

Programmable op amp features low noise



Harris Semiconductor, P.O. Box 883, Melbourne, Fla. 32901. (305) 727-5407. $3.30 to $8.80 (100 up).

An internally-compensated current-programmable op amp—the HA-2720—permits the tailoring of characteristics by use of a single external resistor. Slew rates can range from 0.06 to 6 V/μs while gain bandwidths extend from 5 kHz to 10 MHz. Dc programming offers supply voltages of ±1.2 to ±18 V, supply currents of 1 μA to 1.5 mA, bias currents from 0.4 to 50 nA and output currents up to 15 mA. Typical input current noise is only 0.7×10^{-27} A^2/Hz.

CIRCLE NO. 267

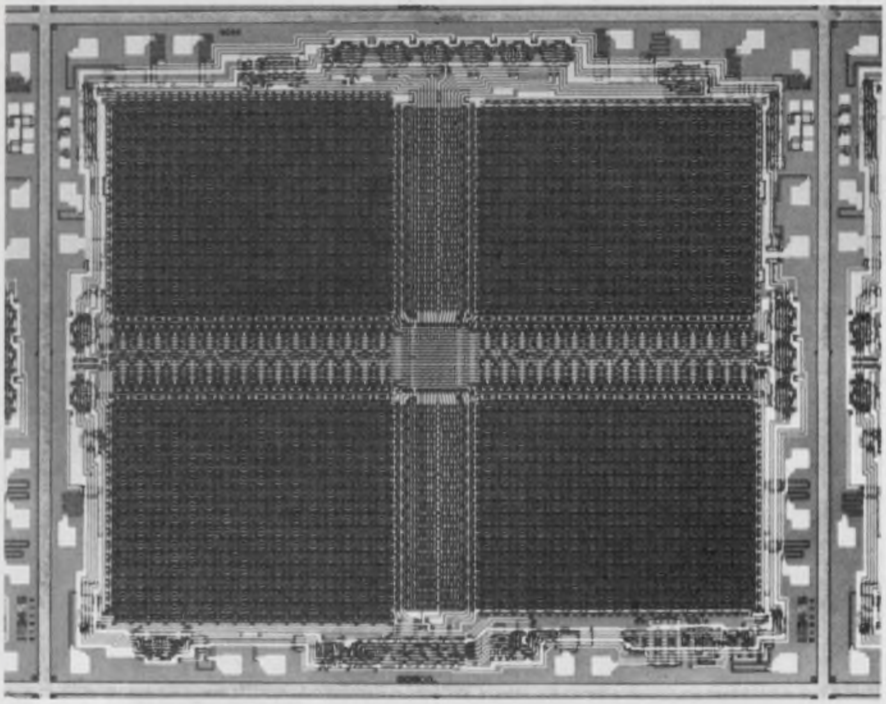
Regulator ICs feature plastic packaging

SGS-ATES Semiconductor, 435 Newtonville Ave., Newtonville, Mass. 02160. (617) 969-1610. $1.40 (100-999); stock.

Three-lead integrated voltage regulators—the L129, 130 and 131—are available in TO-125 plastic packages. The L129 gives an output voltage of 5 V with an input voltage of 7.5 to 20 V. The L130 gives an output of 12 V with the input ranging from 14.5 to 27 V and the L131 provides an output voltage of 15 V with the input voltage ranging from 17.5 to 27 V. The devices can supply a typical regulated current of 850, 720 and 600 mA, respectively. The circuits have a load regulation of less than 1% and a typical ripple rejection of 60 dB.

CIRCLE NO. 268

4-k NMOS RAM combines high speed and low power



Motorola Semiconductor Products, P.O. Box 20912, Phoenix, Ariz. 85036. (602) 244-3466. 6605: $40; 6605-1: $33.30 (25-99); Factory stock.

The latest 4-k, n-channel RAM —Motorola's MC6605—takes the lead in both high speed and low power. The IC combines a maximum access time of 230 ns with an active power drain of 70 μW/bit. These values represent the fastest access and lowest dissipation of any 4096-bit n-channel silicon-gate random-access memory (see "4096-Bit RAMs Making the Scene as an Alternative to Core—Finally," ED No. 3, Feb. 1, 1974, p. 40).

Furthermore the new RAM already has an alternate source in a company that co-developed the 6605 with Motorola—American Microsystems, 3800 Homestead Rd., Santa Clara, Calif. 95051.

Other pace-setting specs include the fastest read and write cycle times—350 and 450 ns minimum, respectively—and the fastest read/modify/write time—470 ns minimum. The RAM requires only 32 cycles every 2 ms for refresh, compared with 64 cycles every 1 to 4 ms for other 4-k NMOS RAMs. The reduced refresh requirements result in a read/write "down" time of only 0.6%.

The 6605 RAM uses a three-transistor cell structure, which Motorola says is more reliable than the one-transistor cell used in other 4-k RAMs. The 6605 chip measures 168 × 195 mils. It dissipates 5 nW per bit in a standby mode; with refresh, the dissipation becomes 0.5 μW per bit. Total active dissipation is 400 mW.

Except for the single high-level clock, all address and control lines are TTL-compatible. Address and data lines also contain latches on the chip. And three-state outputs don't require external sense amplifiers.

Like most other 4-k RAMs, the 6605 comes in a 22-pin DIP. However, a feature of the pinout is the placement of all power connections at the corner pins. This simplifies power bus runs on large memory-circuit boards.

A lower-priced version of the Motorola 4-k RAM—the 6605-1—relaxes the access and cycle-time specs. Access time increases to 300 ns, while read and write cycle times become 450 and 550 ns, respectively. The read/modify/write cycle time is 550 ns.

Both the 6605-1 memory and the premium model operate from +12 and ±5-V power supplies (at corner pins). They exhibit an input capacitance of 5 pF and a clock capacitance of 20 pF. The ICs operate over the 0-to-70-C temperature range.

For even faster applications, Motorola plans to introduce a speedier 4-k RAM. Called the MCM 6606, the IC will feature an access of 190 ns and ECL-compatible output.

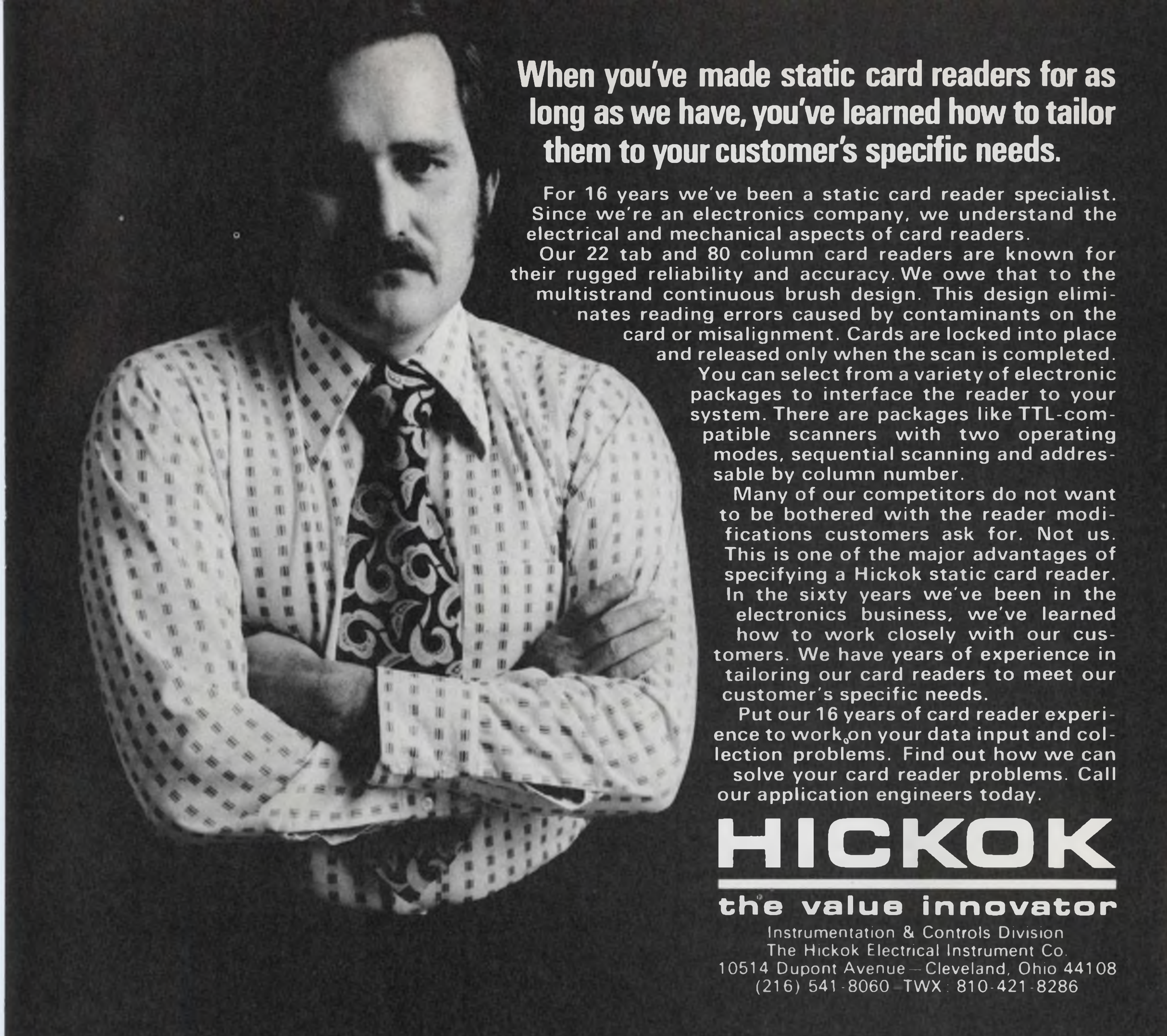
CIRCLE NO. 254

Schmitt-trigger ICs sustain battery reversal

Sprague Electric, 115 Northeast Cutoff, Worcester, Mass. 01606. (617) 853-5000.

A series of Schmitt-trigger ICs can sustain battery reversal indefinitely without damage. Four devices are offered—two single and two dual ICs in eight-pin mini-DIP plastic packages. All circuits operate over a supply voltage range of 2.2 to 6.0 V and a temperature range of −40 to +100 C. The ULN-3303M can switch a 75-nA resistive load with less than 50-nA input current. The ULN-3304M has a zener-diode clamped output and can control a 150-nA load with less than 50-nA input current. Two ULN-3303M devices are contained in the ULN-3305M. The ULN-3306M has zener-diode clamped output for driving inductive loads and contains one 3304M device and a second Schmitt-trigger circuit.

CIRCLE NO. 269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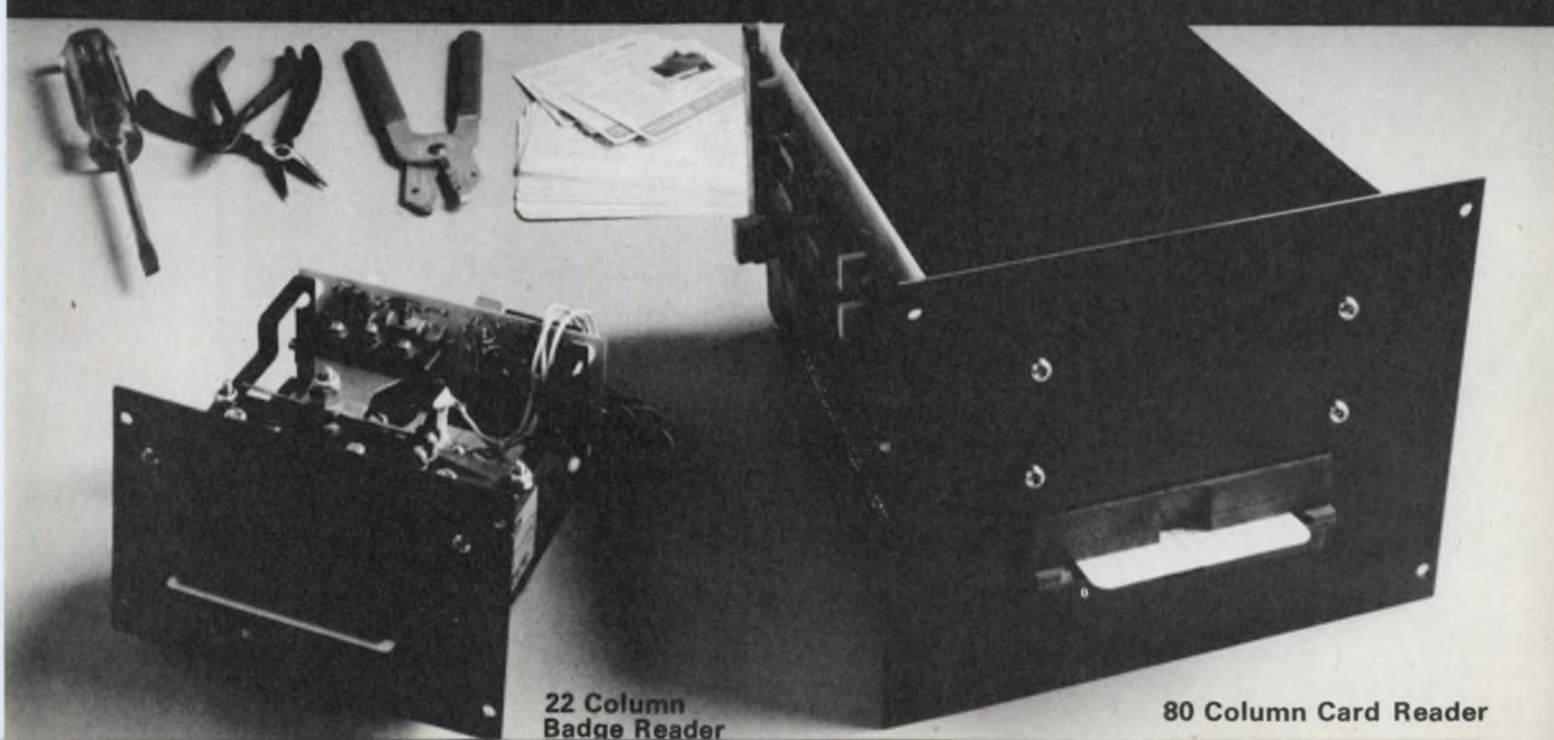
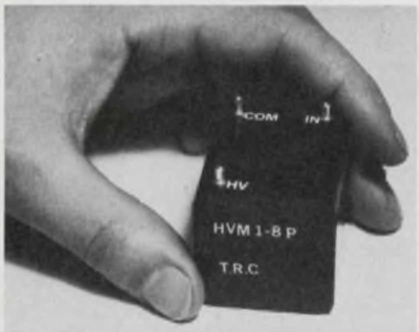

22 Column Badge Reader
80 Column Card Reader

High voltage multipliers accept inputs of 1000 V



Tripp Research, 15231 Quito Rd., Saratoga, Calif. 95070. (408) 354-1916. From $26.70; stock to 5 wk.

The HVM series of voltage multipliers will accept peak inputs up to 1000 V ac at frequencies from 10 kHz to 25 kHz. These units will multiply by 2, 4, 6, 8 or 10 times and deliver a dc output voltage. Load regulation is better than 7% and peak-to-peak ripple is 3% maximum at full load.

CIRCLE NO. 270

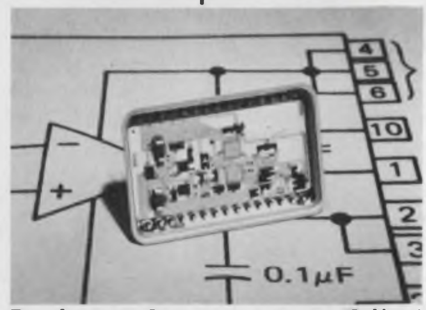
V/f converters deliver outputs to 100 kHz

Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, Mass. 02026. (617) 329-1600. From $79 (1 to 9); stock.

The 4709 series of 100 kHz v/f converters includes four active temperature-trimmed modules. The units have an extremely low drift (6 ppm/°C maximum for the 4709-03), a low nonlinearity (typically ±0.001% full scale plus ±0.004% of signal) and a wide dynamic range (typically 6 decades or 1,000,000 to 1). Full-scale temperature coefficient ranges from 6 ppm/°C for the 4709-03 to 44 ppm/°C for the 4709. The series also has a current input terminal and a package size of 2 × 2 × 0.4 in.

CIRCLE NO. 271

FET-input op amp slews at 1000 V/μs



Beckman Instruments, Helipot Div., D962, Fullerton, Calif. 92634. (714) 871-4848. $125 (1 to 9).

Model 825 FET-input op amp has a 1000 V/μs slew rate. It comes housed in a hermetically sealed, MIL performance, hybrid package. The unit has a full-power bandwidth of 10 MHz and can deliver 100 mA of load current. Other performance features include a ±3 mV offset, a 100 pA maximum bias current, a ±75 μV/°C maximum offset drift, and a 35 MHz unity gain bandwidth. Model 825 also settles to 0.01% in 300 ns.

CIRCLE NO. 272

Analog multiplexers accurate to 0.025%

Transmagnetics, Inc., 210 Adams Blvd., Farmingdale, N.Y. 11735. (516) 293-3100. Model 2204: $175; Model 2208: $225 (1 to 9); stock to 3 wk.

