Cure potting problems with new materials. Epoxies still are used most. But silicones can take the heat, polyurethanes adhere well, polyesters lower costs and fillers improve heat conductivity. Some are opaque, others clear; some rubbery, others hard. And for weight reductions, foams fill the bill. Find a remedy on page 28.
We helped write the book!

Don’t spin your wheels when you shift to established reliability from standard military specifications. Dale has the QPLs and the finished goods stock to save you valuable time. We’re offering fast delivery on many established reliability part numbers for both wirewound and metal film resistors and wirewound trimmers. And we can deliver something else, too: Experience. Our work in the Minuteman program led to the formulation of the first specifications for established reliability resistors. Since then our materials improvement and failure rate documentation programs have become models in the industry. Today our AGS resistors have a proven failure rate of .000032% per 1,000 hours. That’s established reliability. Put it to work for you now. Call 402-564-3131 (wirewound styles) or 402-371-0080 (film styles) or dial 800-645-9200 for the name of your Dale representative.

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INFORMATION RETRIEVAL NUMBER 246
The quickness of the eye never deceives the hand

Keeping up with the display is no problem on this new 50 MHz oscilloscope.

Every control falls naturally and quickly to the hand because we designed it that way. Ya, Yb, delayed and main time bases are all clearly separated with the main controls on exactly the same level. So you find what you want, when you want it, without the eye leaving the screen.

Separating the two time bases also eliminates confusion and a possible source of error. As well as being easy to use the new PM 3240 is also light to carry - 8 kg light to be precise. So it's ideal for service applications, on computers and communications equipment, as well as for general laboratory use.

Neither does the eye get confused by difficult-to-see signals. The screen is a large 8 x 10 cm and 10 kV bright, enabling low duty cycles at high sweep speeds to be displayed clearly.

Get your hands on this new instrument and you'll appreciate the difference that Philips' ergonomics can make. And if you need a higher bandwidth, there's an equally ergonomic 120 MHz model available.

For more information contact: Philips Test & Measuring Instruments Inc., 400 Crossways Park Drive, Woodbury, New York 11797.

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And dollars too, when you’re designing point of sale terminals and other business machines. Teledyne’s Seren-DIP® relays are totally silent, reliable, long life components that can replace a surprising amount of expensive discrete circuits. Our 641 is a low profile TO-116 DIP; one small PC board holds all you need for control and switching a POS terminal or medium size business machine. But small size can mean big performance. The 641 is a small AC powerhouse: 1 AMP triac output with a 10 AMP surge rating; 140 or 280 volts, AC. It’ll easily drive lamps, solenoids, stepping motors, transformers, or any inductive load – without noise or misfire errors. The Teledyne 641 is U.L. recognized. We also make high level DC and Bi-polar Seren-DIPs. Seren-DIP solid-state DIP relays – they make design sense and their dependability and cost effectiveness may help you make POS sales, too. Ask your distributor or call our applications engineers. Call your nearest Teledyne Relays office for location of your local representative or distributor.

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100  International Technology

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Cover: Photo by Tom Bassett, courtesy of Dow Corning Corp., Midland, MI
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4040

4040 CPU
4201 CLOCK GENERATOR
4308 1kx8 ROM & I/O

- GOOD FOR TRAFFIC CONTROLLERS, DIAGNOSTIC INSTRUMENTS VENDING MACHINES, PROCESS CONTROLLERS, LARGE SYSTEM PREPROCESSORS, ETC.

STOP
GO

Cash in on the demand for economical intelligent products with Intel's inexpensive new 4040 CPU, 4201 integrated system clock, 4308 high density, low cost program memory and three new I/O components. Faster and more versatile than any other MOS 4-bit microprocessor unit, the 4040 can totally automate a smaller system or large portions of a big system. Yet an MCS-40 microcomputer system with CPU, clock, memory and I/O costs as little as $29.95.

Many equipment manufacturers are replacing hardwired logic and bulky electromechanical assemblies with MCS-40 systems. Most moderate speed control logic built with TTL can be replaced. The savings certificates show only a few 4040 applications. MCS-40 devices can be used with our 4004 central processor unit, too. The 4004, in production since June 1971, can lower system costs even more.

With either CPU, you'll save development time, lower component count and reduce assembly costs. You'll save even more as microcomputer costs decline while other system costs rise. And you'll gain valuable insurance against product obsolescence. Any design is easy to program and update with Intel's total development support, assemblers and Intellec 4/MOD 40 development systems. Our training centers will even teach you how to use Intel microcomputers.
microcomputer in
than $30.

In high volume for just $29.95, you can buy an MCS-40 system with the 4040 CPU, 4308 1Kx8 ROM with four independent I/O ports, and 4201 system clock generator. The 4040 itself has 60 instructions, 7-level subroutine nesting, 24 index registers, interrupt processing, memory and index register bank switching, single-step operation and a low power standby mode.

A few dollars more buys extra computation flexibility. Use our 4289 interface, for example, to attach standard memory or I/O devices. And, at only $99.95 in quantity of one, the system with the 4702 erasable PROM is ideal for prototypes and low volume production.

At these prices, you can even use several microcomputers in large systems. Knowledgeable designers are putting 4040 intelligence into new products at less cost than simple-minded electromechanical parts and single-minded logic cards. Write for details on the MCS-40 family and the industry's most extensive software support. Or call any Intel office for an appointment with our applications engineers.

Intel Corporation, 3065 Bowers Ave., Santa Clara, Calif. 95051 (408) 246-7501.
How to Design Your Power Supply for $72

You get the complete schematic diagram, and parts list with operating and installation instructions when you spend $72 for an Abbott Model “RN” power supply. Two years in development, this model represents the latest state of the art in power module design. It features close regulation (0.1%), low ripple (0.02%), automatic short circuit and complimentary overvoltage protection and continuous operation in a 160°F ambient.

Abbott Engineers followed specific design criteria in engineering these modules. First, the electrical design was carefully engineered to insure that all components operate well within their limits, under “worst case” operating conditions. Second, the thermal design, including case construction, was carefully made to insure that the maximum temperature limits of all components are never exceeded. Then the size and weight of these modules were controlled to a minimum, without sacrificing reliability. Finally these units were thoroughly tested to make certain that all design and performance specifications were met.

So, you can build your own power supply using our schematic diagram if you want to—but we think we can build it more reliably and for less cost, simply because we have been doing it for ten years. Put our power supply in your system first and try it. Examine its performance. We think you will be pleasantly surprised at the quality, adherence to specifications, and the reliability you find in the Abbott Model “RN”.

Any output voltage from 5 to 100 volts DC with current from 0.15 to 20 amperes is available. Many of the popular voltages are carried in stock for immediate delivery. Please call us for attractive O.E.M. discount prices.

Abbott also manufactures 3,000 other models of power supplies with output voltages from 5.0 to 740 volts DC and with output currents from 2 milliamperes to 20 amperes. They are all listed with prices in the new Abbott catalog with various inputs:

- 60 @ to DC
- 400 @ to DC
- 28 VDC to DC
- 28 VDC to 400 @
- 12-38 VDC to 60 @

Please see pages 307-317 Volume 1 of your 1974-75 EEM (ELECTRONIC ENGINEERS MASTER Catalog) or pages 853-860 Volume 3 of your 1974-75 GOLD BOOK for complete information on Abbott Modules.

Send for our new 60 page FREE catalog.
CMOS circuits are extremely easy to interface with switches—more so than the article “Interface CMOS Logic With Switches” shows (ED No. 17, Aug. 16, 1974, p. 80).

A completely bounce-free circuit is shown in my Fig. 1, in contrast with the author’s Fig. 1. Note that six circuits can be constructed from one dual-in-line package, with \( R = 0 \).

The author refers to his Fig. 2 as the fastest possible transition through the logic decision band. This is not so, since the signal \( S \) will have slower rise and fall times than \( S \). Fortunately CMOS is not too edge-sensitive.

The circuit the author uses in Fig. 4 is a bounce minimizer, not a bounce eliminator. A true bounce eliminator can be configured as in my Fig. 2. Three additional inverters would provide complimentary outputs.

**The author replies**

I would like to thank Mr. Spaniol for his comments, which uncover several points lacking in clarity. But I would remind him not to get carried away with the task of simplifying the interface. The latches of my Fig. 1 were presented as classic textbook latches used as debouncers; as Mr. Spaniol points out, they are not necessarily the simplest circuits. I would not, however, recommend general use of the circuit Mr. Spaniol shows with \( R = 0 \), since output transistors are shorted to the opposite supply voltage for one gate delay with each switch throw. Although at 10 V and room temperature the maximum delay \( t_{pu} + 1/2 \ t_{trans} \) is only 105 ns, I doubt that the manufacturer’s reliability figures apply to devices with this designed-in short. This is a good debouncer, though, if used as the Schmitt trigger of Fig. 3, with the input resistor around 390 \( \Omega \) to provide source impedance similar to that of another gate.

Mr. Spaniol’s second objection is perhaps one of misunderstanding. When the single-throw switch of my Fig. 2 is thrown, the two times of definite input signal polarity (continued on page 8)
Heated objections to oven design

I expected to find much useful information on oven and oven-control design in your article “Split a Temperature Degree to 10 μC” (ED No. 10, May 10, 1974, pp. 102-107). I, however, was most disappointed.

My specific criticisms are as follows:

1. Dr. Williams’ patronizing writing style is quite unsuited for a technical magazine.

2. The article states that sensors in the 1-kΩ range should be avoided in preference to higher resistance sensors, but only a Yellow Springs Instrument Co. (YSI) part number is given. In addition, the oven's operating temperature is never mentioned, so I couldn’t figure out the resistance at temperature—even if I did have a YSI catalog.

3. The hints on oven design (p. 107) are so vague that even Sherlock Holmes would have to work for hours to make any use of them. Cylindrical ovens are quite useful. It would be very helpful if one didn’t have to research thermo books to figure out how to wind heater windings. It's not entirely obvious that atmospheric-pressure changes will cause temperature change, even if PV does equal NRT.

4. Most important, the article leaves many things unsaid. Take the following examples:

- If you change dc gain of the controller to return the closed loop poles to the left-hand plane (“tuning” the controller) changes in the temperature control point occur. A better method would be to have an open-loop zero with a time constant longer than the thermal delay between the sensor and the heater (which should be wound right on top of the sensor).

- Also, the method of measurement of small temperature changes, which presumably was used to produce the photos on p. 104 and the 10-μ°C spec, is not explained.

Nor is the 10-μ°C spec fully explained. Is this value the random peak-to-peak deviation at a constant (controlled) ambient, the peak deviation due to a step-function change in the ambient, or the change in the average temperature caused by changes in the ambient (due to finite servo gain)?

This article only hints at the work (I assume) Dr. Williams did. Much of the work will have to be duplicated by those who wish to build a similar oven to suit their own needs. In all deference to my learned colleague at MIT, if I had written an article such as this while I was at Caltech, my professors would not have considered it suitable for ELECTRONIC DESIGN.

Craig W. McCluskey, 1st Lt., USAF
Sacramento ALC/MMEER
McClennan AFB, CA 95652

The author replies

I am sorry that Lt. McCluskey did not find my article worthwhile. Perhaps I can clear up some of the points he has raised.

1. The article was written in collaboration with an ELECTRONIC DESIGN editor. I assume that he applied the same standards of writing style to my article as any other he works on. Therefore if Lt. McCluskey finds this style odious, perhaps he should cancel his subscription to avoid future pain.

2. As was clearly stated on p. 105, “The sensor bridge uses a Kelvin-Varley divider in one of its arms to provide a linear resistance scale and to enable the bridge to match a wide range of temperatures and sensors.” Plainly, the controller was intended to accommodate a wide variety of sensors (hence temperature setpoints). The YSI part number was only one example of a usable sensor.

The hints on oven design were meant to alert the reader to the necessity for careful thought in this area. In a six-page article, I cannot possibly cover a subject as complex as ovens in a rigorous manner. In addition your comment on cylindrical ovens indicates an unwillingness to work. The winding scheme we employ for cylindrical ovens was originated by a first-team freshman on an aging PDP-7 computer in about two hours.

I agree wholeheartedly with the remarks about atmospheric-pressure changes. The effect is small (not really offensive above 30 μ°C) but decidedly there, especially when a quick storm front moves in. The only other possibility is that my strip-chart recorder is sensitive to pressure changes, but I couldn’t find any such reference in the manual.

In Lt. McCluskey’s fourth point, it is certainly clear that a feedback change will cause a change in temperature setpoint. Also, the change will be quite small (the feedback potentiometer looks into a 10Ω-Ω resistor)—so small that it will be completely swamped by even the best thermistor calibration curve (1%). The stability of the setpoint, however, will remain unaffected. Your solution is unwar- ranted, though it will work.

Next, the photographs had nothing to do with temperature measurement. They are, as stated, “... heater voltage oscillations ...” The 10-μ°C spec was vague. It was produced when the oven was monitored with a separate thermistor and a primary standard resistance bridge (Julie Research Labs PRB 2055). This spec refers to the total temperature shift within the oven for a 1°C ambient shift (settling times are long).

Lt. McCluskey’s last remark is the most interesting, if not re-
Versatile new spectrum analyzer

Take the work out of word generation

Not one, but five new systems

New HP interface bus links instruments

A new approach has been adopted as a major interface standard for HP products. It means you can conveniently interconnect a wide range of HP instruments, calculators, and other devices having stimulus, response, display, control or computational capabilities. Indeed, you can now assemble relatively low-cost systems with minimum engineering effort.

Called the Hewlett-Packard Interface Bus (HP-IB), it accommodates high and low-speed devices in the same system. You can interconnect as many as 15 devices—voltmeter, printer, signal source, calculator, digital clock, etc.—over a total distance of up to 20 meters. Devices are linked via a passive cable network having 16 signal lines. These signal lines carry all information (addresses, commands, program data and measurement...
New combinations of counters and calculators solve difficult measurement problems

Thanks to the new HP interface bus, you can couple the speed and computational power of an HP calculator with the measurement capability of HP electronic counters and state-of-the-art accessories. Several new application notes describe how these versatile low-cost combinations solve difficult measurement problems.

AN 174, a new series of 13 application notes, describes HP interface bus systems configured around the 5345A counter and a 9820A, 9821A or 9830A calculator. These systems are used to:
- Spec VCOs with respect to tuning step transient response and post-tuning drift,
- Characterize digital receiver performance as a function of S/N by measuring the statistical variation in receiver delay time,
- Match the delays through two lengths of cable to within a few picoseconds for antenna feed systems.

The 174 series covers a wide variety of applications from phase measurements to complete VCO linearity testing. We'll be glad to send you an index so that you can order specific notes of interest.

You can also combine the 5340A microwave counter with a calculator to measure the linearity of VCOs operating at frequencies up to 23 GHz. Application note 181-1 describes how this synergistic counter/calculator combination measures, computes and plots the transfer characteristic, differential, non-linearity, and integral nonlinearity of the VCO under test.

Application note 181-2 provides an example of a simple data acquisition system using HP low-cost counter modules, an interface, and a 9820A or 9821A calculator. A multimeter/counter measures frequency, ac volts, dc volts, or resistance and outputs these measurements to the calculator. The calculator computes the mean, standard deviation, and peak-to-peak deviation of the data and even plots a histogram.

For the two 181 application notes and 174 series index, check S on the HP Reply Card.

Two new timing instrument accessories

A timing generator and a digital clock are HP's newest ASCII-programmable instrument accessories. The two modules are compatible with the HP interface bus and, as such, can be linked to counters, digital voltmeters, and other HP instruments.

The 59308A timing generator provides precision time intervals from 1 μs to greater than a day. These time intervals are defined by start/end pulses and HP interface bus start/end “flags.” This flexible way of defining time intervals permits use in a wide variety of hardware and software applications. For example, the 59308A can be used to provide delayed gating pulses to counters or digital voltmeters to obtain frequency or voltage vs. time information. It can also be used to schedule subrouline execution in computer/calculator programs or to measure the time between events with μs resolution.

The 59309A digital clock displays calendar and time data (month, day, hour, minute, second) and can be used for time logging to printers and calculators.

For digital timing applications that require precise intervals from μs to days, use HP's new timing generator and digital clock.
Now, take the work out of word generation

High speed, high capacity, stability, bit pattern programmability, and competitive price put the new 8016A word generator at the top of its class. It's ideal for testing ICs, circuit boards, and data communication systems.

Freely-programmable bit patterns and high capacity produce a flexible output, both in content and format. Data output can be parallel (32 bytes each 8 bits wide) or serial (8 words each 32 bits long) at rates up to 50 megabits/second. The 8016A also has a strobe output (that can function as a ninth data channel or floating trigger), selectable ECL and TTL output levels, and six independent delay circuits.

Unlike the confusing front panels of complex word generators, the 8016A front panel is simple and easy to use. Data can be loaded in either parallel or serial form. As an option, you can also load bit patterns via a card reader, at the rate of 256 data bits in 2 seconds.

The 8016A is especially effective for determining worst-case conditions in IC testing.

For specifications and details, check L on the HP Reply Card.

Interface links instruments

(continued from page 1)

status data) at data rates up to 1 megabyte/sec.

Simple HP interface bus configurations do not require the use of a controller such as a calculator or computer (although HP-IB is compatible with both). In most cases, HP programmable calculators are the ideal controllers for customer-assembled systems whenever some degree of data manipulation is required. Our HP-IB calculator interface package provides everything necessary for interconnecting your HP 9820A, 9821A or 9830A calculator with 14 other HP-IB instruments and accessories.

Several popular measurement solutions are available in the form of complete, pre-assembled HP-IB systems. (See the 3050B data acquisition system in this issue.) They are fully integrated and documented from a hardware and software point of view, and HP takes full responsibility for overall performance of these pre-assembled systems.

Check Q on the HP Reply Card for details on the new HP interface bus and a list of currently available HP-IB products.

Two HP scopes for digital design, testing, and field service

If you work with digital systems, two HP oscilloscopes can make your job easier: the 1710B is a 200 MHz dual-channel scope for field servicing, while the 1720A is a 275 MHz dual-channel scope for digital logic design and testing.

Both have tight accuracy specs for those critical measurements—for example, calibrated sweep to 10 ns/cm (1 ns magnified times 10) and accurate to 3% over the full 10 cm of horizontal deflection. Differential time measurements are accurate to 1% for most applications. Both scopes offer delayed sweep, stable triggering, and selectable input impedance (50Ω or 1MΩ). And both scopes maintain specified performance from 0° to 55°C.

The 1710B with deflection factors to 5 mV/cm is ideal for servicing computers that use ECL 10K or TTL logic.

The precision 1720A has deflection factors to 10 mV/cm. It's used in the design, manufacture, and testing of fast logic systems—computers, peripherals, logic components, and communications equipment.

For the full scoop on these handy scopes, check C on the HP Reply Card.

Accuracy and environmental specifications make either the 1710B scope (shown here) or the 1720A model equally suitable for bench use or field service.
Now, simulate logic designs directly from your schematic

HP's new approach to logic circuit design provides a self-contained digital simulation technique that 1) improves the accuracy of complex designs, and 2) reduces the time engineers spend verifying logic behavior. The system uses an HP 9830A programmable calculator and newly available digital simulation software. Four programs handle:

- Combinational networks for all logic families,
- Synchronous one-clock networks for DTL/TTL/ECL families,
- Synchronous two-phase networks for MOS/LSI families,

- Timing analysis including propagation delays.

You can use the new digital simulation system to generate truth tables, analyze sequential logic circuits, generate state-time maps, document designs, analyze MOS/LSI circuits, and generate timing diagrams.

A basic system consists of the calculator with 4K memory, a string-variables read-only-memory, and a thermal printer.

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

Multiprogrammer provides flexible computer access

Attach HP's multiprogrammer to your computer and you can add up to 240 more I/O channels.

Now you can build your own control or data acquisition system—economically—with an HP 6940A multiprogrammer.

You need just one computer input/output channel to interface with the multiprogrammer. The 6940A itself holds up to 15 plug-in analog and digital I/O cards, mixed in any combination. Some plug-ins convert programmed output into signals to drive stepping motors, control transducers, close contacts, or to stimulate units under test. Other cards convert responses from process instruments into digital data for computer input.

If you need more than 15 input/output channels, simply add the 6941A extender mainframes. Each extender holds 15 plug-ins, and you can add up to 15 extenders—giving you a total of 240 channels controlled from one computer I/O slot.

For details, check J on the HP Reply Card.

New automatic spectrum analyzer delivers spectral, distortion and wave analysis

Now, you can perform spectral analysis, distortion analysis, and wave analysis quickly, automatically with the same system—the new 3045A automatic spectrum analyzer. Using the new HP interface bus, we combined the accuracy of a digital display in a spectrum analyzer with the high resolution of a synthesizer and the computational and control capability of a desktop calculator. The result: a fast, fully programmable, automatic system for production testing, quality control, and lab work.

- Frequency ranges from 10 Hz to 13 MHz. Amplitude is displayed in dB on a digital display—to 0.01 dB resolution. It's easy to use: HP provides all the software for general measurements and programming instructions for more specific measurements.
- The interface bus accommodates up to 15 devices, so you can easily add a plotter to graph relationships—for example, distortion vs. frequency or gain vs. frequency for audio amplifiers.

To learn more about automatic, low-cost analysis, check D on the HP Reply Card.
New digital pattern analyzer works with any scope

Troubleshooting a disc is a typical application for the new 1620A digital analyzer that scans parallel or serial bit patterns at rates up to 20 MHz.

The new 1620A digital pattern analyzer is a versatile trigger source compatible with any oscilloscope. The unit scans digital patterns up to 16 bits, serial or parallel, synchronous or asynchronous; and when it recognizes a preset pattern, it produces a trigger signal (2V, 25 ns). Essentially, the 1620A provides a dynamic window for checking your digital circuitry—using your existing oscilloscope, regardless of the manufacturer.

Use the front panel control to set the trigger word, i.e., the pattern that the analyzer will search for in the passing data stream. The trigger word can be simple (any pulse) or complex (a unique combination of ones and zeros).

Unlike a trigger that depends on a time delay, the pattern-recognition triggering technique eliminates accumulated timing error. If you want to examine the contents of a disc track or any long digital record step by step, the 1620A does have digital delay. You can move the measurement window up to 999,999 clock periods after pattern recognition.

Also to eliminate errors in asynchronous systems, a special filter ignores "glitches" of short duration that could cause spurious triggers.

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

New precision power splitter aids swept measurements

A remarkably versatile and useful device for swept-frequency measurement applications is the new HP 11667A power splitter. Its dc to 18 GHz frequency range makes it an ideal companion for the HP 8755 frequency response test set and the new HP 86290A/8620A broadband (2-18 GHz) solid-state sweep oscillator.

Tracking between output arms is within .25 dB over the full range. When the splitter is used to level a sweeper or to divide signals in ratio measurements, this close tracking has the equivalent effect of improving output source match and frequency response tracking. Thus, your measurements are more accurate.

Some important uses for the new power splitter are described in the data sheet. For your copy, check O on the HP Reply Card.

Add a tracking generator to HP's RF spectrum analyzer

The HP 8558B RF spectrum analyzer now has a companion tracking generator for making swept-frequency response measurements from 500 kHz to 1300 MHz. The HP 8444A option 058 tracking generator's output signal is always the same frequency as the spectrum analyzer, making it possible to achieve more than 90 dB dynamic range in swept transmission and reflection measurements. The generator provides 0 dBm calibrated output with ±0.5 dB full band flatness.

For precise frequency measurements, add a counter to the analyzer/generator combination, and you can selectively determine the frequency of any and all displayed signals.

For more information check M on the HP Reply Card.

Make wide dynamic range swept measurements with HP's 8558B spectrum analyzer and new tracking generator.
New low-cost system helps you gather data, make decisions and control instruments

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kHz

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100Ω

10 MΩ

With the appropriate transducer, you can also measure pressure, torque,

velocity, acceleration, and weight. The
calculator controls data logging and, at

the same time, performs other required
calculations, such as transducer linear-

ization or statistical analysis.

You can easily use the 3050B to mea-
sure multiple physical parameters and
to monitor devices. It’s also suited for
research work, as well as production
testing. Now, you can test 100% of your
pc boards or other electronic devices,
at a fraction of the cost of a computer-
ized system.

If you need to obtain or send data
elsewhere from your test site, HP offers
an optional common carrier interface,
and arrangements can be rented from
the phone company for remote trans-
mission.

For full details, check E on the HP
Reply Card.

New lab computer also handles data management

The new Scientific/310 data system
provides multiprogramming, real time,
and networking capabilities to give you
more than just data from your laboratory.

The S/310’s versatile multiprogram-
ming lets you develop programs con-
currently in FORTRAN, ALGOL, and
assembly language; and we provide
both an easy-to-use and efficient editor
(EDIT II) and a powerful file manager.

The real-time executive software lets
you sense and respond to time-critical
events right away. To its already reliable
system, HP has added fail-safe mech-
nisms that keep the S/310 operating
even if the primary power is removed for
as long as 2-1/2 cycles. And power fail/
auto restart is provided to save opera-
tional status.

A number of options are available.
User microprogrammability and batch
processing with spooling can help re-
duce operator time by speeding up slow
routines and spooling input and output
for processing.

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

The S/310 can be linked to an HP S/250 data
management system, HP 3000 computer sys-
tems, or an IBM/360 to share data and manage-
ment information.
Two new compact recorders for end users and OEMs

HP announces two new compact X-Y recorders (8.5 in. by 11 in. or 20.3 cm by 28 cm DIN A4)—the 7010A OEM model and the 7015A laboratory version. Both models have mechanical pen lift, electrostatic paper holddown, continuous duty dc servo motors, and a universal pen holder that accepts most commercial fiber pens.

Slewing speed is 20 in./sec. (50.8 cm/sec.). Peak acceleration is 500 in./sec. (1270 cm/sec.) on the X axis and 1000 in./sec. (2540 cm/sec.) on the Y axis. Common mode rejection is 130 dB dc and 90 dB ac.

The 7010A OEM version has 100 mV/div. sensitivity. The 7015A is a general-purpose recorder for schools and laboratories and, as such, has three ranges: either 0.01 V/in., 0.1 V/in., and 1 V/in. or 0.01 V/cm, 0.1 V/cm, and 1 V/cm. Several options are available for both models.

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

New polarity and overflow display expands LED family

The new 5082-7750 series displays provide a high contrast ratio and wide viewing angle.

HP introduces the 5082-7752 "±1" overflow LED display. It's ideal for instrumentation such as digital voltmeters and digital multimeters. Designed for use with HP's 5082-7750 series of .43 in. (11 mm) display, it's bright enough to be viewed up to 20 feet away.

These common anode devices are IC compatible and come in a standard 0.3 in. (0.8 cm) DIP lead configuration. Contact any franchised HP distributor for immediate delivery.

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

New calculator LED displays

Nine digits, matched for brightness, are mounted on a single PC board.

Now, you can buy calculator displays, 0.1 in. or 2.67 mm high, in eight or nine-digit clusters on a printed circuit board. The new 5082-7440 series red LED displays have right-hand decimal points, are MOS compatible, and require low power (only 250 μA average per segment). Mounted on 200 mil (5.08 mm) centers, they have a magnifying plastic lens for excellent readability. Use them in handheld calculators or any product that requires small, low-power, low-cost, long-life indicators.

For specifications, check F on the HP Reply Card.

New panel-mount microwave step-attenuators

OEM users of microwave turret attenuators now have an attractive alternative: a choice of four new step-attenuators covering dc to 4 GHz or dc to 18 GHz and available in either 70 dB or 110 dB models.

Typically, turret models must switch both center and outer conductors of the attenuating element so contact repeatability is a problem. The new HP 33320 series uses a new "edge-line" switching design with the attenuating pads connected in cascade. Only the center conductor is switched. Repeatability is within 0.02 dB even after 100,000 complete 11-step rotations.

Required panel space is less than 1 in. by 2 in. (2.5 cm by 5 cm). Bench models with type N or APC-7 connectors and a heavy base are also available.

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

HP's new step-attenuators provide high accuracy, inherent stability, and excellent repeatability at microwave frequencies.
Five new measurement/control systems have MOS memory

Now, HP introduces five new systems, all using our latest computer with semiconductor memory.

The new HP 9611A industrial measurement and control system features new analog and digital I/O capabilities: analog current input signal conditioning, event counter, programmable timer, stepping motor controller, stall alarm, and signal conditioning for 50 Vdc and 117 Vac digital inputs and outputs. It includes screw-type terminations and all other capabilities previously available with the HP 9610 system. All 9611A measurement/control capabilities can be remoted over serial cables up to 10,000 feet. (You avoid the installation problems, high costs and signal degradation associated with long runs of many multiple signal lines.)

A lower-cost system without screw terminations and signal conditioning, the new HP 9603A offers both the local and remote measurement/control capabilities of the HP 9611A. (Another low-cost system, the 9604A, is a single-task dedicated system without timesharing capability.)

A high-accuracy system, the new HP 9602A, provides an integrating A-to-D subsystem for maximum noise rejection. This system measures dc with optional digital I/O and ac, resistance, and frequency measurement capabilities.

The 9611A, 9603A, and 9602A offer a choice of 3 different real-time operating systems for time and event scheduling of multiple tasks—one of these in HP real-time BASIC. The other two are CPU memory-based and disc-based real-time executive systems. The disc-based system, built around the new RTE-II executive, provides two multi-user swapping partitions.

These new systems can be operated together as satellites in a distributed systems network coordinated by the new HP 9700A distributed systems central system. Thus, they can share workloads and benefit from the centralized program development, data storage, and file management facilities of the HP 9700A central system.

To learn more, check N on the HP Reply Card.
Bell Labs also makes versatile active filters

I was interested to read your survey "The Rise of Active Filters: They're Running Strong in Two Major Fields" (ED No. 13, June 21, 1974, pp. 34-44).

The list of commercial manufacturers was quite complete. However, you failed to report on active-filter progress at Bell and Western Electric, and implied (on p. 40) that we do not make active filters for use with our equipment. This failure denies the reader knowledge of the status of the work of perhaps the largest producer of active filters in the world.

Readers can obtain information on our STAR active-filter, building-block design if they write to us.

Another report on an active filter being produced in very large volume can be found in the Bell Labs Record, Vol. 51, No. 4, April 1973, entitled "Active Filters Make It Small in the D3 Channel Bank" by R. A. Friedenson.

Economical discrete and thin-film active filters have been produced in high volume by Western Electric for the past few years, and their usefulness and cost competitiveness are continuing to grow.

J. J. Friend, Supervisor
Circuits and Technology Group

Bell Laboratories
Holmdel, NJ 07733

Ed. Note: We're aware that Bell is doing work in active filters. The laboratory was, however, reluctant to disclose the full details of this work.

Correction

In a listing of packaged-oscillator manufacturers for a Focus article in the Sept. 13 issue, Precision Dynamics Corp. was inadvertently included. The company, which is at 3031 Thornton, Burbank, CA 91504, makes digital displays. For information on these products, circle No. 319 on the Information Retrieval Card.

A few numbers needed in gain-control circuits

The following errors appeared in my article "Get Gain Control of 80 to 100 dB" (ED No. 13, June 21, 1974, pp. 94-99):

1. Fig. 1—R is X OFFSET; 50 k.
2. Fig. 2—the value for R1 is 20 k.
3. Fig. 4—R is 9.53 k.
4. Figs. 5 and 6—pin 2 is the inverting input; pin 5 is the amplifier bias input.

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Forest Hill, MD 21050
decoding the codes
With ever-changing technology and increasing demands for innovative products, more precise safety guidelines are a must.

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If you want answers right now, phone:
(312) 887-1800, Transportation Division
(312) 681-8920, Electrical Division
(317) 966-6681, Electronic Division
Or write Belden Corporation, 2000 South Batavia Avenue, Geneva, Illinois 60134.
Watts New

Sorensen introduces the new, higher power density DCR-B series lab/system dc power supplies. Designed specifically as an extension of the popular single-phase DCR-A series. Minimum panel height is 3½". Power output is up to 2700 watts. Noise and ripple are 50% lower than in previous models.

Other DCR-B advantages: low cost-per-watt; fast response time; choice of 32 new versatile models to cover a broad range of applications; exceptional efficiency and dependability; and new, less expensive overvoltage protection option that can be installed at the factory or in the field. For complete data, contact the Marketing Manager at Sorensen Company, a unit of Raytheon Company, Manchester, N.H. 03103. (603) 668-4500.

**Representative Specifications – DCR-B**

<table>
<thead>
<tr>
<th>Panel Height</th>
<th>Cooling</th>
<th>Nominal Output Power (watts)</th>
<th>Price Range</th>
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<td>500</td>
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Sorensen POWER SUPPLIES
Bipolar IC microcomputer claims a number of ‘firsts’

Employing “bit manipulation, as opposed to number crunching,” a new microcomputer system is said to have an architecture that is unique for control and communications.

The system—the SMS MicroController by Scientific Micro Systems, Mountain View, CA—also has such “firsts” as these, according to James Geers, vice president of marketing:

- The most extensive use of high-speed, bipolar/LSI technology in a microcomputer to date.
- Execution of control sequences at speeds up to 100 times faster than available microcomputers.
- Direct processing of I/O variables at the same speed at which the internal registers operate—300 ns.
- A low cost of $370 in 100 quantities.

The SMS MicroController is a complete microcomputer, Geers says. It contains a microprocessor, an integrated I/O structure, ROM/PROM program storage and RAM data storage. The machine is designed to handle most minicomputer applications where extensive data processing is not required.

I/O efficiency is achieved Geers says, with an integrated structure, expandable from 32 to 224 individually addressable I/O connection points. As a result, control, status and data lines of user devices are instantly accessible by the MicroController program.

Another feature, Geers points out, is direct variable-field addressing, which gives access to any 1-to-8-bit I/O field of the array of 224 I/O points. Testing and branching on a 1-to-8-bit I/O field is performed in a single 300-ns instruction.

Transferring a single preselected data field from an I/O source to an I/O destination requires two instructions (600 ns). Any register or I/O field can be conditionally tested for a specific bit pattern in 900 ns, Geers says.

Design support for the SMS system is provided for both hardware and software. A MicroComputer simulator, a real-time, on-line replica of the SMS machine, is available with front-panel controls for program modification and control during debugging.

A MicroController machine compiler, a symbolic programming language, allows the user to program with an assembler-level instruction set. With the compiler, the manufacturing information for producing the firmware is generated.

CMOS parking meter eliminates dead time

A popular sport of the urban motorist—finding a parking meter with some time left on it—will become a thing of the past if an electronic parking meter comes into widespread use.

Developed by Applied Technology Systems, Inc., of Lewisburg, TN, the new meter uses programmable CMOS logic, throwaway or rechargeable batteries and an optional Hall Effect electromagnetic sensor.

The meter has several options. The most interesting, from the buyer’s point of view, is that the Hall Effect sensor, which can be included for only $5 or $10 can detect when a car leaves the space controlled by the meter. Once the car leaves, the sensor automatically resets the timer in the meter to zero.

This feature makes it possible to increase the revenue of the meter. Instead of being limited by a number of time periods in a day, the money taken in reflects the number of cars that use the space.

Readout options are also available. An analog readout of time can make the meter look exactly like present mechanical meters. Or a liquid-crystal digital display can be used. A third possibility that several municipalities are looking at is a go/no-go display that indicates time is left but not how much.

According to Dr R. B. Rubenstein, executive director of Applied Technology Systems, the new meter has many advantages over present mechanical devices. The mechanical meters, he notes, require removal and preventive maintenance twice a year. This work requires two hours per meter, he says, and if the maximum time period of the meter has to be changed, another two hours per meter are needed. Many of the mechanical meters must also be wound by hand once every two weeks.

The electronic meter is made from solid-state components; no preventive maintenance is required. If the maximum time period of the meter has to be changed, it can be done on location by the flipping of a switch.

The new meters are being marketed at costs comparable to those for mechanical units, Rubenstein says.

Army vehicles to get intelligent terminal

A rugged, powerful intelligent terminal will ride in the Army’s armored field vehicles before long. Called a Query Control Station, the terminal will be used for computation, data entry, message composition, validation, storage and display printout of digital and voice messages.

The terminal, to be developed by Singer Librascope, Glendale, CA, consists of a processor, plasma panel display with keyboard, 1200-lpm line printer and communica-tion interface.

A 1602, 16-bit microprogrammed minicomputer from Rolm Corp., Cupertino, CA, is the heart of the system. It has 64-k words of core memory. Four of these minis can be interconnected for multiprocessor applications in an expanded system.

The communications interface is
expandable to handle 64 channels of data and voice.

Henry Pinzeower, program manager at Singer, emphasizes: "This system is rugged, compact, lightweight and modular in construction. It is meant for use on the field of battle."

It will be part of the Army Tactical Data System. Development is supported by the U.S. Army Electronics Command at Fort Monmouth, NJ.

Delivery of the two systems under the current contract is due in 28 months.

Cooled alloy promises better magnetic circuits

Cooling a molten amorphous alloy to normal ambient temperatures at the fantastic rate of a million degrees a second produces a glass-like alloy that, under stress, is reported to have substantially better magnetic properties than today's best available soft magnetic materials. The superior properties of the magnetic amorphous alloy, termed Metglas 2806 by Allied Chemical Corp., Morristown, NJ, promises significant performance improvements in magnetic components and circuits.

Metglas 2806 is one of a family of low-cost amorphous alloys produced by an Allied Chemical process in which quenching from the liquid state occurs so rapidly that the random atomic structure of the liquid phase is retained in the solid at normal ambient temperatures.

The unique atomic structure gives these materials exceptional strength combined with good ductility, superior corrosion resistance, high hardness and low acoustic attenuation.

An independent investigation of the properties of Metglas 2806, was headed by Prof. C. D. Graham Jr. at the University of Pennsylvania. The researchers determined that when a 0.002-in-thick x 0.070-in.-wide ribbon of the alloy is stressed to 25 kg/mm², its magnetic properties are far better than those of one of the best soft magnetic materials, 80-20 Permalloy. The Metglas is better in the following ways:

- It has an almost perfect, square-loop hysteresis characteristic compared with the rather broad loop of the 80-20 Permalloy.
- The Allied Chemical alloy can be magnetized more easily to higher saturation levels. The Metglas reaches a saturated level of 8600 G with a small coercive field of 0.03 Oe compared with the 0.015 Oe required to saturate the Permalloy at about 8000 G.
- Upon the removal of the coercive field, the Metglas retains a substantially higher percentage of its magnetism—about 96% of its saturated value, or 8-k G, compared with 75% of the 80-20 material's saturated value of about 6-k G.
- The Metglas is substantially harder and stronger than Permalloy and similar magnetic materials.

Metglas 2806 has an electrical resistivity of about 180 μΩ-cm, which is three times greater than that of 80-20 Permalloy. As a result, the hysteresis losses of Metglas are substantially less. This means that Metglas can be used as transformer cores for high-frequency power devices such as inverters and converters. Permalloy and similar materials are not used now in these applications because of the excessive losses.

While the magnetic properties of the Metglas material are at their best when the material is stressed, the unstressed-material properties are still good. They are about equal to those of 8020 Permalloy, Allied Chemical reports.

CIRCLE NO. 318

Mini systems grab attention at Interkama

An IBM plant terminal—a ruggedized minicomputer that operates with a host computer in steel, chemical and other industrial plants—drew more than a passing glance at the recent Interkama '74 exhibition.

The exhibition, the largest trade fair in the world dedicated to instrumentation and automation, attracted 90,000 visitors to a new display center outside of Dusseldorf, West Germany. A total of 841 companies exhibited products for eight days.

The IBM prototype plant terminal—designated the 5937—has a gas-panel display rather than a CRT. It can accommodate 240 character lines or six 40-character lines.

The terminal was developed by IBM Stockholm and is to be sold first in Europe and then, in a year or so, in the U.S.

Among the other attractive exhibits was one by Siemens, the largest company in Europe, with 200,000 workers. It showed its 300 Series minicomputer, which according to Dr. Karl Heinz Kaske, program manager, should be competitive with Digital Equipment Corp.'s PDP series.

DEC displayed its PDP-11 at the show, with a VT'30 color mimic diagram display, which allows any part of the screen, or the whole screen to flash in color under software control.

Siemens also displayed a gas chromatograph for monitoring air pollution. It measures pollution particles per billion.

An American company, Hybrid Systems of Burlington, Mass., showed for the first time its Delta Verda system, a digital transmitter that features low cost and ease of multiplexing (see "The Low-Cost Way to Send Digital Data," ED No. 2, Jan. 18, 1974, p. 68).

Of the 841 exhibits at Interkama, 616 were by West German companies. And although the United States accounted for only 16, the American displays covered 8% of the floor space.

From the Communist bloc, East Germany sent three exhibitors, Yugoslavia one, Poland two, Czechoslovakia one and Hungary one.

A cross-section of visitor views at the show indicated the following:

- They were interested in low cost, but not at the expense of quality. They wanted reliability, ease of maintenance and flexibility.
- Software must be part of a hardware package. Buyers have learned that it's too expensive to fashion their own software. They want their programs flexible enough to use for future projects. And they want language compatibility.
- Users are systems-oriented. They don't want to put things together themselves.
- Low power requirements are important, which makes components such as CMOS attractive.
Dialight sees a need:

(Need: The widest choice for your every application.)

730 SERIES Your choice... a red or green LED readout with large 0.625" characters... low power, operates with standard IC power supply levels. Comes in plus-minus module. Display uses standard or high brightness LEDs for maximum light output arranged in a seven-segment format. Available with or without on-board decoder/driver. Unique lens design generates bright, highly legible characters.

739 SERIES Save design time and installation costs... this LED display assembly is attractively designed in a convenient package with bezel and is ready for instant panel mounting. Available in groups of one or more characters, with or without decoder/driver... characters are 0.625" and come with either green or red LEDs in seven-segment format. Readout offers lowest cost per character for comparable size.

745-0005 Dot matrix LED readout display produces a bright 0.300" high character or symbol display. Has wide angle visibility and is compatible with USASCII and EBCDIC codes. Low power requirements. Mounts into standard 14-pin DIP socket. The display is also available in bezel assemblies with or without code generator.

745-0007 LED hexadecimal display with on-board logic operates from 5 to 6 volt supply, low power consumption. Integral TTL MSI chip provides latch, decoder and drive functions. 0.270" character display has wide angle visibility and mounts into standard 14-pin DIP socket.

755 SERIES High brightness planar gas discharge displays in a 0.550" character. Orange color gives high contrast ratio and allows readability to 40 feet even in high ambient lighting. Designed for interfacing with MOS/LSI, displays have an expected life of 100,000 hours or more.

Dialight, the company with the widest choice in switches, LEDs, indicator lights and readouts, looks for needs... your needs... and then they develop solutions for your every application. No other company offers you one-stop shopping in all these product areas. And no other company has more experience in the visual display field. Dialight helps you do more with these products than any other company in the business, because we are specialists that have done more with them. Talk to the specialists at Dialight first. You won't have to talk to anyone else.

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That's our price for our new 3660J IC Instrumentation Amplifier. Now, if you are building your own, do you know what yours is really costing you? Take a few minutes to add up your costs. Just to match the performance of our new IAs, it would take a well matched pair of op amps, four matched and tracking precision resistors, and at least three more resistors to hook your unit into a circuit. After you design yours, you still have to purchase the parts. Calculate your design and purchasing time, plus all the paperwork. Now, add in your production and testing time, and a little bit for overhead. You might even have to rework your design. And chances are that you'll have to do some tweaking, too. By the time you get through, your costs could be two or three times as high as our price of $10.70 in 100's. Then, your parts will probably be spread out all over a PC board that you'll have to make fit somewhere in your system. That's a lot of trouble and money, especially if you need one amplifier per channel. And, what about your performance? Although our 3660J is the lightweight of the new 3660 series, just look at what it has to offer. It lets you adjust the gain from 1 to 1000V/V with a single resistor. At a gain of 1000, it has a guaranteed voltage drift of less than 10 µV/°C; a CMR of 96dB, and an input impedance of 20 Megohms. It also offers nonlinearity of 0.1%, a bias current drift of ≈2nA/°C, and of course, IC reliability. It's especially useful in applications where size, accuracy, reliability, and economy are your primary considerations. And, just in case you have an application that demands a lower bias current and a higher impedance, we also have the 3670 FET IC series. These amplifiers guarantee a bias current of ≈10pA, and an input impedance of 1010 Ω. The price tag is a little higher than the 3660, but not that much.

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"The end" had a fantastic beginning.

Never before has a laboratory tape recorder gained acceptance as rapidly as the Model Ninety-Six. It was recognized as the industry leader within a year after we introduced it as "the end"...

... The end of head wear worries. Superb, trouble-free performance in dozens of labs has proven how right we were, how reliable our patented solid ferrite heads really are.

... The end of spectral pollution. The Model Ninety-Six gives you super-clean data. A wideband servo produces absolute minimum TBE and virtually eliminates recorded flutter.

... The end of configuration problems. Users have told us omniband electronics make sense. Only six plug-in assemblies support any configuration.

Users have also told us about other great Model Ninety-Six features: selective track recording capability, 100% digital electronic shuttle, and non-contacting, optic-free end-of-tape sensing system. You can learn about these and other superior features when you talk to a man who’s used the Model Ninety-Six. Or call or write our expert, Ed Haines, (303) 771-4700. Honeywell Test Instruments Division, P.O. Box 5227, Denver, Colorado 80217.

INFORMATION RETRIEVAL NUMBER 11
For Demonstration, Number 196
With new developments in potting and embedding, the designer who goofs in packaging has only himself to blame. It's becoming hard to miss with progress like this:

- **High viscosity** in early epoxy resins made it tough to process the material. Today there are resins with almost any viscosity.
- **Costs** used to be high. Now fillers hold down the costs and improve the product as well.
- **Materials** once were toxic and smelly. Newer compounds have largely overcome these health problems.
- **Flame resistance** formerly was poor. New materials can meet the most stringent safety standards.
- **Large castings** used to be hard to make, because of the speed and magnitude of exothermic (self-heating) reactions. Today there are many resin systems specifically designed for large-volume parts.

This is not to say that the engineer can't go wrong. He can if he doesn't know his materials. Without such knowledge, materials designed to protect can cause more damage than the environmental hazards they are intended to protect against, according to Harold M. Lester, vice president and research director of Sigma Plastics of Dearborn, MI. He believes that specialized potting compounds should be selected for each application.

"The trend is away from one kind of slop that can do all jobs," he notes. "The all-purpose compound is like aspirin. It can't cure serious problems."

For example, when hard epoxies are used to protect thick-film resistors, the expansion and contraction during temperature cycling can cause the resistor to delaminate from the substrate. It is essential to match the thermal coefficients of the protective material and the circuit assembly. Another solution is to cover the substrate with a resilient conformal coating, or encapsulant—such as silicone or urethane—and then embed the circuit in rigid material.

A very similar problem occurs when metal containers are used for potting. The relatively high thermal coefficient of expansion of the metal, unless matched by the potting compound, results in the separation of the embedding material from the walls of the container and thus poor thermal contact and overheating. In addition cracks can appear around leads and sharp corners and allow seepage of moisture, with subsequent circuit failures.

In potting, a rigid shell forms the outer surface of the final product, and the embedding material should fill the entire space not occupied by the electronic assembly within the shell. But in casting, a mold, which is removed after the embedding material hardens, gives the proper dimensions to the finished product. Thus casting eliminates the problem of the embedding separating from the shell; there is no shell.

In both methods, the potting or casting material is poured slowly into the shell or mold. The process may be done in a vacuum to avoid air entrapment. The assembly is
then cured, either at room temperature by its own exothermic heat or in an oven.

Another problem—one that may arise with potting in a metal shell but not with a cast assembly—is electrical shorts to the case. A sheet of insulating material between the assembly and the shell is often needed, especially at high voltages.

Emerson & Cuming of Sharon, MA, has more than 50 epoxy resins for casting in its Stycast series. Stycast 2850, for example, features high thermal conductivity; Stycast 1090, light weight, Stycast 2651, low cost, and Stycast 1467, fire retardant properties.

The ubiquitous epoxy

Epoxies owe their success to their extensive range of properties. Among the more important ones are these:

- Wide range of viscosities. The viscosity of epoxies ranges from an extreme low of about 100 centipoises to the more common 1000 to 5000 cp and paste-thick 40,000 cp. (Water is about 1 cp at room temperature.) Low viscosity is very important to ease the penetration of small openings and to avoid air cavities. Low-viscous material is also easier to mix and pour. And even very viscous thixotropic epoxies, which don't flow unless stirred, are made for dip-coating components and assemblies.

- Ease of curing. Temperatures for curing can be tailored from about 50 to 150°C, depending on the curing agent. And epoxies cure quickly.

- Good electrical properties. Volume resistivities range from $10^{12}$ to over $10^{15}$ Ω-cm. Dielectric constants less than 4 are readily obtained and dielectric strength is about 250 to 400 V/mil.

- Excellent mechanical properties. Low shrinkage. Good adhesive and mechanical strength.

Diectrics can be obtained. One is its recent Lab 0953 formula, which has a low dielectric constant of 2.18 at 1 to 10 MHz; Teflon has 2.10.

(Note: Most tabulations of dielectric constant list measurements at 1 kHz. Dielectric constant changes with frequency and should be measured at the frequency desired.)

In addition to low dielectric constant, the 0953 formula bonds better than Teflon, which is often used in microwave devices, and it can flow around corners or into cavities where a Teflon insert cannot be placed, according to Lester of Sigma Plastronics. The formula's coefficient of thermal expansion is also much lower than that of Teflon's.

These properties, Lester says, make the epoxy excellent for radar and other microwave devices.

Another Sigma Plastronics epoxy has quite different characteristics: The Barrier Grades I, II and III are extremely "hydrophobic," according to the manufacturer. The material resists the passage of water vapor or liquid. When properly cured, these epoxy resins are said to exhibit extraordinary adhesion to aluminum.

Diluents reduce viscosity

In general, the viscosity of liquid resins must be reduced to facilitate handling. Usually heat is used. But when the material must be dispensed at room temperature, diluents are added—like styrene oxide, xylene and allyl glycidyl ether. Heat is preferred, because the diluents can permanently impair the resin's electrical properties, whereas heat has only a temporary effect.

But a very recent development by Dow Chemical, Freeport, TX—an experimental epoxy resin, XD-7818—has low viscosity at room temperature and contains no diluents. The viscosity at 25°C is 3500 cp. Its low viscosity allows excellent bubble release and high filler loading, according to Robert M. Bercaw, the company's technical development manager.

Fillers help

Low viscosity and high thermal conductivity generally don't go to-
Fillers such as sand can lower costs and improve the thermal and other properties of potting compounds. An automotive electronic ignition system, shown before and after embedment in Hysol’s ES0269 sand-casting resin, is a high-volume application. Special dispensing methods limit equipment wear.

gather in most potting compounds. However, a filler-like silica, or sand, can increase thermal conductivity two to 12 times in a low-viscosity resin.

And fillers can have other favorable features. They generally reduce the exotherm of a resin during curing and shrinkage after cure.

The Hysol Div. of Dexter Corp., situated in Industry, CA, has developed a low-cost, sand-filler potting system, ES0269, which is being used to embed automotive electronic ignition systems. The cost is low, because only one part of ES0269 is used to five parts of sand. Thus the potting system figures out only to 20 to 30¢ a pound.

The filler is not in the resin when poured, but mixes directly in the system. Thus the usual abrasive wear in the dispensing equipment is minimized.

Some epoxies have bounce

Flexibilizers lessen the basic hardness of epoxies. They reduce internal strains during curing, and this makes possible castings of large volume and complexity. Also, they improve adherence, peel strength, low-temperature performance and crack resistance during temperature cycling.

But offsetting these mechanical advantages, flexibilized epoxies lose some of their desired electrical properties. As the rubber-like qualities increase, dielectric loss factor and dielectric constant increase, and resistivity decreases. Moreover the material loses some strength and softens at elevated temperatures.

Thus manufacturers recommend that designers use the most rigid, cured resin that will provide the needed mechanical properties. Flexible epoxies are especially deficient in high-frequency, high-temperature applications.

Examples of flexible epoxy compounds include two recently developed by the 3M Co., St. Paul, MN: Nos. 280 and 281 liquid-epoxy resins. These compounds cure relatively fast and feature a semi-flexible, shock-resistant consistency. The flexibility is said to remain even with long-term, high-temperature aging.

And the Novalac epoxy formulation, Isochemerez 448—made by Isochem, Lincoln, RI—can be cured into a rigid, semi-flexible or flexible form with the proper curing agent.

There are many flexibilizer agents and flexibilized epoxies on the market. But designers are advised to ask suppliers for the latest, since the field is very active and new compounds continually become available.

Other resins important, too

Though epoxies probably fill 85% of the embedment market, silicones, polyurethanes, polyesters, some thermostetting hydrocarbons and even acrylics also find a place. In addition the foams of all the resins are used when weight reduction is important.

Though the silicones are technically not organic, they are loosely classed as resins because their properties are similar to those of organic compounds. Silicone embedment materials fall into three categories:

1. RTV (room-temperature vulcanized) silicone flexible resins. With excellent thermal-shock resistance and low internal curing stresses, they come colored or clear, and they have excellent stability in a vacuum. Thus they can be used in deep-space applications.

2. Silicone gels. Very tough, they withstand considerable breaking forces and heal themselves when punctured for testing.

3. Rigid solventless silicones. Though little used because of poor crack and thermal-shock resistance and the need for elevated temperatures for curing, they do find applications because of other desirable silicone properties.

The strong points of silicones include these:

- Wide temperature stability from about −65 to 300 °C, with only moderate variations in properties.

- Excellent electrical properties, with low loss factors.

- Ease of handling.

Silicones come in a wide range of viscosities, and most varieties can be cured at or near room tem-
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MONO-KAP™ radial-led epoxy coated capacitors are reliable performers; they're rugged enough to work in MIL environments. 4.7pF to 10Mfd., 50 to 200 WVDC in a variety of dielectrics and case sizes. Immediate delivery from stock; large volume production orders in eight weeks . . . and price competitive.

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Remember, USCC/Centralab.
temperatures with little if any exothermic action.