Models 2204 and 2208 are compact dual 4 and dual 8-channel analog multiplexers. Up to 128 dual channels can be handled by combining these multiplexers. They have a full scale accuracy of ±0.025% maximum. Settling time is typically 3 μs. Gain of all channels is 0.9995 ±0.0005. Drift is ±25 μV/°C maximum. Frequency output is 150 kHz for full output or 5 MHz for small signal bandwidth. Both units can be supplied to operate in ambient temperatures of 0 to +70 C or −55 C to +85 C.

CIRCLE NO. 273

Bin level controller uses modulated LEDs

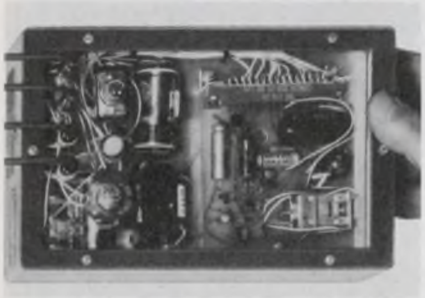
Automation Products Manufacturing, Inc., 2600 N.W. 1st Ave., Boca Raton, Fla. 33432. (305) 391-1881. From under $100.

The 35CJ or 35CJT (time delay model) bin level controls are used in conjunction with projectors and receivers to monitor high and low level beams which are interrupted by product buildup. The 35CJT model allows a 0 to 10 s adjustable time delay on detection of either high or low level. This system functions with equal efficiency in darkness, brilliant sun, or artificial light. It also can operate in ambient temperatures to 170 F.

CIRCLE NO. 274

INFORMATION RETRIEVAL NUMBER 73

Fault monitoring system detects power problems

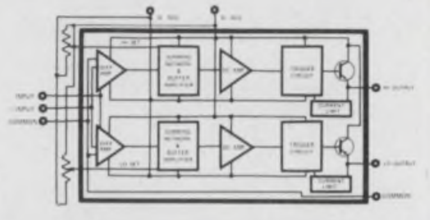


Eltron, 22 Market St., Bramwell, W. Va. 24715. (304) 248-8263.

A ground circuit monitoring system, Model GM-101, can monitor a variety of circuits, including high voltage on-pole and bore hole feeder cables, underground feeder cables, underground distribution equipment, trailing cables and more. The system consists of a transmitter which generates a low cycle signal, and impresses it on the conductors to be monitored. A companion receiver "listens" for the signal. If a fault occurs, the transmitter's control circuitry causes the supply breaker to trip and drop out. Power requirements are minimal, ranging from dc to 550 V ac, 100 W. Under normal operation, a built-in recharging system keeps small self-contained emergency power batteries at full charge. In event of a fault, the system switches to battery power and continues to monitor for approximately four hours. The system weighs less than 3 lb. and measures only 8-1/2 × 5-1/2 × 3 in.

CIRCLE NO. 275

Voltage level detector has 20 μV sensitivity



Calex, P.O. Box 555, Alamo, Calif. 94507. (415) 932-3911. $94.

The Model 512A Voltsensor, a solid-state voltage level detector, has a differential input and a sensitivity of better than 20 μV. Two independently adjustable trip points and two separate, high level outputs are provided. The unit is available as a module or already mounted on a PC card which includes trimmer pots, pin connector and several relays.

CIRCLE NO. 276

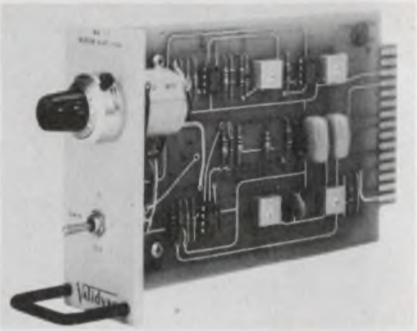
Eight-pole active filter covers 1 Hz to 20 kHz

Frequency Devices, 25 Locust St., Haverhill, Mass. 01830. (617) 374-0761. From $75 (100 up).

Models 756L8B, 756L8L, 757L8B and 757L8L are eight-pole low-pass Butterworth and Bessel active filters. They are available with (−3 dB) cutoff frequencies from 1 Hz to 20 kHz. Specifications include: Passband insertion loss of 0.02 dB, 2% cutoff frequency accuracy, 1 Ω output impedance, offset voltage of less than ±2 mV (adjustable to zero), offset drifts of ±60 μV/°C and output noise of less than 75 μV.

CIRCLE NO. 277

Signal conditioning amp has three gain ranges



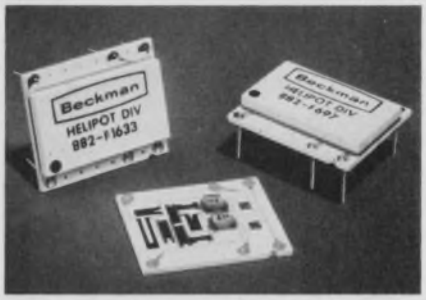
Validyne Engineering, 19414 Londelius St. Northridge, Calif. 91324. (213) 886-8488. $125; stock.

A signal conditioning amplifier plug-in module, BA112, provides a high impedance, differential input for ac and dc signals, and a low impedance, single-ended output. Over-all gains of 10, 1 and 0.2 are obtained by a three position toggle switch. Additionally, the gain may be varied from zero to 100% at each gain setting with a 10-turn, calibrated control. Output is high level, ±10 V at 10 mA maximum. There is no damage if output terminals are shorted. Output impedance is less than 10 Ω. Frequency response is flat from dc to 10 kHz while the common-mode rejection is 60 dB typical, dc to 1 kHz and may be further increased by internal adjustment. The offset voltage is nominally zero although a small change is possible with gain settings. There is separate internal adjustment at each amplifier. The input bias current is 0.02 μA typical. The temperature range is 0 to 160 F, zero shift is ±20 μV/°F referred to input and span shift is 0.005%/°F.

CIRCLE NO. 278

THE NEW SHARP PC-1001.

Active telephone-tone filters are low cost



Beckman Instruments, Helipot Div., D962, Fullerton, Calif. 92634. (800) 437-4677. $12 (1 to 9).

Series 882 telephone tone filters are pretuned bandpass active filters. F_0 is preset (±0.5%) to a standard tone frequency of 697, 770, 852, 941, 1209, 1336, 1477, or 1633 Hz, and Q is preset to 18 ±10%. Also, gain is preset to unity at the bandpass center frequency. Each unit has an input impedance of 30 kΩ and can supply ±2 mA output current with less than 1 Ω output impedance. The F_0 temperature coefficient is less than ±100 ppm/°C over 0 to 70 C.

CIRCLE NO. 279

Voltage regulator cards make simple supplies

ERA Transpac Corp., 311 E. Park St., Moonachie, N.J. 07074. (201) 641-3650. $14; stock to 30 day.

The RR series of circuit card voltage regulators is available in a choice of voltage outputs of 5, 6, 12, 15 or 24 V dc with maximum current ratings of 150 mA or 1 A. Unregulated dc input voltage can go as high as 35 V and regulator drop-out voltage is 5 V or less. Ripple reduction factor is greater than 40 dB. Input regulation is within ±0.1% and load regulation within 0.3%. The response time is less than 50 μs for a 10 to 100% load change. The regulators can operate over an ambient temperature range of −20 to +71 C and have a temperature coefficient of better than 2 mV/°C. All components are accessible for adjustment or servicing. Size of the 150 mA design is 1-1/8 × 2-3/16 × 3/8 in. and it weighs 3 oz. The 1 A models are 1-5/16 × 2-7/16 × 1/2 in. and weigh 5 oz.

CIRCLE NO. 280

Measure changes in tilt from 0.0003 degree

Columbia Research Labs, Woodlyn, Pa. 19094. (215) 532-9464. $250; 2 wk.

The Series 701 inclinometers use a force balance principle. They provide an electrical output proportional to the angle of inclination from 0.0003 to 90°. Input requirements are ±15 V dc.

CIRCLE NO. 281

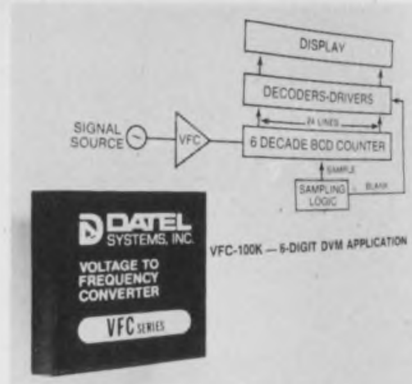
Power line protection predicts line overloads

Weston Instruments, P.O. Box 3041, Sarasota, Fla. 33578. (813) 958-0811. Typical $7510; 4 mo.

A thermal-overload relay can protect high and medium voltage overhead lines from deterioration caused by excessive temperature rise. It can also anticipate line failures prior to their occurrence. The PSLS relay includes an analog model which reproduces the thermal condition of the line and calculates the instantaneous cable temperature from the following parameters: load current, cable thermal time-constant, line heating curve, ambient temperature and preselected solar radiation conditions. The cable temperature is displayed by a meter on the front of the device, or at a remote location. Two independent outputs are provided, one to alarm in the 40 to 80 C range, the other to trip in the 50 to 100 C range. An optional plug-in module calculates the time remaining before tripping, based on present line conditions, to permit gradual implementation of emergency procedures.

CIRCLE NO. 282

V/f converters deliver outputs to 100 kHz



Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. (617) 828-6395. VFC-10K: $89, VFC-100K: $109; stock.

The Model VFC-100K voltage-to-frequency converter has an output frequency of 0 to 100 kHz and the Model VFC-10K has an output frequency of 0 to 10 kHz. The analog input may be either a voltage (0 to +10 V) or current input (0 to +1 mA). The output is TTL or CMOS compatible and the waveform is a fixed width negative going pulse. Voltage to frequency conversion is performed with a transfer accuracy of 0.01% and with a zero to full scale linearity of 0.005% for the VFC-10K and 0.01% for the VFC-100K. The temperature coefficient of both units is 20 ppm/°C. Step response is within one output cycle of the new frequency. Both models are housed in 2 × 2 × 0.4 in. plastic packages with DIP compatible pinning. Power consumption is ±20 mA at ±15 V dc.

CIRCLE NO. 283

Modular active filters cover 1 Hz to 20 kHz

Frequency Devices, 25 Locust St., Haverhill, Mass. 01830. (617) 372-6930. $57 (100-up).

Models 723H6B and 724H6B six-pole high-pass Butterworth active filters are available with preset cutoff frequencies (−3 dB) from 1 Hz to 20 kHz. Specifications include passband insertion loss of 0.05 dB, 2% cutoff frequency accuracy, 1 Ω output impedance, offset voltage of less than ±2 mV (adjustable to zero), offset drifts of ±20 μV/°C and output noise of less than 75 μV.

CIRCLE NO. 284

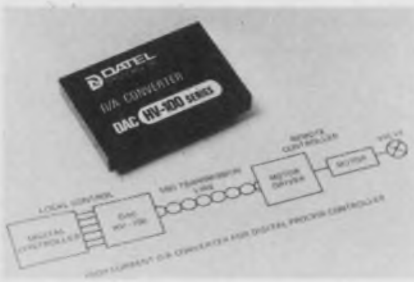
If time is your business, you need Burroughs' new PANAPLEX™ clock panels* for clear, legible display. In two character heights (0.5″ and 0.7″), four or six digits per panel, with AM/PM indicator, for maximum design flexibility. Easy to see and read; wide viewing angle; low power requirements; compatible with MOS circuits; assured long life and dependability because PANAPLEX clock panels are backed by Burroughs' years of pioneering technology and manufacturing know-how . . . and they are available at competitive prices. Time will tell how much that means to you and your customers. For more information, write Electronic Components Division, P.O. Box 1226, Plainfield, N.J. 07061, or call (201) 757-3400 or (714) 835-7335.

Sample quantities of panels available immediately.

Burroughs

INFORMATION RETRIEVAL NUMBER 77

Fast d/a converters can drive 100 mA load



Datel Systems, 1020 Turnpike St., Canton, Mass. 02021. (617) 828-6395. From $235 (1 to 9); stock.

The DAC-HV-100 series of d/a converters has a settling time of 50 ns while driving a 100 mA load at 5 V. The high-speed high-drive capability allows the units to directly drive 50 Ω transmission lines. The series consists of three standard versions with 6, 8 or 10-bit input resolution. Accuracy of these units is 0.1% of full scale, linearity is ±1/2 LSB and the temperature coefficient is ±100 ppm/°C. Long term stability of these converters is specified at ±0.5% per year. Inputs are standard TTL positive true logic levels. Power requirements are ±15 V dc at ±70 mA max (all bits off) with a power supply rejection ratio of 0.1%/V. The 2 × 3 × 0.375 in. modules operate in a temperature range of 0 to 70 C. In addition, two extended operating temperature ranges from −25 to +85 C and −55 to +85 C are offered as options.

CIRCLE NO. 285

Logic pulse divider uses true binary control

Banner Engineering Corp., 1247 Hopkins Crossroad, Hopkins, Minn. 55343. (612) 544-3164.

The Model BIC-256P is a logic module for high-speed batch-counter operation. It receives, registers and stores sequential input pulses that are generated either by a photoelectric, proximity or other mechanical switch. This module produces one output pulse for every preset number of up to 255 input signals, with an adjustable time range from 0.02 to 1 s. It requires from 9 to 16 V, 50/60 Hz or 12 to 20 V dc, 4.5 W. Output is 15 V dc, 0.25 A maximum.

CIRCLE NO. 286

Displays come in single or multidigit arrays

Apollo Corp., No. 465, SUWA, Takatsu-Ku, Kawasaki, Japan. From Yen 3250.

The DN series of Newtron digital displays are available in various tube sizes and arrays. The display circuits are TTL compatible and operate from 5-V-dc supplies. The typical current requirement is 105 mA at an operating frequency of 10 MHz. Operating temperature range for the single and multidigit arrays is 0 to 70 C. Options are available for the single digit arrays, starting with the basic display tube and the decoder/driver, to the tube with decoder/driver, counter and latch. The multidigit arrays also have options starting with the decoder/driver.

CIRCLE NO. 287

Linearized bridge amp uses platinum sensors

Hy Cal Engineering, 12105 Los Nietos Rd., Santa Fe Springs, Calif. 90670. (213) 698-7785.

The Model SC-2878 linearized bridge amplifier consists of a bridge network, amplifier, constant current power supply, and linearization for platinum resistance thermometers. The system provides an output voltage which is directly proportional to temperature over a specified range. It is compensated for ambient temperature changes from 0 to 120 F. Zero and span adjustments are provided, using separate potentiometers. The 1132 is designed for use with a three-wire, 100 Ω platinum resistance sensor. For short lead lengths of 10 ft. or less, a two-wire sensor may be used. Operating ranges are available from −165 to 0 C to 0 to 540 C.

CIRCLE NO. 288

relays renewed

Two more of the over 800 relay applications submitted last year to Struthers-Dunn's 50th Anniversary Relay Contest. These thought starters are a small sample of the endless possibilities for relay-operated systems. This month's circuits use three different members of S-D's growing family of 12-pin plug-in industrial relays.

TEMPERATURE-CONTROLLED SAFETY INTERLOCK

The interlock circuit of Figure 1, submitted by JWS of McKeesport, Pennsylvania, protects electric furnace operators by cutting off high frequency power following the heating cycle. The heating cycle is under control of a cam programmer operated by motor M.

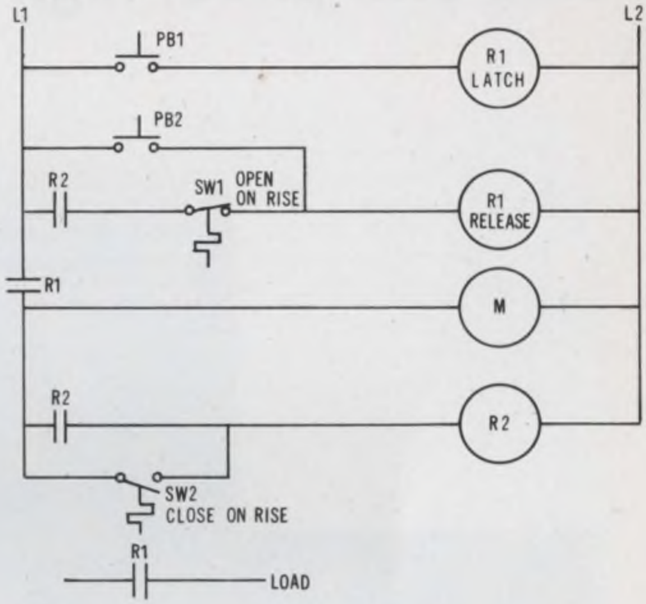
R1 is a two-coil latch relay, such as S-D type MRRNL2A reed relay or electromechanical type A255XBXP, depending upon load contact requirements. R2 may be any DPST reed or electromechanical relay, such as S-D type MRRN2A or 219XBXP.

SW1 and SW2 are temperature-controlled switches, shown in the low-temperature start-up position. Pushbutton PB1 energizes latch relay R1, completing the circuit through external limit switches to allow furnace operation and powering the program drive motor.

During the heating cycle, as the temperature approaches the high end of the program, SW1 opens so that the R1 release coil can not be energized. Approximately 10 degrees higher, SW2 closes to energize relay R2.