The new 3102 RTV silicone rubber from Dow Corning, Midland, MI, illustrates many of the advantages of silicones. It is rated to be thermally stable from 54 to 250°C, and it has a viscosity of 8000 cp, as supplied. The material bonds to metals, glass, other silicones and organic resin laminates or moldings, and to vulcanized silicone rubber. And it cures in deep sections.

And Dow Corning's Sylgard line covers a wide range of different properties. One variety is a clear resilient material that can be cut with a knife for fast access to repair circuits. Voids can then be refilled with fresh resin that cures at room temperature.

General Electric, Waterford, NY, also offers a silicone-rubber potting compound, designated RTV-627. GE believes that silicones are replacing epoxies and other conventional compounds—many of which, it says, are becoming scarce because of material shortages. RTV-627 can be cured in minutes at 150 to 350°F. At room temperature, the potting compound sets in less than 24 hours. The color of the cured compound is black.

Polyurethanes

Moca is DuPont's trade name for 4,4'-Methylene(bis) 2-chloroaniline, a compound used until recently in polyurethane resins. Now the compound is restricted by Federal regulations because of toxicity.

But non-Moca polyurethanes, or urethanes, are available. Examples include Emerson & Cuming's Stacycast CPC-18 and the RF-1730 compounds made by the Resin Formulators Co.'s Evra Div., Culver City, CA.

RF-1730 is derived from castorbean oil and thus not dependent on petroleum supplies. The hard, semi-flexible material costs substantially less than silicone resins and about 10% less than epoxies, according to the manufacturer. Also, because of its extremely low exothermic properties, it can be cast in large volumes.

Echo gel is another polyurethane. Made by Communications Technology Corp., Los Angeles, it's low in toxicity, free flowing, nonexpanding and sets in about 15 minutes. Mixing and handling is simplified by premeasured packaging in sealed plastic bags. After a separator between two parts of the package is removed and the mixture kneaded until uniformly mixed, the material is ready to pour.

But Dail de Villenueve, development manager of Communications Technology, warns that misapplications of some two-part compounds can result in a real mess. Frequently unknown to the novice is the fact that some compounds set up properly only in large volumes. An attempt to coat a PC board with such a compound can decrease the exotherm to the point where the compound may not cure.

Some epoxies come in powder form, such as this one-part Eccofoam EFF-14 from Emerson & Cuming. The material is vibrated into place and cures to a fine-structured foam with a density of about 15 lb/ft³.
Some people stop half way. Sum people get it all together, like TRW/Cinch Connectors does with its new integrated circuit logic boards.

Working from the logic of a national distribution network to assure fast, off-the-shelf delivery on popular board configurations, Cinch assembled the features and flexibility that facilitate prototyping and short production runs:

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3. A full line of accessories—adapter plugs—input/output plugs, board interconnectors, and edge connectors.

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For additional information see listings in EEM Vol. 4 or contact your TRW/Cinch logic board distributor or TRW/Cinch Connectors, An Electronic Components Division of TRW Inc., 1501 Morse Ave., Elk Grove Village, Illinois 60007; (312) 439-8800. cc-7311

*T.M. Gardner-Denver
because of the large surface. Like silicones, polyurethanes can cure at or near room temperature. However, the silicones are far superior in withstanding high temperatures. Polyurethanes are generally limited to operating below 150 °C, as compared with the common silicone rating of 250 °C. And polyurethane reacts with moisture, so components must be carefully dried before embedment to prevent the formation of bubbles. On the other hand, polyurethanes adhere better and to more materials than silicone resins do.

Polyesters are economical

Polyester cost is low compared with that of most other embedding materials, and polyester handles easily. But it has higher shrinkage and poorer adhesive qualities than the epoxies. Also, its resistance to extreme environments is not as good.

Other materials also find limited uses in potting. They include thermosetting hydrocarbons—like Buton, made by Enjay Chemical Co., NY—thermosetting acrylics and polysulfides.

And most liquid resins can be made into foams to cut package weight. The polyurethane foams are the most popular, though epoxy and silicone foams are also used.

The price paid for light weight is lower mechanical strength and lower thermal conductivity, but dielectric strength and electrical losses usually improve.

Though fillers have a dramatic effect upon a compound's thermal properties, there are other benefits. Fillers can:

- Reduce exothermic heat during curing.
- Reduce weight loss with heat aging.
- Reduce shrinkage and expansion.
- Improve fire resistance.
- Extend pot life.
- Cut costs.

Certain electrical properties can be improved with fillers, but the designer is advised to watch out for degradations, too. Dielectric strength, for example, is usually adversely affected, especially if the filler has absorbed moisture or another contaminant. The dissipation factor and dielectric constant can be varied, up or down, by a change in the filler.

Fillers are often classified as reinforcing, or fibrous, and bulk, or nonreinforcing. Some bulk fillers are sand, talc, clay and calcium carbonate. Typical reinforcing fillers are mica, asbestos and chopped glass.

Filler materials are generally cheaper than unadulterated embedment materials of the same volume. Hardness is usually increased and machinability reduced by bulk fillers, especially with abrasive materials like sand. Impact and tensile strengths are increased by reinforcing fillers, but bulk fillers tend to decrease these strengths.

**Stripping an embedment**

When a company has made an investment in a successful new electronic device and wishes to protect the device's secrecy, the unit often is sold in potted form. However, a competitor's curious engineer has a counterweapon—the stripper.

Sigma Plastronics says that there are few epoxies that can resist its XMIS-408-100 epoxy stripper. "A competing powerful stripper," according to a Sigma spokesman, "took four hours at 125 °C to strip Emerson & Cuming's ARC-138-S epoxy-molding compound. But the -100 stripper did the same job in six minutes at room temperature."

And to escalate the intrigue, Sigma Plastronics has developed a "nonstrippable" resin, its "No. 1 Secrecy Resin," an unusually high-density cross-linked epoxy.

"In addition," the Sigma spokesman says, "the resin can be filled with small sheets of lead to foil X-ray snoopers."

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**For more information**

For a list of manufacturers of potting compounds, refer to the following sections in the Product Directory of ELECTRONIC DESIGN's Gold Book:

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**Complete resistor choice.** Understand, TRW isn't locked in to wirewounds. If we think your design will fly better with, say, precision film, we'll suggest it. In fact, TRW offers a total resistor capability—carbon comp., thin-film, Metal Glaze™, wirewound, networks.

For specs and application data on wirewounds, contact your local TRW sales representative. Or write TRW/IRC Resistors, an Electronic Components Division of TRW, Inc., 401 N. Broad St., Philadelphia, Pa. 19108.
Iron-core transformers get tiny; Now only the price must shrink

Iron-core transformers, traditionally bulky components, are catching up—or, rather, down—in size with other microsized elements in electronic packages.

A new generation of miniature iron-core microtransformers has many desirable characteristics for use in signal-processing circuitry. And the smaller transformers are available from several sources.

Cost is holding down use of the units, however, even where they could provide superior performance. Each unit must be hand-fabricated (see photo). Many designers are using less-expensive but also less-effective solid-state circuitry and components.

At present the principal use of microtransformers is in aerospace and military applications. But manufacturers see improvements in production processes lowering costs eventually. One expert believes that these microsized structures may revive the use of magnetic amplifiers, which were outmoded by the growth of solid-state technology.

Excellent isolation given

"Magnetic devices are still required in some applications," says Octavio Forte, group section chief at the Charles Stark Draper Laboratory, Cambridge, MA. "The excellent isolation of transformers is valuable in circuits such as line drivers and in signal-processing in modulators and demodulators.

"We're using microsized, 1/4-in-cube transformers in synchronous demodulator circuits for telemetering applications in military systems. These devices are compatible with the 1/4-by-1/4-in. flat-packs used in the NAFI [Naval Avionics Facilities, Indianapolis] standard module.

"In the NAFI package, two small PC boards are mounted back-to-back. We have a very high-density packaging format. The transformers are placed so that they efficiently fill the available volume."

Transformers have no equal in signal-processing applications, Forte asserts. For example, he says, optical couplers can be used for isolation, but they are not suitable equivalents.

"First of all, they're very lossy and they require a lot of power to drive them," Forte points out. "Also optical couplers have low bandwidth. In addition they have to be biased, which leads to offset-voltage problems."

With the development of micromagnetics, Forte sees the reappearance of magnetic amplifiers.

Jim McDermott
Eastern Editor

Iron-core microtransformers require detailed hand assembly and fabrication. Joining of heavy leads to wires between 0.001 and 0.0005-in. thick is a critical operation. Here skilled operators, using microscopes of 10 to 30 power magnification, are stacking tiny laminations in the bobbin of a Bourns 1/4-in-cube transformer.

If you're really serious about cost, be serious about quality.
“Magnetic amplifiers still have a place,” he insists. “They are simple, reliable, don’t drift and don’t require power. In addition, for some military applications, they are resistant to radiation.”

A penalty in reducing iron-core transformers to minuscule dimensions is the need to reduce the linear power-handling capability to milliwatts. For example, microtransformers used by Draper Laboratory in the NAIf application—units by Bourns Pacific Magnetics Corp., Romoland, CA—have a flat output from 400 Hz to 250 kHz, with a rating of 5 mW at 400 Hz and 200 mW at 2 kHz.

The smallest Bourns unit is a 1/8th-in. cube with a rating of 24 mW at 10 kHz and a flat response from 2 kHz to 500 kHz.

Similar units of essentially the same size, but differing magnetic design, are produced by Pico Electronics, Inc., Mt. Vernon, NY, and TRW/UTC Transformers, New York City.

A Pico Electronics unit, the PG603, handles 65 mW with 5% distortion at 400 Hz and 200 mW at 1.6% distortion at 1 kHz, according to Joseph Sweeney, a co-inventor of the Pico design.

The UTC micro-sized package—the Bit 250 series—has a frequency response of ±2 dB between 300 Hz and 250 kHz. The typical power levels, for 5% maximum distortion at 1 kHz, is 80 mW, according to Burton Yudin, UTC design engineer.

Construction of the microtransformers differs among companies, but the objective is to pack the most copper and core material within a given space. Bourns uses magnetic laminations that are inserted into coils wound on a bobbin.

Pico Electronics and UTC enclose their transformer-coil structures within a tiny can of highly permeable material, which forms the outside magnetic circuit. Variations of this design are patented by both companies.

**Lead termination critical**

The most time-consuming and critical part of microtransformer fabrication is the lead termination. The transformer wires are less than 0.001-in. in diameter. Special solder is used by most fabricators, but Piconics, Inc., of Tyngaboro, MA, a manufacturer of microchip inductors, welds some of its leads.

“We weld the leads on our more expensive units,” says Steven Slenker, president. “Although this required development of special equipment, we find it gives us the highest reliability.”

In recent thermal-shock tests—with the units cycled between 125 and -65 C—100 of the welded-lead units survived 1300 temperature cycles with only one failure, according to Slenker.

“Usually,” he notes, “after 50 cycles, 50% of most components fail. The military requires but five cycles.”

There are two ways to reduce the size and cost of present microtransformers, says Dr. Guenter Finke, director of R&D for Magnetic Metals, Camden, N.J. One is to improve materials and design, the other way is to improve production methods.

“Today’s materials are good,” Finke notes, “and designs of lamination shapes with higher inductance can be expected.”

The handling of tiny laminations and components can be improved, he says.

“We have considered making this type of core lamination by photoetching rather than stamping,” Finke reports. “In that case, the laminations could be stacked many at a time and simply dropped into a fixture to speed assembly.”

---

**Microminiature 1/8-in.-cube transformer**, by Bourns, is used in a 19.2-kHz accelerometer circuit.

**Leads for these microsized Pico Electronics transformers are suitable for cordwood or PC-boards.**

**Terminations for flat-pack mounting are provided on this micro-unit by TRW/UTC Transformer.**

**Twelve microtransformers are mounted on this 1-in. NAIf board. Six units are stacked on each side.**
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Your voice tells when you're lying with small, solid-state analyzer

You’re on the phone talking to the mechanic who has towed your car in and is giving you an estimate for repair work. You ask him if it's a minor problem that requires a simple adjustment. He says no, the starter has to be replaced, and that will cost well over $50. You know he's probably lying. A small instrument in your attaché case tells you so.

The briefcase-sized instrument is the Mark II voice analyzer from Law Enforcement Associates, Inc., Belleville, NJ. It acts as an emotional stress detector—just as the more familiar polygraph does—to help detect lies. But unlike the polygraph, it requires no electrical connection to the person being questioned. It detects changes in the rapid, involuntary and inaudible variations—known as tremolo—in the voice.

Fred Fuller, president of Technical Planning Inc., the Bethesda, MD, research company that originally developed the Mark II, notes that the voice analyzer can be operated in the presence of the subject or via a remote microphone, tape recorder or telephone pickup coil.

The voice analyzer does not "detect" lies, Fuller stresses. What it does uncover, he explains, is the emotional stress created when the average person lies. By asking a few "neutral" questions—such as, "Is this the XYZ Garage?" "With whom am I talking?"—the examiner can establish a base line that takes into account any inherent nervousness on the part of the subject. When a subject departs from this base line, Fuller notes, the examiner may infer that he is lying.

In describing how the solid-state circuitry works, Fuller says that the incoming audio signal is first rectified and filtered. The filtered waveform contains spikes that are related to the spoken words. These spikes are then differentiated and fed back to the input, through a low-pass filter, to eliminate the audio carrier. The resulting signal is then fed to a Schmitt trigger, whose output pulses are accumulated in shift registers. The pulses are counted and either read out on a digital display or recorded on a built-in strip chart recorder.

The normal digital value for emotional stress varies from between 10 to 100. The absolute value is not important, says Fuller. "What is important," he emphasizes, "is the variation from each individual's base line."

Comparative studies conducted in cooperation with nationally recognized polygraph-test concerns have produced matches of over 95% in the assessment of guilt or innocence for specific crimes and a 90% match in pre-employment examinations, Fuller reports.

A big advantage of the voice analyzer over the polygraph, Fuller says, is that no extensive training is required to use it. Polygraph outputs must be interpreted by skilled operators, and the results may vary from operator to operator. The Mark II voice analyzer's digital readout gives objective findings, the developer points out. ■■
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Heavyweight
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Commerce Dept. bullish on electronics sales

Predicting that 1974 will go down in the records as a good year for the electronics industry—especially the computer segment—the Dept. of Commerce is bullish on the future. In a new industrial outlook report, the department sees industry shipments of electronic components up 11% over 1973, commercial, military and industrial equipment up 3% and computer-industry shipments up 22%.

In a projection to 1980, the Government outlook is for all electronics sales to increase at an annual rate of 5.5%, reaching $35-billion by 1980. The highest growth rate, the department says, will be in electronic systems and equipment—8.9%. Electronic components are seen growing at an estimated 3.3% and consumer electronics at 2.6%.

Computer industry growth is estimated at 14% in 1975, with a five-year average somewhat lower—10%. Software is expected to be the major emphasis in this field during the remainder of this decade. An average annual growth of 21% through 1980 is predicted for calculator sales.

U.S. and Soviet pushing joint technical efforts

A bright spot in the international outlook is the progress being made in scientific and technical cooperation between this country and the Soviet Union.

Some efforts, started last year by the formation of a U.S.—Soviet Joint Commission on Scientific and Technical Cooperation, are now moving from the planning stages to joint research. Four chemical-catalysis projects and two projects applying computers to management are the first to make this transition. Projects in electrometallurgy, such as solid-state joining, are also reported ready. The joint commission, following its recent meeting in Washington, requested that the U.S. National Academy of Sciences and the Soviet Academy of Sciences select experts to carry out work on solid-state theory.

Rising unemployment making engineers wary

With unemployment rising, a U.S. Labor Dept. monograph, "Labor Market Experience of Engineers During Periods of Changing Demand," may enjoy a healthy sale. Should the unemployment rate of engineers rise as dramatically as it did in the last recession, the defunct Technology Mobilization and Re-employment Program may also be revived. This was a national effort to find jobs for engineers, primarily those in the hard-hit aerospace industry.
The national unemployment rate for all workers was up to 6% in October, for all professionals and technicians, it was 2.3%. Among professionals, engineers have had the highest unemployment rate in recent years. In 1967 it was 0.7%, and by 1971 it had climbed to 2.9%. The Bureau of Labor Statistics doesn’t classify engineers as a group; they are lumped with scientists and technicians. In 1973 when the national unemployment rate for all workers was 4.9%, the bureau’s scientist-technician category stood at 3.4%.

The monograph may be purchased for $1.05 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

**Private processing of nuclear fuel backed**

While the nuclear-power industry’s most visible problems are posed by the environmentalists, one equally serious for it and the electronics industry is the future supply of fuel for the reactors. Unless something is done, by 1982 U.S. uranium-enrichment facilities will not be able to satisfy demand here and abroad. At present nuclear fuel is enriched at three gaseous-diffusion plants owned by the Atomic Energy Commission. Even if they are upgraded, as planned, they won’t be able to accept new customers. A bill introduced in the House would create a quasi-governmental corporation to stimulate nuclear-fuel processing by private industry.

Called the United States Enrichment Corp., it would be self-supporting and would take over the AEC’s plants. The corporation would expand production, probably through encouragement of private industry to build plants and development of the centrifuge process, which is less power-consuming and water-consuming than the gaseous-diffusion process.

To ensure a market for private industry, the corporation would not construct competing facilities and eventually would turn all enrichment processing over to commercially operated plants. It’s estimated that an annual investment of $2-billion would be required to provide the added production facilities.

**Capital Capsules:** The Air Force is looking for sources to develop varactor diodes for ECM voltage-controlled oscillators, with emphasis on minimizing post-tuning drift and settling time. . . NASA is interested in demonstrating the feasibility of automating solar-cell-array fabrication with use of production wrap-around cells and FEP plastic films. The agency is also seeking a contractor to develop standard specifications for silicon solar cells. . . .

Fairchild Industries has delivered to the Army a system that will electronically identify shipping containers, trucks and other vehicles, even when they are whizzing by an interrogator at speeds up to 85 mph. The device, which is triggered by a label on a box or vehicle, records the serial number. The system is to be tested. . . . NASA reports that flat conductor electrical cable, a spinoff of the space program, is being installed in private housing for the first time. Developed originally for wiring in satellites, the flat wire will be used to make a surface-mounted, snap-on baseboard electrical system in six apartments in Yonkers, NY.
Capture Those Hard to View Signals at Low Cost

Single shot events; high speed, low repetition rate signals; changes in successive sweeps, very slow signals; repetitive signals obscured by random noise—all of those hard to display waveforms are easy to view using the new 5403/D41 Variable Persistence Storage Oscilloscope from Tektronix.

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Electronics Design 25, December 6, 1974
INFORMATION RETRIEVAL NUMBER 22
There's nothing new about a 2N3055 but there's a powerful difference in this one.

That's why we call ours the 2N3055C *"C"designates it as the Cadillac of power transistors.

Compare the specs below and see at a glance why Sensitron's upgraded version of the workhorse 2N3055... the 2N3055C... is your best bet for a wide range of power transistor applications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conventional 2N3055</th>
<th>RSM Sensitron &quot;Cadillac&quot; 2N3055C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chip size</td>
<td>140-175 mil²</td>
<td>210 mil²</td>
</tr>
<tr>
<td>$P_D$</td>
<td>115 W @ 25°C case temp.</td>
<td>150 W @ 25°C case temp.</td>
</tr>
<tr>
<td>$I_{C_{max}}$</td>
<td>15 A</td>
<td>30 A</td>
</tr>
<tr>
<td>$BVEBO$</td>
<td>7V</td>
<td>10V</td>
</tr>
<tr>
<td>$BVCEO$</td>
<td>60 V</td>
<td>120 V</td>
</tr>
<tr>
<td>$BV_{CER}$</td>
<td>70 V</td>
<td>130 V</td>
</tr>
<tr>
<td>$I_{CEX}$</td>
<td>@ 100 V &lt; 5 mA</td>
<td>@ 120 V &lt; 1 mA</td>
</tr>
<tr>
<td>$h_{FE}$</td>
<td>20 @ 4 A</td>
<td>25 @ 4 A</td>
</tr>
<tr>
<td>$h_{FE}$</td>
<td>5 @ 10 A</td>
<td>10 @ 8 A</td>
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<tr>
<td>$V_{CE(sat)}$</td>
<td>1.1 V @ 4 A</td>
<td>0.75 V @ 4 A</td>
</tr>
<tr>
<td>$V_{CE(sat)}$</td>
<td>8.0 V @ 10 A</td>
<td>3.0 V @ 10 A</td>
</tr>
<tr>
<td>SOAR</td>
<td>60 V @ 1.9 A</td>
<td>70 V @ 2.15 A</td>
</tr>
</tbody>
</table>

Write or call for more information or applications assistance on the 2N3055C and other RSM Sensitron single diffused power transistors.
Nice young girls and consultants

Walking the streets of Hong Kong a few weeks ago, I was stopped on several occasions by individuals brushing past me and whispering an offer, “Nice young girl?” I wondered why they selected me and a few others among the thousands working their way down the crowded streets. And why, “Nice young girls”?

Was that the only “merchandise” they had available? Or did they spot me as the type who might prefer “nice young girls” to “nice old girls,” “not nice young girls,” “not nice old girls,” or a similar choice among boys. At any rate, I was a customer for none of the above, so their message was wasted on me.

In Tokyo, a few days later, I had a somewhat similar encounter when a charming young lady stopped me on the way to my hotel room, engaged me in an intellectual discussion, asked about my line of business, then volunteered that she was a consultant. Now, by a common definition of a consultant—one who lives more than 100 miles from the office—she may have qualified.

But in other respects she differed from most consultants I’ve met. At any rate, like other consultants, she tried to convince me that I was in urgent need of her consulting services. When she saw that I was not to be a client, and that precious minutes of her professional time were being wasted, she left in search of those more desperate for consulting services.

If we can ignore the moral, religious and sociological considerations involved in these transactions, we can take a dispassionate look at the business approach. Recognizing that the purveyors, in these cases, couldn’t influence the basic design of the product, we can wonder if they merchandised it effectively. Did they not waste a call? Could they have used their time more effectively by selecting more likely clients? Should they have promoted a different feature of the product?

I think the lessons from my experiences in Hong Kong and Tokyo are the same: (1) Know your customer. (2) Learn to find your customer efficiently; don’t waste your efforts with unlikely prospects. (3) Learn your customer’s needs. (4) Design the product to meet your customer’s needs—if possible.

GEORGE ROSTKY
Editor-in-Chief
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Available in active lengths of 7" and 8" at $75.00 each, with thermal transport capacities of 20 watts with the evaporator 90° below condenser, 7.5 watts horizontal operation, 2.5 watts with evaporator 90° above condenser. Recommended operating range: −40° to +120°C. Weight: 20 grams. Diameter: ¼".

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Celanex: the original thermoplastic polyester

Which dc/ac inverter? At least eight different circuit schemes are used. Learn what these increasingly important units can do and know their limitations.

With the rapidly growing use of dc ac inverters in uninterruptible power systems (UPS), portable equipment and power frequency converters, it has become imperative for a specifying engineer to understand the capabilities and limitations of the many inverter types available today. Eight types of commercial inverter designs are presently popular, with each trading off one set of performance characteristics for another.

But whatever the type, the emphasis in recent applications increasingly bears on such factors as efficiency, weight, reliability, EMI and safe operation—as well as on the more traditional areas of frequency stability, harmonic content, regulation and transient performance. Today’s inverter frequently encounters—and must be able to handle—nonlinear loads, such as those of the ubiquitous computer peripheral.

The first decision in comparing design techniques starts with the needed power level. By and large, inverters can be split into two groups based on power: the low-power, transistor-based design and the high-power SCR-based system.

Transistors vs SCRs

Limited to low-power designs because of its dissipation, the power transistor can nevertheless be found today in 3-φ systems with apparent powers up to 15 kVA. Above that level, the SCR can handle the power; SCR versions go as high as 1 MW in a large UPS arranged in a complex, power sharing array.

Each type—the transistor and the SCR—has its problems. For instance, for an SCR to turn completely off, its anode-to-cathode current must be reduced to zero for about 30 μs. This isn’t easy to do when the prime power source is dc. Dozens of “solutions” to the turn-off, or commutation, problem have been applied—much to a specifier’s dismay.

On top of the turn-off problem, SCR designs are sensitive to noise and EMI so that a specifier must worry about these too.

George A. O’Sullivan, President, Abacus Controls Inc., 65 Fourth St., Somerville, NJ 08876.
3. **To avoid the poor response** and low efficiency of the voltage regulator, phase-shift voltage control can be used. But clean sinusoids are hard to get.

4. The simplest inverter is the ferroresonant-transformer type, which inherently provides regulation, filtering and overload protection, but not variable voltage.

Power 10 to 20 times greater than its dissipation rating. But to obtain a low-harmonic sine wave requires substantial filtering: A square wave contains all odd harmonics in inverse proportion to the number of the harmonic. That is, the ratio of the third harmonic to the fundamental is 0.333; the fifth is 0.20; and the seventh is 0.143.

**Harmonics are a problem**

To remove harmonics close to the fundamental, without attenuation of the fundamental frequency, requires massive filters. Most commonly used is a series-tuned LC network, followed by a parallel-tuned LC circuit across the load. Tuning is critical, and loads with power factors other than unity upset the harmonic rejection of the filter.

Two modes of voltage control are popular in square-wave units. The first precedes the square-wave generator with an independent voltage regulator (Fig. 2). The voltage is sensed at the output of the inverter and returned to the regulator through a feedback network. Response to load transients is extremely poor because the closed-loop response must be much slower than that of the four-pole series and parallel-tuned filters located inside the feedback loop.

And since full power is handled twice—once in the voltage regulator and again in the square-wave generator—efficiency plunges and cost and weight soar. To avoid this problem, two square waves can be added with a controlled phase shift (Fig. 3). Each square-wave generator can supply half the power. When the two square waves are in phase, maximum load is delivered. Out-of-phase operation provides zero power to the load.

However, the filtering problem with two square-wave generators becomes more severe. This is because at some relative phase angles, the harmonics of the two generators add in-phase and become a much higher percentage of the fundamental frequency.

Note that poor response to load transients is inherent in all square wave/tuned-filter inverters. Variable voltage may be incorporated in
5. One of the purest sine waves is delivered by the step approach, in which a number of square waves—controlled in phase and amplitude—are added. Harmonics are related to the number of steps.

6. In the stepped-waveform approach to inversion, output harmonics depend on the number of steps and the step height. Step number is usually a multiple of three: 6 (a), 12 (b) and 24 (c) are commonly used.

square wave/tuned-filter inverters, but not variable frequency.

By far the least complex inverter—the ferroresonant transformer—provides voltage regulation, harmonic suppression, and overload protection in a simple circuit (Fig. 4).

The ferroresonant inverter

Because of the transformer's large leakage reactance, the square wave in the primary circuit is not transformed into the secondary. Instead, the impulse from the primary activates a tuned, saturating magnetic circuit and ac-capacitor combination. At a constant frequency, this tuned circuit provides a constant voltage to the load.

Harmonic content of the ferroresonant transformer's output is satisfactory for most applications. But a further reduction in harmonics is possible with the addition (in series with the capacitor) of an inductor selected for third-harmonic suppression.