When the temperature peaks out and starts down, switch SW2 opens, but relay R2 remains energized through its own holding contacts. Approximately 10 degrees lower, switch SW1 re-closes and energizes the R1 release coil. This drops out both relays and the program stops until manually restarted by pressing pushbutton PB1. The program can be stopped at any time by pushbutton PB2.

FIG. 1



A255 Frame industrial plug-in

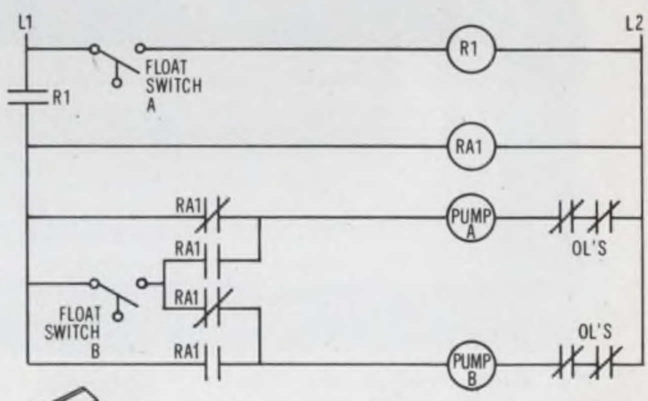
MRRN type open reed

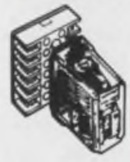
SIMPLE PUMP ALTERNATOR WITH A PLUS

A Struthers-Dunn Frame 211 sequence relay offers an economical way of equalizing the useage of two pumps, according to ZAP of Sulphur, La. In his automatic level control, Figure 2, float switch A operates one of two pumps to maintain the desired level. When one pump can't keep up with demand, float switch B cuts-in the second pump. The stepping action of sequence relay RA1 helps increase motor life by alternating operation between pumps A and B to provide approximately the same amount of operating time for each pump. Relay R1 carries the load to increase the operating life of float switch A.

RA1 should be our Type 211XBXPR which transfers contacts when de-energized. It's a close relative of the Type 219XBXP recommended for R1. Both use our rugged, 12-pin industrial socket.

FIG. 2





219 Frame & 12-pin socket

211 Frame sequence relay

Struthers-Dunn Relays Are Stocked by Over 125 Distributors

STRUTHERS-DUNN, INC.

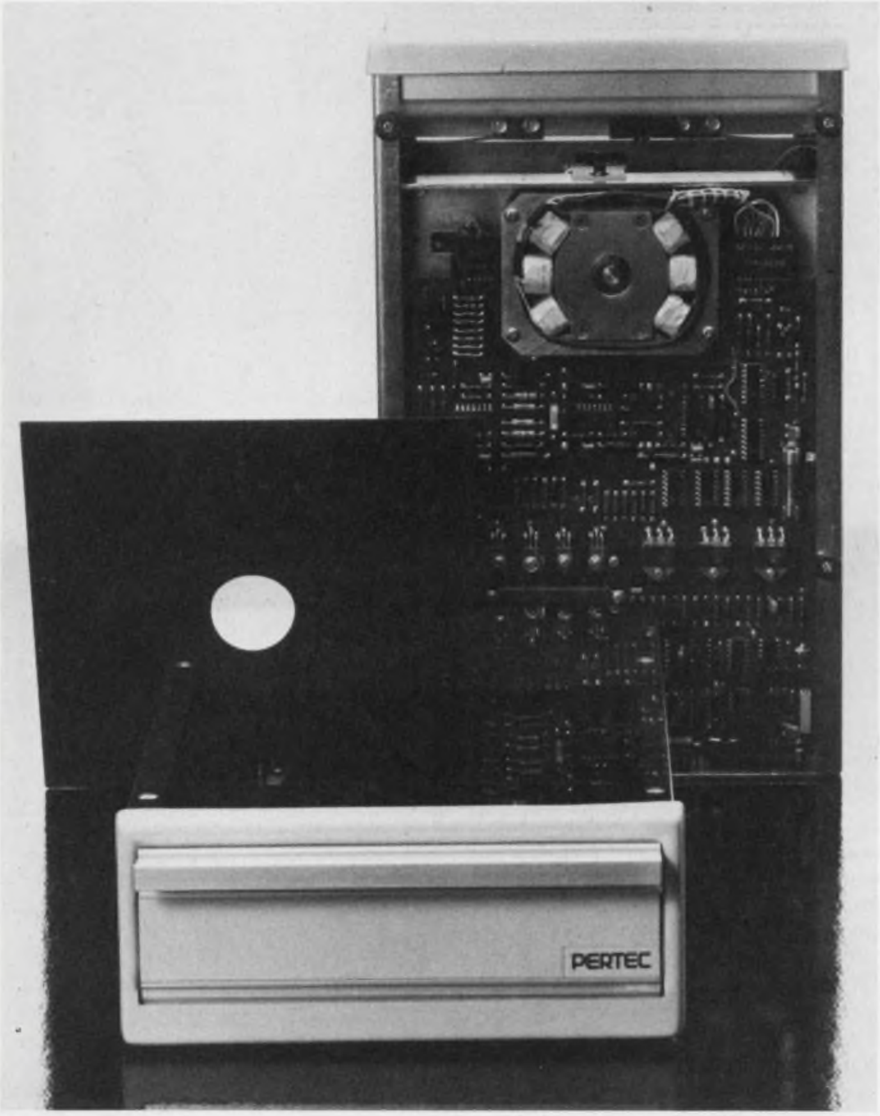
PITMAN, NEW JERSEY 08071

Canada: Struthers-Dunn Relay Div., Renfrew Electric Co., Ltd.

INFORMATION RETRIEVAL NUMBER 79

1974 Catalog specs over 100 basic relays —EM, Reed, Hybrid, Solid State— plus solid state Programmable Controllers. Circle reader service card with number below for your copy.

Floppy-disc drive scores low in size and price, high in capability



Pertec, 9600 Irondale Ave., Chatsworth, Calif. 91311. (213) 882-0030. See text; 30 day.

The smallest and least expensive floppy-disc drive is the D0330 from Pertec. It measures 3.5 × 8.75 × 14 in. and weighs 10 lb.

The flexible-disc drive costs $650 in 1 to 99 quantities and drops to $475 for 100 to 249. This is at least 20% cheaper than for comparable quantities of any other drive available.

Like several other drives, the D0330 is IBM-compatible. That means that the disc is an IBM Diskette or equivalent that costs $8 or less and that data recorded on an IBM 3740 or 3540 system can be played back on the D0330, and vice versa.

Unlike most drives the D0330 operates with only dc power supplied. A brushless dc motor rotates the disc at 360 rpm. This motor was designed inhouse by Pertec to deliver speed accuracy of ±1.5%.

Each disc contains 77 tracks on an 8-in-diameter format. There are 48 tracks/in., each track with a width of 0.012 in. With no formatting, the disc has a capacity of 3.2-million bits. With formatting to IBM standards, the capacity drops to 1.95-million.

The packing density is 6631 bits/radian and the recording code is double frequency. The data-transfer rate is 250,000 bits/s maximum.

Access times include track-to-track seek time of 10 ms; average latency of 83.3 ms; start and stop times of 3 s; head settling time of 10 ms at the last track addressed; and head loading time of 20 ms max. When the disc is inserted or unloaded the recording head moves to about 30 mils above the disc. During a stand-by condition, a command can also unload the head, for increased head life—a unique feature of this drive.

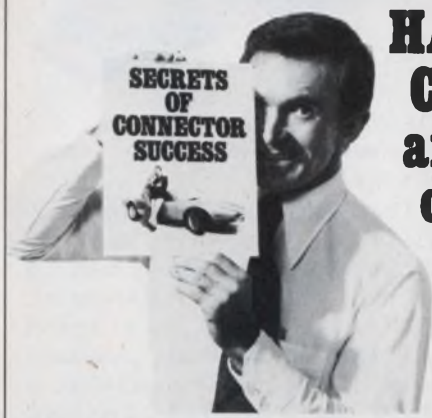
A soft error rate of 1 per 10^9 bits minimum and a hard error rate of no worse than 1 per 10^{12} bits is assured. Accuracy is related to head positioning. This D0330 drive uses a head-positioning motor that is a stepping motor with three steps per track. All competing drives offer only one step per track.

Outputs from the drive are all TTL-compatible. There is no separation of clock from data pulses. No formatting and no controller are included in the basic price. An optional board, for about $100, gives data separation, addressing and status signals. For a small additional charge, the front panel can be color-coordinated.

The drive operates over +10 to +42 C with a 20-to-80% range of relative humidity. Its dc power requirements are: +24 V ±10% at 2 A; +5 V ±5% at 1 A; and −5 V ±10% at 0.1 A.

CIRCLE NO. 253

"CANNON'S PRESS-T-MATE CONNECTORS GOT US CONNECTIONS AT HALF THE COST, and me congratulations all around."



"Because PRESS-T-MATE eliminates the cost of wire wrapping and the disadvantages of soldering, it saved us a bundle. See why in 'Secrets of Connector Success.' It's a 'how to' book for 'can do' guys like us."

Contact ITT Cannon Electric, International Telephone and Telegraph Corporation, 666 East Dyer Road, Santa Ana, CA 92702. (714) 557-4700.

CANNON ITT

INFORMATION RETRIEVAL NUMBER 81

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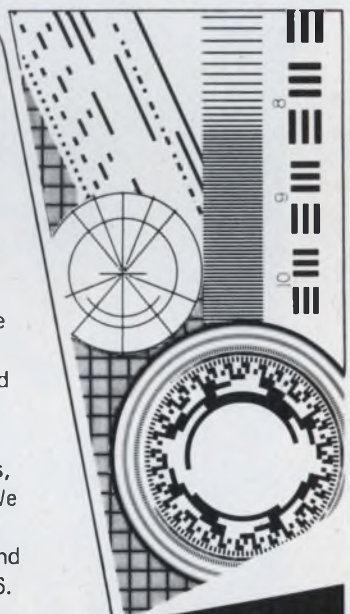

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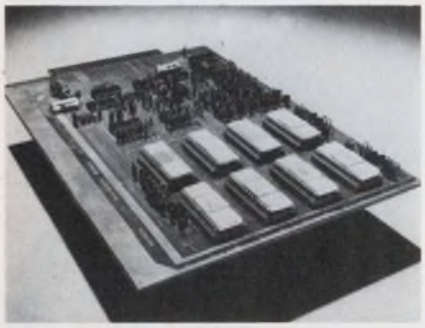
DATA PROCESSING

EAROM card stores 1-k bytes



Nitron Corp., 10420 Bubb Rd., Cupertino, Calif. 95014. (408) 255-7550. $995.

The NIT-80T memory card offers 8-k of EAROM organized as 1 k × 8. Address, data I/O and control signals are compatible with TTL and CMOS levels. Read access is 20 μs; write time is 1.2 ms. The units provide indefinite storage without power (to 125 C) and require no clocks or refresh cycles. All reprogramming is done electrically through standard TTL/CMOS inputs.

CIRCLE NO. 289

Rotational limits set from keyboard controller

Astrosystems, 6 Nevada, Dr., Lake Success, N.Y. 11040. (516) 328-1600.

The ASI programmable limit switch replaces rotary cam-operated switches. A set of pushbuttons on the control panel allows independent user selected limits between 0 and 359.9 degrees in 0.1-degree increments. The limits can be changed even while the controller machine is in operation. The unit, which is remote from the angle transducer, provides outputs in the form of logic levels, relay contacts or solid-state switches and displays the actual shaft angle.

CIRCLE NO. 290

Data collection system has card output

Varifab, 1700 Putnam Ave., Old Greenwich, Conn. 06870. (203) 637-1434.

The Series 600 Data Recorder-Vari-Punch is a source data collection system that can be matched to individual user requirements. The system consists of a control unit with up to three automatic input devices cable-connected to a Model 404 Vari-Punch. The control unit handles any combination of a 10-switch digital array; a 10-column badge or card reader and a time clock. Input rate is 12-columns/s. Manual information can also be entered on the Vari-Punch keyboard. Output data are punched and printed on standard 80-column tab cards or tab-card sets.

CIRCLE NO. 291

Closed-circuit monitor detects changing scene

Siemens, Box 3240, D-8520, Erlangen, West Germany.

The Telemat closed-circuit TV monitor unit stores the original scene and compares it with the new images for change. When a discrepancy is detected, audio and visual alarms are generated. In the associated electronics, the picture is resolved into 3200 points. When anyone of these points changes, marks appear on the screen to indicate the place where the image changed. The system is sensitive enough to detect smoke as well as intruders.

CIRCLE NO. 292

Pocket calculator solves engineering problems

Texas Instruments, P.O. Box 5012, Dallas, Tex. 75222. (214) 238-3741. $169.95; stock.

The highly advanced SR-50 slide rule calculator with scientific notation can process a wide range of problems from simple arithmetic to complex scientific calculations. The unit performs simple arithmetic, reciprocals, squares, square roots, nth powers, nth roots, factorials, trigonometric and hyperbolic functions (sine, cosine, and tangent), inverse trigonometric and hyperbolic functions, common and natural logarithms, and e^x. Two state-of-the-art MOS ICs built with ion-implantation technology provide the computational power required for the SR-50. One of the ICs, an arithmetic chip (233 × 240 mils), is considered to be the most complex IC ever produced. The other is one of the largest ROMs in existence (200 mils square) with 13,312 bits of memory storage. Answers are calculated to 13 significant digits and rounded 10 significant digits when displayed. The SR-50 uses all 13 significant digits for subsequent internal calculations. Answers are computed and displayed as large as $\pm 9.999999999 \times 10^{99}$ and as small as $\pm 1.000000000 \times 10^{-99}$. A portable calculator, the SR-50 comes complete with vinyl carrying case and a fast-charge (3 hours) rechargeable battery pack that provides four to six hours of operation.

CIRCLE NO. 293

Process control system is also easy to use

Siemens AG, D-8520 Erlangen, Postfach 3240, West Germany.

Compatible subsystems provide open-loop control, closed-loop control and computing functions. The Teleperm-Telepneu 300 system includes electrical and pneumatic controller stations of the indicating and recording type as well as process recorders, process indicators and other switchboard instruments for process automation. The electrical and pneumatic units have the same design (dimensions and controls) making it quite easy to intermix electrical and pneumatic instrumentation. The units can be removed from their castings without interruption of operation. Ergonomic considerations are an integral part of the design. For example, only the most important indicators and control devices are on the front of the units. Uniform color schemes for the indicators and the arrangements for the controls make it easy to read or operate several neighboring units in quick succession.

CIRCLE NO. 294

Remote scanner resolves alarms to within 1 ms

Optron, 1201 Tappan Circle, Carrollton, Tex. 75006. (214) 242-6571.

The Model 120 event recorder is capable of scanning 2048 points in 128 μs with no alarms present. The interrupt time required to store a status change is 10 μs per point. Alarms occurring less than one ms apart, but greater than 400 μs, will be printed out sequentially with 1-ms resolution. Transitions in excess of 120 events will be stored as space becomes available. The logic cabinet of the Model 120 is situated remotely and contains terminal columns, logic systems, memory, power supplies and local control panel for maintenance use. Its printer has a full alphanumeric capability on ASR-35 or other typing devices. No alarm events are lost in the event of power failure. A core memory retains information.

CIRCLE NO. 295

System gives 19.2-k bps over voice-grade lines

Codex Corp., 15 Riverdale Ave., Newton, Mass. 02195. (617) 969-0600. Stock.

The CT-6 Terminal is a packaged system comprised of the 296 Biplexer and two 9600C Data Modems enclosed in a single cabinet. This system provides full-duplex data transmission at speeds up to 19,200 bit/s by combining the capacity of two independent voice-grade channels, each operating at 9600 bit/s. Significant savings can be realized by use of the CT-6 with voice grade lines instead of wideband facilities previously needed for data transmission above 9600 bit/s. In addition, the CT-6 can maintain a usable communications link despite line degradation and failures. System monitor and fault isolation features permit the user to easily check performance of each element of the communication system.

CIRCLE NO. 296

Real-time tasks run on inexpensive systems

Modular Computer Systems, 1650 W. McNab Rd., Fort Lauderdale, Fla. 33309. (305) 974-1380. See text.

MAX III a real-time multiprogramming system can run on a $19,500 computer system. The system designated the II/200 includes a 64-kbyte minicomputer, a direct memory processor and a controller for TTY and paper tape reader. The software schedules and runs real-time tasks written in Fortran in three partitions—background, middleground and foreground. The software also supports multi-user basic assembly languages. A larger system, the II/220 sells for $32,-000 and includes a 5.2 M-byte disc.

CIRCLE NO. 297

Modem on PC board operates at 1800 baud

RFL Industries, Powerville Rd., Boonton, N.J. 07005. (201) 334-3100. $210; 60-90 days.

Small in size and low in cost, the Model 6385 Data Modem operates at speeds of 1200 and 1800 baud on two and four-wire Type 3002 private lines. The modem is compatible with Bell 202D Systems and offers a variety of interfaces, including EIA, CCITT, DTL/TTL, and positive neutral. Transmit frequency, transmit level, receive sensitivity, and receive bias are all adjustable. The bias control provides adjustment to zero-bias distortion. Total peak distortion, at 1200 baud back-to-back at 25 C, is typically 4%. The modem, mounted on a PC board, measures 4.713 in. wide by 8 in. long by 0.9 in. high and uses 11-to-16-V-dc power.

CIRCLE NO. 298

Metallized polyester capacitors wound

The Plessey Co. Ltd., Plessey Precision, Alma Rd., Ponders End, Mddx, England. (01) 804-9511.

High output, simplicity of construction and reliability are features of the type E11794 machines for winding metallized polyester capacitors. Up to four of these machines can be controlled by one operator and they can run for 24 hours a day, with minimum downtime for reel changing. Each machine can produce up to 18.2 elements/min when winding 50-torn capacitor elements (as an example). The machine is easily preset for the number of turns required. The unit winds capacitor elements from two or four reels of film and finishes the element with a length of pressure-sensitive tape. Completed elements are ready for end spraying and soldering of lead wires. Though designed particularly for the production of tubular polyester film elements, the machine can be used with other films such as polycarbonates having similar strength characteristics. There are facilities for offsetting one film slightly from the other. The machine is supplied with four unwind mandrels and can wind and tape two capacitor elements simultaneously.

CIRCLE NO. 299

ASCII storage terminal performs text editing

Western Telematic Inc., 3001 Red Hill, Costa Mesa, Calif. 92626. (714) 979-0363. $3875; 8 wks.

Designated the Data-Master I, this floppy-disc storage terminal accesses any selected line at speeds equivalent to the "carriage return" time (0.5 s) of most terminals. The unit interposes directly between existing ASCII printer/display terminals and their dataset through the RS 232 connector and in effect adds 264,000 characters to "working storage." An internal text editor simplifies corrections and updates. Organized as 2000 addressable records of up to 132 characters, each line is automatically numbered and stored with access from either the printer/display keyboard or remote processor. Edit access to the file is from a 10-key pad. Line location is constantly displayed and can be printed at the users' option. Data rates from 110 to 1200 baud are switch selectable. User selections also include Batch or Interactive modes, and a line printout width of 72, 120 or 132 characters.

CIRCLE NO. 300

Flexible disc memory unit is IBM-compatible

Syvor, 100 Phoenix Dr., Ann Arbor, Mich. 48104. (313) 971-0900. $900 (100 quan); 30 days.

A flexible-disc memory that is IBM 3740-compatible, the Model 145 can store and access 250-k bytes of data (equivalent to one box of punched cards) on each side of the two discs. A stepper motor indexes the heads by one track in 2.5 ms. Average access time to a data block is 83 ms and the transfer rate is 250-k bit/s.

CIRCLE NO. 301

Key-to-disc system has two I/O channels

Mohawk Data Sciences Corp., Box 362, Utica, N.Y. 13503. (315) 792-2202. From $25,000.

A shared-processor key-to-disc system designated the 1200 Key Display System includes a disc, tape drive and processor all in a single package. Each unit supports four to 12 keystations and provides a wide range of data checks and computations. A maximum of two I/O channels can be provided—one for communications and the other for a printer. Communications are half-duplex at rates up to 9600 baud. The disc provides storage for 8000, 125-character records. Tape speed is 18.75 in/s, seven or nine-track, with recording density to 1600 byte/in.

CIRCLE NO. 302

Printing counter offers many function variations

Farad Electronics AB, Nyborgsgrand 1, S-126 34 Hagersten-Stockholm, Sweden.

A dual channel printing counter from AB Farad has a built-in time division multiplexer for expansion to 8 or 16 channels. The counter is controlled by either contact closures or logic level signals. The printing counter contains modules for each function: mechanical module for printing, clock and sequence unit, memory unit, timer for print intervals, start-stop controller, paper feed control and an alarm unit.

CIRCLE NO. 303

Card reader lets program select useful fields

Digital Laboratories, 377 Putnam Ave., Cambridge, Mass. 02139. (617) 876-6220. $3850; 30 days.

The DRC-202 card reader offers data field selection that can be changed from card-to-card under program control. This flexibility can reduce line costs and increase speed by as much as a factor of 10 for remote data transmission. The unit is plug-compatible with most minicomputers, display terminals, printers and modems. Furthermore, the control method and command code assignments allow use with virtually all current software systems from commercial time-shared and remote batch to programmable calculators. The card mechanism handles a stack of over 400 cards at 200 cards per minute. Card data are stored in a buffer so that they may be retransmitted as many times as desired.

CIRCLE NO. 304

Program debugs Fortran source code for minis

Binary Systems, 88 Sunnyside Blvd., Plainview, N.Y. 11803. (516) 822-1585. $200.

A program named Breakpoint allows interactive debugging of Fortran programs written for minicomputers. When operated in the interactive mode, the program allows the user to place breaks at any line of source code. The users program executes until the break is encountered. At the break, the source-code variable name and its value is examined by the user, and changes can be made if desired. The breakpoint can then be moved to another line of code and the program continued. Breakpoint contains other features such as selective printout, suppression of breaks, and other functions useful for debugging. Versions of Breakpoint are available now for IBM, DEC, Data General, Hewlett-Packard, and Mod Comp computers.

CIRCLE NO. 305

Tester checks 30 capacitors/min

The Plessey Co. Ltd., Plessey Precision, Alma Rd., Ponders End, Mddx., England. (01) 804-9511.

The type T2730 tester subjects metallized polypropylene capacitors to a series of tests and, according to which test they have failed, separates those that are defective. The speed of testing—up to 30 capacitors per minute—makes feasible 100% testing of production batches. Capacitors are hand-loaded onto a horizontal chain conveyor which transports them past pairs of connector brushes placed along the length of the machine. Each pair of brushes connects the capacitor to one of the tests. If a capacitor fails a test, it is ejected from the conveyor by solenoid-lifted ramps. After tests that involve charging, capacitors are automatically discharged before the next test, or ejected if they failed.

CIRCLE NO. 306

Infrared source emits over 0.4-to-5-μm range

Chicago Miniature Lamp Works, 4433 N. Ravenswood Ave., Chicago, Ill. 60640. (312) 784-1020.

The new lamp, Model CM8-3968, emits a 0.4 to 5-μm spectrum, operates on a power input of 33 W at 12 V ac or dc. Its life expectancy averages in excess of 5000 h at rated voltage. Primarily for use in automotive exhaust analyzers and other pollution detecting equipment, the new lamp offers three to eight times the efficiency of standard IR sources in the 4.7 μm wavelength necessary for carbon monoxide detection and in the 3.4 μm wavelengths required to detect particulate matter in gases. A ceramic backplate, which is positioned next to the filament, concentrates radiation into a beam.

CIRCLE NO. 307

FET offers 6 dB NF at 8 GHz

Plessey, Optoelectronics and Microwave Unit, Wood Burcote Way, Towcester, Northamptonshire, England.

Field-effect transistor, GAT 3, is intended for use in amplifier and oscillator applications up to X band. Performance depends upon its method of mounting. The device is available as either a chip or mounted in an LID package. Gate breakdown voltage is 10 V at $I_g = 10$ μA, while drain saturation current is 50 mA for a V_{ds} of 5 V. Cutoff voltage is 10 V and cutoff frequency is 20 GHz at $V_{ds} = 5$ V. Common source gain is 6 dB with $V_{ds} = 5$ V and $V_{gs} = 0$ V. At 8 GHz, common source spot noise figure is 6 dB at $V_{ds} = 5$ V and $I_{ds} = 15$ mA. Total power dissipation at or below 25 C is 300 mW.

CIRCLE NO. 308

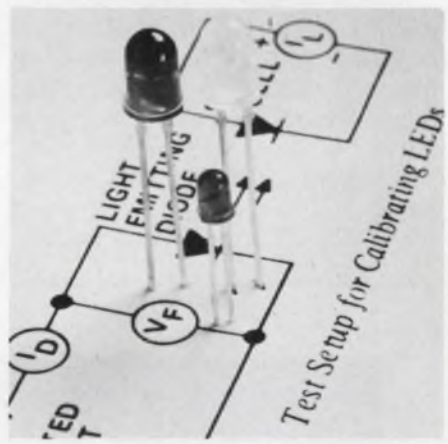
Infrared emitting diode chip delivers 2.3 mW

RCA, Harrison, N.J. 07029. (201) 485-3900. $0.19 (10K-up); stock.

The SG1007, a gallium arsenide infrared emitting chip, is 0.016 × 0.016 × 0.007 in. The SG1007 has a wavelength of peak radiant intensity of 940 nm that allows good spectral matching with silicon photodetectors. When the SG1007 is operated continuously, it provides a typical radiant flux (power output) of 2.3 mW at 100 mA.

CIRCLE NO. 309

Green VLEDs have clear or diffused lenses



Texas Instruments Inquiry Service, P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. (100-up prices); $0.46 (211), $0.48 (222 and 223); 4 wk.

Three gallium-phosphide green VLEDs are the TIL211, TIL222, and TIL223. The TIL211 has a 0.12-in. lens diameter. At a forward current of 25 mA the TIL-211 has a minimum luminous intensity of 800 microcandelas. The filled-epoxy lens provides a diffused green source for easy viewing. Other features include 0.02 in. square leads and a lead-frame package that is adaptable to wrapped-wire installation and lead forming. The TIL222 and TIL223 have 0.25 in. diameter plastic lenses and rectangular leads. The TIL222 has a filled-epoxy lens which emits a diffused green light. The TIL223 has a clear diffused lens and a typical viewing angle of 45°. Both have a minimum luminous intensity of 1 millicandela when forward biased at 25 mA.

CIRCLE NO. 310

High current power transistors handle 100 A

Solitron Devices, 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404. (305) 848-4311. From $35 (100 up); 3 wk.

Two series of industrial npn silicon power transistors have peak current capabilities of 70 and 100 A. Each series is available in two packages, the standard TO-3 (100 A: SDT 96401-2-3; 70 A: SDT 96304-5-6) and the TO-63 (100 A: SDT 96401-2-3; 70 A: SDT 96404-5-6). The devices are from the JAN 2N5250 family and are constructed with a single planar chip. Other features include at V_{CE} (sat) at 70 A of 1.5 V (typical), at h_{FE} at 70 A of 20 (typical) and BV_{CEOS} from 60 to 300 V.

CIRCLE NO. 320

IC contains FM stereo decoder

N. V Philips, P.O. Box 523, Eindhoven, the Netherlands.

The TCA290A FM stereo decoder IC features a voltage gain of 10 dB and maximum output voltage of 1 V rms. Channel separation at 1 kHz exceeds 40 dB and total distortion, with 1 V output at 1 kHz, is less than 0.2%. The chip has provision for a mono/stereo switch.

CIRCLE NO. 321

Fast recovery 10 A bridges need only 200 ns

Varo Semiconductor, P.O. Box 676, 1000 N. Shiloh, Garland, Tex. 75040. $1.84 (1000-up); stock.

Models VJO48X to VJ684X are fast recovery time 10-A bridge rectifiers. The units in the series have a 200-ns reverse recovery time. They are rated for a 10 A (I_O) and 74 A (I_{FSM}) at a $T_C = 60$ C. The devices are available in 50, 100, 200, 400 and 600-V models.

CIRCLE NO. 322

LED alphanumeric digits use 5 × 7 dot matrices

Precision Dynamics Corp., 3031 Thornton Ave., Burbank, Galif. 91504. (213) 845-7606.

The Nova 7 series of ASCII alphanumeric display modules uses replaceable 5 × 7 LED dot matrices. The displays are 0.35 in. high and accept a standard six-line binary code. Displays operate from a single 5-V-dc supply and have a 350 foot-Lambert brilliance. Each display module is molded in black thermoset plastic and may be stacked with up to 24 digits in a single array. A red nonglare viewing screen and brackets for mounting are provided.

CIRCLE NO. 323

DISCRETE SEMICONDUCTORS

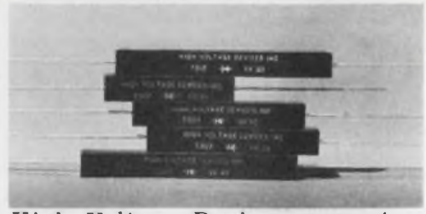
SCR surges to 1.2 kV and 2.5 kA

International Rectifier, 233 Kansas St., El Segundo, Calif. 90245. (213) 678-6281. $805 (prototype qty.)

Setting the pace for SCRs, the company reportedly has the highest power SCR ever manufactured in production quantities. Called the 1600PA, the SCR has a current rating of 2500 A rms (1600 A average) at up to 1200 V. Surge current reaches 35,000 A. The device is intended for such applications as rapid transit, earthmoving vehicles and metals processing.

CIRCLE NO. 324

Rectifier PIV reaches 40 kV



High Voltage Devices, 7485 Avenue 304, Visalia, Calif. 93277. (209) 733-3870.

The VX series of Multistac Rectifiers has a range of PIVs from 15 to 40 kV. Called the VS 15, 20, 25, 30 and 40 (corresponding to the PIV rating), the new devices have an average rectified current of 25 mA at 50 C and 5 mA at 100 C. Reverse recovery time is 250 ns and forward voltage at 25 mA ranges from 24 to 48 V.

CIRCLE NO. 325

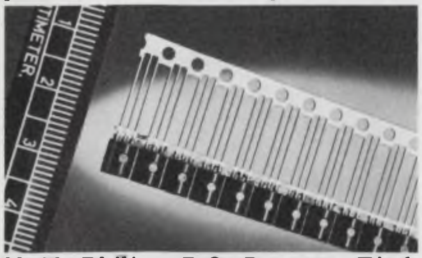
10-A Darlingtons come in improved versions

Solitron Devices, 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404. (305) 848-4311. TO-66 versions: $5; TO-5 versions: $3 (1-99); stock.

A version of the company's 10-A Darlington ICs reportedly offers improved reliability, performance and versatility. The npn versions are called the SDM 3100-3300 series, and the pnp versions are labelled the 3400 series. Typical features include a V_{CEO} from 40 to 80 V, multiple gain selections at 2.5 or 5 A, typical 5-A h_{FE} of 1000 minimum and typical 1-A h_{FE} of 10,000 minimum. They have a typical f_t of 70 MHz, and on and off time of 0.6 and 2.5 μs, respectively.

CIRCLE NO. 326

Complementary drivers provide 1-W output

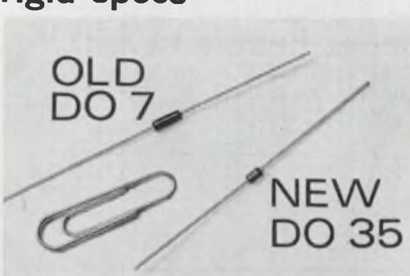


N. V. Philips, P.O. Box 523, Eindhoven, the Netherlands.

Six silicon planar epitaxial transistors, each in a TO-92-type package, have a maximum power output of 1 W at an ambient temperature of 25 C. Called the BC-635 to BC640, the new transistors have peak collector currents of 1 A, junction temperatures of 150 C and transition frequencies of typically 50 MHz. The BC635, BC637 and BC639 are npn versions having collector-emitter voltages (R_{BE} = 1 kΩ) of 45, 60 and 100 V maximum, respectively. The open-base collector-emitter voltages are 45, 60 and 80 V maximum, respectively. The pnp complements are BC-636, BC638 and BC640.

CIRCLE NO. 327

Diodes meet rigid specs



Microsemiconductor Corp., 2830 S. Fairview St., Santa Ana, Calif. 92704. (714) 979-8220. $1.65 to $3.15 (100); 6-8 wk.

A series of diodes meets or exceeds the requirements of MIL-S-19500/240D with interim amendments that call for metallurgically bonded devices. Called IN645-1, IN647-1 and IN649-1, the devices are electrically similar to other commercial devices but are packaged in the company's voidless-glass DO35 case. The IN645-1 conducts 500 mA forward current at 1-V V_f. PIV is 225 V. The IN647-1 conducts 500 mA at 1 V with 400-V PIV. The IN649-1 conducts 500 mA at 1 V with 600-V PIV.

CIRCLE NO. 328

Solid-state sensor monitors gasses

Thunder Scientific Corp., 623 Wyoming S.E., Albuquerque, N.M. 87123. (505) 265-8701.

Selective solid-state semiconductor sensors and systems monitor CO_2, CH_4 and H_2 in air and cover ranges of gas concentrations from 0 to 1, 5, 25 and 100%. Humidity has negligible effects upon calibration. Sensor physical dimensions are 0.37-in. diameter by 0.16-in. height.

CIRCLE NO. 329

Fetrons replace glass vacuum tubes

Tekelec Airtronic S.A., Cité des Bruyères, rue Carle Vernet, 92 Sevres, France.

Fetrons, or solid-state tubes, can be used to replace conventional glass vacuum tubes. Fetrons use field-effect transistors that have transconductance characteristics that are similar to those of vacuum tubes. Two standard models are available. The TS6AK5—equivalent to a 6AK5 vacuum tube—operates from a 350-V plate supply, and has a plate resistance of 5 MΩ and a transconductance of 4500 micromhos. The TS12AT7—equivalent to a 12AT7 vacuum tube—also operates from a 350-V supply, and has a plate resistance of 250 kΩ and a transconductance of 3000 micromhos.

CIRCLE NO. 330

Micropill Impatt diodes have 5% efficiency

Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. For 10 or more: $140 (621), $300 (621A); 5 wk.