The square-wave ferroresonant-filter inverter provides a constant voltage and constant frequency that are not adjustable in the field. Efficiency of the system runs 70 to 85%, depending upon power level.

Three-phase inverters require three square-wave/ferroresonant-filter inverters that can be synchronized and controlled at 120-degree phase shift. In this configuration, the basic simplicity of the ferroresonant transformer is lost. The square-wave ferroresonant-filter inverter is a low-cost solution to low and medium-power single-phase applications that operate from batteries with outputs of 12, 24, 28, 48, and 120 V. To get variable voltage, line synchronization or a more perfect sinusoid, however, other approaches are needed.

The oscillator/amplifier provides a clean sine
wave but at a sacrifice in efficiency; the square-wave generator is efficient but can’t give a good approximation of a sine wave. In the search for an inverter that yields a clean sine wave, the step wave emerges (Fig. 5).

In the step technique, several square-wave generators are controlled in phase and amplitude to make a step wave. Usually, the steps are evenly spaced across 360 degrees and the height of each step is selected to eliminate low-order harmonics.

The general relationship between the number of steps and the retained harmonics is:

\[ \text{Harmonic number} = \sum_{M=1}^{M} \frac{MN \pm 1}{\lambda} \]

where \( M \) includes all positive integers and \( N \) is the number of steps. A 12-step wave thus contains the 11th, 13th, 23rd, 25th and succeeding harmonics, and the amplitude of each retained harmonic is inversely proportional to the number of the harmonic—the same relationship as that of the square wave.

Theoretically, the number of steps can be any integer. But in practice only even multiples of three are chosen. These provide positive and negative half-cycle symmetry and generate three phases with a single set of components. The amount of hardware needed to generate a step wave is substantial, and the technique is practical only for large three-phase systems in which power sharing between components is required.

Most popular are 12 and 24-step waves (Fig. 6). The three-phase square-wave generator consists of six power-switching circuits arranged in a three-leg bridge, with a delta-connected transformer joining the centers of each pair of power-switching circuits.

Voltage control with the step approach is similar to that of the square wave. A separate voltage regulator (with its inefficient double handling of power) is one approach. A phase shifter that moves a second complete set of steps with respect to the first is most often used in a large SCR UPS (Fig. 7).

Variable voltage and variable frequency over a limited range are possible. Harmonic control is simple: With an LC filter tuned at about the fourth harmonic, the speed of response to load transients is reasonably good—about 3 cycles of the line frequency. Efficiency at full power is about 85% but, at partial power, losses are significant and efficiency falls off with decreasing power.

The latest inverter: digital synthesis

The step-wave inverter provides an efficient low-harmonic sine wave. But the high parts count makes it impractical at low and intermediate power levels. With the introduction of large-scale integrated circuits, especially the programmable read only memory (pROM), the hardware required to build a digital equivalent of the step wave becomes practical.

To synthesize a sine wave digitally, a pROM is
8. Digitally synthesized sine waves (a) are made possible by programmable, read-only memories (pROMs) which store patterns of pulses (b). Outputs from the pROM provide switching signals to a 3-phase bridge.

9. To get the best efficiency (80%), the switching-regulator technique (a) is used to control, or modulate, used to store a pattern of pulses, both positive and negative, that are selected to eliminate low-order harmonics. A simple LC filter reduces the higher order harmonics; these are more prevalent than in the step-wave approach.

The digital synthesizer regulates voltage by increasing the amount of time the pulse pattern stays at zero as the dc voltage increases. Overload and short-circuit conditions are automatically compensated by operation in a current-limit mode. Since harmonic rejection and voltage regulation are combined in one set of switching instructions stored in a pROM, the power stage contains the minimum number of switching components.

A three-phase system requires six switching circuits arranged in a three-phase bridge. A single-phase system requires four switching circuits arranged in a bridge. The power-to-weight ratio is high, as is the efficiency over the entire operating range from no load to full load.

One method of digital synthesis is shown in Fig. 8. A reference frequency 360 times higher than the operating frequency yields a one-degree resolution in the pulse pattern. A nine-step binary counter provides the cyclical information to a 512 x 4 pROM. Three of the pROM outputs provide switching instructions to each leg of the three-phase bridge. The fourth output resets the binary counter.

Digital synthesis is practical from 500 W, single phase, to 15 kW, three phase. At low powers, the cost of the digital controller becomes significant. The upper power limit is set by the
limited power dissipation of available transistors (With SCRs, the upper limit can go as high as 100 kW.) Speed of response and purity of the sine wave are similar to those of the step wave. Variable voltage and frequency are available simultaneously. In a UPS application, synchronization with the line voltage is readily accomplished with a phase-locked loop.

High-frequency switches emerge

With the rapid evolution in power handling ability and switching speeds of power-transistors and SCRs, and with the development of dc switching power supplies, it was natural to look for ways to apply high-frequency switching technology to the dc/ac inverter. Several workable techniques have been developed. The most popular uses a sine-wave oscillator and a switching amplifier with positive and negative output capability, much like the original oscillator/amplifier combination (Fig. 9).

In the switching-amplifier—or pulse-width-modulation—method, before the output is filtered it resembles a two-polarity “picket fence.” To get voltage regulation and control, the picket fence is made narrower or broader as required to decrease or increase the output voltage. When the switching frequency is high compared with the generated frequency (by a factor of 20, or more), the harmonic content is low.

The modulated inverter’s response to load transients is good, and efficiencies greater than 80% are achievable. Variable voltage and frequency over a broad range (45 to 450 Hz) are available and the weight-to-power ratio is attractive. However, pulse-width-modulated inverters are relatively expensive because of the high price of very fast switching power transistors.

When a single transistor is used in each switching position, the inverter is limited to a few kilowatts. Higher power units have been built with transistors operating in parallel, but the circuitry becomes very complex: It is impossible to force transistors in parallel to share the load during the inactive switch-off mode of operation, and it is risky to count on load sharing when dynamic characteristics—which are subject to aging—are matched.

The combination of high response speed and high efficiency makes the pulse-width-modulated inverter a poor performer for short circuits and overloads. Most designs turn the inverter off when an overload exists, rather than limiting the current (because current can’t be limited fast enough to save the power devices). But to turn an inverter off in the face of an overload is clearly contrary to the requirements of a UPS."
What’s a Gudebrod?

Many of the new-today company names and images are dreamed up in public relations and advertising agency offices. The company and its product names will have an interesting ring to them, will be catchy, quick on the tongue and easy to remember, which in turn helps to sell the product.

The Gudebrod Brothers formed this company in 1870 B.P.R.H. (Before Public Relations Hoopla!). But even with this time honored image . . . our name sure takes a beating!

Chances are, one of our GOOD BOARD Salesman is teaching a young apprentice in the harness room, the proper way to tie the no-lost motion knot . . . we often do that you know! Chances are somewhere in the world, there is an electronics show where the GUDIE BROD (as they say in Denmark) products such as lacing tapes, cable lacers, harness pins, WHO clips, swivel tilt board mounts, snips and cutters are on display.

As for the GOOD BROAD lacing tapes . . .

Why, they’re of the highest quality and we offer you a complete range from which to choose. Nylon*, Dacron*, Teflon*, Nomex*, Glass. All have a definite purpose. Many meet and exceed military specifications, and if none meet your requirements . . . we’ll research for one that does.

Good Guide’s been thru it!

We’ve been all through those vibrations, extreme heat and cold, fungus, chemical reactions and self-extinguishing problems. We know how to tie it up, hold it down or cut it off! Knots won’t slip, harnesses stay tied, assemblies remain firm and secure . . . and it’s a lot faster and less expensive than you think. Give one of our 6 branch offices a call today and we’ll talk about it. Don’t be alarmed if our switchboard operator also pronounces the name wrong . . . she’s been doing that for the better part of the last 103 successful years!

By the way . . . GUDEBROD is pronounced GOOD BROD but of course, those of you buying our products may continue to call us whatever you like!

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Combine Murata’s 30-year-old world renown reputation as the leader in ceramic capacitors with its new “Made in Georgia, U.S.A.” label and you’ll find unexcelled quality, delivery and service. Discs, dipped, molded and chip monolithic multilayers, reduced titanates—Murata has a complete line of everything in the ceramic capacitor field. Write, call or circle the number below. We’ll let you know how Murata can solve your ceramic capacitor problems.

made in Georgia, U.S.A.!
Avoid wiring-inductance problems.
Properly configured wiring can reduce unwanted coupling, troublesome feedback and noise pickup.

Do you know that there are 465 nH in just one foot of 30-AWG wire? And that a 10-ns current pulse of 10 mA produces a 0.5-V noise spike? But place the wire over a ground plane, and you reduce the inductance to 100 nH and the noise spike to 0.1 V.

Wiring inductance is often overlooked in the design of PC boards, back panels and cables. And many of the less obvious characteristics of inductance are not accounted for, even when an attempt is made to consider inductive effects. The result of this neglect is noise pickup, unwanted coupling and troublesome feedback.

You can calculate wiring inductances, however, and alleviate problems from this source. Let’s see how.

What is inductance?

Inductance, L, can be defined by the equation

\[ L = \frac{N\phi}{I} \]

Magnetic flux “lines” \( \phi \), or linkages represented by the quantity \( N\phi \) (turns \( \times \) flux), accompany all current flow, I. Flux lines occur both internally and externally to the conductor. Inductance also is considered the parameter that represents how well flux lines can oppose changes in the flow of current in a circuit. The opposition to the change in flow of current, or self-inductance, is manifested by a back voltage, e, that develops in the circuit,

\[ e = -L \frac{di}{dt} \]

When the flux lines “cut” across, or couple, with other nearby conductors, voltage is induced in these conductors. The amount of induced voltage is determined by the degree of coupling, called mutual inductance.

Most engineers know how to calculate the self-inductance of an isolated wire, but they often overlook the mutual-inductance effect of a nearby return-current conductor. This neglect can lead to serious errors. If the return conductor is near, which is the usual case, the effect of the mutual inductance subtracts from the isolated self-inductance value and lowers the over-all self-inductance, \( L_\text{s} \).

Fundamental formulas reviewed

The over-all self-inductance of two mutually coupled conductors in series (Fig. 1a) is given by the equation

\[ L_\text{s} = L_1 + L_2 \pm 2L_m, \]

where

\[ L_1 = \text{over-all self-inductance}; \]
\[ L_2 = \text{self-inductance of one wire, if isolated}; \]
\[ L_\text{m} = \text{self-inductance of the other wire, if isolated}; \]
\[ L_m = \text{mutual inductance between inductors.} \]

If \( L_2 \) is a current-return conductor of the same length and diameter as \( L_1 \), then \( L_2 = L_1 \) and

\[ L_\text{s} = 2(L_1 - L_m). \]

Usually, a load, \( Z_L \), connects between the ends of a feed wire and its return (Fig. 1b). The ef-

Paul M. Rostek, Senior Circuit Design Engineer, NCR Corp., San Diego, CA 92127.
The effective inductance, \( L_e \), of each separate lead—feed or return wire—if the inductances are considered equal, is one-half of the over-all inductance, \( L_n \). Thus

\[
L_e = \frac{L_1 L_2 - L_{im}^2}{L_1 + L_2 - 2L_{im}}.
\]

Since the current flows in the same direction in both wiring legs, the mutual inductance, \( L_{im} \), limits the reduction in over-all inductance. At large distances between the conductors, \( L_{im} \) approaches zero and \( L_e \) attains a maximum reduction of 50% in inductance.

**Inductance changes with frequency**

Magnetic flux traverses both the outside and inside of a wire that carries current. The self-inductance is thus composed of both the internal and external flux linkages. Since more total flux encloses, or links, the inside of a wire than its surface, a filament of the wire near the wire's center has greater inductance than a filament near its surface. Thus at high frequency, less current flows in the wire's interior. This phenomenon is known as the "skin effect," because the current concentrates at the wire's surface. Since the center of the wire carries less current,
## Inductances for common wiring configurations

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Formulas</th>
</tr>
</thead>
<tbody>
<tr>
<td>All dimensions in inches, inductance is in nH</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Isolated Wire</strong> (l &gt;&gt; r)</td>
<td>$L_s = 5I \left[ \ln \frac{2l}{r} - \frac{3}{4} \right]$ Low frequency, l &gt;&gt; r, $\delta = 1/4$</td>
</tr>
<tr>
<td></td>
<td>$L_s = 5I \left[ \ln \frac{2l}{r} - 1 \right]$ High frequency l &gt;&gt; r, limit as $f \to \infty$, $\delta \to 0$</td>
</tr>
<tr>
<td></td>
<td>$L_m = 5I \left[ \ln \frac{2l}{d} - 1 + \frac{d}{l} \right]$ Mutual inductance between thin parallel wires.</td>
</tr>
<tr>
<td></td>
<td>$L_s = \frac{L_1 + L_m}{2}$ or $\frac{L_s + L_m}{2}$ Over-all self-inductance of two parallel wires, as used in distribution cables, or bus bars, where current is in the same direction.</td>
</tr>
<tr>
<td></td>
<td>$L_s = \frac{L_1}{2} + \frac{L_m}{2}$ Inductance of each of two wires in close proximity to each other, with current in each in opposite directions.</td>
</tr>
<tr>
<td></td>
<td>$L_s = 5I \left[ \ln \frac{2h}{r} + \frac{\mu \delta}{r} \right]$ Self-inductance of a wire only, when current return is via a ground plane.</td>
</tr>
<tr>
<td></td>
<td>$L_s = 5I \left[ \ln \left( \frac{2l}{W + t} \right) + \frac{1}{2} + \frac{2}{9} \left( \frac{W + t}{l} \right) \right]$ Self-inductance of a flat etched conductor, bus bar or ground plane when isolated from a return path at low frequency.</td>
</tr>
<tr>
<td></td>
<td>for low frequencies: $L_s = 5I \left[ \ln \left( \frac{W}{W + t} \right) + 2.75 \frac{d}{W} \right]$, for W &gt; d, W &gt; t</td>
</tr>
<tr>
<td></td>
<td>$L_s = 5I \left[ \ln \left( \frac{d}{W + t} \right) - \frac{d}{l} + \frac{2}{9} \left( \frac{W + t}{l} \right) \right]$, for d &gt; W, W &gt; t</td>
</tr>
<tr>
<td></td>
<td>for high frequencies and W &gt;&gt; t: $L_s = \frac{14I}{W} \left( d' + \Delta \right)$, $\Delta = \frac{2.6}{\sqrt{f}}$, skin depth for copper</td>
</tr>
<tr>
<td></td>
<td>Self-inductance of each conductor. Total inductance is the sum of inductances of the feed and return bus bar.</td>
</tr>
<tr>
<td></td>
<td>$L_s = 5I \left[ \ln \frac{d}{W + t} + \frac{3}{2} \right]$ for low frequencies</td>
</tr>
<tr>
<td></td>
<td>Self-inductance of each conductor. If feed conductor (+I) is flanked by two return flat conductors, the feed conductor's inductance remains the same.</td>
</tr>
<tr>
<td></td>
<td>$L_s = 5I \left[ \ln \frac{6h}{t + 0.8W} + \mu \delta \right]$ Self-inductance of flat conductor only, when current return is via a ground plane.</td>
</tr>
</tbody>
</table>
the effective cross-section area is less and the wire's ac resistance is higher (Fig. 2). In addition the inductance is reduced by a skin-depth factor, as follows for an isolated circular wire:

\[
L_s = 5.081 \left[ L_n \frac{21}{r} + \mu \delta - 1 + \frac{r}{l} \right],
\]

where

\[
L_n = \text{wire self-inductance in nanohenrys};
\]

\[
r = \text{wire radius in inches};
\]

\[
l = \text{wire length in inches};
\]

\[
\mu = \text{relative magnetic permeability (copper \(= 1.0\)};
\]

\[
\delta = \text{skin depth factor} = K/r \sqrt{\rho/\mu} \quad (0 < \delta < 0.25);
\]

\[
\rho = \text{volume resistivity in ohms-in.} = 0.68 \times 10^{-8} \text{ for copper};
\]

\[
K = \text{conversion constant} = 3168.
\]

The change in inductance with frequency is small for a circular wire. Skin effect at very high frequencies decreases inductance by roughly 6% in short wires and about 2% in long wires. However, in parallel conductors, especially flat bus bars, the skin effect has greater influence and should not be neglected.

**Lowering the self-inductance**

The diameter of a wire does not have a major influence on its self-inductance (see table of sample calculations). For example, the self-inductance of a 2-AWG isolated wire with a diameter of 0.26 in. is approximately half the inductance of a 30-AWG wire with a diameter of 0.01 in. An increase of the wire size can provide a reduction of about 50% in self-inductance.

If the current is divided between two parallel conductors and flows in the same direction in each, the self-inductance can also be reduced to half if the wires are spaced far apart. For example, two 30-AWG wires, separated by 0.02 in., will reduce the over-all self-inductance only 18%; and for 0.2-in. separations, by 32%. A separation of several inches between wires reduces the over-all inductance approximately 50% of the self-inductance.

The most effective way to reduce inductance is to place the forward and return-current conductors in very close proximity. Two 30-AWG wires separated by 0.02 in., reduce the over-all self-inductance to one-fifth of a single isolated wire. Laminated bus bars or multilayer boards with closely spaced ground and voltage layers can reduce wiring inductance to one-tenth or less that of conductors isolated far from their return, or ground, plane.

**Reference**

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INFORMATION RETRIEVAL NUMBER 30

Electronics Design 25, December 6, 1974
New GE-MOV® Varistors

...Voltage transient protection - 25¢*

New axial lead "MA" series GE-MOV® Varistors offer both low cost, compatibility with automatic insertion and better voltage transient protection than back-to-back zener diodes because of 4-7 times better peak pulse current rating (20A @ 75°C).

- 14 types in the "MA" series GE-MOV® Varistors offer ratings of - 88-264V RMS - 121-365V DC

<table>
<thead>
<tr>
<th>Type</th>
<th>Voltage RMS DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>V150MA1A</td>
<td>88 121</td>
</tr>
<tr>
<td>V220MA2A</td>
<td>132 181</td>
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<tr>
<td>V220MA4B</td>
<td>138 191</td>
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<tr>
<td>V430MA3A</td>
<td>253 349</td>
</tr>
<tr>
<td>V430MA7B</td>
<td>264 365</td>
</tr>
</tbody>
</table>

- Over 110 companion GE-MOV® Varistors in 5 different packages offer transient protection 12-100V RMS. 16 - 780 V DC. peak current ratings up to 2000A.

*Suggested resale price 10,000 lots 25¢

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2. Off-the-shelf delivery from bonded inventory.

After final QA acceptance, i38510 product is placed in bonded inventory and held for immediate delivery.

<table>
<thead>
<tr>
<th>Date</th>
<th>NOV. 25</th>
</tr>
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<tbody>
<tr>
<td>Number</td>
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<tr>
<td>101A</td>
<td>Op Amp</td>
</tr>
<tr>
<td>108</td>
<td>Lo Lvl Op Amp</td>
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<tr>
<td>108A</td>
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<tr>
<td>111</td>
<td>Volt Comp</td>
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<tr>
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<td>Volt Reg</td>
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<td>741</td>
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<tr>
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<td>256 Bit RAM</td>
</tr>
<tr>
<td>5603A</td>
<td>1024 Bit P/ROM</td>
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<tr>
<td>5604</td>
<td>2048 Bit P/ROM</td>
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<td>6523</td>
<td>256 Bit CMOS RAM</td>
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<tr>
<td>7552</td>
<td>1024 Bit MOS RAM</td>
</tr>
<tr>
<td>8007</td>
<td>FET Op Amp</td>
</tr>
<tr>
<td>8021</td>
<td>Lo Pwr Op Amp</td>
</tr>
</tbody>
</table>
What is the i38510 Reliability Program?

It's Intersil's exclusive in-house program for military hi-rel products. These devices are made with MIL-M-38510A processing and MIL-STD-883 test methods, plus scanning electron microscope analysis and positive wafer traceability. They are delivered off-the-shelf with no minimum quantity required. In addition, Intersil will process to custom reliability specs; call Francis Azariah, (408) 257-5450 for details.

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<table>
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<th>Digital Equipment</th>
<th>4K</th>
<th>PDP-11/04</th>
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<tr>
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<td>Data General</td>
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<td>Nova 2/4</td>
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<td>General Automation</td>
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<tr>
<td>Interdata</td>
<td>4K</td>
<td>7/16</td>
<td>$3200</td>
</tr>
</tbody>
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*50-unit quantities. Prices apply to U.S.A. and Canada only.
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You can see the difference

Burroughs

### DC Volts and Current

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<thead>
<tr>
<th>SERIES 200AS</th>
<th>SERIES 200BS</th>
<th>SERIES 253</th>
<th>SERIES 257</th>
</tr>
</thead>
<tbody>
<tr>
<td>For resolution of 0.05%, counts to ±1999 in four voltage and six current ranges. Up to 60 readings/second. Low-cost. Sperry display. From $159.</td>
<td>Single polarity low cost OEM meter with BCD outputs. 1999 volts full scale; 0.05% resolution. Up to 60 readings/second. Sperry display. From $139.</td>
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<td>Small size. Line powered. ±1999 counts with 10μV basic sensitivity. 12 voltage and current ranges selected by plug-in range module. Sperry display. From $145.</td>
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</table>

<table>
<thead>
<tr>
<th>SERIES 400AS</th>
<th>SERIES 2000AS</th>
<th>SERIES 2000BS</th>
<th>MODEL 2400AS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-cost unit counts to ±3999 in four voltage and five current ranges. Gated and buffered BCD outputs provide easy multiplexing. High common-mode rejection. Sperry display. ±4999 counts optional. From $189.</td>
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### Temperature Measurements

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<th>SERIES 260</th>
<th>SERIES 2600</th>
<th>MODEL 6110</th>
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<tr>
<td>Measure and display temperature in standard NBS thermocouple ranges. Four digits (to ±380000 counts) give 1° resolution. Excellent conformity. Reading rates to 60/second. 0.1° resolution for RTD models. From $500.</td>
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### Compatible Accessories

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<th>SERIES 270</th>
<th>MODEL 6151</th>
<th>MODEL 6700S</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 810 is a basic 9 column printer expandable to 18 columns. It records in two colors at rates to 3.7 lines per second. New formats can be quickly made by rearranging the internal format patchboard. From $495.</td>
<td>Used with any digital panel instrument with BCD output, digital comparators provide instant alarm or control outputs whenever an input digital number exceeds a preset limit. From $135.</td>
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</tr>
</tbody>
</table>
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**Predict wideband amplifier response**

with a simple graphical procedure. Spec sheets provide the basic data needed to compute closed-loop response.

A high-frequency operational amplifier's performance can be predicted with high accuracy in any number of closed-loop configurations if you use the Nichols Chart. Employed widely by control-system engineers, the chart helps evaluate an op amp's closed-loop response by using the op-amp manufacturer's open-loop gain and phase-response curve. Once some points are plotted on the chart, it's easy to pick off op-amp peaking, phase margin and bandwidth data.

A brief review of control-system fundamentals shows how closed-loop performance is calculated for a high-frequency amplifier. In most wideband systems the general amplifier configuration in Fig. 1a is drawn. The control system representation of this circuit (Fig. 1b) can then be modeled, where

- \( G' \) is the feed-forward transfer function;
- \( G \) is the amplifier open-loop transfer function;
- \( H \) is the feedback transfer function.

The closed-loop expression is

\[
\frac{E_o}{E_i} = \frac{-G'G}{1 + GH}.
\]  

(1)

The functions \( G' \) and \( H \) are derived if we assume an ideal operational amplifier and use the principle of superposition. To calculate \( G' \), mentally disconnect the amplifier summing point from the rest of the circuit and solve for voltage \( e_o \), using an ideal voltage source, \( E_i \) (Fig. 1c). Solving for \( G' \), we get:

\[
G' = \frac{e_o}{E_i} = \frac{Z_cZ_v}{Z_cZ_v + Z_lZ_v + Z_cZ_v}.
\]  

(2)

The feedback-transfer function (Fig. 1d) is similarly calculated when we solve for \( e_o \) with \( E_o \) impressed:

\[
H = \frac{e_o}{E_o} = \frac{Z_cZ_l}{Z_cZ_v + Z_lZ_v + Z_cZ_v}.
\]  

(3)

When \( G' \) is compared with \( H \), we see that

\[
G' = \left( \frac{Z_c}{Z_v} \right) H.
\]  

(4)

The closed-loop expression (Eq. 1) can now be expressed in a form suitable for graphic manipulation on the Nichols Chart,

\[
\frac{E_o}{E_i} = \frac{-Z_v}{Z_l} \left( \frac{GH}{1 + GH} \right).
\]  

(5)

**Using the chart**

We can see how the chart works by using the example of a very-high-frequency amplifier. Since most high-frequency amplifiers use the feed-forward technique to achieve high-frequency performance, consider a typical inverting amplifier, the Harris HA-2530. The open-loop response of

---

*Ernie Thibodeaux, Linear Applications Engineer, Harris Semiconductor, P. O. Box 883, Melbourne, FL 32901.*
this op amp (Fig. 2) is representative. Using the open-loop response curve, together with the feedback factor, we determine the closed-loop response with the Nichols Chart (Fig. 3).

Using the amplifier configuration in Fig. 4, we'll first predict closed-loop response for unity gain, compare the results with actual lab data, and show how the results can be used to predict performance for virtually any gain configuration.

In any high-frequency application, resistors \( R_i \) and \( R_f \) should be chosen so their interaction with stray and input capacitance occurs well beyond the bandwidth of the amplifier. In our example, \( R_i = R_f = 500 \, \Omega \) and \( C_f = 10 \, pF \) (to cancel the effects of input capacitance). This results in a purely resistive feedback factor, as defined by Eq. 3. From Eq. 3, a solution for \( \mathcal{H} \) yields a figure of \( \frac{1}{2} \), or \(-6 \, \text{dB}\). The loop gain \( (\mathcal{G}\mathcal{H}) \) can be derived from Fig. 2 if we adjust the open-loop gain curve \( (\mathcal{G}) \) by \(-6 \, \text{dB}\).

The graph is plotted as follows:
1. Plot both gain and phase of the \( \mathcal{G}\mathcal{H} \) function on semi-log paper. Add the poles and zeros of \( \mathcal{H} \) to the manufacturer's open-loop gain and phase curves. In our example, the feedback factor is resistive; when the open-loop gain curve is adjusted downward by \(-6 \, \text{dB}\), the values in Table 1 result.