The MDX621 and MDX621A are diffused silicon mesa Impatt diodes. They are packaged in durable hermetically sealed alumina micropill packages. These diodes have a built-in heat sink and are optimized for V-band applications. Other features include a conversion efficiency of up to 5% and a power output of up to 100 mW at a junction temperature of 200 C.

CIRCLE NO. 331

Blowout-proof transistor handles 40 W at 2 A

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, Calif. 95051. (408) 732-5000. 100-up prices $17 (195), $4.95 (395); stock.

The LM195 is a three-terminal bipolar IC that simulates a 40-W power transistor with a high switching speed. The internal protective circuitry makes the LM195 blowout-proof at output current levels of up to 2 A and at an input and output voltage level of 40 V. The current limiting and thermal shutdown circuits built into the device shut down the output stage if the output current exceeds 2 A or if the chip temperature exceeds 165 C. The only way the device can be damaged is by applying an excessive voltage, and if this happens, the LM195 fails safe—it becomes an open circuit. Electrically, the LM195 looks like a pnp transistor driving an npn Darlington with an over-all gain of over 10^6. Input base current is 3 μA or less over the input voltage range of 0 to 42 V.

INQUIRE DIRECT

Complementary power semis handle to 400 V

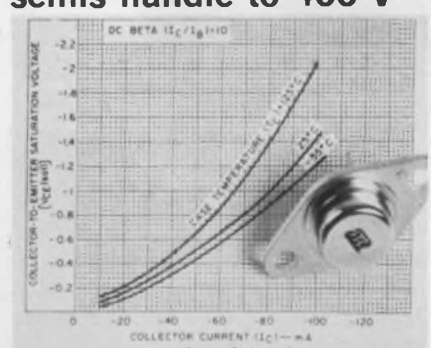


FIGURE 9.

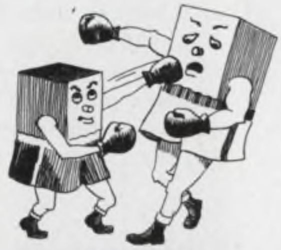
TYPICAL VCE (SAT) VERSUS IC FOR

Silicon Transistor Corp., Katrina Rd., Chelmsford, Mass. 01824. (617) 256-3321. From $1.08 (100-up); stock to 3 wk.

Eight different high voltage complementary power transistors can handle 35 W each and are housed in JEDEC TO-66 packages. They are rated at V_{ceo8} of 175 to 400 V. The transistors are tested at 1 A for gain, V_{sat} and switching time. They are designated as follows: 2N3583, 84, 85, 2N4240, 2N6211, 12, 13, 14.

CIRCLE NO. 332

Our Amps Don't Quit in a Mismatch!



Amplifier Research has a tough line of broadband amplifiers -- all unconditionally stable and built to take on any mismatched load. These amplifiers sweep the spectrum from DC to 700 MHz and provide up to 5000 watts of RF power. Rugged design makes them perfect for antenna and component testing, equipment calibration and EMI susceptibility testing -- you'll never have to throw in the towel! Amplifier Research will also provide custom OEM packaging to meet your special requirements. Get the facts, contact:

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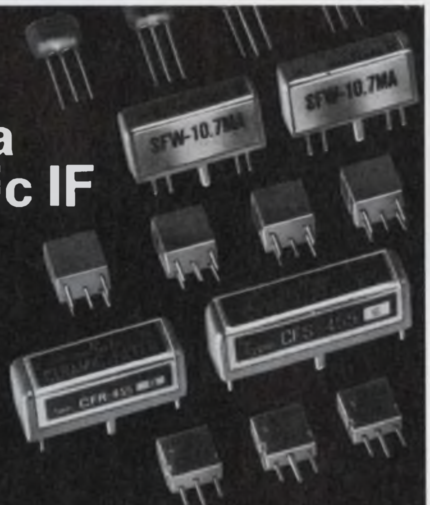
INFORMATION RETRIEVAL NUMBER 97

Solid! Murata ceramic IF filters



They're sharp. They're small. And, they're solid . . . for years! Murata's ceramic IF filters provide the solid-state performance in AM, FM ,TV and Communications IF's that's expected by every one of our customers . . . consumer, industrial or military. Find out all there is to know about Murata's renown ceramic IF filters. Complete information is yours for the asking.

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INFORMATION RETRIEVAL NUMBER 98

I.C.W.A.

international coil winding association

(Devoted Entirely To The Coil Winding Industry)

PRESENTS

COIL WINDING CHICAGO '74

CONVENTION & EXHIBITION

21, 22, 23, May, 1974 — **SHERATON O'HARE HOTEL ROSEMONT, ILLINOIS, U.S.A.**

Devoted exclusively to the coil winding industry this event is being held yet again to serve as a platform for presentation of specialized papers on new materials and techniques and a showcase for displaying the latest product developments.

CONVENTION:
Papers will be presented by Internationally recognised authorities in various fields of coil winding.

PRODUCT DISPLAY:
Covering the entire spectrum from coil winding machines to custom built coils.

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please complete in BLOCK LETTERS

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POSITION ....
COMPANY ....
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PRODUCTS ....
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CH

INFORMATION RETRIEVAL NUMBER 99

Attenuator series covers 1.14 to 140 GHz

Flann Microwave Instruments, Ltd., Dummere Road, Bodmin, Cornwall, PL31 2QL, England.

The direct reading precision rotary vane attenuators in the 11 series provide 0 to 60 dB attenuation to an accuracy of 0.1 dB or 1% of the reading, whichever is greater. Models are available for every waveguide size between 1.14 and 140 GHz. The VSWR is less than 1.15; insertion loss ranges from 0.5 to 1 dB depending on model size.

CIRCLE NO. 335

X, Ku-band diodes withstand 20, 10 W

Alpha Industries, 20 Sylvan Rd., Woburn, Mass. 01801. (617) 935-5150. X-band: $4 to $8 (1-9); Ku-band: $20 to $40; stock to 30 days.

A line of point-contact mixer diodes reportedly can withstand the highest powers. X-band units—called the DMA 6497 series—handle 20 W peak for 3 ns minimum at 9.4 GHz. Ku-band units—called the DMA-6499 series—handle 10 W peak for 3 ns minimum at 16 GHz. The X-band diodes have a maximum noise figure of 7 and 7.5 dB, i-f impedance of 335 and 465 Ω and maximum VSWR of 1.3. The Ku-band units have a maximum noise figure of 7.5 to 8.8 dB, i-f impedance of 400 and 565 Ω and maximum VSWR of 1.5.

CIRCLE NO. 336

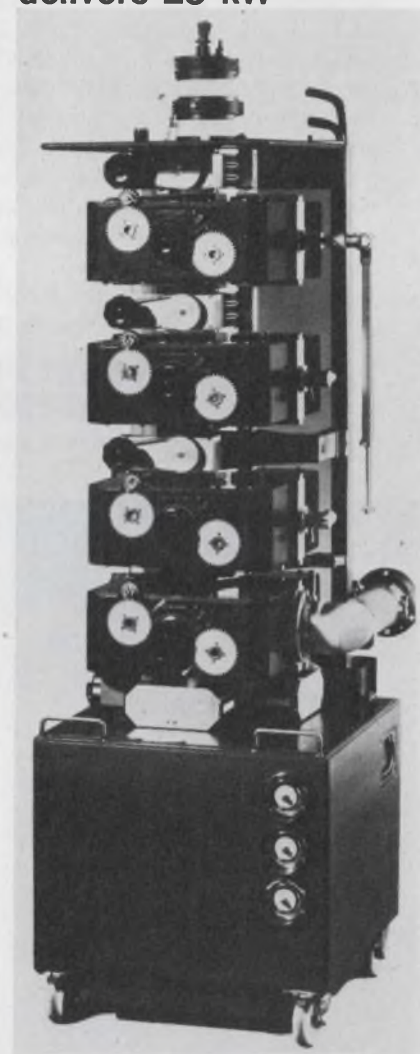
3-lb, 6-GHz TWT delivers 50 W

Varian, 611 Hansen Way, Palo Alto, Calif. 94303. (415) 493-4000.

A conduction-cooled TWT operates between 5.925 and 6.425 GHz and weighs only 3 lb. Called the VTC-6161H2, the tube delivers a saturation output of at least 50 W. It has a minimum 50-W gain of 45 dB and a maximum noise figure of 35 dB.

CIRCLE NO. 337

Uhf klystron delivers 25 kW

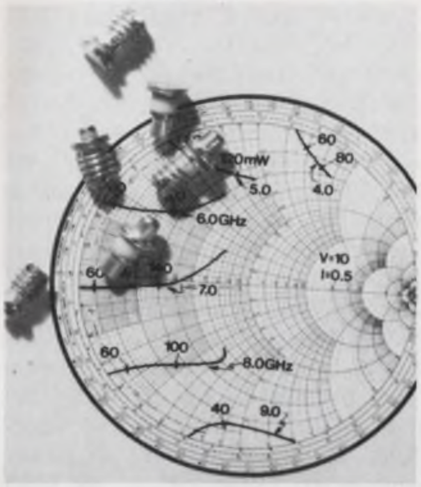


Amperex Electronic, 230 Duffy Ave., Hicksville, N.Y. 11802. (516) 931-6200.

An air-cooled uhf TV klystron, type Yk1151, outputs 25 kW, comes with permanent-magnet focussing and has a built-in ion pump. The klystron has an efficiency of about 40%, a gain in excess of 40 dB, and it requires less than 2.5 W of drive.

CIRCLE NO. 338

TEDs boost power, frequency

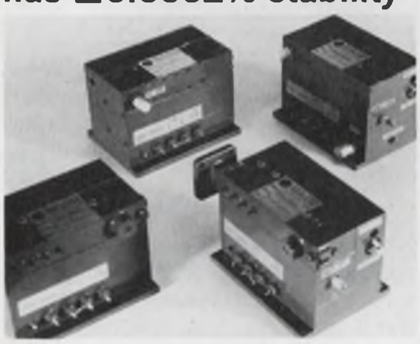


RCA Electronic Components, 415 S. Fifth St., Harrison, N.J. 07029. (201) 485-3900. $25 up (small production qty.); stock.

A line of C and X-band transferred-electron diodes, called the S3053 through S3099, consists of 47 diodes in six basic package styles. Maximum output power reaches 500 mW. Operating frequencies range from 4 to 18 GHz in one-half and full-octave bandwidths. Life test data reportedly verify a failure rate of only 1×10^{-5} failures per hour.

CIRCLE NO. 339

Phase-locked osc has ±0.0002% stability

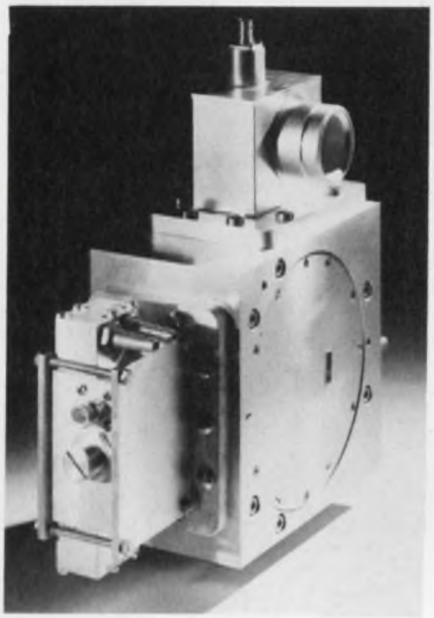


Solid State Technology, 3650 Charles St., Santa Clara, Calif. 95050. (408) 247-8620. 60 days.

The SSX series phase-locked oscillators are available with 10% bandwidths from 750 MHz to 18 GHz. A long-term stability of ±.0002% over the −30 to +60 C temperature range is obtained with an internal crystal oven. Output power ranges from 10 to 300 mW. And afc frequencies range from 200 kHz to 10 MHz.

CIRCLE NO. 340

Isolator spec'd for 6 kW



N. V. Philips, P.O. Box 523, Eindhoven, the Netherlands.

An isolator rated at 6 kW can be used for industrial microwave heating applications. It consists of a three-port circulator with a matched load on the third port and operates over the 2425-to-2475-MHz frequency range. The isolator requires 3 litres of water at 20 C per minute, with a maximum inlet temperature of 40 C. Isolation is better than 26 dB and insertion loss is less than 0.3 dB (guaranteed). In the matched condition, input VSWR is less than 1.10.

CIRCLE NO. 341

400-MHz transistors output up to 15 W

Motorola Semiconductor Products, P.O. Box 20924, Phoenix, Ariz. 85036. (602) 244-3466. MRF5174: $6 (1-99); MRF5175: $12.50 (1-99): MRF5176: $15 (25-99): stock.

Three rf transistors—the MRF-5174, MRF5175 and MRF5176—are designed for 28-V dc transmitter applications. The MRF5174 has 2-W output and 12-dB gain at 400 MHz, while the MRF5175 yields 5-W output and 11-dB gain at the same frequency. The MRF-5176, has 15-W output at a gain of 10 dB. All outputs and gains are at 50% efficiency.

CIRCLE NO. 342

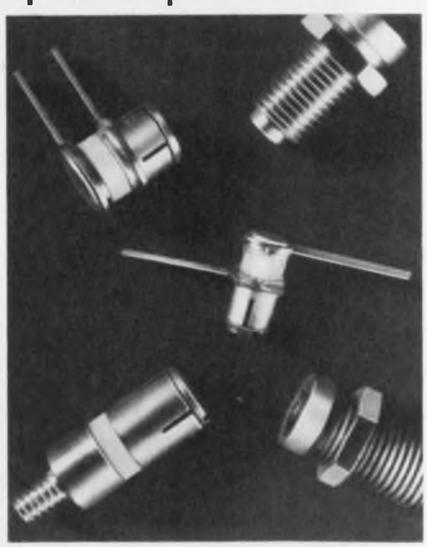
Transistors receive JAN ratings

Ampower Semiconductor, 375 Kings Hwy., Smithtown, N.Y. 11787. (516) 582-6767. $55.20 to $66.50 (100-999).

The company's 2N2812 and 2N-2814 power transistors, qualified to MIL-S-19500/415 specs, have received the JAN, JAN-TX and JAN-TX (V) ratings. The 2N2812 lists a 50-MHz power of 50 W at 100 C and 60 V. Gains range from 40 to 120 at 5 A and exceed 15 at 10 A. The 2N2814 has a minimum sustaining collector voltage of 80 V. Both units come in the TO-61 configuration and operate from −65 to 200 C.

CIRCLE NO. 343

Microwave capacitors operate up to K band



Tekelec-Airtronic S.A., Cité des Bruyères, rue Carle Vernet, 92-Sevres, France.

A family of subminiature adjustable capacitors, called the Gigatrim series, operates up to several gigahertz and has a reactive tuning capability into K band. The Q-factor is as high as 4000 at 100 MHz. The new series has a voltage rating of 500 V dc and an insulation resistance of 10^4 megohms at 200 V dc.

CIRCLE NO. 344

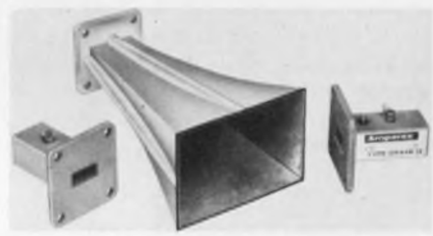
Si Impatt diodes offer high powers

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 493-1501. 5082-X001, 5082-X002 and 5082-X003: $175; 5082-X004: $225 (10 up); 4 wk. (small qty.).

Peak powers of 12 W at 10 GHz and 10 W at 16.5 GHz are available with two pulsed silicon Impatt diodes. Also announced are two cw Impatts capable of 1.3 and 2.3 W at 11.2 GHz. Efficiencies of the pulsed Impatts are 11%, and 10% can be achieved with the cw diodes. The two pulsed units are called the 5082-X001 for X-Band and 5082-X002 for Ku-Band. For cw power sources at X-Band, the 5082-X003 provides 1.3 W of output power and the 5082-X004 provides 2.3 W. Operating voltages are from about 100 to 143 V, with operating current from about 50 to 900 mA.

CIRCLE NO. 345

Components make up doppler radar system



Amperex Electronic, 230 Duffy Ave., Hicksville, N.Y. 11802. (516) 931-6200. DX-446: $37.50; ACX-01: $6.95: DX-492: $19.95; stock.

A horn, cavity and oscillator form a doppler radar component system. The DX-446 Gunn oscillator assembly delivers 8 mW at 10.525 GHz, while drawing only 130 mA from a 7-V source. Temperature coefficient is typically −0.25 MHz/°C, and the second harmonic is guaranteed to be below −30 dBm. The oscillator has a tangential sensitivity of −56 dBm. The ACX-01 horn provides a 16-dB gain. The horn and the DX-446 combine to produce a 1-mV pk-pk signal in response to a moving target at 10 meters. The DX-492 is a Schottky-barrier mixer diode mounted in a waveguide cavity with a WR-90 flange. This component can be combined as a receiver into a system that uses the DX-446 and the ACX-01 for 50-meter ranges.

CIRCLE NO. 346

TOOL KITS

FIELD ENGINEER TOOL KIT JTK-17

Write for brochure!