### Table 1. Basic gain and phase

<table>
<thead>
<tr>
<th>( f(\text{MHz}) )</th>
<th>( \mathcal{G}\mathcal{H} , (\text{dB}) )</th>
<th>( \mathcal{G}\mathcal{H} , (\text{degrees}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33</td>
<td>-132</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>-120</td>
</tr>
<tr>
<td>4</td>
<td>21</td>
<td>-114</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>-114</td>
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<tr>
<td>10</td>
<td>12</td>
<td>-120</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
<td>-128</td>
</tr>
<tr>
<td>17</td>
<td>5</td>
<td>-132</td>
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<tr>
<td>20</td>
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<td>-137</td>
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<tr>
<td>25</td>
<td>0</td>
<td>-142</td>
</tr>
<tr>
<td>30</td>
<td>-2</td>
<td>-148</td>
</tr>
<tr>
<td>38</td>
<td>-5</td>
<td>-155</td>
</tr>
<tr>
<td>42</td>
<td>-7</td>
<td>-160</td>
</tr>
</tbody>
</table>

### Table 2. Gain and phase from the chart

<table>
<thead>
<tr>
<th>( f(\text{MHz}) )</th>
<th>( \frac{\mathcal{G}\mathcal{H}}{1+\mathcal{G}\mathcal{H}} , (\text{dB}) )</th>
<th>( \frac{\mathcal{G}\mathcal{H}}{1+\mathcal{G}\mathcal{H}} , (\text{degrees}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.14</td>
<td>-1</td>
</tr>
<tr>
<td>2</td>
<td>0.22</td>
<td>-2.5</td>
</tr>
<tr>
<td>4</td>
<td>0.3</td>
<td>-5</td>
</tr>
<tr>
<td>6</td>
<td>0.45</td>
<td>-8</td>
</tr>
<tr>
<td>10</td>
<td>0.7</td>
<td>-15</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>-30</td>
</tr>
<tr>
<td>17</td>
<td>2.3</td>
<td>-35</td>
</tr>
<tr>
<td>20</td>
<td>3.2</td>
<td>-45</td>
</tr>
<tr>
<td>25</td>
<td>4.0</td>
<td>-70</td>
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<tr>
<td>30</td>
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<tr>
<td>38</td>
<td>0</td>
<td>-130</td>
</tr>
<tr>
<td>42</td>
<td>-2.5</td>
<td>-145</td>
</tr>
</tbody>
</table>
3. A plot of function $GH/(1+GH)$ on the Nichols Chart. The curve defines performance of the amplifier under unity-gain, maximum-bandwidth conditions. The amplifier used is Harris’ HA-2530 op amp.
Table 3. Predicted vs actual response

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Calculated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth (0 dB) — MHz</td>
<td>29</td>
<td>31</td>
</tr>
<tr>
<td>Closed-loop phase margin — deg.</td>
<td>39</td>
<td>42</td>
</tr>
<tr>
<td>Peaking — dB</td>
<td>2.3</td>
<td>2</td>
</tr>
</tbody>
</table>

4. Closed-loop response at unity gain is plotted for an op amp with this feedback configuration. Note that feedback is considered resistive.

2. Transfer gain and phase points to the rectangular coordinates of the Nichols Chart.

3. Pick gain and phase of the function $\frac{GH}{(1+GH)}$ at the selected data points on the chart. The results are shown in Table 2.

4. Transfer these points to semi-log paper and construct the $\frac{GH}{(1+GH)}$ curve as shown in Fig. 5.

5. Add $\frac{Z_f}{Z_1}$ or the pole defined by $\frac{1}{1+SR_fC_f}$ in this case. At this point, the complete closed-loop expression (Eq. 5) has been graphically determined and is shown as $\frac{E_o}{E_i}$ CALC in Fig. 5.

6. Read bandwidth, peaking and closed-loop phase margin directly from Fig. 5.

A comparison of lab data with the calculated results reveals very close agreement (Table 3).

Though the results define the performance of the amplifier under unity gain, maximum-bandwidth conditions, performance at other gains can be interpolated from the Nichols Chart. Construct a tracing paper template of the unity curve already drawn on the chart. Gain change is determined by shifting this curve up or down the vertical axis. Increased gain corresponds to moving the curve down an amount proportional to $H$ in decibels.

The technique works for inverting op amps, too. Move the template curve by an amount equal to $20 \log \left[ \frac{R_f}{(R_f + R_p)} \right] + 6$ dB. Note that for inverting op amps, the curve is already shifted by 6 dB due to the equal voltage division of feedback and input resistors. For example, to read out a 20-dB gain, shift the curve by approximately $-14$ dB; the $\frac{GH}{(1+GH)}$ data points are obtained directly.

For the complete closed-loop response (Eq. 5), remember to add the poles and zeros of $\frac{Z_f}{Z_1}$ as a final step. In our example, $C_f$ equals $0.1 C_i$, or 1 pF for pole-zero cancellation of the feedback factor. But with $R_f = 500 \Omega$, the pole frequency $(s = \frac{1}{R_fC_f})$ or $\frac{Z_f}{Z_1}$ occurs well beyond the amplifier bandwidth and would not contribute to any degradation in frequency response. Therefore, for computing gains of 10 or more, the procedure is simplified. Correct each $\frac{GH}{(1+GH)}$ point by $20 \log \left( \frac{R_p}{R_i} \right)$ to get complete closed-loop information directly from the chart.

Reference

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**Printer control:** a minor task for a fast microprocessor. An interrupt-driven approach frees the processor for other tasks and saves hardware.

The second generation of fast microprocessor units (MPUs) easily controls high-speed printers. And with lower-speed printers—such as those used for terminals—microprocessors can perform additional tasks: They can operate displays, store information on tape or disc and do arithmetic calculations.

An interrupt-driven approach frees the processor for other jobs and saves hardware. In applications like transaction terminals, control of the printer involves a small percentage of the processor's time (Fig. 1). Use of a microprocessor also allows a designer to reduce a relatively complex system to a few manageable tasks. Service routines can be developed for the various peripherals, and a suitable executive control program can tie the system together.

**Define the problem**

A specific microprocessor system that includes a simple drum printer will show how to define and tackle the tasks associated with the printer. The printer selected, a Seiko AN-101F, uses a continuously rotating drum (Fig. 2a). Actuation of the trigger magnet causes the hammer to strike the paper through the inked ribbon and to print a character.

Any of 42 alphanumeric characters plus the special characters *, $, ”, ', . and / can be printed in 21-column format. Each column position has a complete character set spaced evenly around the drum. A given character appears once during every revolution of the drum and is the same for all column positions. The hammers operate in parallel. All column positions that have the same letter must therefore have the corresponding lines (trigger magnets) armed simultaneously.

The control circuitry must also actuate the hammers at the right instant if printing is to occur. Timing signals are generated by detection heads and ferrite magnets associated with the ratchet shaft and drum.

The ratchet shaft rotates 42 times to each rotation of the drum and generates signals TP and TL for each character (Fig. 2b). TP defines the time for energization of the trigger magnets and TL de-energizes. The reset signal R is generated on a separate line, once for each rotation of the drum, and denotes completion of the line (Fig. 2c).

The designer must decide on an optimal trade-off between external circuitry and MPU use.

In this case, the printer manufacturer provides a suggested controller design that can be implemented with 16 to 20 SSI and MSI circuits (without magnet-drive circuitry). With this approach the processor only monitors status and

Al Moore, Manager Microprocessor Applications and Mark Eidson, Applications Engineer, Motorola Semiconductor Products, 5005 E. McDowell Rd., Phoenix, AZ 85008.
transfers bytes of data at the proper time.

At the other extreme, the processor could assume as much of the control function as possible and eliminate external circuits. If over-all system timing allows, this is usually the most cost-effective approach.

An alternate approach is to use interface circuits provided by the microprocessor manufacturer. Sometimes these devices let you handle a wide variety of equipment with minimal additional logic and simple programming. For example, Motorola's MC6820 peripheral interface adapter (PIA) mediates between the processor and various external devices. To the processor, the unit appears as six memory locations that can be addressed in the same manner as main memory (Fig. 3). To the external devices, the unit provides a separate 8-bit bidirectional data bus along with two control lines for each of two peripherals.

Internally the PIA is divided into two symmetrical but independent register configurations. Each half contains an output register, control register and data-direction register (Fig. 4).

Individual bits in the data direction registers set the corresponding peripheral data lines to be either input or output. The control registers affect the operation of the four peripheral control lines and determine which registers can be selected by the processor. Bit b, in either register A or B masks (blocks) interrupt signals IRQA and IRQB, respectively. Bit b, determines which transition (high-to-low or low-to-high) of CA1 (CB1) sets the interrupt flag and generates an interrupt request (IRQ) to the processor.

The register has two interrupt request flags or bits that can be set by transitions on the CA1(CB1) and CA2(CB2) control lines and read by an MPU Read Control Register operation. The status of the interrupt flags cannot be altered by an MPU write instruction. They are reset indirectly to zero each time the MPU reads the corresponding Output Register or can be cleared with the hardware Reset.

When b = 0, b, and b, of the Control Register perform similar functions to b, and b, for control of the interrupt bits via the CA2(CB2) input. When enabled, the IRQA (B) external interrupt responds to either b, or b,. Bits b, and b, are set, respectively, by lines CA1(CB1) and CA2(CB2), and the bits are also named IRQA1 (IRQB1) and IRQA2 (IRQB2).

If b = 1, CA2(CB2) acts as an output and will function in one of three modes. If b is also equal to 1, CA2(CB2) serves as a program-controlled set reset output to the peripheral and follows b,
3. **Peripheral interface units** are addressed by the processor in the same way as memory locations. They provide convenient control and data signals for use with the peripherals and can signal the processor via the common interrupt line when asynchronous operation is needed between processor and peripheral.

4. The **peripheral side of the PIA** includes two 8-bit bidirectional data busses and four interrupt/control lines. The PIA permits data transfer between the processor bus and peripheral data busses. And the processor can read or write into either set of registers. The PIA also provides handshake control logic.
as it is changed by the MPU Write Control Register operations.

If \( b_1 = 0 \) when \( b_0 = 1 \), CA2 (CB2) can be used in either a pulse-strobed or handshake mode. Operation of the two sections differ slightly for these two operating modes.

In the handshake mode \( (b_1 = 0) \), CA2 is taken low by the negative transition of the MPU Enable Pulse after an MPU Read Output Register operation. And CA2 returns high when IRQA1 is set next by CA1. This, in effect, "tells" the peripheral that it has been read and allows it to acknowledge via CA1. The "B" side operation is similar, except that CB2 is taken low after an MPU Write Output Register operation and returned high by the next CB1 transition. This tells the peripheral that data have been written into it and that it can respond via CB1.

In the pulse-strobed mode \( (b_1 = 1) \), CA2 is set low again by a Read Output Register command but is now returned high by the next MPU-originated Enable Pulse. The CB2 operation is similar, except that an MPU Write Operation initiates the pulse. The Enable pulse is generated by ANDing the Valid Memory Address signal (labeled VMA) line with phase two of the clock.

The output registers, when addressed, store data present on the processor data bus during a write operation. These data will also appear on the peripheral lines that have been programmed as outputs. If a peripheral line is serving as an input, the corresponding bit position of the output register can be written into by the processor. However, the data will not appear on the peripheral data line. During a processor Read operation, the data present on the peripheral lines are transferred directly to the processor's data bus.

The data-direction registers and control registers are programmable from the processor. Lines RS0 and RS1 (connected to the processor's address bus) select the register, and data are transferred through the 8-bit data bus (D0 to D7).

With this scheme, control registers A and B are selected unequivocally; and the interface registers are selected in accordance with the data on RS0 and RS1, as well as the contents of control-register bit two.

**Assign one line to a print column**

Use of the PIA still requires some hardware judgments. If—as in this sample case—you want to print 16 columns, you could build an external 1-of-16 decoder and use four PIA data lines.

However, since you have all 16 data lines, you can assign one to each print column. If there had been only four spare lines in the system, the decoder approach might warrant further consideration.

As a further tradeoff, consider what happens if you use all 21 columns of the AN-101F. Then the designer might choose between five extra PIA lines as opposed to an external 5-bit shift register.

The final design objectives are these:

- To minimize use of external electronics (other than the PIA).
- To use only timing signals from the printer without modifications other than pulse shaping.
- To reduce the time in which the MPU must be involved with printer control activity.

Each hammer driver is controlled by one of the PIA's 16 data lines. These lines are the outputs of registers ORA and ORB in the PIA, which are regarded as memory locations by the MPU. Hence the MPU can enable the activation of a particular column hammer by setting the appropriate bit position in the memory locations assigned to ORA and ORB (Fig. 5).

During initialization, CB2 is established as an output and is used by the MPU to strobe the enabled hammer drivers at the proper time. At the end of a print cycle, the printer's paper and ribbon must be advanced. This requires a 36-ms pulse. A control program generates the pulse and applies it through CA2, which has been established as an output during initialization.

After being shaped and inverted by the MC3302 comparators, the printer timing and reset pulses are applied to the CB1 and CA1 inputs, respectively. By means of these signals and the MC6800 interrupt structure, the printer "tells" the MPU that it requires servicing. Part of the printer control program's function is to establish suitable interrupt modes through use of the PIA Control Registers.

For example, in the following control sequence, negative transitions on the CB1 timing input during a print cycle must initiate service to the printer by the MPU. The MPU sets this up by writing \( b_1 = 1 \) and \( b_0 = 0 \) into Control Register B during processing. For subsequent timing transitions, the PIA issues an Interrupt Request to the MPU via the system IRQ line.

The MPU responds by interrupting its current activity (the MPU's internal registers are saved on a "stack" so that the task may be resumed later). The processor fetches the starting address of an executive service routine from a memory location permanently assigned to the Interrupt Request. The service routine directs the MPU to poll its peripherals: it tests the flag bits in the PIA Control Registers to see which needs servicing. Flag bit \( b_0 \) of the printer PIA's control register is set by the same transition that caused the interrupt. When the MPU finds this flag set, it jumps out of the polling routine to an appropriate printer control program.

The basic task, or algorithm, of the control program is to examine the text of the message to
be printed and make sure that the appropriate bits in the PIA's output registers, ORA and ORB, are set at the proper time.

Inform the MPU of the character position

The time for one print-drum rotation is divided into 42 intervals, \( t_n \) through \( t_{n+1} \). All similar characters in the text are printed simultaneously; that is, all 0s are printed during \( t_n \); all 1s during \( t_n \), etc. For example, if the text requires the letter C in columns 3 and 9, column hammers 3 and 9 must be engaged during the time interval \( t_n \) in which all Cs are under the hammers.

After each TL interrupt, the MPU examines the entire message to see if there are any characters to be printed during the next time interval. The text to be printed may be either a "canned" message stored in ROM or variable information generated by the executive program and stored in RAM. Messages are stored in memory in 16-byte blocks, with each memory position corresponding to a printer column position. Prior to calling the printer, the executive program loads the starting address of the message to be printed into a buffer. The printer routine then uses this address in conjunction with the MPU's indexed addressing mode to locate the desired message. This technique permits use of the same subroutine for all of the system printer requirements.

A 42-byte Character File, corresponding to the printer's character set, is stored in a ROM in the same sequence as it appears on the printer drum. As each TL interrupt is serviced, the Character File pointer is incremented and points to the address of the next character on the drum.

The MPU then compares every character of the text with the current Character File character and keeps a running column count. Each bit position in the PIA Output Registers is set or cleared, depending on whether or not the respective text with the current Character File character.

The flow charts and control programs that result are shown in Figs. 6 and 7. The control problem is divided into four tasks: (1) Initialization; (2) Printer Enable; (3) Reset Service Routine; (4) Print Service Routine.

The Initialization routine, PKIPRT, defines the housekeeping tasks that are done routinely by the executive program during system power-up.

Lines 300 and 310 (see program listing) clear CRA and CRB (XPICRA, XPICRB) and set \( b_0 = 0 \), so DDRA and DDRB can be addressed. Lines 320 to 350 store ones in all of the DDR bits that define the 16 data lines of ORA and ORB as outputs. Lines 360 to 380 load the control registers with the hexadecimal (HEX) value \( 3C \), which gives them the bit configuration shown:

\[
\begin{array}{cccccccc}
\text{CRA} & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\
\text{CRB} & b_7 & b_6 & b_5 & b_4 & b_3 & b_2 & b_1 \\
\end{array}
\]

3
where

\[ b_0 = 0 \] IRQ interrupts are disabled.

\[ b_0 = 0 \] CA1, CB1 are established as negative edge-sensitive inputs.

\[ b_1 = 1 \] ORA, ORB are now selected.

\[ b_1 = 1 \] CA2, CB2 are established as outputs

\[ b_1 = 1 \] that follow \( b_1 \); they are now high.

\[ b_1 = 1 \]

With CA2 and CB2 high, all the driver circuits are disabled, since one input of each driver AND gate is held low (Fig. 5). CA2 and CB2 are inverted before they reach the AND gates.

Lines 390 and 400 are “dummy reads” of ORA and ORB, which clear the IRQ flags that may have been set and ensure that the IRQA (B) lines are high; that is, inactive. Line 410 returns control to the executive program.

The Printer Enable routine, PKNTRL, is called by the executive program whenever a line of text is to be printed (Fig. 6b).

Since the printer drum continuously generates reset pulses at CA1, the IRQA flag will be set. But the IRQA line will be inactive (it was disabled during initialization when the MPU set \( b_0 = 0 \)). To ensure that the next reset pulse starts the print cycle instead of the CA1 interrupt enable, the IRQA flag is cleared by a dummy read of ORA (XPIICRA) before CA1 is enabled (lines 490 to 510).

The “printer done” flag (#$29) is cleared by another service routine before it returns to the main program. Subsequent interrupts generated by the printer will cause the line of text to be printed, and further control by the executive program is unnecessary.

When the CA1 input is triggered by the printer reset pulse, the MPU interrupt sequence directs processing control to the PRNTIR routine (Figure 6c). Since the IRQA flag and line are active, they must be disabled before the processor exits from the routine, to allow further interrupts. Line 590 reads ORA (XPIORA) to accomplish this as the first instruction.

Lines 600 to 620 test \( b_i \) of CRA to determine whether the CA1 input was positive or negative edge sensitive:

- If \( b_i = 0 \), then the CA1 input was a negative transition, and the program branches to PKSCN1. Lines 780 and 790 set CRA to 3C, as in the Initialization routine, to disable the CA1 interrupt input. The starting address of the printer character file PKCF00 is stored by lines 800 to 810 for use during the first scan loop. Lines 820 to 840 clear the previous time interrupts and set CRB to allow the next negative CB1 transition to interrupt the MPU. The RTI instruction at line 850 returns the MPU to the status at the time the interrupt occurred and the program execution resumes.

- If \( b_i = 1 \), CA1 was positive, signaling the

6. The control problem is broken into four tasks: Initialization (a), Printer Enable (b), Reset Service (c) and Print Service (d). The initialization routine defines housekeeping tasks. PKNTRL is called by the executive when a line is to be printed and enables reset interrupts from the printer PIA. PRNTIR is used at the beginning and end of a print cycle (line print and paper feed). PRNTIT selects the proper hammers.
7. Each bit position in the PIA registers is set or cleared by PKSCAN depending on whether or not the text character seen at the printer end of the printing cycle. The routine disables the hammer stroke CB2 with lines 630 and 640 by setting CRB to 3C (b₃ = 1). The next two lines store 34 in CRA, which clears b₁ and makes CA2 go low. A delay loop is generated with lines 670 to 720. Accumulators A and B are loaded with the values 48 and 92, respectively. Accumulator B is decremented 92 times (to zero) each time Accumulator A is decremented once. When Accumulator A is zero (~36 ms), the program jumps out of the delay loop. And the program stops the paper ribbon feed by loading CRA with 3C (b₂ = 1), which makes CA2 go high. The delay-loop accumulator values depend on the system clock frequency—in this case ~875 kHz.

The printer done flag (#$29) is then set by a jump to another service subroutine before the MPU is returned to the program flow where the interrupt occurred.

Printer operation is asynchronous

The printer timing signals are asynchronous with respect to the MPU clock. Hence if the printer interrupt is enabled immediately following an interrupt, it could take nearly two full print drum rotations, or approximately 1.5 s, to print a line of text. This is a relatively long period for MPU processing time. If the printer requires continuous control during this period, it would be impractical in many applications. Fortunately the printer signals may be used to interrupt the MPU briefly while it is performing other tasks. This interrupt-driven approach will be clarified as more of the control program is described.

The printer-interrupt service routines are designed for the MPU to resume other system tasks shortly after each printer interrupt is serviced. The relationship between the printer signals and MPU activity is shown in Fig. 8. The approximate time during which the MPU is busy servicing the printer is indicated by the cross-hatched area that follows each allowed interrupt. Use of this interrupt-driven approach involves intervention by the MPU for less than 30 ms out of each 850 ms print cycle.

Program loop selects the hammers

The majority of the time is used during the Print Service routine, PRNTIT. Printer operation requires that the selected print hammers be engaged only during the time between TPₙ and TLₙ. The PRNTIT routine selects the hammers that are required during a given interval and causes them to engage and disengage at the required times. Most of the processor time (approximately 0.6 ms following each TL pulse) is spent determining which hammers should be engaged during the next interval.

In Fig. 8, TLₙ will be the first CB1 transition after PRNTIR has enabled CB1 to be negative-edge sensitive. TLₙ₁ will cause the IRQB line to go low and therefore interrupt the MPU in the same way as before. The exception, this time, is that the IRQB flag is set by CB1. The interrupt sequence will jump to PRNTIT (Fig. 6c) instead of PRNTIR.

Again, the first thing is to have the processor clear the IRQB flag and the IRQ line by reading ORB (XPIDRB). Then lines 910 to 940 test b₁ of register CRB to determine whether the CB1 input to the PIA was positive or negative-edge
sensitive, as follows:

- If $b_1 = 0$, CB1 was a negative transition. The program branches to PKSCN2 (line 1030), which loads the index register with the current character file (CF) address pointer. The scan loop follows and will be described further on (Fig. 7).
- If $b_1 = 1$, CB1 was a positive transition; namely, a TP timing pulse. This means that the hammers must now be strobed. Before this is done, the CA1 is enabled (lines 950 to 970) to allow the next positive reset transition at CA1 to signal the end of the print cycle. The hammer strobe is then armed to be set low on the next Write in ORB by having the processor store #$25 in CRB (lines 980 and 990). This combination of $b_1$, $b_2$, and $b_3$ also returns CB2 high on the next CB1 interrupt at TL. The eight data bits set by the previous scan loop for the B side outputs are then stored in ORB (lines 1000 and 1010), causing CB2 to go low. The strobe inputs on the driver AND gates go high and activate the hammer whose data lines have been set high. Line 1020 returns control to where the interrupt occurred.

The scan loop, PKSCAN, is the actual data-processing section of the program. The column counter (Accumulator B) is cleared and the current character-file character stored in the test buffer (lines 1080 to 1100). The next character-file character address is then stored (lines 1110 to 1120) to initialize the next loop. The first text character address is loaded into the index register before the start of the scanning process.

The first instruction (see table) in the actual loop (line 1140) compares the column count with #$10 (decimal 16) to see if the last character of text has been checked. If it has, the program enables an interrupt by the next positive timing-pulse transition (lines 1160 to 1170) and returns control to the executive program. If the last text character has not been tested, the program branches to PVNXT1. Line 1190 loads accumulator A (ACCA) with the text character corresponding to the present column counter value. The next two lines determine which output register is to be written into. If the column count is $\geq 8$, it will be ORA; if $< 8$, ORB. The text character previously stored in ACCA is compared with the current character file (CF) character (lines 1220 to 1280 for ORB; lines 1290 to 1340 for ORA). The carry bit is set if both are equal; it is cleared if they are not. The carry is then shifted into the ORA or the ORB buffer with the ROL instructions on line 1270 for side B and line 1340 for side A (since a Write into ORB is required to activate CB2, the data are stored in a buffer until the time for hammer activation).

When the shift has been completed, the column counter and text address pointers are incremented (lines 1350 and 1360). Then a branch is executed to the start of the loop.

This control operation might appear slow and cumbersome. However, during an actual print operation, less than 4% (30 ms out of 850 ms) of the MPU's capability is really used.

Combined with the fact that only 20 conven-
### Processor instruction set and organization

**Programmable Registers:**
- Accumulator A: 8 bits
- Accumulator B: 8 bits
- Index Register: 16 bits
- Program Counter: 16 bits
- Stack Pointer: 16 bits
- Condition Codes Register: 6 bits

#### Instructions:
- **ABA**: Add accumulators
- **ADC**: Add with carry
- **ADD**: Add
- **AND**: Logical and
- **ASL**: Arithmetic shift left
- **BCC**: Branch if carry clear
- **BCS**: Branch if carry set
- **BEQ**: Branch if equal to zero
- **BGE**: Branch if greater or equal zero
- **BGT**: Branch if greater than zero
- **BHI**: Branch if higher
- **BIT**: Bit test
- **BLE**: Branch if less or equal
- **BLS**: Branch if lower or same
- **BLT**: Branch if less than zero
- **BMI**: Branch if minus
- **BNE**: Branch if not equal to zero
- **BPL**: Branch if plus
- **BRA**: Branch always
- **BSR**: Branch to subroutine
- **BVC**: Branch if overflow clear
- **BVS**: Branch if overflow set
- **CBA**: Compare accumulators
- **CLC**: Clear carry
- **CLI**: Clear interrupt mask
- **CLR**: Clear
- **CLV**: Clear overflow
- **CMP**: Compare
- **COM**: Complement
- **CPE**: Compare index register
- **DAA**: Decimal adjust
- **DEC**: Decrement
- **DES**: Decrement stack pointer
- **DEX**: Decrement index register
- **EOR**: Exclusive or
- **INC**: Increment
- **INS**: Increment stack pointer
- **INX**: Increment index register
- **JMP**: Jump
- **JSR**: Jump to subroutine
- **LDA**: Load accumulator
- **LDS**: Load stack pointer
- **LDX**: Load index register
- **LSR**: Logical shift right
- **NOP**: No operation
- **ORA**: Inclusive or accumulator
- **PSH**: Push data
- **PUL**: Pull data
- **ROL**: Rotate left
- **ROR**: Rotate right
- **RTI**: Return from interrupt
- **RTS**: Return from subroutine
- **SBA**: Subtract accumulators
- **SBC**: Subtract with carry
- **SEC**: Set carry
- **SEI**: Set interrupt mask
- **SEV**: Set overflow
- **STA**: Store accumulator
- **STS**: Store stack register
- **STX**: Store index register
- **SUB**: Subtract
- **SWI**: Software interrupt
- **TAB**: Transfer accumulators
- **TAP**: Transfer accumulators to condition code reg.
- **TBA**: Transfer accumulators
- **TBA**: Transfer condition code reg. to accumulator
- **TST**: Test
- **TSX**: Transfer stack pointer to index register
- **TXS**: Transfer index register to stack pointer
- **WAI**: Wait for interrupt

---

**Notes:**
- Electronic Design 25, December 6, 1974
Microprocessor coding for printer control

Assembly listing fields

PKIPRT

Assembly listing

PKNTRL

PKNIT

PKSCAN

a minimum of additional expense in hardware (200 bytes of ROM) and engineering development time. In addition many of the chips in the example are alternate-sourced. American Microsys-tems (Santa Clara, CA) plans to alternate-source Motorola's MC6800 family by early 1975.

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Manufacturers listed in boldface in the second sub-group have provided catalog pages, but not for the specific product heading the list.

In a constantly moving industry, these measures of verification are of course subject to change. Yet they can be helpful guides as you seek out potential suppliers.

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'Meet' the applicant before talking to him.
Prepare for those in-depth job interviews by learning how to study the engineer through his resume.

Hiring an engineer happens to be one of the most important and difficult challenges a manager is likely to face; yet few managers know how to interview applicants in the depth that's required to get qualified staffers.

In selecting many engineers over a period of years, I've learned that the future isn't in the job, unless it's in the man. This means that the interviewer must not only study the candidate during the interview, but also through his resume and get to know him as well as possible before interviewing him in person.

Getting to know you

Questions I ask myself when I look at a resume are:
- **What is the applicant's relevant experience?** I remember one time I hired an engineer with a Ph.D. in electronic engineering to design circuits, and he was useless. He had eight years of schooling and four years of theoretical engineering, and he just couldn't make anything work. Moral? Pay particular attention to the theoretical-vs-practical experience ratio; this ratio must be compatible with the requirements of the position. The only exception is hiring someone with long-term potential.
- **Is his current salary compatible with his experience level?** If I talk to an engineer who has been out of school four years and who's making $22,000, I tend to think that he has missed his calling; maybe he's a better politician than he is an engineer. It could be he worked for a company with a fat Government contract that needed a high-priced guy to fulfill the contract and they jacked up his salary to fill the breech. I think a graduate designer pulls down about $12 k in a small company and about $13 k in a large company. A good circuit designer with eight years of experience should get between $18,000 and $20,000 a year.
- **Does the resume reflect an ability to communicate ideas?** When I read a resume that says that Joe Engineer "was instrumental in helping the engineering department achieve growth quotas," I still don't know what he did. A good resume is the one that makes me feel I've actually talked to the guy after I've read it.
- **Is the resume too "slick"?** Does it look like it may have been prepared by a professional resume writer or that the candidate is attempting to oversell himself? If the typing is perfect and the English is flawless and full of industry cliches, I suspect that the applicant hired a professional to write his resume. If the engineer is a good prospect, I'll call him and talk to him for awhile. If he can write that well, he should be able to articulate as well verbally. Even if he didn't write his own resume, I wouldn't reject him automatically. Engineers, like everyone else, can accept poor advice.
- **What is the average length of time of his employment with current and former employers?** According to a Government manpower study, the ideal length of service is two to seven years. A shorter period than two years tends to indicate a lack of ability to identify with an organization and its objectives. Periods in excess of seven years show a lack of ambition and drive. The average tenure for electronic engineers is about three years nationwide.

This rule of two to seven years should be used with great care; many a good engineer has changed positions more often than every two years because of circumstances beyond his control. One could say, I suppose, that if the engineer repeatedly falls into situations that don't work out, that his judgment is suspect.
- **Is the applicant's educational background commensurate with experience and the new position?** A Ph.D. in theoretical physics is about as unrelated to circuit design as is a Ph.D. in history. There are exceptions to this rule; the best circuit designer I ever met was self-taught.

The protocol of buying and selling

A well-conducted personal interview is the clincher in the successful acquisition of engineers.
Alan Rider is one of those engineers who has involved himself in more than engineering during his career. He has spent much of his time designing and inventing, but he has also been a manager, a manufacturer’s rep and a company founder—twice.

Before he came out of his engineering cocoon, he’d spent five years at a Naval research laboratory designing instrumentation for basic underwater sound studies, and another two years developing and producing optical character readers at Control Data. Then he went into management working as an engineering supervisor at NAVCOR, where he was responsible for the development of special proposals of analog and digital systems, plus product development of analog and digital systems, and product development of analog-to-digital converters and function modules. Later, Acuity Systems Corp. hired him as V.P. of Engineering and there he invented and developed an automatic eye refraction device to aid doctors in preparing eye glass prescriptions. At one point along the line, Rider also worked as a manufacturer’s representative. For three years he sold electronic system components, magnetic tapes and core memories.

To develop low-cost optical recognition terminal equipment he founded Recognition Terminals, Inc. Now he has formed the Reston Consulting Group that specializes in engineering management consulting, management training, management studies, documentation systems and production engineering.

Rider is married, has two children, and when asked if he has a hobby, answers, “any man who owns a house these days can keep himself busy mowing the grass, fixing the plumbing, and so on. without looking for any other extracurricular activity.”
The objective, of course, is to gain enough information about the candidate to ensure an accurate prediction of his ability to fulfill the requirements of the position.

Many people conducting an interview don't act in a manner consistent with that objective. The protocol of the employee-selection process calls for the potential employer to assume first the role of seller and the candidates that of buyer. This is the advertising and initial contact phase. Upon selection of one or more potential candidates, the roles reverse; the candidates become the sellers, and they must sell themselves. When a candidate is chosen, the roles reverse again; the company must sell him on joining the staff.

A thorough understanding of this protocol is important. Too often the interviewer is impressed with the applicant's credentials, or he has an urgent engineering need and assumes the seller's role during the interview. The end result is that the interviewer has not learned enough about the applicant to make a wise prediction.

If you have done a super job of interviewing the candidates and then made a wise choice, you probably won't have to sell your choice on joining you—your competence will already have done the job.

Let the applicant do the talking

I always make it clear to the applicant that the purpose of the interview is to learn a great deal about him and that he is to do 80% of the talking. The interviewer is not learning anything about the candidate while he himself is talking. Usually in this situation, he is selling when he shouldn't be.

Having an interview is a traumatic experience for most people, and as we are discussing the hiring of engineers, and not politicians, who must be able to react quickly under pressure, some effort must be made to relax the applicant. I generally provide him with a soft drink or a cup of coffee and engage him in small talk for a few minutes.

In addition I explain that it is our policy to have all likely candidates visit the company at least twice. This helps relieve some of the pressure on both parties. The applicant knows that the one interview is not an all-or-nothing affair, and the interviewer has a longer time to choose his candidate.

Next, I explain to the applicant that I consider his knowledge to be a set of "N" vectors and that I am interested in the magnitude of those pertinent to the position to be filled. A list of pertinent vectors and their relative magnitudes must be prepared beforehand and used as a guide throughout the interview. Obviously the basis for this list is the position description.

Every engineer must understand thoroughly and use with facility the basic tools of his trade. Logic designers must know Boolean algebra, minimization methods, NAND logic and asynchronous circuits. Circuit designers must know time-and-frequency-domain analysis and passive- and-active-circuit analysis. Each must be familiar with the basic components used by his specialty and also with device parameters and what companies manufacture them.

In search of knowledge

I conduct interviews with the "N" vectors concept in mind. To learn the magnitude of the knowledge vector, I start off by querying at a level that I believe anyone with the applicant's experience should be able to cope with. Then I ask increasingly difficult questions in search of the magnitude of his knowledge.

With a little skill in this technique, you will find that there need not be a progression of increasingly difficult questions. Rather, depending upon the ease with which the first question was answered, you can often jump ahead. Occasionally you will go too far and then you have to backtrack. The object is to determine the magnitude of the candidate's knowledge.

Some attempt to determine the applicant's relevant aptitudes should be made. Unfortunately engineering schools graduate many men and women who have little aptitude for engineering and who will never be successful engineers.

Most engineers generally do some maintenance on their cars and home appliances. They are not satisfied with the workmanship performed by tradesmen. In addition the engineer interested in his profession will faithfully read trade journals in depth.

Two of the major reasons why engineers turn down job offers are these: (1) Lack of understanding of the responsibilities, and (2) Lack of understanding of exactly what will be expected of them. Both of these unknowns generate a subconscious fear.

To help ensure that the good candidate will join your company, give him a copy of the job description and a professional critique of his knowledge vectors as they relate to the position. Emphasize the strong points he will bring to the position and how the job will help him on his weak points. The critique enables the applicant to understand your expectation level as he relates to the position. ■■
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Two BCD numbers are added in IC₁, as if they were binary, and the sum is checked by the add-six circuit. If the sum is less than 10, the output from the add-six circuit is a ZERO. If the sum is greater than or equal to 10, a six is added into IC₁. Thus, for sums that are greater than nine, the result is advanced by six, and a carry to the next decade is produced.

For example, if BCD numbers 0101 and 0111, or 5 and 7, are added, the result is 1100, or 12. Since this result is greater than nine, a six is added, and the resulting 10010, or 12 in binary, becomes a one carry with a weight of 10 and 0010, or 2. This translates to 12 in BCD.

The basic circuit is shown in Fig. 1a. A variation of the add-six gating circuit is in Fig. 1b. Other such gating circuits can be devised from the available gates to achieve the necessary logic.

This circuit can also be used to convert a 4-bit binary number to BCD. In this case the first 4-bit adder, IC₁, is not needed, and the C₀ input to the add-six circuit also is eliminated.

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<td>135.00</td>
<td>DB15-50</td>
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</tbody>
</table>

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Up/down counter controls pulse width of a one-shot

The pulse width of a monostable multivibrator can be controlled by numerical data. Applications for such a circuit include the following:
- Variable time delay.
- Display intensity modulator.
- PCM generator.
- Sample-and-hold gate time modulator.

Let's examine a conventional TTL one-shot (Fig. 1). If gate G, turns ON when V_g decreases below 1.6 V, the circuit's pulse width is \( T = 0.66 \times RC \). Thus the period of the monostable can be changed by a variation of resistance R.

However, the allowed change in resistance of R, and hence the change in pulse width, is small. Resistor R must be greater than 200 \( \Omega \) to prevent the overloading of G, and less than 1000 \( \Omega \) to keep G, OFF when no trigger input is present. The low resistance limit can be reduced to below 20 \( \Omega \) by the addition of an emitter follower to the output of G, (Fig. 2).

Control of the multivibrator's pulse width is achieved by use of a 7442 decoder, which selects one-out-of-10 diode-resistor pairs. The pulse width is then a function of the BCD input to the decoder. This BCD number is derived from the number stored in the counter.

The pulse width, after second-order effects are taken into account, is given by:

\[ T = 0.59 \left( \frac{n+1}{R-30} \right) C, \]

where n equals the number stored in the counter. The 74192 counter allows you to parallel load this BCD number to select the desired pulse width. The counter can count up or down in single steps via its clock input.

The addition of a second emitter follower at the input of G, would allow an increase of the upper resistance limit to well beyond 1000 \( \Omega \) and thus a much wider range of pulse-width control.

Dr. Robert Mauro, Assistant Professor of Electrical Engineering, Electrical Engineering Dept., Manhattan College, Bronx, NY 10471.

CIRCLE NO. 312

1. The pulse width of this conventional one-shot is determined primarily by the RC time constant.

2. The range of pulse widths of the variable-width one-shot is increased to 10:1 by the emitter-follower circuit at the G, output. Another follower at the G, input would extend this range.
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GUARANTEED MIN/MAX SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>monoOP-07AJ</th>
<th>monoOP-07J</th>
<th>monoOP-07EJ</th>
<th>monoOP-07CJ</th>
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<td>110</td>
<td>110</td>
<td>106</td>
<td>100</td>
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<tr>
<td>Price @ 100 Pcs. (TO-99)</td>
<td>$60.00</td>
<td>$25.00</td>
<td>$15.00</td>
<td>$9.95</td>
</tr>
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</table>

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INFORMATION RETRIEVAL NUMBER 36  
Electronic Design 25. December 6, 1974  
95
Voltage-tunable active filter features low, high and bandpass modes

You can build a voltage-tunable filter with low-pass, high-pass or bandpass characteristics and variable Q. Just four discrete general-purpose transistors and a few other discrete components are required. The circuit can tune across the whole audio spectrum (20 Hz to 20 kHz) without the need for range switching. The design is particularly suited for electronic-music synthesis.

The circuit uses a standard, noninverting amplifier configuration, as in the simplified diagram of Fig. 1. The three-modes are obtained by the introduction of the signal into three different points of the circuit. An increase in the gain of the amplifier increases the filter's Q. The Q remains almost constant as the filter's cutoff frequency is tuned across the audio spectrum. Cutoff frequency is changed when R1 and R2 are varied simultaneously.

In the actual circuit, silicon diodes replace R1 and R2 (Fig. 2). The diodes change resistance when their forward bias voltages are changed. The differential-amplifier transistors Q1 and Q2 apply the bias voltage in opposing phase to the two RC diode networks in parallel. The opposing phases cancel the control voltage so that the control voltage doesn't appear at the signal output terminal.

The bias effect of the input signal on the diodes is also cancelled, when the signal level across each diode pair is kept below 50 mV.

The noninverting amplifier's transistors, Q1 and Q2, and potentiometer R3, control the amplifier's gain, and consequently, the Q of the filter. But excessive gain can cause the circuit to oscillate. An op amp can also be used for the noninverting amplifier.
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INFORMATION RETRIEVAL NUMBER 37
2. The Q of the voltage-tuned active filter is adjusted by $R_6$. The Q remains almost constant over the complete frequency range. At high Qs the input signal level should be limited to $-10$ dBm.

The plots shown were made with the center frequency set arbitrarily at 500 Hz. Pass characteristics and Q remain essentially the same as the center frequency is changed. The output amplitudes in the pass portions of the curves are approximately $-25$ dB from the input signal. The circuit operates well with an input signal level of 0 dBm (0.77 V rms) at low Q. However, with a Q of 10 or higher, the input signal should be limited to about $-10$ dB to prevent the circuit from being overdriven. Plots were made with an HP-650A oscillator and an HP-400-L ac voltmeter. Nyle A. Steiner, 334 “L” St., Salt Lake City, UT 84103. Circle No. 313

IFD Winner of August 2, 1974

Michael O. Paiva, McIntosh Laboratory Inc., 2 Chambers St., Binghamton, NY 13903. His idea “Start a Logic Circuit in the Proper Mode When Power Is Turned On Or Interrupted” has been voted the most valuable of Issue Award. Vote for the Best Idea in this issue by circling the number of your selection on the Information Retrieval Card at the back of this issue.

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Milliwatt calorimeter used to sense waveguide heat

A milliwatt calorimeter for waveguide measurements in the 90- to 140-GHz band has been developed at the Max Planck Institut für Radioastronomie in Bonn, West Germany. The calorimeter has a short time constant and compensates for losses in its own waveguide section by sensing the heat generated in the waveguide. The operating range is 1 to 100 mW. Accuracy is within 4% between 10 mW to 100 mW and 6% from 1 to 10 mW.

A length of silver waveguide in the calorimeter connects a flange and a brass-heater mount with an absorbent filmohm termination (see figure). Microwave power applied to the calorimeter is converted into heat, which is conducted back along the waveguide to the flange.

The waveguide walls are very thin, to keep the time constant to a minimum. Consequently the termination temperature rise is rapid. The load is maintained at a constant temperature above ambient by a heater in the brass mount for the load. The small amount of power that passes through the termination is reflected by a copper disc back along the waveguide to be absorbed by the load.

The calorimeter is enclosed in a cylindrical copper shield that is protected from air currents by a plastic-foam cover. Variations in the heater current maintain a thermistor-bridge balance and keep the load at constant temperature. Heater resistance is constant for powers up to 200 mW, and the small voltage changes obtained in power measurement are identified when the heater voltage is compared with the output of an adjustable, precision voltage source.

Microwave exposure monitored by Ge films

A small, personal monitor to protect against excessive exposure to microwave energy makes use of the absorption of rf power in germanium films. As the radiation is absorbed, the film temperature increases and its resistance changes.

The instrument has been developed at the University of Newcastle-upon-Tyne in England. Studies with animals show that a safe exposure level is 10 mW/cm² for five minutes at frequencies above 10 GHz. Exposing the animals to radiated power of 100 mW/cm² for 100 minutes killed them.

Germanium films 3 μm thick with a conductivity of $1.75 \times 10^4 \Omega^{-1} \text{m}^{-1}$ have been obtained for the monitor by deposition of the germanium on a heated glass surface. The electrical contacts are formed by deposition of aluminum films on the substrate. The tempco of the germanium-film resistance is $0.3\% /^\circ \text{C}$.

This type of germanium sensor can reliably monitor power levels from 1 mW/cm² to 1 W/cm². For display of the level, light-emitting diodes are used. They are driven by the outputs of a decade counter that can be switched on or activated automatically when a danger level is reached.

To show the accumulated radiation over a week, an integrated exposure-level indicator is used. It can be either a silver cell at the input to the counter or a piece of photographic film adjacent to the LEDs. CMOS logic is used throughout the instrument.

High-impedance probe cuts off below 3 Hz

A high-impedance, ac-coupled oscilloscope probe with an unusually low cutoff frequency of less than 3 Hz has been designed by the Dept. of Electronic and Electrical Engineering at the University of Sheffield in England. The input impedance is maximized by use of a matched pair of junction FETs, operating as a self-biased, source-follower circuit. The source follower is bootstrapped by an operational amplifier.
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1975 TOP TEN CONTEST

"We enjoyed every minute we were there," writes Paul R. Saunders, winner of last year's Top Ten Contest. "The islands, the people of those islands and the cruise are wonderful . . . the hardest part of the whole trip was returning to reality." Paul and his wife are shown, left, at the end of their trip at English Harbour, Antigua. Paul also won $1,000 cash and round-trip air tickets for two to the Windjammer Cruise home port. At the time of the contest Paul was associated with Varisystems Corporation, Long Island, N.Y.

WATCH FOR COMPLETE RULES AND ENTRY BLANKS IN ELECTRONIC DESIGN'S JANUARY 4, 1975 ISSUE
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For more information, circle our reader service number or contact Wavetek direct.
Single monolithic chip holds 16-bit microprocessor

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. P&A: See text.

The first 16-bit microprocessor on a single chip—National Semiconductor's processing and control element (PACE)—offers all the basic features of the company's multichip model. Though not as fast nor as flexible as the older version, PACE provides the convenience and cost savings of single-DIP packaging. And it can be used for either 8 or 16-bit data processing.

The PACE chip permits a sizable reduction in components for an equivalent IMP-16—National's earlier multichip, 16-bit microprocessor on a card. Excluding memory, only six ICs are needed when PACE is used, compared with 20 to 25 for the IMP-16. When special circuits become available, PACE and just 10 other ICs will constitute a microcomputer with 1-k words (each 16 bits) of ROM and 256 words (also 16 bits each) of read/write memory.

But PACE won't necessarily replace the IMP-16. While the two are software-compatible, the new chip has a longer instruction-execution time of, typically, 10 μs. For the same algorithm, PACE yields a throughput of 1/2 to 2/3 that possible with the IMP-16. Alternately, common software and common peripheral hardware for the two suggest the use of PACE as a low-level processor with IMP-16 as the host processor.

In addition designers can't expand or change the 45-instruction set provided with PACE, as they can with the IMP-16. The earlier unit's 43-instruction set can be extended with a special CROM (control read-only memory). Moreover microprogramming techniques can tailor the IMP-16's instructions to specific applications.

A single PACE chip incorporates the single CROM and four RALUs (register and arithmetic logic unit) that the IMP-16 uses as the central processor. Hence PACE contains the microprogram storage, registers, accumulators and stack for a 16-bit processor.

Furthermore PACE incorporates a number of support circuits found on the IMP-16 board. Internal to the chip, for example, are interrupt-control circuitry, an eight-phase clock generator, control flags and a jump-condition multiplexer. As a result, support components for PACE reduce to a simple clock driver, and input and output buffering circuits. (To keep the PACE chip's power dissipation down, National has reduced the IC's output drive capability, so it is lower than that available from the multichip processor.)

A data-processing controller using PACE can be built on a 4 1/2 × 4 1/2-in. PC board (see photo). Besides the PACE chip, the board contains four hex MOS sense amplifiers, three hex buffers, a crystal oscillator and clock drivers.

The PACE circuitry can respond to six different interrupt levels, each of which can handle a number of peripheral devices. If, say, three interrupts occur, PACE selects the ones with the highest priorities. And any interrupt results in a vectoried branch to a specific memory location.

PACE's ability to handle 8 or 16-bit data simplifies designs that employ either of the data word lengths. Double-precision software operations or hardware changes aren't required when going from one data word length to another. At the same time PACE offers the advantage of a 16-bit instruction set and 16-bit addressing.

(continued on page 106)
INTEGRATED CIRCUITS (continued from page 105)

Designers using PACE can employ the same software development aids offered by National for the IMP-16. For example, a slightly modified version of the earlier unit's prototype system (IMP-16P) comes with a PACE processor card and with programs in PROMs geared for PACE. And an application program already written for the IMP-16 can be converted directly to one for PACE with a special translator program.

Like the IMP-16, PACE employs established p-channel MOS, silicon-gate technology. PACE requires supplies of +5 and -12 V, and the chip comes in a 40-pin DIP.

Tentative prices for PACE are under $400 in single quantities and below $100 in very high volume. The manufacturer plans to sample PACE in next year's first quarter and to begin shipments by the second quarter.

16-k ROMs have 450-ns access

Motorola Semiconductor, P.O. Box 20924, Phoenix, AZ 85036. (602) 244-3466. $23.95 (100-999); stock to 8 wk.

A 16-k mask-programmable ROM employs n-channel MOS, metal-gate technology to achieve address access times of 800 ns maximum, and 450 ns typical. Called the MCM6590L, the ROM has a 2048-bytes × 8-bit organization. A pre-programmed version, the MCM-6591L, contains six conversion codes: ASCII to Selectric, to EBCDIC and to a modified 8-bit Hollerith; Selectric to ASCII, EBCDIC to ASCII and a modified Hollerith to ASCII. Also stored are 128 USASCII characters using mixed character fonts of 5 × 7 and 7 × 7 dot matrices with extra check bits. Also featured are three-state outputs and compatibility with TTL and CMOS. Power dissipation is less than 500 mW, and the ICs come in 24-pin packages.

Dual IC boasts broad uses

Philips, P.O. Box 523, Eindhoven, the Netherlands.

The general-purpose TCA240 monolithic IC contains two entirely separate but identical long-tailed pairs. Each consists of four transistors, two resistors and a diode. The supply voltage range of the IC is 0 to 16 V. Total power dissipation is 500 mW at 25 C. Applications extend from modulators, mixers and switches/choppers to AM synchronous demodulators, FM quadrature detectors and phase comparators. The TCA240 comes in a 16-pin DIL housing.

LED-driver chips aim for watches

Dionics Inc., 65 Rushmore St., Westbury, NY 11590. (516) 997-7474. 40c to $1.10 (100,000).

Four monolithic bipolar ICs can be used as LED drivers in digital wristwatch applications. Two of the chips, the S 913N and DI 913P, are nine-position LED segment drivers using npn common-collector and pnp common-emitter designs, respectively. The DI 413N and DI 413P are four-line digit drivers, using npn common-emitter and pnp common-collector designs, respectively. All circuits are glass-passivated with aluminum bonding pads and are gold backed for eutectic or epoxy die bonding.

1-k NMOS RAM has 60-ns access

Nortec Electronics Corp., 3697 Tahoe Way, Santa Clara, CA 95051. (408) 732-2204. $22 (100-999).

The 7001, a 1024 × 1-bit MOS RAM, offers 60-ns access and 180-ns cycle times. Moreover, it uses one-tenth the power of similar speed bipolar memories. The n-channel, metal-gate RAM has a special internal refresh mechanism that enables static operation without the need for synchronous periodic refresh cycles. Power dissipation is 60 µW standby and 640 µW under maximum operating conditions. The 7001 has internal address-input latches, and it accepts TTL levels at all inputs, except Chip Select.
Clean up your act!

Opto-isolate your critical circuits with Monsanto's MCT2's.

Here's a cost-effective way to get top signal transfer (50% CTR for MCT2's, 250% for MCA 230's), yet isolate critical components against transients of 1.5 to 2.5kV. Put an opto-isolator in the circuit. Switching speeds range from 150kHz (MCT2) to 10kHz (MCA230). Millions of them are in daily use in industrial controls, telephone interfaces, computer mainframes and peripherals. Cleaning the noise out of critical paths.

**System interface problems?**

We've put together App Notes on sixteen of the thorniest design problems that O/I's can help solve. Includes:

- Input drive circuits.
- Solid-state 125 MA relay.
- Low-cost AC relay.
- O/I's in linear coupling.
- Gated amplifier functions.
- Phone line coupler isolator.
- Logic isolation, line receiver.
- Interfacing Darlington O/I's to TTL logic . . . and more!

We'll be glad to send you a copy of this 64-page applications book. Simply ask for it on your letterhead. And give us an idea of your application, will you please?

**And now . . . more!**

We've increased our production of these widely accepted components during the past six months and can now deliver the quantities you specify when you need them. Call your Monsanto distributor or Monsanto Commercial Products Company, Electronics Division, 3400 Hillview Avenue, Palo Alto, CA. 94304. Phone: (415) 493-3300.

Putting innovation to work.
HERE’S HOW WE MAKE IT EASIER FOR...
YOU TO CONTACT SUPPLIERS

COMPLETE STREET ADDRESS, STATE, ZIP AND PHONE FOR EACH LISTING SAVES TIME

Knowing only a name and city isn’t much help if you or your secretary want to contact several manufacturers at once for information or a quote. That’s why Electronic Design’s GOLD BOOK repeats each manufacturer’s full name, street address, city, state, zip and phone number every time the manufacturer is listed in our PRODUCT DIRECTORY. It’s all there. You don’t have to leaf through other directories to find the missing information.

IT’S ANOTHER REASON TO REACH FIRST FOR ELECTRONIC DESIGN’S GOLD BOOK.

Electronic Design’s GOLD BOOK

BIGGEST AND BEST ELECTRONICS MASTER CATALOG & DIRECTORY IN THE WORLD
MODULAS & SUBASSEMBLIES

Crystal clock oscillator has DIP-sized case

Conner-Winfield Corp., West Chicago, IL 60185. (312) 231-5270. $38; stock to 5 wk.

The S14R DIP crystal TTL oscillator measures only 0.3 × 0.49 × 0.78 in. It can plug into an IC socket, and is available at any frequency from 4 to 20 MHz. The oscillator has a frequency tolerance of ±0.01% from -25 to +75 C, a fanout of 10 TTL loads and a duty cycle of 30/70 or better.

CIRCLE NO. 306

Audio amplifiers made for studio applications


Three PC-card amplifiers include the AM-27 microphone pre-amplifier, the ABL-27 bridging line amplifier and the AL-27A line amplifier. All three use the company's MAP 1731A audio operational amplifier as its active element. Model AM-27 is a general purpose audio module that has transformer coupled inputs and outputs and an adjustable gain from 25 to 65 dB. Model ABL-27 is designed for amplification of medium to high level (+20 dB) signals. It has an adjustable gain from -7 to +33 dB. Model AL-27A has a transformer coupled output, adjustable gain/loss up to +47 dB and low noise of -125 dBm.

CIRCLE NO. 307
S/d converter operates at rates up to 3600°/s

Control Sciences, Inc., 10315 Woodley Ave., Granada Hills, CA 91344. (213) 342-3067. $5500 (unit qty); stock to 45 day.

The Series 168B synchro (and resolver) to digital converters function at both 60 and 400 Hz. They work with both 26 and 115-V references and with 11.8 and 90-V stator inputs. Models may be selected to provide error-free tracking rates to 10 rps (3600°/s). Typical of tracking-type converters, analog synchro (and resolver) input data are accurately and continuously converted into binary digital format. Data are always available, except when a digital transition occurs. This condition is indicated by a logic 1 on the converter busy line. During readout, data may be prevented from changing by pulling the inhibit line to logic 0. All units are completely trimmed and adjustment free. Typical electrical specifications include: accuracy, ±4 min ±0.9 LSB at 25 C; resolution, 14 bits (0.022°); and digital output, parallel natural binary angle positive logic, DTL/TTL levels, one inhibit and one converter busy.