More than 100 fine tools used for maintenance and adjustment of electronic equipment, computers and office machines. Small tools are held securely on two removable pallets. Three roomy compartments in the bottom of the deluxe attaché case hold larger tools, optional test meter and parts boxes. A space for service manuals and schematics is provided in the cover.

FIELD ENGINEER ATTACHE TOOL CASES

Five styles available

Jensen attaché cases provide a convenient way to carry a large number of tools. Three models are offered: thin-line, standard and extra deep. All cases feature solid wood frames with mahogany paneling and dovetail corners, solid brass hardware and anodized aluminum partitions. Covering is scuff-proof Marvelon. Removable small-tool pallets and partitioned compartments in bottom of the case hold tools securely in a well organized manner. Write for brochure giving dimensions and full details.

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Lists over 1700 hard-to-find tools used by electronic technicians, instrument mechanics, engineers and scientists. Includes a solder section and four pages of useful "Tool Tips" with valuable data on insulations, color coding, fasteners, and tool selection. Write for your free copy!

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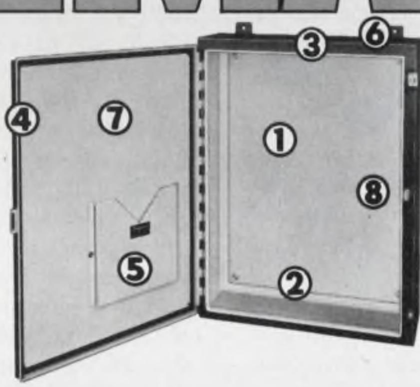
INFORMATION RETRIEVAL NUMBER 103

NEMA 12*



OIL TIGHT

DUST TIGHT

1. Heavy gauge steel rigid construction. 2. All seams continuously welded. 3. Rolled lip for strength, also helps keep dirt and liquid out when door is open. 4. Neoprene door gasket with oil resistant adhesive and steel retaining strips. 5. Removable print pocket. 6. External mounting feet. 7. All sizes, full stock: wall and floor mounted, one to five door. 8. Models available in stainless steel and aluminum. For detailed specifications, write for new catalogue.

*Also meets NEMA 13 specifications.

Hoffman® ELECTRICAL ENCLOSURES

HOFFMAN ENGINEERING COMPANY
Division of Federal Cartridge Corporation
Anoka, Minnesota, Dept. ED-11

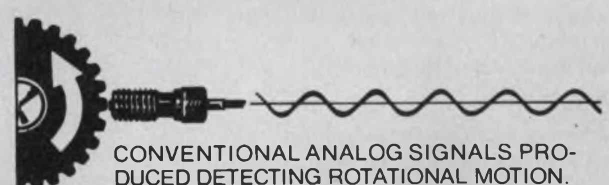
INFORMATION RETRIEVAL NUMBER 104

DI-MAG®

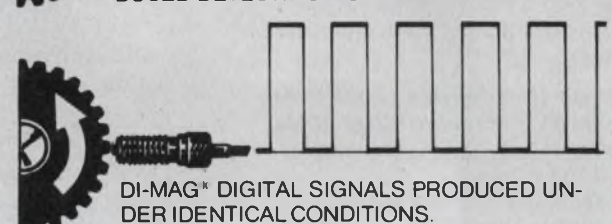
...SUPER SENSORS

THE SENSIBLE CHOICE...

- DIGITAL OUTPUT — Constant amplitude pulses independent of surface speed or air gap.
- COMPATIBILITY — Direct interface with TTL, DTL or HTL logic.
- NOISE IMMUNITY — High signal-to-noise ratio not achievable in analog sensors.



CONVENTIONAL ANALOG SIGNALS PRODUCED DETECTING ROTATIONAL MOTION.



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DI-MAGS® work particularly well in these computer peripheral functions and applications:

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- ☐ DISK AND TAPE DRIVE RPM MEASUREMENT
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- ☐ CONTROL SIGNAL FOR CLOSED-LOOP SERVO SYSTEMS.

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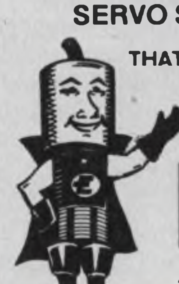

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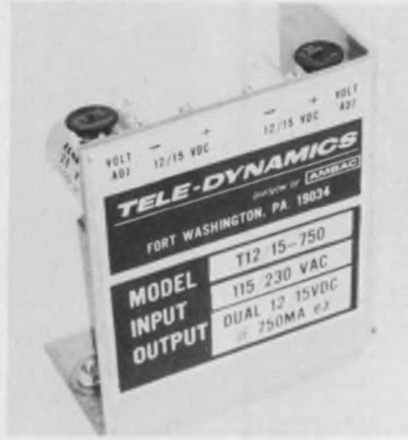
INFORMATION RETRIEVAL NUMBER 105

POWER SOURCES

Dual-output supply has adjustable output



Tele-Dynamics/Wanlass, 525 Virginia Dr., Fort Washington, Pa. 19034. (215) 643-6161. $51. (1 to 9); stock.

A dual output power supply has independently adjustable outputs from 11.7 to 15.3 V dc at 0.75 A. The T12/15 Series of supplies is designed specifically for powering op amps and logic circuits. Outputs may be paralleled for a 1.5 A output or be series connected for 23.4 to 30.6 V outputs. For powering op amps, outputs may also be connected for series tracking. The unit weighs only 2.5 lb. and operates from either 105 to 125 or 210 to 250 V, 47 to 63 Hz ac, while providing a line and load regulation of ±0.1%.

CIRCLE NO. 347

Dc/dc converters handle 125 to 48-V inputs

Wilmore Electronics, P.O. Box 2973, West Durham Station, Durham, N.C. 27705. (919) 489-3318. Start at $580 (10); stock to 30 days.

Available in 12 rack-mount models, Series 1240 dc-to-dc converters provide voltage conversion, source-to-load isolation and protection against input transients. Models are available for the two most commonly-encountered station battery inputs of 48 and 125 V dc. Nominal dc outputs are 24, 28, 36 and 48 V and standard power output levels are 300 and 600 W. Efficiencies range to greater than 85% for some models. All models are 5-1/2 × 19 × 14-in. and weigh from 36 to 43 lb.

CIRCLE NO. 348

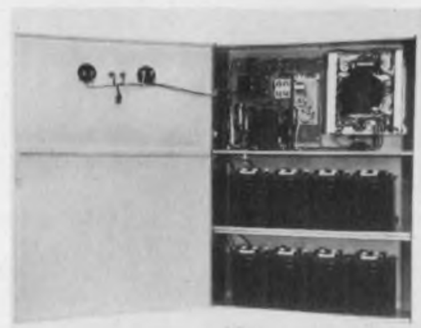
Dc voltage calibrator settles in 100 μs

Electronic Development Corp., 11 Hamlin St., Boston, Mass. 02127. (617) 268-9696. $1350.

Model 501 programmable dc voltage calibrator features a settling time of 100 μs max to within 0.01% of programmed value; accuracy within ±0.01% of programmed value; and stability of less than ±0.001% drift in 24 hours.

CIRCLE NO. 349

Emergency ac system handles load to 1500 VA



The Dual-Lite Co., Simm Lane, Newton, Conn. 06470. (203) 426-2585.

The Emergency AC System consists of a fully automatic, solid-state battery charger, sized XL lead or nickel-cadmium battery, dc to ac static inverter and transfer relay. The ac system is capable of powering a load from 250 VA to 1500 VA. Standard models provide 120 V, 60 Hz single phase output. The connected load is powered normally by the utility input and immediately switches over to the emergency system when normal power fails. Upon restoration of utility power, the connected load will automatically be reconnected to normal ac power. All ac system models are mounted in heavy sheet metal cabinets and are designed so that all equipment is easily accessible. Standard features of the units include a solid-state pulse type charger. The transfer circuit is unaffected by dust or dirt. Automatic dropout is also standard—a feature which disconnects the connected load from the battery after it has been discharged to a point where further use would endanger the battery itself. A pilot light indicates when the battery is being recharged.

CIRCLE NO. 350

Switching units offer efficiencies to 88%

Electro-Module, Inc., 2855 Metropolitan Pl., Pomona, Calif. 91767. (714) 593-3565. From $525; stock to 30 days.

DLR (direct line rectification) Series of modular dc switching power supplies operate at up to 88% efficiency. Five models are available in the new series: 4.2-6 V dc (100 A) 80% efficiency, 6-11 V dc (50 A) 82% efficiency, 10-17 V dc (30 A) 83% efficiency, 12-23 V dc (25 A) 85% efficiency, and 22-30 V dc (20 A) 88% efficiency. The units are packaged in aluminum cases. Key specs include output ripple and noise (max.) of 2% pk-pk, 0.5% rms; and transient response time of 0.5 ms.

CIRCLE NO. 351

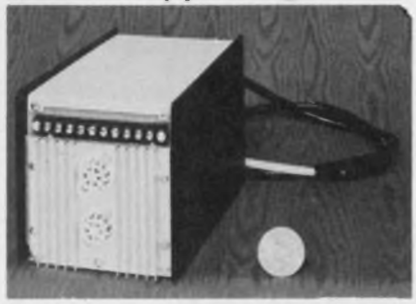
Modular high voltage supplies deliver 10 W

Datel Systems, Inc., 1020 Turnpike St., Canton, Mass. 02021. (617) 828-6395. From $175; stock.

The HV Series of high voltage power supplies is available with 10 W outputs up to 20 kV while operating from a 115/230 V ac line or a ±24 V dc source. The units are available with a choice of five different fixed voltage outputs; 10 kV at 1 mA, 12 kV at 830 μA, 15 kV at 670 μA, 18 kV at 560 μA and 20 kV at 500 μA. In addition, one of three different inputs can be selected; 100 to 125 V ac, 210 to 250 V ac or +21 to +27 V dc. Line and load regulation are typically better than 0.1% while the temperature coefficient is 0.02%/°C. Transient response is less than 2 ms, to within +5 V after a full load step change. Noise and ripple measured with a 500 pF load is 0.05% at full load. Other features offered by these HV supplies include: a voltage output monitor for connection to a meter, a means of programming the output voltage with an external resistor or, the output can be modulated with a current source such as an op amp. In addition, these supplies offer full output protection. The units are both short-circuit and overload protected by current limiting. Surge limiting provides protection for semiconductors from anode arc-over.

CIRCLE NO. 352

High-voltage modules boast 10 ppm regulation



Spellman High Voltage Electronics, 1930 Adee Ave., Bronx, N.Y. 10469. (212) 671-0300. From $450; 6 wk.

SRM line of modular, high-voltage supplies boasts 10 ppm line and load regulation, as well as 0.001% rms ripple. All models operate from 28-V-dc input and are continuously adjustable over the entire range from zero to maximum-rated output voltage. Programming terminals are provided for connection to remote potentiometric or voltage-input programming sources. Size is 5-1/16 × 5-1/2 × 9-1/2 inches.

CIRCLE NO. 353

Ac voltage regulator comes in 10 models

Advanced Power, 1621 Sinclair St., Anaheim, Calif. 92806. (714) 997-0320.

The AO series Controfluxer is an ac regulating filter. Rated identically for either leading or lagging load power factors these units are up-rated at all power factors below unity. Available in two input voltage ranges (117 and 234 V ac), the AO series units accept either 60 Hz or 50 Hz input power, with accessory kits available enabling full-rated output at 50 Hz. There are 10 models in the AO series, including single and dual output types. Average voltage regulation is better than ±1% for a ±10% line change at 80% of full load. Because the form factor is relatively constant, regulation of the rms output is ±2%. Load regulation is better than ±2% for a 0 to 100% load change at nominal input voltage. Input overvoltage protection maintains output down to 60 V ac, depending on load. Overload protection is provided by inherent current limiting.

CIRCLE NO. 354

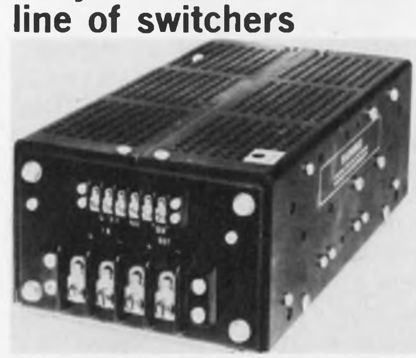
Dc converting supplies have 65% efficiency

RO Associates, 3705 Haven Ave., Menlo Park, Calif. 94025. (415) 322-5321. About $500; stock to 60 days.

The Series 400 high power, 20 kHz, high efficiency converters can use input power from 12 V dc to 115 V ac. Model 450 provides 5 V dc at 50 A for logic circuitry with 115 V ac input. The over-all efficiency of these units exceeds 65% and the units have heat sinking surfaces, self-restoring crowbar overvoltage protection, logic level inputs for turn on and turn off and rapid turn off by means of the crowbar function. Output specifications based on the 5 V output are: Load regulation of 0.2% from 0 to 50 A, ±0.1% for ±10% change in input voltage; ripple and noise at 50 mV pk-to-pk dc to 20 MHz; temperature stability of 0.02%/°C and storage times greater than 10 ms in the worst case situation. These units can be operated to full output power at case temperatures of 70 C. Dual output units with outputs of 12 to 15 V dc are available at up to 10 A each side. The Series 400 size is 5.01 × 5.01 × 16.85 in. and the weight is 14 lbs.

CIRCLE NO. 355

Sixty models form new line of switchers



Technipower, Inc., Benrus Center, Ridgefield, Conn., 06877. (203) 438-0333.

All models of the new CL switching power supplies are designed for 12, 24, 28, 48, 130 V dc and 115, 230-V-ac source applications. Efficiencies range to 75%, and ambient temperature ratings to 71 C. More than 60 basic and overvoltage protection models are available, with voltage outputs between 3 and 32 V dc and power levels up to 256 W.

CIRCLE NO. 356

COMPONENTS

Electrolytic capacitors wound automatically

The Plessey Co. Ltd., Plessey Precision, Alma Rd., Ponders End, Mddx., England. (01) 804-9511.

Single-sectioned electrolytic capacitor elements can be wound automatically at a rate of around 4000 per eight-hour shift. The type T2400 machine winds elements from reels of pre-tabbed anode and cathode foil and from up to four reels of separator paper. The completed winding is finished with a length of pressure-sensitive tape and is ready for impregnation and assembly. The machine is designed for continuous 24-hour operation. Up to four units can be controlled by one operator. Cutouts stop the drive if the foil breaks, fails to feed, runs out, or if a tab is missing or misplaced. And the machine stops if the compressed air supply fails.

CIRCLE NO. 362

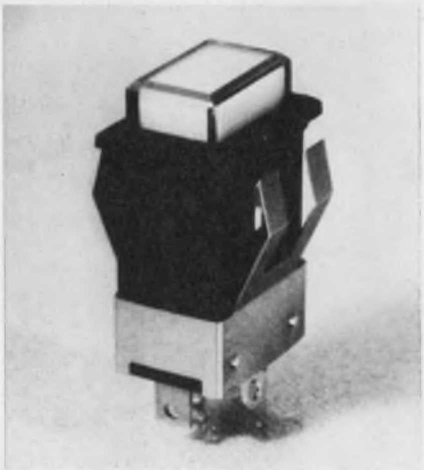
Moving coil, iron-free rotor starts in 17 ms

Hico Maxon Co., 716 Willow Rd., Menlo Park, Calif. 94025. (415) 328-1111.

A new larger, higher-torque, 26-mm (about 1-in.-D) motor, the Super 26, dwarfs Hico-Maxon's older 12-mm motor. The Super 26 is standard with a 3 × 13-mm shaft (about 1/8 × 1/2 in.), but it is also available with a 2-mm diameter shaft for interchangeability with other 26-mm motors. With a long and powerful Alnico-core magnet and an iron-free, moving-coil rotor on oilite sleeve bearings, the motor has a starting time of 17 ms and a very-high torque-to-size ratio (not given). Ball bearings of several grades are available and its 6-in. leads are securely attached. A double-ended-shaft version will be available soon.

CIRCLE NO. 363

Lighted pushbutton switch has many options



Oshino Electric Lamp Works, Ltd., 2-5-2, Minami-shinagawa, Shinagawa-ku Tokyo, Japan. $5 (1-10); 1-2 wks.

Series LPS-100 lighted pushbutton switches are available with either momentary or alternate-closure actuation and in SPST or DPST contact configurations. The switches need only 0.75 × 0.55 in. of panel space for mounting, and require a force of 8 oz. for operation. Lamps used are T-1-3/4 based. Contact resistance is 30 mΩ max and insulation resistance is 10 MΩ. Contact specifications are 115 V ac at 1 A and 30 V dc at 0.2 A, both for resistive loads. Switch life is a minimum of 100,000 operations over an operating temperature range of −10 to 70 C.

CIRCLE NO. 364

Reed relays are small and come in many styles

Kempston Electrical Co. Ltd., Shirley Rd., Rushden Northants, England.

The M30 series of reed relays has a package size just over an inch long. They have a typical operating time of 400 μs, including bounce. The nominal coil voltage ranges from 3 to 48 V. Higher sensitivity is offered by a second series, the M31. Efficient screening is incorporated in the construction of the M30 relays and the encapsulation and other design features give a high mechanical strength at the pin-outs. Mercury-wetted contacts are also available, and internal suppression diodes may be specified.