CIRCLE NO. 308

Programmable controller includes pROM storage

Barber-Colman, 1309 Rock St., Rockford, IL 61101. (815) 877-0241. From $1189; 6 wk.

The Maco III programmable control system includes a 256 word pROM memory (expandable to 2048 words, eight 115-V-ac input functions and eight output functions (expandable to 256 functions in any combination). Analog and high accuracy digital timing functions are also available. A separate programmer, which uses simple relay ladder symbology, and a diagnostic card for easy machine and control troubleshooting are available options to the system.

CIRCLE NO. 309

Did You Know
Dearborn Makes 31 Styles of Film Capacitors?

HERMETICALLY-SEALED METAL CASE TUBULAR CAPACITORS

BARE METAL CASE
Style LP9, metallized polycarbonate film
Style LPN9, metallized PETP-polyester film
Style AP7, polycarbonate film
Style AM8, PETP-polyester film
Style AS5, polystyrene film
Style AF8, PTFE-fluorocarbon film

METAL CASE WITH INSULATING SLEEVE
Style LP9, metallized polycarbonate film
Style MP7F, metallized PETP-polyester film
Style AP9, polycarbonate film
Style AM9, PETP-polyester film
Style AS9, polystyrene film
Style AF9, PTFE-fluorocarbon film

WRAP-AND-FILL ROUND TUBULAR CAPACITORS
Style LP66, metallized polycarbonate film
Style LP66, polycarbonate film
Style A566, polystyrene film

WRAP-AND-FILL OVAL TUBULAR CAPACITORS
Style LP77, metallized polycarbonate film

EPOXY-CASE RECTANGULAR CAPACITORS
AXIAL-LEAD
Style LP7A, metallized polycarbonate film
Style LM7A, metallized PETP-polyester film
Style AP7A, polycarbonate film
Style AM7A, PETP-polyester film
Style AS7A, polystyrene film

RADIANT-LEAD
Style LP7S, metallized polycarbonate film
Style LM7S, metallized PETP-polyester film
Style AP7S, polycarbonate film
Style AM7S, PETP-polyester film
Style AS7S, polystyrene film

HERMETICALLY-SEALED CERAMIC CASE TUBULAR CAPACITORS
Style SML, high voltage paper/PETP-polyester film, inserted tab construction
Style SMLE, high voltage paper/PETP-polyester film, extended foil construction

EPoxy CASE RECTANGULAR CAPACITORS
Style EFX, high voltage paper/PETP-polyester film

Write for engineering bulletins on those capacitor styles in which you are interested.

SPRAGUE ELECTRICAL COMPANY
Dearborn electronics division
P.O. BOX 1076, LONGWOOD, FLORIDA 32750
Multicircuit timers adjust for 0.01 to 30 s

Multi-circuit solid state timer-stepper can be adjusted from 0.01 to 30 s per step. No tools are needed for the 10140 circuit board to change both the step program and the duration of the steps. Other field changes can be made with simple tools. The standard model is available with up to 10 circuits. Starting with this form and size, the user can utilize any number of circuits less than 10 simply by moving a jumper to any one of nine terminals. The standard 10140 timer-stepper has 10-A triacs rated for 600-W tungsten-filament lamps but can drive triacs as large as 40 A for 2000-W loads. The complete 10140 board, with time interval control potentiometer, ten 10-A triacs, and cable and plug for connection to a 60-Hz ac power supply, is cased in a 12 x 10 x 4 in. standard NEMA box. Options include pushbutton start and toggle switch with single-cycle and repeat-cycle position.

Bayside Timers, 43-69 162 St., Flushing, NY 11358. (212) 463-8935. $160; 1 wk to 10 day.

Bandpass/reject filter spans 1 Hz to 20 kHz

Frequency Devices, Inc., 25 Locust St. Haverhill, MA 01830. (617) 374-0761. $40 (100-up); 2 to 4 wk.

The 7810IQ2 bandpass/band reject active filters cover the frequency range from 1 Hz to 20 kHz. The Q is externally adjustable from 0.5 to more than 100. The notch depth is typically 50 dB and trimmable to 60 to 80 dB. Both bandpass and band-reject outputs are simultaneously available and a ±5% fine frequency adjustment is also provided. Power requirements are ±5 to ±18 V at 48 mA. The filter can handle input voltages swings of ±10 V (Vsupply = ±15 V). The input impedance is 20 kΩ while the output is less than 10 Ω.

See through opto-control has range of 150 ft

Honeywell, 11 W. Spring St., Freeport, IL 61032. (815) 282-1122. $150 (large qty.).

The MLS5 high-intensity photoelectric unit produces a pulsed infrared beam that will sense through glass, denim, rubber, multiple sheets of paper, cardboard or even wood. The emitter and receiver units, less than 3.5 in. high, are designed to scan farther than 150 ft. even in direct sunlight. The photoelectric control is said to be able to sense an object as small as 1 in. wide at any scanning distance up to 150 ft. The units can also be used for machine-control operations and traditional speed counting and sorting operations. The control can be used in either direct or reflective scan applications. The MLS5 may be interfaced directly with various logic circuits or wired to a 12 V dc relay. Input voltage is 12 V dc max and 18 V dc max., with a 20% maximum power supply ripple. The light emitter draws a current of 70 mA max.; the receiver needs 40 mA max. Response time is 15 ms for both on and off states when operated at a maximum rate of 33 operations/s within a temperature range of −40 to 70 C.
Here are 10 more good reasons to turn to Amperex...

These ten bring our total... so far... to 23 high-performance, small-signal RF transistors with gain-bandwidth products from 1 to 6 GHz... covering the operating current range from 100 µA to 150 mA. There’s an Amperex GHz transistor to fill virtually any small-signal application up to 2 GHz... CATV/MATV amplifiers, portable pagers and transceivers, high bit-rate communications equipment, frequency counters and high frequency oscilloscopes, to name but a few.

World leadership in shallow diffusion technology and unsurpassed packaging skills come together at Amperex to produce the industry’s best combination of GHz transistor specifications, packages and prices.

- Gain-bandwidth products from 1 to 6 GHz at collector currents from 100 µA to 150 mA
- Noise figures as low as 1.9 dB at 500 MHz
- Low intermodulation and cross-modulation distortion types for wide band and other sophisticated linear applications
- Package-Versatility: plastic Micro-T, ceramic Micro-T, Stud-mounted stripline and JEDEC TO39 and TO72 metal cans
- An entire line priced so low that only two of the 23 devices cost more than $3.95 in quantities of 1,000... and most are priced between $2.00 and $3.00

For further information on the Amperex line of high-performance, GHz-range transistors, write Amperex Electronic Corp., Solid State and Active Devices Div., Slatersville, R.I., 02876, or phone (401) 762-9000.

A GHz Transistor-Line Sampler

<table>
<thead>
<tr>
<th>TYPE NUMBER</th>
<th>CASE STYLE</th>
<th>fGHz</th>
<th>Ic (mA)</th>
<th>PRICE EACH*</th>
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<tr>
<td>BFT24</td>
<td>Plastic Micro-T</td>
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<td>1</td>
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<td>A400</td>
<td>TO-72 metal</td>
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<td>Stripline Stud</td>
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<td>$7.25</td>
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<tr>
<td>BFR95</td>
<td>TO-39 Metal</td>
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<td>100</td>
<td>$3.95</td>
</tr>
</tbody>
</table>

*In 1000 piece quantities
†Also available as type BFR49 in special high-reliability ceramic stripline package. Price each: $15.25

Amperex
TOMORROW'S THINKING IN TODAY'S PRODUCTS
Sold through North American Philips Electronic Component Corporation

INFORMATION RETRIEVAL NUMBER 150
With MINI / BUS®

It's the PC card bus bar that saves space on a PCB. Saves money too. Makes board design and layout easier.

all these DIPs

How can you put 36 DIPs on a 30 sq. inch board without using costly multi-layer PCBs?

go on a 5" x 6" 2-sided PCB

Take Voltages and Grounds off the board with MINI/BUS. Use all the board geometry for interconnecting DIPs.

like this

With MINI/BUS, you'll save design and layout time. You'll save space on the board. And you'll save money — up to half the cost of a typical 4-layer PCB.

INSTRUMENTATION

4-1/2-digit DPM fits standard panel cutout

Analog Devices, Route 1 Industrial Pk., P. O. Box 280, Norwood, MA 02062. (617) 320-4700. $295; stock.

This 4-1/2-digit, ac line-powered DPM, the AD2008, features a Beckman gas-discharge display and a case designed to fit the 1.68 x 3.33-in. panel cutout that has virtually become an industry standard for ac-powered DPMs.

To mount, the user simply slips the DPM into the panel cutout, snaps in two nylon mounting blocks and tightens two screws on the rear plate. The snap-on lens comes with an anti-reflective surface and two color choices: red or amber.

The AD2008 measures bipolar voltages over a full-scale range of ±1.9999 V with an accuracy of 0.005% reading ±50 μV ±1 digit. The unit's gain tempco is 15 ppm/°C; automatic circuitry corrects for zero offsets. Gain stability is 100 ppm per 1000 h and zero stability is 10 μV per 1000 h.

A fully floating opto-isolated input section allows measurements to be made with common-mode voltages up to 300 V rms, and provides more than 100 dB of common-mode noise rejection, even with control signals and optional data outputs connected. Normal-mode rejection is over 60 dB.

In its ratiometric version, available at no extra cost, the Analog Devices unit accepts external reference voltages over the range of 600 mV to 1.3 V at full specified accuracy. Power consumption of the AD4008 is 4 W.

The unit offers two optional data output formats: full parallel latched BCD for 4-1/2 digits, polarity, and overload lines; or a pulse-train output, which can be counted externally to the DPM.

Rogers Corporation Chandler, Arizona 85224 Phone: (602) 963-4584

Represented in Canada by LLOYD A. MEREDITH,
1560 Watersedge Road, Clarkson, Ontario L5J 1A4 Phone: (416) 533-2367

INFORMATION RETRIEVAL NUMBER 47

ElectroniC DESIGN 25, December 6, 1974
Scope computes and displays results


Using the microprocessor from the company's familiar HP-35 calculator, a new dual-channel, 275-MHz scope, Model 1722A, provides digital LED readout of time interval, frequency, de voltage, peak or instantaneous voltage, and percent difference between amplitudes. All these and the scope display are taken from a single probe to the circuit under test. For time intervals, such measurements as clock phase, rise time, pulse width, period or propagation delay can be made with resolution as great as 20 ps. When the 1722A is set to the 1/TIME mode, the microprocessor computes the reciprocal of whatever was set in the TIME mode and displays the answer on the LEDs. The unit may also be set to digitally indicate the average (dc) voltage at the input of Channel A. It functions then as an autoscaling 3-1/2-digit DVM. Scope performance characteristics are similar to those of the HP Model 1720A.

CIRCLE NO. 325

10-MHz pulser sells for just $159

The Pal Kit Co., P. O. Box 1056, Minnetonka, MN 55343. $159 assembled: 2 wks.

Model BP2 pulse generator offers a repetition rate of 1 Hz to 10 MHz and a variable width of 50 ns to 1 s. Output level varies from 0.5 to 10 V, no load, and 0.25 to 5 V into 50 Ω. Max rise and fall times are 20 ns. A 4-V (no load) sync pulse is also provided. Output modes include normal, invert and square wave.

CIRCLE NO. 326

Reticon Corporation, a pioneer in solid state image sensing, has now applied its technological leadership to the field of analog memories. These devices are large scale integrated circuits which sequentially time sample an analog input signal and store each sample as an analog voltage level on one of a series of storage capacitors. The stored samples are then read out in sequence to reconstruct the original input signal with a new time base. Several device types are available from inventory with up to 128 elements of storage. Applications include time base correction (expansion or compression), tapped delay lines, correlation, digital filtering, real-time Fourier transforms, chirp radars and many others.

Write or call for further information including detailed peripheral circuits. There are over 60 salesmen and 14 distributors to serve you worldwide.

Reticon Corporation

910 Benicia Avenue,
Sunnyvale, California 94086
Phone: (408) RET-ICON TWX: 910-339-9343
Oscillator slashes phase noise


Model Y-1128 crystal oscillator has a typical phase noise of only 150 dB/Hz at 10 kHz from carrier and typical short-term stability of just three parts in $10^{-10}$ per second. The available center frequency range is 1 to 100 MHz with two units. Input voltage requirement is $+28$ V dc ±2% and output power is 10 mW into 50 Ω. Other features include EMI filtering in the dc-input line, stability of ±0.005% from 0 to 50 C and 40-dB minimum harmonic suppression.

CIRCLE NO. 328

1.8-GHz class C amp delivers 132 W

Microwave Power Devices, Inc., Adams Ct., Plainview, L1, NY 11803. (516) 433-1400. 60-90 days.

Model PWA 1718-12 cw solid-state class-C amplifier delivers 132-W saturated power output over the frequency band of 1750 to 1850 MHz. Other features include 50-dB gain, output circulator for protection against load mismatches and stripline and MIC construction. The unit employs field-replaceable modules.

CIRCLE NO. 329
Advantages of the Slo-Syn ®
AC synchronous motor.

Slo-Syn AC constant speed, brushless motors have extremely rapid starting, stopping and reversing characteristics.

Their operation is simple, requiring only single-pole, three position switches to provide forward, reverse and "off" control.

And, because of the low shaft speeds, 28.8 to 200 rpm, Slo-Syn synchronous AC motors are uniquely dependable as control components.

Motor runs directly off incoming line voltage. Low speed allows direct load coupling without gearing. Clutching and braking can be eliminated because of instant start, stop and reverse. Torque being proportional to voltage, the increase or decrease of voltage controls torque directly.

This is the first of a series of ads dealing with the basics of AC synchronous and DC stepping motor design and application.

Send for Superior Motor Catalog—60 pages packed with design opportunities.

Write, wire or telephone Jack Wallace. The Superior Electric Company, Bristol, Conn. 06010. 203/582/9561
5-28 Vdc modular power supplies
• Stock delivery • Low cost
• Same performance as Lambda LM

Tele-Dynamics Series HR modular supplies are offered in 30 models in 5 case sizes, all interchangeable with Lambda LM and similar units.
Output: 5-28 Vdc, 1.3-20 A. Ripple: 1 mV rms.
Regulation: ±0.05% line, ±0.05% load.
Input: 105-125/210-250 V, 47-63 Hz.
Unit price: $113 to $256.

System finds antenna directions


Model ARAS-100 antenna direction-finding system features compatibility with many current electronic-warfare receiving systems. The new system provides vertical or horizontal polarization over the 0.7-to-2-GHz frequency range, circular polarization over the 2-to-18-GHz band and a continuously variable rotational speed of 0 to 350 rpm. Pointing accuracy is 1/2 degree with a servo-controlled manual mode. A CRT with 4-in. diameter polar-signal presentation provides the display and video dynamic range extends from 0.1 to 3.0 V.

CIRCLE NO. 331
Attenuator has flat characteristics

The Model ARE-1 electronic attenuator features flat attenuation characteristics of ±0.5 dB in the 0-to-20-dB range and over the 2-to-100-MHz frequency band. Other characteristics include intermod intercept point of +43 dBm (two-tone, third-order); maximum insertion loss of 1.3 dB; maximum VSWR of 1.5:1 with impedance of 50 Ω; bias voltage/current of 15 V at 5 mA and control voltage/current of 0 to 15 V at 0 to 30 mA. Maximum input power is +10 dBm.

CIRCLE NO. 332

2-to-4-GHz VCO has 200 ppm/°C stability

Operating from 2 to 4 GHz, the Model VTS-621 voltage-controlled oscillator provides 50-mW rf power with a stability of 200 ppm/°C. Harmonics are down 20 dBc minimum and spurious signals are down 60 dBc minimum. The unit operates over a temperature range of −54 to +85 C and gives a linearity of ±3% BSL. The unit measures 2.0 x 1.5 x 1.0 in.

CIRCLE NO. 333

Put it all together with TRIAD

Who else but Triad has the printed circuit cards, the plug-in transformers and inductors, and the right connectors in stock at your industrial electronic distributors—ready for you to use? Triad's new standard series of plug-in telephone coupling transformers are designed particularly to interconnect remote data entry and display terminals to computers over voice grade telephone lines. Useful for impedance matching, isolation, line balance, bridging, hybrid and holding coil applications. Other plug-ins for transistorized control and instrumentation include units for both power and audio use.

All Triad plug-ins fit precisely into standard grid patterns on our versatile line of integrated and universal circuit cards. And—when you put a “CO” prefix ahead of the card number, you'll get the applicable Winchester connector in the same package with the card—ready for you to put together. Call your distributor for Triad’s latest catalog. Triad Distributor Services, 305 North Briant Street, Huntington, Indiana 46750.

CIRCLE NO. 333

Merrimac Industries Inc., 41 Fairfield Pl., West Caldwell, NJ 07006. (201) 228-3890. $165; stock to 45 days.

Teledyne Microwave, 1290 Terra Bella Ave., Mountain View, CA 94040. (415) 968-2211.

Litton TRIAD-UTRAD Distributor Services

Electronic Design 25, December 6, 1974
A pushbutton switch for "peace of mind" applications—
that's Yankee ingenuity.

Switchcraft's ORCON pushbutton switches are designed and manufactured specifically for applications where economy is measured only by maximum reliability. Where "peace of mind" is mandatory.

ORCON Series OA lighted pushbutton switches provide you with 2PDT through 6PDT circuitry in a 3/4" diameter package. ORCON Series OB offers SPDT, DPDT switching in a 23/32" diameter housing. Both offer features that give you that extra peace of mind. Consider ORCON's exclusive snap-slide migration-free lifting and wiping action of the self-cleaning cobalt-gold contacts which eliminates arcing.

ORCON switches accept single lamp, redundant-lamp pushbuttons in a variety of colors and shapes—square, round, rectangular. And we have them all. You can specify momentary silent, momentary positive, alternate action or push lock/push release functions.

When you want to specify a little extra peace of mind, see what ORCON—and a little Yankee ingenuity—can do for you. Contact your Switchcraft Representative, or Switchcraft Inc., 5555 N. Elston Avenue, Chicago, Illinois 60630. Or phone (312) 792-2700.

PACKAGING & MATERIALS
Silicon-iron strip cores need no impregnant

Inter-Technical Corp., Inc., P.O. Box 23, Irvington, NY 10533. (914) 591-8822.

A new method of manufacture produces distributed-gap transformer cores in very small sizes. Made from silicon-iron strip, the new cores offer the full magnetic qualities of silicon iron, unimpaired by impregnation and the cutting operation after annealing. The cores can be as small as H121 cut cores or EE 24-25 laminations. At 400 Hz, they can readily substitute for 4-mil cores or 6-mil laminations. In some cases, they can be used instead of costly nickel-iron laminations or toroids. Often they offer the only solution when the gapped VA rating of cut cores is unacceptable. Since no impregnant is used, there is no lamination movement when the operating temperature rises. The usual resultant increase of exciting current with increase in temperature is thus limited. New LL (Low Loss) distributed-gap cores are available in strip widths up to 1-1/2 in. and build-ups to 3/8 in. Minimum window length and width are 1/2 and 1/4 in., respectively. Maximum window length and outside periphery are 2 and 8-1/4 in.

Part holder adapts to perforated boards

E-Z-Hook, 114 E. Saint Joseph St., Arcadia, CA 91006. (213) 446-6175.

Perf-board adaptors in E-Z-Hook's NailClip line provide an economical way to breadboard or pretest components and circuits prior to assembly. The adaptors are constructed of natural nylon. The Perf-Eze, Model PE-93, insert adaptor snaps into 0.093-in. dia perf-board holes. Any of the four NailClip models, available in 10 colors, may then be pressed into the adaptors. Insert and NailClip may be removed and reused. Solder connections may be made on the back plane to interface with automated checkout systems.

CIRCLE NO. 336

Degreaser system recycles solvents


A degreaser/cleaner system, Micro-Clean 300, reuses solvents by recirculating them through a replaceable micron filter. Large filters are easily replaced. They come in ratings of 5, 10, 25, 50 and 100 microns. The system is set at bench height and provides a recessed work area for retention of the solvent.

CIRCLE NO. 337

Soldering-iron holder saves solder tips

Plato Products Inc., 4357 N. Rowland Ave., El Monte, CA 91731. (213) 283-0466. $9.99 (1-9); stock.

Plato soldering-iron holders with tip saver, TWH-905, solve the problem of tip detinning. The tip saver is a solder dispenser attached to the soldering-iron holder. After soldering, the tip is touched to the tip-saver solder before placing in the holder. This procedure prevents oxidation of the solder tip, because the 0.062-in. diameter solder provides an abundance of flux and solder to keep the tip tinned.

CIRCLE NO. 335
Why settle for less than Preston’s “Balanced Precision” Amplifiers?

Here’s how Preston’s 8300 XWB Series compare with the “next best” amplifiers at overcoming the FOUR major sources of instrumentation system errors:

COMMON MODE REJECTION — 3 to 5 times better! Preston’s amplifiers deliver the highest CMR available: 150 db at DC, 130 db at 60 Hz!

TEMPERATURE STABILITY — 2 to 5 times better! Gain Temperature Coefficient is an outstanding 10 parts/million/°C, and Zero Shift is a super-small 0.1 uV/°C RTI!

PUMPOUT CURRENT — 10 times better! Every model in the 8300 XWB Series stays under ½ nanoamp over the entire temperature range!

OVERLOAD RECOVERY — 10 times as fast! Recovers to within 0.01% of the overload signal in only 30 microseconds!

And Preston’s 8300 XWB Series deliver the accuracy and versatility to meet every instrumentation system requirement:

ACCURACY — from 0.1% to 0.005%

GAIN SELECTION — 10 manual or remotely controlled steps!

BANDWIDTH SELECTION — Five steps from 10 Hz to 100 kHz with full output power over the entire bandwidth!

PROGRAMMABLE GAIN AND BANDWIDTH — for direct control from computers and controllers at standard digital logic levels.

TEN NEW OPTIONS — including triple outputs, three- and four-pole Bessel filters, and remote calibrate relays.

Get all the details in our 12 page “Balanced Precision” brochure that shows how to determine your instrumentation system’s true accuracy! Write to Preston Scientific, Inc., 805 East Cerritos Avenue, Anaheim, California 92805, or call us at (714) 776-6400.

We’ll put all our years of experience on the line!
IMC introduces fan for cooling sandwiched areas

IMC’s new, high performance FULMAR fan features maximum efficiency for cooling high power density enclosures and rows of printed circuit board arrays. Unique design of this fan allows for convenience of “Side by Side” mountings for maximum airflow distribution and stable motor performance under low voltage (brown out conditions). Fulmar’s low noise level is a natural for computer room use.

Circle the “Bingo” for details! For immediate service please call Fred Taylor, Sales Manager at (603) 332-5300 or write:

IMC MAGNETICS CORP.
NEW HAMPSHIRE DIVISION
ROUTE 16B, ROCHESTER, NEW HAMPSHIRE 03867

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Breadboarding kit allows easy rf design

Christiansen Radio, Inc., 3034 Nestall, Laguna Beach, CA 92651. (714) 497-1506. $60 (unit qty); stock.

Christiansen Radio’s new rf breadboarding kit is the latest addition to the Mini-Mount line of breadboarding equipment. Designed around the company’s adhesive-backed circuit pads and specially designed movable rf partitions, the kit allows the circuit designer to mount components interwire stages and distribute power without drilling. The kit includes 100 assorted Mini-Mounts, a 4 x 8-in. double-sided solder-plated G-10 ground plane and 10 rf partitions.

CIRCLE NO. 338

DIP receptacle features low profile, easy insert

Amp Inc., Harrisburg, PA 17105. (717) 564-0101.

A new series of 0.600-in. wide low-profile DIP receptacles is available in 24, 28 and 40-position versions. These solder-to-board receptacles feature closed contact entry with large lead-in ramps for easy insertion of the circuit package. The receptacles are less than 0.160-in. high, excluding the ramp, and the housings are of flame retardant, glass-reinforced nylon with anti-bridging, easy-cleaning standoffs. Contacts are beryllium copper and may be ordered with tin or gold plate. Contact current rating is 1.5 A and dielectric withstand voltage is 1000 V rms. Individual contact engagement force is 0.9 oz min. Contact durability is 25 cycles.

CIRCLE NO. 339
Gaskets made with wires embedded in silicone

Radcon Corp., 246 Columbus Ave., Roselle, NJ 07203. (201) 241-5550. 80.07 per in.²; stock to 6 wks.

Radcon’s series 1550 rf gasketing material has a conductivity of approximately 0.003 Ω cm. The resistivity, though, varies with the type of conductive material dispersed through the material’s silicone-rubber base. The material is made in sheets and in custom shapes ranging from 0.002 to 0.125-in. thickness. Other thicknesses also are available. The series 1547 material is made conductive by running wires through the silicone rubber. Those wires are usually monel, but almost any conductive wire can be used. The 1547 material comes in 25-durometer solid silicone with a minimum thickness of 0.062 in. and in sponge silicone of medium density with a minimum thickness of 0.093 in.

CIRCLE NO. 340

Kit of ferrite cores for wide-band xformers

Fair-Rite Corp., Wallkill, NY 12589. (914) 895-2055. $10; stock.

A sample kit contains 18 different core shapes of nickel-zinc and new high-permeability manganese-zinc ferrites for winding wideband transformers. The cores are specially selected for effectiveness at frequencies above 2 MHz. The core shapes are provided in three different materials each, with application data that include characteristics curves. The data also describe how to choose the right material and core size for a particular application.

CIRCLE NO. 341

These ceramic trimmer capacitors are designed for broadband application, from audio to 500 MHz and afford an ideal low cost means of “trimming” circuitry such as crystal oscillators, CATV amplifiers and all varieties of communication and test equipment.

FEATURES

- Capacitance values from 1 – 3 to 5 – 25 pf
- Low profile – .208 above board height
- Low cost – 75c in 1000 quantities
- Delivery from stock

MANUFACTURING CORPORATION
BOONTON, NEW JERSEY 07005
201 / 334-2676
TWX 710-987-8367
INFORMATION RETRIEVAL NUMBER 58
**Bridge rectifiers handle 10 A and are tiny**

Sarkes Tarzian, 415 N. College Ave., Bloomington, IN 47401. (812) 332-1435. From $1.98 (100-up).

The H-FB series of bridge rectifiers, with 10 A ratings, is available with PIVs from 100 to 1000 V. The devices are housed in a 0.75 in. diameter machined aluminum case with plastic insulation on all sides except where the built-in heat sink is exposed. Maximum case temperature is 150 C, and maximum one-cycle surge current is 240 A. Maximum heat dissipation at 10 A is 21 W. The H-FB series is normally available with standard silicon avalanche devices, 0.04-in. diameter wire leads and a 0.156-in. mounting hole for a #6 screw. They can also be supplied with 200-ns fast recovery devices or with special polarization and terminal configurations.