CIRCLE NO. 365

Internal flag, magnetic latching BITE indicator.

ACTUAL SIZE

The MI57D low power drain (1 watt - 25 milliseconds) fast response, high sensitivity indicator has met the test in both military and industrial applications.

The flag in the MI57D is magnetically held in position and will change color only when the reset coil is pulsed. Qualified to MIL-I-83287/02.

Further information and complete specifications on request.

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Division General Time Corp.
A TALLEY INDUSTRIES COMPANY
135 SOUTH MAIN STREET • THOMASTON, CONN. 06787
PHONE: 203/283-8261 • TWX: 710/475-1091

INFORMATION RETRIEVAL NUMBER 118

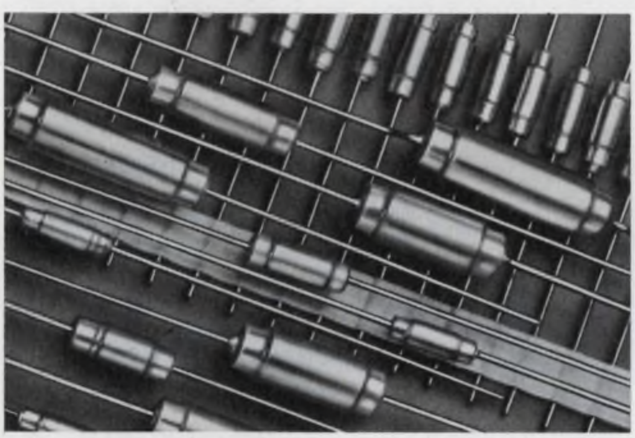
Unlike beer, tires, and Italian actresses, C&K's Flatted Toggle Switch is appealing because it's flat.

Engineering samples on request.

It's also competitively priced, made in America for rugged high-quality performance, and available in SPDT, DPDT, 3PDT and 4PDT models. A sleek,modern-looking visual design element that's as flat as Twiggy.

For more information, contact:
C&K COMPONENTS, INC.,
103 Morse St., Watertown, MA 02172
(617) 926-0800.

"See us at NEPCON Southwest"
INFORMATION RETRIEVAL NUMBER 120



Last year these Paktron® film capacitors were revolutionary. Now they are the standard.

Because our polyester and polypropylene Micromatic® capacitors are uniquely better. Both are self-encased and wound on their own leads—no outside wrapping, no separate lead attachments. Close capacitance tolerances too. Ideal for automatic PC board insertion. For free catalog, write:

PAKTRON, Division Illinois Tool Works Inc., 900 Follin Lane, S. E., Vienna, Virginia 22180. Phone (703) 281-2810. TWX 710-833-0682.

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innovators in film capacitors
The Innovative Electronic Group of ITW...
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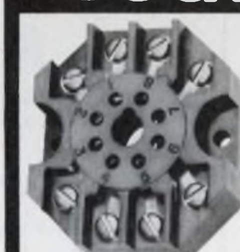
INFORMATION RETRIEVAL NUMBER 119

Custom Relay Sockets for every purpose



MODEL RB 08
Top Wired
Closed Back
Construction
10 AMPS.—
300 Volts

MR SERIES
Miniature
No retaining ring. Can be pre-wired before installing. Rated 5 AMPS. 4 PDT

MODEL QC 11
Top Wired
Closed Back
Construction
10 AMPS.—
300 Volts

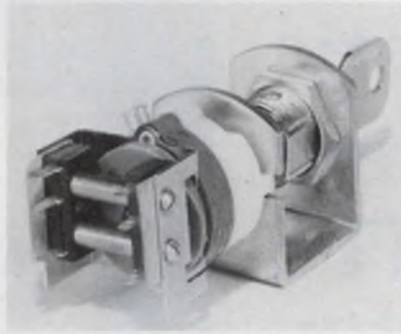
MODEL RB 11
Top Wired
Closed Back
Construction
10 AMPS.—300 Volts

CM SERIES
Miniature
Square base. Chassis mount. Solder or quick connect terminals. Rated 10 AMPS. 2 PDT and 3 PDT.

Custom Connector Corporation
1738 EAST 30TH ST. • CLEVELAND, OHIO 44114 (216) 241-8064

INFORMATION RETRIEVAL NUMBER 116

Rotary switch locks to control use



Stackpole Components Co., P.O. Box 14466, Raleigh, N.C. 27610. (919) 828-6201. $7.29 (1000 up); 4 wks.

Stackpole's new rotary-switch assembly centers around its 1-1/8-in. D enclosed rotary switch that has 30, 45, 60 or 90-degree index angles, 1-A switching and 15-A carrying capacity. A number of standard BCD codes are available. Mounted behind the rotary switch is a single-pole or double-pole, double-throw, 10-A precision snap-action line switch for cam-operated, power, ON-OFF switching. The front of the unit is a keylock, in a flat or tubular key style, for control of equipment use.

CIRCLE NO. 366

Solid-state relay handles 25 A at 250 V

Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, Calif. 90250. (213) 973-4545.

Model 611 solid-state relay is rated at 140/250 V ac, 25 A and is optically isolated. It is designed to allow IC logic (3 to 32 V dc) circuits to control such tough loads as motors, solenoids and lamps. Other features include high (200 V/μs) output transient immunity and synchronous, zero-voltage switching for quiet rf-free operation and freedom from arcing.

CIRCLE NO. 367

Tri-axial accelerometer claimed to be smallest

Columbia Research Laboratories Inc., MacDade Blvd. & Bullens Lane, Woodlyn, Pa. 19094. (215) 532-9464.

Miniature accelerometers, Models 612TX and 614TX, provide the simultaneous measurement of acceleration in three mutually perpendicular axes. The Model 614TX has its three low-noise cables located along one edge of the accelerometer block. Columbia Research says that these transducers are the world's smallest—50% lighter (less than 8 gr) and 70% smaller (0.082 in.^{3}) than the smallest devices of this type previously available. Sensitivity of both models for each axis is 5 mV/g peak; charge sensitivity is 1.5 C/g; frequency response is flat within ±5% from 1 Hz to 5 kHz; and and amplitude linearity is ±1%. The standard operating temperature range is from −100 to 350 F, with high temperature units available to 500 F.

CIRCLE NO. 368

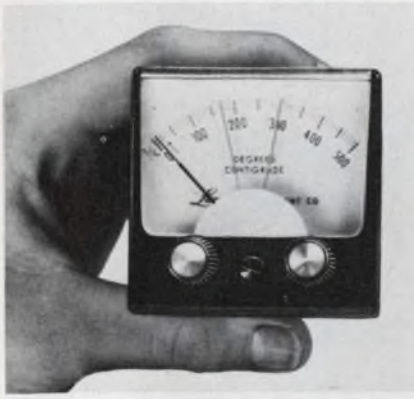
Miniature flasher fits DIP socket

Projects Unlimited, 3680 Wyse Rd., Dayton, Ohio 45414. (513) 890-1918.

A miniaturized, solid-state flasher, Model FL 200 DIP-Flash, in a four-pin configuration that fits a standard DIP socket, operates on any voltage from 5 to 15 V dc and handles loads to 200 mA with a current drain of less than 10 mA. It withstands temperatures from 0 to 70 C. Solid-state interruption eliminates mechanical contacts and rf noise. Typical life exceeds 6 million cycles. The nominal flash rate is 90/min.

CIRCLE NO. 369

Small meter controller is contactless



Larson Instruments Co., Greenbush Rd., Orangeburg, N.Y. 10962. (914) 359-3800. 2 wks.

Type CMC contactless meter controller, only 2-1/2-in. square and 3-in. deep, can be mounted in spaces too small for conventional units of comparable performance. The unit is completely self-contained with solid-state amplifier circuitry. Adjustable controls are accurate to within ±1/4% repeatability and the unit can control a 7.5-A, 115-V-ac load. A 24-to-32-V-dc model is also available for battery-powered equipment. The meter controllers can be supplied with scales ranging from 10 mA to 1000 A or 10 mV to 1000 V, dc or ac. Pyrometer controllers have scale ranges from −200 to 3000 F, or equivalent centigrade temperatures.

CIRCLE NO. 370

Infrared detector has element, FET and op amp

Plessey Optoelectronics, Wood Burcote Way, Towcester, Northants, England.

The PSC-222 broadband infrared detector uses a sensitive triglycine sulphate (TGS) element that operates at room temperature. The detector consists of the element, a low-noise FET preamplifier, and a standard operational amplifier output stage. Signal-to-noise ratio falls off as the square root of the frequency within the usable bandwidth. Spectral response has a lower limit of 2 μm (set by the detector material); upper limit is set by the window transmission (maximum about 40 μm).

CIRCLE NO. 371

Edge connector handles different size PC boards

The McMurdo Instrument Co. Ltd., Rodney Road, Portsmouth PO4 8SG, England.

The RL series of edge connectors has self-adjusting contacts that can accommodate plug-in PC boards of different thicknesses. They are optimally designed for 1.58-mm-thick boards, but adjustment of the contact spring length enables boards between 1.43-mm and 1.82-mm thick to be accommodated. The contact design also has low insertion force, typically 1.7 newtons per contact, for a 1.6-mm thick board. Contact resistance is less than 10 mΩ. RL connectors come in lengths to accommodate up to 40 contact positions with a 3.8-mm pitch, or up to 85 contact positions with a 2.5-mm pitch, in either one or two rows.

CIRCLE NO. 372

Connector interfaces PC and power circuits

Amerace Corp., 2330 Vauxhall Rd., Union, N.J. 07083. (201) 964-4400.

A new PC connector directly interfaces electrical and electronic circuits. Designated the Buchanan PCB block, the connector accepts the direct plug-in of 0.2-in., contact-spaced, PC boards that contain components or flat, flexible cable. And 12 through 30-AWG stranded wire can be attached to the same one-piece block. The block has 300-V insulation between circuits and each circuit can carry up to 5 A. Currently available blocks can handle 6, 12, 18, 24, 30 or 36 circuits.

CIRCLE NO. 373

Temp-sensitive paints available in kit form

Synthetic & Industrial Finishes Ltd., Imperial Works, Imperial Way, Watford, WD2 4JN, Herts., England.

A research and laboratory kit of Thermindex temperature-indicating paints can give an accurate picture of surface temperatures. The paints are temperature-sensitive compounds that undergo a sharp, definite change of color, when the temperature of a surface reaches or exceeds a predetermined value. Intricate surfaces or moving parts, which would otherwise require elaborate measuring equipment, can simply be coated with one or more of these paints. Isotherms can then be plotted from the resulting color changes. The kit contains a full range of paints in 1/2-oz. bottles, and a 4-oz. bottle of Solvent 'O'.

CIRCLE NO. 374

Dispenser places shot of material accurately

Kenics, One Southside Rd., Danvers, Mass. 01923. (617) 774-8600.

The Kenics 500 series dispenses all flowable and thixotropic materials in small shot sizes. Its positive, no-drip, shut-off device provides accurate placement of the fluid from a 5, 75, or 200 cm^3 polyethylene cartridge. All components wetted by the fluid are disposable to enhance the safe handling of reactive resin formulations.

CIRCLE NO. 375

application notes

Zener voltage regulators

The uses of high power zener voltage regulators are described in a two-page application note. The literature discusses how to use the devices with basic zener regulators, for simple voltage protection, in voltage transient suppression, in semiconductor voltage protection and for controlled inductor discharge. Each application is illustrated with a circuit diagram. International Rectifier, El Segundo, Calif.

CIRCLE NO. 376

Magnetic foil

The use of magnetic foil, for determining the amount of shielding required for new applications, is described in a two-page application note. James Millen Manufacturing, Malden, Mass.

CIRCLE NO. 377

Adhesives

"A Guide to Surface Preparation and Pretreatments for Adhesive Bonding" describes various techniques of surface preparations. This 45-page booklet is available for $1 to cover postage and handling. Hardman, Belleville, N.J. 07109.

INQUIRE DIRECT

Motor controls

The Troubleshooting Motor Control guide lists the major problems encountered in motor controls, explains the cause of these problems, and details the appropriate remedy to correct the problem. Arrow-Hart, Hartford, Conn.

CIRCLE NO. 378

Keyboard encoding system

The use of a single MOS IC as a complete keyboard interface system is detailed in a bulletin. The theory of operation, features and design are given. National Semiconductor, 2900 Semiconductor Dr., Santa Clara, Calif. 95051

INQUIRE DIRECT

Converters

Application notes describe a parallel-to-serial converter for dot matrix printer data input. A block diagram, truth table and logic circuits to fully illustrate the circuit are included. The text includes data on the operation of the 6-bit ASCII serial output, 20-character line input multiplexer and scanning counter. Amperex, Hicksville, N.Y.

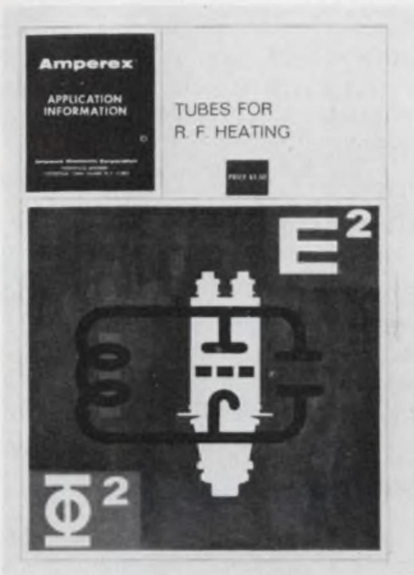
CIRCLE NO. 379

Multiple op amps

Features and applications of multiple micropower operational amplifiers are contained in a brochure. "Programmable Micropower Triple Op Amps" describes the device function, elements of programming and the effects of slew rate limiting. Specific applications circuits include instrumentation amplifiers, tone detectors, triple-amplifier active filters and a micropower double-ended limit detector. Siliconix, Santa Clara, Calif.

CIRCLE NO. 380

new literature



Rf heating generators

A 180-page application textbook entitled "Tubes for Rf Heating" gives data on the practical considerations in the design of induction and dielectric rf heating generators. Amperex Electronic Corp., Hicksville, N.Y.

CIRCLE NO. 381

Noise abatement

The environmental noise abatement brochure gives a summary of acoustical terms and community noise criteria. Also included in the 12-page brochure is a brief history and summary of current status of noise control efforts. B&K Instruments, Cleveland, Ohio.

CIRCLE NO. 382

Digital tape deck

Features, specifications and options of the Model 6400 OEM digital tape deck are given in a two-page illustrated brochure. Gould, Instrument Systems Div., Cleveland, Ohio.

CIRCLE NO. 383

Power supplies

Specifications, dimensions, photographs and ordering information for the PT series of rack-mounting power supplies are described in a bulletin. Models covered provide outputs from 1.5 to 50 V dc and to 60 A. Acopian, Easton, Pa.

CIRCLE NO. 384

Ac power failures

Two brochures deal with the problems of ac power failures encountered by users of computer-controlled process equipment. Lorain Products, Lorain, Ohio.

CIRCLE NO. 385

Stripswitch

PC board mounting stripswitch is described and illustrated in a four-page brochure, which contains specifications, photos and outline drawings. Electronic Engineering Company of California, Santa Ana, Calif.

CIRCLE NO. 386

Monitoring-recording system

Edition 61 of "News from Rohde & Schwarz" contains features on the radiomonitoring-recording system, a TV monitoring receiver for mobile and stationary use and a mobile 20-kW antenna system for extremely rapid deployment. Rohde & Schwarz, Munich, Germany.

CIRCLE NO. 387

Bonding systems

A 10-page illustrated brochure describes the "Jet-Melt" bonding systems that overcome disadvantages associated with conventional hot-melt systems. 3M, St. Paul, Minn.

CIRCLE NO. 388

Wire markers

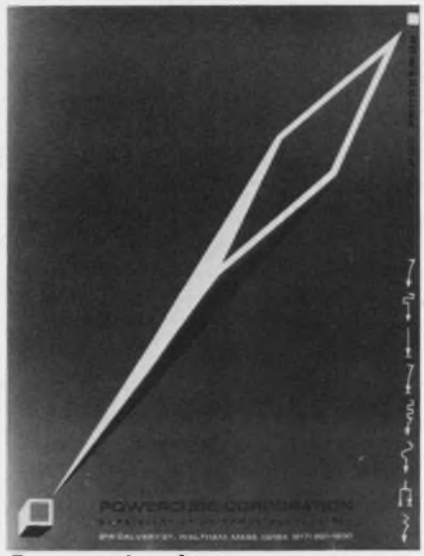
Wire, cable and safety markers are listed in sequential order, whenever possible, in an eight-page catalog. AMP Special Industries, Valley Forge, Pa.

CIRCLE NO. 389

PM motors

A 20-page bulletin describes computer-aided design techniques for optimizing size, cost and temperature rise tradeoffs in permanent magnet motors. Motor parameters evaluated include choice of magnetic material, magnetic-to-electrical loading ratio, efficiency, and angle of magnet arc. Indiana General, Valparaiso, Ind.

CIRCLE NO. 390



Power circuits

A 24-page catalog describes miniature power modules (preregulators, inverters, regulated and complementary converters, regulators and filters), complete power systems and hardware. Specs are given as well as "how-to-use" building block diagrams. Powercube, Waltham, Mass.

CIRCLE NO. 391

Ceramic disc capacitors

Ceramic disc capacitors, designed for coupling or uncoupling in a wide range of applications, are described in a bulletin. The bulletin contains dimensional information, test data, performance graphs and ordering specifications. Sakata International, Elk Grove Village, Ill.

CIRCLE NO. 392

Rotary switches

A 1-in. diameter rotary switch is described in a bulletin. The eight-page bulletin presents standard capabilities and options of the switch, designed to meet MIL-S-3786/SR-05, and contains photographs, illustrations and diagrams. OAK Industries, Crystal Lake, Ill.

CIRCLE NO. 393

Software packages

Four software packages for computer output microfilm (COM) systems are described in a six-page brochure. The software packages are DATACOM, CM/360 and CM/COBOL, COMTREVE and BANCOM. Pertec, Santa Ana, Calif.

CIRCLE NO. 394

Photoelectric products

Retroreflective photoelectric control devices are featured in a product sheet. Applications, specifications and mounting-dimension drawings are given. A pricing and ordering guide, with full options, completes the product sheet. Micro Switch, Freeport, Ill.

CIRCLE NO. 395

Automatic test equipment

A 40-page brochure describes applications of computer-controlled test systems and provides configurations of specific user-oriented test systems. Instrumentation Engineering, Franklin Lakes, N.J.

CIRCLE NO. 396

Hermetic transistors

A 32-page catalog describes hermetic transistors, including beam lead chips, NASA and military-type devices, and the company's SURE line of wireless bonded semiconductors. Raytheon Semiconductor, Mountain View, Calif.

CIRCLE NO. 397

High noise immunity logic

Literature that includes a 12-page condensed catalog and a 64-page applications and specifications catalog covers nearly 40 different HiNIL devices. A description and diagram for each HiNIL device, a summary of HiNIL characteristics and basic nomenclature data are included. Teledyne Semiconductor, Mountain View, Calif.

CIRCLE NO. 398

Air filters

E Z Kleen air filters that come in a variety of sizes and shapes for both air filtration and EMI/RFI attenuation are described in a four-page brochure. Research Products, Madison, Wis.

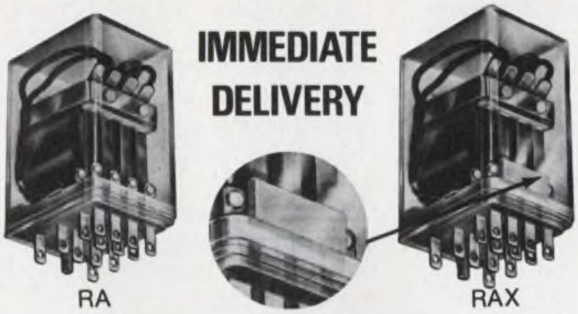
CIRCLE NO. 399

LSI/IC design system

A six-page full-color brochure describes the MIDAS MD-180 LSI/IC design system. Complete with photos and block diagrams, the brochure explains the system in general terms and highlights its main features. Details of the hardware and software are included. Macrodata, Woodland Hills, Calif.

CIRCLE NO. 400

VERSATILITY PLUS HIGH QUALITY



The new RAX relay is an adaptation of the popular RA Type and includes plastic barriers between the movable arms, thereby enabling opposite polarity voltages to be applied to the unit without fear of arc-over.

Its rugged, compact design makes this relay ideal for commercial use, communication equipment, computers, process control applications, etc. Both the RA and RAX are miniature compact relays with 4 PDT or double make-double break action, with dust cover and pierced Faston terminals for quick connect-disconnect or soldering, or PC terminals.

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INFORMATION RETRIEVAL NUMBER 138

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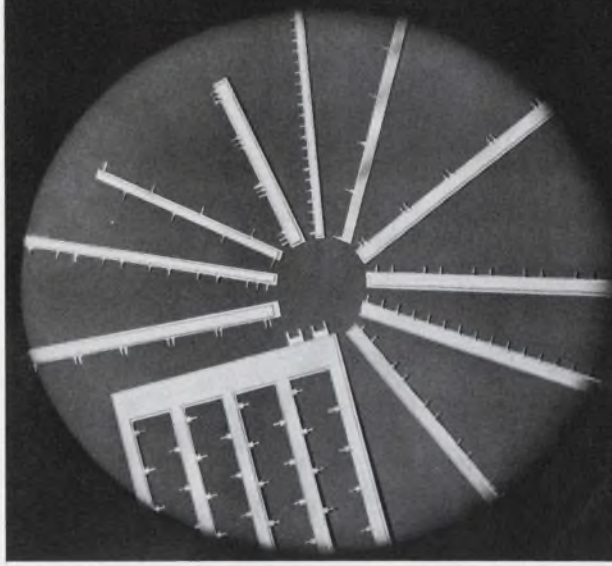

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INFORMATION RETRIEVAL NUMBER 139

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INFORMATION RETRIEVAL NUMBER 140

Immersible connectors

Aquacon electrical connectors are described in a 24-page catalog. The catalog layout permits ease of selection from hundreds of contact arrangements in either resilient or hard dielectrics (hermetic and nonhermetic) and solder or crimp contact terminations. The Bendix Corp., Sidney, N.Y.

CIRCLE NO. 451

Active filters

An article on filters for telephone message circuit noise measurement describes the history of the development of C-message and bandpass related notch filters. Specifications, based on Bell System Technical Reference 41009, are given. The article lists other filters for telephone circuit noise measurement—ERL, SRL, program weighting filters, etc. Kinetic Technology, Santa Clara, Calif.

CIRCLE NO. 452

Nickel-cadmium batteries

A 16-page manual covers the installation, operation and maintenance of pocket-plate nickel-cadmium storage batteries. NIFE, Copiague, N.Y.

CIRCLE NO. 453

Communications oscillator

Specifications for the Model 415A digital communications oscillator are given in a catalog. Bowmar Instrument Div., Acton, Mass.

CIRCLE NO. 454

Mass flowmeters

A six-page bulletin describes mass flowmeters. The bulletin offers details on standard specifications and options and provides costs for various model features (including nonlinear, linear, bidirection and integrating mass flows) for both single-range and dual-range flowmeters. Technology, Instruments and Controls Div., Dayton, Ohio.

CIRCLE NO. 455

Disc memories

The "Disc Memory Buyers' Guide" deals with modern disc design and covers the criteria for selecting the best storage device for small or medium-size computer applications. The first part of the 28-page guide deals with selecting the right medium, discusses the pros and cons of core memory, magnetic tape and disc-core units. The second part is devoted to fixed and moving-head disc drives. Engineered Data Peripherals, Santa Monica, Calif.

CIRCLE NO. 456

Potentiometers and dials

Turns counting dials and related 10-turn precision potentiometers are described in a 16-page short-form catalog. Specifications, dimensional line drawings and design features of both component lines are provided. Amphenol, Broadview, Ill.

CIRCLE NO. 457

Rectangular connectors

A 10-page catalog features Instamate DL rectangular connectors with cam-actuated contacts for mainframe computer and peripheral equipment applications. Drawings, photographs, charts, tooling plus plugs, receptacles and accessories are included. ITT Cannon Electric, Santa Ana, Calif.

CIRCLE NO. 458

Technical papers

A listing of technical papers that deals with quantitative thin-layer chromatography describes separation techniques with a spectrum of compounds and contains many unique, original insights. Drugs, steroids, amino acids, lipids and sugars are just a few of the topics covered. Schoeffel Instrument, Westwood, N.J.

CIRCLE NO. 459

Clad metals

A 22-page handbook for clad metals describes stripe-inlay and solder cladding. The handbook provides details on base metals, cladding metals and typical configurations. A section on metallurgy and technology is followed by design information and application photos. A glossary of terms is included. Technical Materials, Providence, R.I.

CIRCLE NO. 460

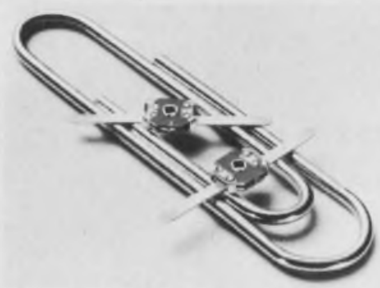
PC connectors

A 34-page printed circuit connector catalog provides data on two basic PC-board groups, the edge-on (card receptacle) and the plug-and-receptacle types. A table of recommended PC-board dimensions, specifications, drawings and applications is given, as well as some of the latest gas-tight high-pressure (GTH) connector applications. Burndy, Norwalk, Conn.

CIRCLE NO. 461

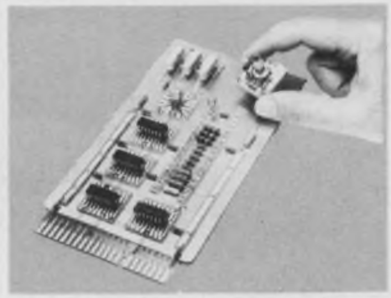
quick ads

New and current products
for the electronic designer
presented by their manufacturers.



Thin-Trim variable capacitors provide a reliable means of adjusting capacitance without abrasive trimming or interchange of fixed capacitors. Series 9401 has high Q's and a range of capacitance values from 0.2-0.6 pf to 3.0-12.0 pf and 250 WVDC working voltage. Johanson Manufacturing Corporation, Boonton, New Jersey (201) 334-2676.

INFORMATION RETRIEVAL NUMBER 181

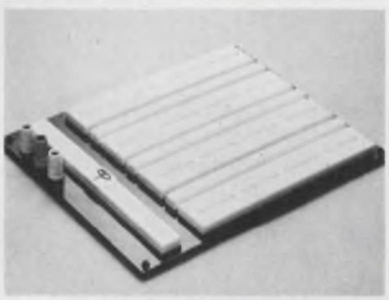


Free sample shows how you can assemble your prototype circuits in minutes even your card cage bread board. Mini-mounts, a series of etched patterns which adhere to your ground plane, mount all electronic components for prototype circuits from dc to GHz. Christiansen Radio, Inc., 1950 San Remo, Laguna Beach, Ca 92651. (714) 497-1506.

INFORMATION RETRIEVAL NUMBER 182

UDT-80X Opto-Meter offers low cost photometric/radiometric measuring capability from 10^{-10} watts or 10^{-4} footcandles for $865. The 80X has 3½ digit readout, silicon detector, radiometric (flat 450-950 nm) photometric filters, AC and battery operation. United Detector Technology, 1732 21st St Santa Monica Ca 90404 (213) 829-3357

INFORMATION RETRIEVAL NUMBER 183

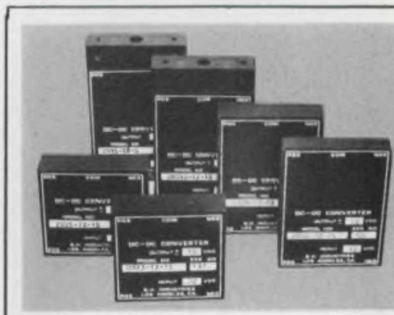


A P Breadboard II. Completely assembled; 2696 solderless plug-in tie points; no special patch cords required. Accept DIPs, TO-5's or discrete components with leads to .032". Has low impedance distribution with integral ground plane. Unparalleled high-speed circuit performance. A P Products Inc., Box 110, Painesville, Ohio 44077.

INFORMATION RETRIEVAL NUMBER 185

400 Ideas for Design, Vol. 2, Edited by Frank Egan. Ready to borrow, modify, or adapt, the top recent contributions to Electronic Design's popular "Ideas for Design" column range from amplifiers to switching circuits. 288 pp., illus., cloth, $11.95. Circle below for 15-day examination copies. Hayden Book Co., New York, N.Y. 10011.

INFORMATION RETRIEVAL NUMBER 186



Modular DC/DC Converters. 1.5 W to 30 W. Miniature easy to use P.C.B. mtg. Hundreds of standard variations are available. All have low-noise filtered inputs and outputs. Inputs are reverse voltage protected. Regulated units have current limited outputs. (1 to 9) qty from $37.25 B. H. INDUSTRIES, Los Angeles, Ca. (213) 479-8278.

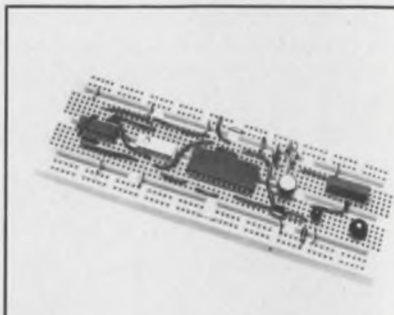
INFORMATION RETRIEVAL NUMBER 187

NOVA/DCC-116 General purpose interface board provides multiple device selection, 4 I/O registers, DMA zero word count detect, 105 socket positions for 14, 16, 24 and 40 PIN ICS. Basic board (all features of data general 4040 plus multiple device select) $350.00. MDB Systems, Inc., 981 N. Main, Orange, CA 92667. (714) 639-7238.

INFORMATION RETRIEVAL NUMBER 189

Free catalog of 34,500 power supplies from the worlds largest manufacturer of quality Power Supplies. New '73 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.

INFORMATION RETRIEVAL NUMBER 190



A P Super-Strip. Universal breadboarding with 840 solderless, plug-in tie points, incorporates eight distribution buses. Specifically designed for LSI packages and components with lead diameters up to .032". Accommodates up to eight 14 pin DIPs. No special patch cords required. A P Products Inc., Box 110, Painesville, Ohio 44077.

INFORMATION RETRIEVAL NUMBER 191

Advertisers wishing to reserve Quick Ad units should note the following mechanical requirements: Specs—Supply glossy photo of product and approximately 40 words which will set no more than 10 lines of 34 characters each. AFTER SUBMISSION NO COPY CHANGES CAN BE ACCEPTED. Quick Ads cost only $300 per insertion, less for frequency advertisers.

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Tape system for minis

Specifications and descriptions of a series of magnetic tape drive systems are included in a brochure. DIVA, Eatontown, N.J.

CIRCLE NO. 401

PC-board power relays

The Model V23027 miniature PC-board power relay, for 8-A continuous and 15-A switching loads, is described and illustrated in a two-page data sheet. Siemens, Iselin, N.J.

CIRCLE NO. 402

Wiring devices

A 200-page catalog includes the latest wiring products plus product improvements. The catalog's new format is designed to facilitate product selection. All products are grouped by rating and by the same configuration or basic function. The only exceptions are those products which do not lend themselves to a centralized listing. Arrow-Hart, Hartford, Conn.

CIRCLE NO. 403

Power supplies

A 14-page component power supply reference guide includes modular encapsulated ac-to-dc, dc-to-dc and high efficiency switching regulator designs. A glossary of definitions, testing diagrams and procedures used by manufacturers in production testing of power supply units, wiring information and mechanical outlines are included. Semiconductor Circuits, Haverhill, Mass.

CIRCLE NO. 404

Electronic Design

ELECTRONIC DESIGN's function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
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CIRCLE NO. 174

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SEMINARS ABOUT INTEL MICROPROCESSORS	PHILADELPHIA	WASHINGTON	NEW YORK	BOSTON
INTRODUCTORY WORKSHOP In this two-day program you'll be introduced to the Intel MCS-4, MCS-8 and 8080 with hands-on experience in writing, assembling and debugging of small programs (2 days, Monday & Tuesday, $325 or $300)*	May 13-14	June 3-4	July 8-9	August 19-20
PROGRAMMING LANGUAGES AND SOFTWARE For experienced users, or those who've attended the workshop, this seminar provides understanding of the programmers' tools. How to exploit the assemblers and simulators, the proper use of debugging software, and programming in PL/M will be covered (1 day, Wednesday, $150 or $125)	May 15	June 5	July 10	Aug. 21
INTRODUCTION TO MICROPROCESSORS For those too busy to attend the workshop, we offer this one-day condensed seminar at which the features of the MCS-4, MCS-8 and 8080 are all described. This seminar offers no hands-on experience (1 day, Wednesday, $150 or $125)	May 15	June 5	July 10	Aug. 21
DESIGNING WITH MICROPROCESSORS This seminar is aimed at the system designer who understands the overall features of the MCS-4, MCS-8 and 8080, but needs to know how to interface to TTL and CMOS, and how to make the best hardware/software trade-offs (2 days, Thursday & Friday, $225 or $200)	May 16-17	June 6-7	July 11-12	Aug. 22-23

SEMINARS ABOUT NATIONAL MICROPROCESSORS	WASHINGTON	NEW YORK	PHILADELPHIA	ATLANTA
APPLICATION OF NATIONAL'S MICROPROCESSORS This short-course is an intensive introduction to National Semiconductor's IMP-8, IMP-16 and GPC/P. Emphasis will be on how to use these products in systems, how to interface, and how to program them. Limited hands-on experience will be provided (3 days, Mon.-Wed. or Wed.-Fri., $350 or $325)	May 29-30-31	June 17-18-19	July 24-25-26	July 31 August 1-2

*The lower price always prevails if you attend another of our seminars in this series.

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CIRCLE NO. 175

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Important information about a semiconductor device or material can be determined by measuring the capacitance and conductance characteristics as a function of voltage and frequency. Measurement of flat band voltage, mobile ion concentration, doping profiles, carrier lifetime and surface state concentrations using lock-in amplifier (i.e. phase sensitive detection) techniques are described in a series of application notes. Equipment available for R&D as well as Production/QC applications.

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CIRCLE NO. 176

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