**Rf power transistors deliver 150 W**

Communications Transistor, 301 Industrial Way, San Carlos, CA 94070. (415) 591-8921. $40 (1000-up); stock.

The S150-50 rf power transistor can deliver 150 W and is available in a rugged 1/4-28 stud-mounted package as well as in the 0.5-in. flanged package. S150-50 is designed specifically for operation (from a 50-V supply) in broadband linear power amplifier applications in the 1.6-to-30-MHz range. It is capable of operation in Class A, AB or C amplifiers.

**LED displays claim largest size available**

Litronix, 19000 Homestead Rd., Cupertino, CA 95014. (408) 257-7910. $2.90 (100-up).

Three 0.6-inch high red LED displays complete the DL-747 series of jumbo digits. The DL-750 seven-segment display has a left-hand decimal and common cathode connection, the DL-749 polarity/overflow display has a common-cathode connection and the DL-746 polarity/overflow display has a common-anode connection. All three displays are 44% larger in area than 0.5 in. high displays, the largest the company claims is available from other major LED manufacturers. Light pipes spread illumination evenly over broad segments. Black plastic surrounds the segments, providing excellent contrast. The displays have a typical luminance of 5 med at 20 mA per segment. Forward voltage per segment is 3.4 V typical and 4 V maximum when operated at 20 mA. All the displays are packaged in standard 18-pin DIPs.

**Dual monolithic JFETs have epoxy packages**

Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. (408) 246-8000. From $0.99 (100-up); stock.

A series of monolithic matched dual FETs is available in epoxy packages. The E410 family of n-channel dual JFETs is intended for low and medium frequency small-signal differential amplifiers. Characteristics of the E410 family include offset voltage of 10 mV max, CMRR of 70 dB min, offset tempco of 10 µV/°C and Rθja of 5 µmho max at an ID of 200 µA.

**Other voltages are available for both ANALOG and DIGITAL applications**

SEMIQUAD CIRCUITS, INC.
306 RIVER STREET • HAAVERHILL, MA 01830
(617) 373-9104 • TWX 710-347-0269
INFORMATION RETRIEVAL NUMBER 59
Pretrigger recording is a simple concept. And it is the most powerful recording method for short-lived signals. But Roy Tottingham, Biomation Product Manager, has found that almost no one grasps its usefulness until shown a demonstration. So here’s his demo.

"Let’s start with the familiar, then move to the unfamiliar. You work with scopes now, right?"
"Right."
"Good. And scopes do a fine job catching repetitive signals for analysis."
"No sweat. But my signal is a unique waveform—once per test shot."
"Exactly—A classic for one of our waveform recorders with pretrigger recording—this Model 8100, for instance. Its 25 MHz bandwidth is ideal for a wide range of waveforms. Let’s connect your signal and I’ll show you why."
"O.K."
"Set the input coupling and sensitivity and select the timebase for the signals' duration. Next choose the trigger coupling, polarity and internal source."
"Say, that’s just like a scope setup."
"You’re right! But if this was a typical scope/camera or storage scope capture, we would now face what I call the trigger level dilemma."
"What’s that?"
"Set the trigger level low and we risk triggering on noise or signal echoes. Or set the level high and the scope loses most of the leading edge. Here, like this upper trace on the chalkboard,"
"Arrgh! That gets me where I live! I tried solving that problem with a special trigger detector and trigger path to externally trigger my scope. but that was a pain to set up and only worked about half the time."
"M-hmm, twice the cost and half the reliability... nobody wins."

"You mean... this Biomation box gets around all that hassle?"
"With the waveform recorder in pretrigger mode, we can’t miss. Let’s set the 8100’s trigger level high and its trigger delay to about 80% of the record length. Now I’ll reset the trigger circuit and you can trip your test anytime you want!"
"O.K. Here goes."
"And there you have it!—on the CRT monitor output of the 8100!"
"Wow! Look at that leading edge trigger point! 20% from the left end of the trace. What do you have in that 8100? A superfast disc or tape loop?"
"No way! The 8100, like all of our waveform recorders, uses a superfast A/D converter and semiconductor memory for recording."
"But how does that give me pretrigger data?"
"In pretrigger mode, the delayed trigger is used to stop recording, not start it. So the memory can be continually updated with the newest data from the A/D—in real time—until the trigger is detected. Then it’s stopped after the trigger delay. Here, I’ll illustrate this effect on the board. The stored signal is then repetitively reproduced through a D/A for display on a scope or CRT as you see here. Or you can output it slowly onto a chart recorder."
"Hey! That’s a clean deal! Does it have digital output too?"
"Of course, and we also have models with digital input for recording digital signals. One of our units is sure to fit your need."

So there’s the demo. Now if you want data sheets or applications ideas, drop us a line. Biomation, 10411 Bubb Road, Cupertino, CA 95014. (408) 255-9500.
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The Series CT-400 Automatic Torque Control Systems are the most complete and versatile, industrial line available from off the shelf today for electrical control and inspections of torque directly on the production line. The electrical output signal permits control either on site or remotely. Available in one to five channels, these units feature a wide range of torques of less than 1 ft-lb to more than 100,000 ft-lbs. Adjustable lower and upper dimensional relay trip levels, provide automatic selective rejection of under and over torqued components to meet automotive and other safety requirements.

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INFORMATION RETRIEVAL NUMBER 61

Decitek gives you accurate, reliable tape reading whatever your reader requirements.

Regardless of what reader you select from the Decitek line, you will be assured of proven reliable performance. A patented dual sprocket drive gives consistently accurate character registration up to 600 cps without tape wear. The fiber optic-photo transistor read system provides highly stable error-free reading. Write for brochure giving details on the full Decitek line of high-performance punched tape readers.

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INFORMATION RETRIEVAL NUMBER 62

DISCRETE SEMICONDUCTORS

LED numeric displays designed for watches

Litronix, 19000 Homestead Rd., Cupertino, CA 95014. (408) 257-7910. From $7.05 (1000-up).

The DL-5175 series of 4-digit LED displays is available in four different types, each with a colon between second and third digits. The DL-5175 is a 4-digit display of continuous-line monolithic digits 0.1 in. high, the DL-5176, a 3-1/2-digit display 0.115 in. high, the DL-5177, a 4-digit display in a monolithic package with magnified digits 0.1 in. high and the DL-5178, a 4-digit version of the DL-5176 for 24-hour timepieces. The pin-out configuration of the DL-5175 series has been optimized to allow close spacing of integrated circuits, such as the company's LBC-1060 and LBC-1070 bipolar drivers, without the need for jump bonds or multilevel interconnect schemes.

CIRCLE NO. 346

Photodiode array has support electronics


A module in the company's 4000 series is designed for optical scanning. It consists of a printed-circuit board and a self-scanned linear array of 64 photodiodes. The printed-circuit board contains all necessary driving and processing electronics to provide an electrical video output when supplied with dc voltages.

CIRCLE NO. 347
Bridge rectifiers have 300-ns recovery time


The PBR and PBRL series of rectifier bridges handle currents of 15 A and have PRVs that span 50 to 1000 V. The bridges have maximum reverse recovery times of 300 ns. All units have a max range current of 200 A and a max peak repetitive current of 50 A. Both bridge models measure 1.125 x 1.125 x 0.438 in., not including terminal height.

CIRCLE NO. 348

LED lamps available in orange, yellow or green

Monsanto, 3100 Hillview Ave., Palo Alto, CA 94304. (415) 493-3306. 80.70 (1000-up); stock.

A line of LEDs is available in green, yellow and orange. The series is mechanically identical to the company's MV5050 series of red lamps. The lamps use a unique reflector assembly, seated behind the LED, to collect the available light and project it along the central axis. Two lenses are available for each of the new colors. The MV5153 is an orange LED, encapsulated in orange diffused epoxy and projects a wide (65°) beam angle. The MV5154 is a similar device with a narrow (24°) beam angle. The other models in the series follow the same pattern: MV5253—green LED, green epoxy package, narrow beam; MV5353—yellow LED, yellow epoxy package, wide beam angle; MV5354—yellow LED, yellow epoxy package, narrow beam angle. All of the lamps have a maximum power dissipation of 105 mW, with a maximum continuous forward current rating of 35 mA at 25 C. In addition, they can be pulsed at a maximum of 5 A.

CIRCLE NO. 349

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A Data Acquisition System In a Single Module.

Save time and money... translating analog data into digital words. Data Translation's DATAX™ is a line of fully integrated data acquisition system modules that outperforms clusters of modules... and all at lower cost.

Imagine, for $395 in 100's you get a complete system that includes:
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Technological advancements in engineering and manufacturing ceramic capacitors in volume have made Centre Engineering an excellent source of supply.

Hit the bull's-eye with Centre Engineering.
Write for additional information.

CIRCLE NO. 349

INFORMATION RETRIEVAL NUMBER 63

INFORMATION RETRIEVAL NUMBER 64
Small computer systems added to Honeywell line

Honeywell Information Systems, 200 Smith St., Waltham, MA 02154. (617) 237-4100. See text.

Honeywell has introduced to U.S. markets two small computers in the $1400 to $4000 monthly rental range. The Level 61 models, smallest in Honeywell's recently announced Series 60 computers, are designed to meet the growing data processing requirements of firms or departments currently using service bureaus, and to provide a growth path for Honeywell's Model 58 users. The Model 61/58 batch and multitasking versions and the Model 61/60 transaction processing system compete with such equipment as IBM's System/3 Models 6, 8, and 10; Burroughs' 700 and 1700 and Singer's System Ten. The Model 61/58 can be leased at prices ranging from about $1400 to $3000 per month and will be available for delivery in the fourth quarter of this year. The Model 61/60 can be leased at prices ranging from about $2900 to more than $4000 and will be available in the second quarter of 1975. Both models can function as independent systems in a small or medium-sized company or as a satellite system, processing and transmitting information to a large central computer. The main processing memory has a complement of 78 hardware instructions and a cycle time of 1.2 μs. A 350-ns read-only memory, peripheral simultaneity and a no-sort disc file structure contribute to low storage requirements and reduce total processing time. An optional 800-ns MOS extended-memory store, ranging from 16K to 64K bytes, enhances the 5k or 10k main memory. Peripherals include mass storage subsystems with capacities ranging from 3456 megabytes, printers with operating speeds of from 100 to 650 lines per minute, and various input devices including card readers and punches and an optical mark reader.

Process monitor replays channels for fault study

Metra Instruments, 1340 Space Park Way, Mountain View, CA 94043. (415) 961-7249. From $105-500; 3 mo.

An 0.25-in. tape cartridge in the Metrecorder holds up to 76 Mbits (40 min) of data. A CRT bargraph display presents the data visually and at the same time, the data are made available for channel monitoring and alarms. The unit can monitor up to 80 process variables and replay them for use in visual diagnosis of failures if they occur. The data are presented to auxiliary equipment in 11-bit ASCII code.

Intelligent terminals are IBM-compatible

Sanders Associates, Daniel Webster Highway, Nashua, NH 03060. (603) 885-2810. $29,925: March.

The Sanders Series 8171 and 8172 terminals are compatible with the IBM 3270 operating specifications and include features such as dual intensity, key click, audible alarm, coaxial cable and Photopen. The 8171 represents an extension of the 8170 remote systems while the 8172 is a new product directed towards the local environment market. Designed to meet a variety of on-line alphanumeric requirements, such as inquiry/response, data entry, and order distribution, the 8171 and 8172 can be placed in 3270 application systems without change. The standard IBM 3270 terminal control function, performed with the display and keyboard, plus the binary synchronous communication line control is provided by control programs in the controller memory of the 8171 and 8172. Each system consists of a 12k microprocessor, two CRT displays with keyboards, and emulation software. Configurations ranging up to 32 CRT terminals and eight printers are available.
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6000 Series Systems combine per-channel low level amplifiers with a high level multiplexer and a programmable gain amplifier to provide complete multi-channel signal processing in a small, rugged package. Outstanding performance is provided by the transformer coupled, chopper stabilized design which offers extremely low drift and noise and accommodates common mode voltages up to 300 volts. The standard systems are capable of scan rates of 20,000 channels per second (higher on special order). Integral A/D converters are optional.

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INFORMATION RETRIEVAL NUMBER 66

INFORMATION RETRIEVAL NUMBER 67

INFORMATION RETRIEVAL NUMBER 68
Typewriter attachment enhances CRT terminals

Tycom Corp., 26 Just Rd., Fairfield, NJ 07006 (201) 227-4141. $2350; 30 to 45 days.

A high-print quality typewriter attachment for intelligent terminals with CRT displays is now available. The Model KSR-38 can be used with CRT terminals that have an RS-232 output. The system includes a customer-supplied IBM Selectric and Tycom electronics. The depressed keys of the Selectric are converted to ASCII code and the data are then transmitted at a rate of 15 characters per second. Copy can be prepared on the Tycom or CRT terminal keyboards or obtained directly from a computer and edited on the CRT display. The revised copy can then be printed in hard-copy form on the Selectric or stored in the computer for later use.

CIRCLE NO. 353

Logger has separate alarm set-points

Austron Inc., 1915 Kramer Lane, Austin, TX 78758. (512) 836-3533. $3600 (typ); 90 days.

The DL-1200R logs data from 10 analog channels on an 18-column drum printer. The unit displays data value and channel ID and can scan for alarms in the time between periodic loggings. The alarm option provides independent set points for high and low values. Input impedance is 20 MΩ and source impedance must be 10 kΩ or less. Full scale readings are from 10 mV to 10 V with 0.1% FS or 5 μV resolution (whichever is greater). The DL-1200R response is settable from one reading/s to one every 10 s. Input isolation is provided (90 dB CMR at 60 Hz) and the number of channels is expandable to 50. In addition open circuits are noted automatically.

CIRCLE NO. 354

Instrument coupler has flexible output format

Data Works, 18752 Bryant Ave., Northridge, CA 91324. (214) 885-8985. See text; stock to 30 days.

A dual instrument coupler, the Model 1700, accepts up to 40 parallel inputs per channel and formats them to serial or 8-bit parallel characters. Program modules establish the type of conversion which can include BCD to ASCII, octal to ASCII or binary to all eight data bits. The output drives modems, TTYs or CPUs to form a complete data acquisition system. One suggested use for the two-channel version includes a multiplexing DVM (for nine analog inputs) and a digital clock to form a logging system. The maximum serial baud rate is 9600. Model 17X1 (single channel) costs $895; the 17X2 (double channel) $1195.

CIRCLE NO. 355

Electronic unit checks entry by fingerprint

Calspan Technology Products, P.O. Box 233, Buffalo, NY 14221 (716) 632-7500. From $29,500, ea. terminal $2950; 2 to 3 mo.

Equipment capable of verifying an individual's identity within two seconds, by "reading" his or her fingerprint is now available. Designated Fingerscan, the system consists of one or more access terminals connected to a specialized central station in which are stored the identification numbers and fingerprints of persons authorized to enter the controlled area or use controlled equipment. The individual activates the system by entering his identification number into the access terminal and pressing his finger onto a template. Within two seconds, the Fingerscan system will read the fingerprint, compare it with the one registered, and signal back either Access Permitted or Access Denied. Some of the technology used in Fingerscan was developed by the company for the Finder automatic fingerprint reader system, which has been in operation for more than 1-1/2 years at the F.B.I. Finder includes substantial innovations in digital image processing technology, and patents have been applied for.

CIRCLE NO. 356

Flame retardant, polyester TEMP-R-TAPE M67 passes U/L and ASTM requirements. This outstanding flame retardant safety feature, in combination with the excellent electrical and physical properties of polyester film backing provides you with a self-adhering tape for use in a wide variety of coil winding, coil holding, harness wrapping and other electrical/mechanical applications. It is especially valuable for radio and tv appliances to reduce fire and electrical shock hazards.

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INFORMATION RETRIEVAL NUMBER 69
CUT PRODUCTION TIME WITH THESE LOW COST COMPONENT LEAD BENDERS

Up to 1200 component leads per hour may be formed with these simple, precise units. They cut production time and eliminate damage to components and leads. Designed primarily for resistors and diodes, MARK Series Component Lead Benders produce perfect bends. Tantalum capacitors, axial lead components, jumper wires, and other similar parts may also be formed easily and efficiently. Ideal for both prototype and production situations.

Bends are made rapidly with gentle finger pressure and meet N.A.S.A. Specification MSFC-PROC-256. No other tools are required. The aggravation and component damage associated with the long-nose plier "free bending" technique is completely eliminated. Industry proven since 1959, the MARK Series offers 5 models for forming 1/8 watt, 1/4 watt, 1/2 watt, 1 watt, and 2 watt size component leads. Priced under $5.00, these quality tools are available for off-the-shelf delivery. For complete information write or call:

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The New Brush 2400: the best performing, most versatile wide channel recorder you can buy.

It is available in 2, 3 and 4 channel configurations utilizing combinations of 50 mm and 100 mm channels totalling 200 mm. It had a 99.65% linearity over the full 100 mm channel. Its frequency response is an outstanding 30 Hz at 100 mm, 50 Hz at 50 mm and up to 125 Hz less the 3dB down. It has a full range of plug-in signal conditioners for just about any industrial-scientific-medical application.

For full details on why the new Gould 2400 is the best performing direct writing recorder you can buy, write Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Kouterveldstraat Z/N. B 1920 Diegem, Belgium.

0.1 Hz to 1 MHz
for only $140.00*

This new function generator from Heath offers sine, square & triangle waveforms, wide frequency range, 10 V output, 70 dB attenuation for only $99.95* kit, $140* assembled

Every lab needs a good function generator. And now Heath offers a true function generator at a price everyone can afford. Our 1271 provides sine, square or triangle waveforms from 0.1 Hz to 1 MHz with a 10 volt peak-to-peak output into a 50-ohm load. The calibrated attenuator provides 0 to 50 dB attenuation in 10 dB steps with up to 20 dB additional variable attenuation for each step, for a total of 70 dB. Triangle waveform nonlinearity is 5% maximum, with waveform symmetry within 10%. Sine wave harmonic distortion is 3% maximum from 5 Hz to 100 kHz. Square wave rise and fall times are 100 ns max. Its light weight and small size allow it to be placed almost anywhere. The adjustable tilting handle provides easy carrying and positioning for best access to the front panel controls. For $140*, you can have the SG-1271, completely factory assembled and calibrated. Or buy the kit-form IG-1271 for only $99.95* and save by building it yourself — a triggered scope is all that's needed for alignment.

Our latest catalogs contain complete description & specs for the 1271 and many other high-performance, low cost instrument values from Heath. Send for your free copies and see how you can get more value for your instrument dollar.
COMPONENTS

Gas-discharge display provides high contrast

Cherry Electrical Products Corp., 3800 Sunset Ave., Waukegan, IL 60085. (312) 689-7600.

Digital readouts, called Plasma-Lux, are gas-discharge display panels that are totally interchangeable with other similar panels. According to Cherry, an advanced thick and thin-film technology produces the high contrast and brightness, uniformity of each of the seven segments, low power consumption, high reliability and long life. A halo-effect back light gives the appearance of a continuous line for greater visibility, clarity and sharpness. The neon orange color is easy on the eyes and may be readily filtered. The 0.40-in-high digit size is easily read from distances up to 25 ft.

Replace indicator lamps without tools

Aerospace Optics Inc., 7112 Burns St., Fort Worth, TX 76118. (817) 284-2993.

Standard T-1 flange-base lamps are easily replaced from the front of this new indicator without any tools. The indicator connector mates with the Standard MIL-C-390-29/1-16-20 pin. Indicator messages are readable in sunlight and come in four illuminated colors—red, amber, green and white. Two separate messages can be displayed in each module.

Four DPDT switches housed in 24-pin DIP

Amp Inc., Harrisburg, PA 17105. (717) 564-0101.

Four separate DPDT switches are housed in this DIP. Each screw-driver actuated switch is bidirectional with a center-off position. Over-all body dimensions are 1.344 L × 0.428 W × 0.312 H in. Lead spacing is the standard 0.100 × 0.300 in. DIP pattern. Contact resistance is typically 30 mΩ max. The nonswitching rating is 50 V at 100 mA and the switching rating is 5 V at 100 mA. Dielectric breakdown voltage between adjacent switches is 500 V dc minimum. Contacts and terminals are phospho-bronze, plated-gold over nickel with an electrical life of 2000 switching cycles.
IMPROVE YOUR GOLD BOOK

Several errors crept into Electronic Design’s GOLD BOOK. You might find it handy to clip out the following corrections and attach it to your copy of THE GOLD BOOK.


Volumes 2 and 3 include 2820 catalog pages, organized within 52 basic product categories. So the three volumes include a massive amount of data and, as the errors show, the GOLD BOOK is not perfect. So we’re not happy.

We want to make next year’s edition as perfect and complete as humanly possible. We’d appreciate your help. If your company offers products or services to the electronics industry, help us make certain your company is listed. Take a few moments to fill out the card following page 114.

Acopian Corp., 131 Loomis St., Easton, PA 18042 Tel: (215) 258-5441

The company’s catalog pages were not listed completely in all the appropriate product categories in the Product Directory. The complete listing of product categories that should carry catalog page references, and the associated catalog page references are as follows: Power Supplies, A-C Input, 0 to 100 VDC Output (Vol 3/875-900); Power Supplies, A-C Input, 0 to 1000 VDC Output (Vol 3/876-877, 880-891, 893-897-900); Power Supplies, A-C to D-C, Modular (Vol 1/Inside Front Cover, Vol 3/875-900); Power Supplies, A-C to D-C, Unregulated (Vol 3/890-891); Power Supplies, High D-C Current, Low Voltage (Vol 3/888-889); Power Supplies, Isolated (Vol 3/896); and Power Supplies, Operational Amplifier (Vol 3/879-881,892).

Artisan Electronics, 5 Eastmans Rd., Parsippany, NJ 07054 Tel: (201) 887-7100

The company does not make Generators, Impulse, for which it was listed.

Clarke-Hess Com Research Corp., 46 W. 16th St., New York, NY 10011 Tel: (212) 255-2940

The company was listed as Com (Communication) Research Corp, with a cross reference from Clarke-Hess Com Research Corp. The company prefers its primary listing as Clarke-Hess Com Research Corp.

Further, in the Index of Catalog Pages in Volumes 2 and 3, the company was listed as Clarke-Hess, Research Corp with a cross reference to Research Corp. (This error resulted from a telephone order, in which a typesetter mistook “Com” for a comma.)

Computer Labs., 1109 S. Chapman St, Greensboro, NC 27403 Tel: (919) 292-6427

The company’s listing under Converters, Analog-to-Digital (Except IC) should reference Catalog Page Vol 3/1289.

Del Electronics Corp., 250 E. Sandford, Mount Vernon, NY 10550 Tel: (914) 699-2000

The company feels that it deserves a printer’s bullet (indicating that literature was supplied for verification) for each of its products. The GOLD BOOK staff, unfortunately, did not receive the literature.

Dow Corning Corp, South Saginaw Rd, Midland, MI 48604 Tel: (517) 636-8000

All of the company’s listings in the Product Directory should be boldfaced.

GTE Automatic Electric, 400 N. Wolf Rd., Northlake, IL 60164 Tel: (312) 562-7100

The company was listed in the Index of Catalog Pages, the Product Directory and the Manufacturers Directory as GTE Sylvania Automatic Electric. GTE Sylvania and GTE Automatic Electric are, in fact, separate companies, though both are wholly owned subsidiaries of General Telephone & Electronics Corp.

EF Johnson Co., 2999 Tenth Sw, Waseca, MN 56093 Tel: (507) 835-2050

The company’s catalog pages (Vol 2/925-929) appeared in Section 1100 (Function Modules) instead of Section 3100 (Connector Products & Terminal Boards). Further, the company’s city was listed as Waseek, MN instead of Waseca, MN.

Superior Electric Co., 3000 Middle St., Bristol, CT 06010 Tel: (203) 582-9561

Catalog pages Vol 2/1375 and 1376 should have been facing pages (with Page 1376 on the left), instead of back-to-back.

Tech Wire Prods Inc., 129 Demody St, Cranford, NJ 07016 Tel: (201) 272-5500

All of the company’s listings in the Product Directory should be boldfaced.

TRAK Microwave Corp., 4724 Eisenhower Blvd., Tampa, FL 33614 Tel: (813) 884-1411

Catalog pages Vol 3/1384 and 1385, referenced from Geo Space Sys Div of TRAK Microwave Corp, also at 4724 Eisenhower Blvd, Tampa, FL 33614, should instead have been referenced from TRAK Microwave Corp in the Index of Catalog Pages.

Further, TRAK should be listed, with a cross-reference to the indicated catalog pages, in the Manufacturers Directory and under the following product headings in the Product Directory: Amplifiers, I-F (Vol 3/1384); Amplifiers, Microwave (Vol 3/1385); Microwave Circulators & Gyrotrons (Vol 3/1385); Microwave Isolators (Vol 3/1385); Oscillators, Microwave (except Klystron & Magnetron) (Vol 3/1384,1385); Oscillators, Pulse (Vol 3/1384); Oscillators, R-F (Vol 3/1384); and Preselectors (Vol 3/1385).

Union Carbide/Components, Box 5928, Greenville, SC 29606 Tel: (803) 963-7421

The trade name KEMET, for the company’s components, was omitted from the Trade Name Directory.

Vectrol Inc., 1010 Westmore Av., Rockville, MD 20853 Tel: (301) 424-6900

The company’s listing under Controls, SCR in the Product Directory should have referenced Catalog Page Vol 3/1418. This page was referenced erroneously in the listing for Vectrol under Power Converters, A-C to A-C, Solid State.

Wabash Relay & Elecs, First & Webster St., Wabash, IN 46992 Tel: (219) 563-2191

Catalog page Vol 2/1224 instead of Vol 2/1244 was referenced for this company’s data page in the Index of Catalog Pages, and in the Product and Manufacturers Directories.
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Control system
A four-color brochure describes the company’s microprocessor-based Autodata Eight monitor/alarm/control system. Vidar Autodata, Mountain View, CA

Op amps
The second edition of “Operational Amplifiers” contains the theory of op amps, construction of circuits and is complete with schematics. But have your French-English dictionary handy, you’ll have to translate it. Thomson CSF, Paris, Cedex, France.

Instrument catalog
A 164-page catalog describes and illustrates thousands of unusual and hard-to-find bargains for design engineers, research labs, safety specialists, experimenters and hobbyists. Edmund Scientific, Barrington, NJ

Metalized substrates
“Processing of Micaply Conductor Metalized Substrates for Hybrid Microcircuits” describes the preparation of this substrate material for various chip and wire bonding techniques. Also included are processing sequences suitable for fabricating several types of conductor networks. The Mica Corp., Culver City, CA

Picture tubes
A 24-page guide includes an interchangeability directory that lists RCA replacements for 975 pictures tubes including 85 foreign types. The guide includes basing diagrams, pictorial views illustrating safety feature considerations and keys to tube sizes in the old, new and foreign type designation systems. RCA Commercial Engineering, Harrison, NJ

Rubber parts
A four-page technical bulletin covers fire-retardant rubber parts. The Stalwart Rubber Co., Bedford, OH

Bayonet terminals
A bulletin describes a bayonet terminal for use with both 1/16 and 1/32-in. PC boards. Dimensional outline drawings and a photograph of the unit attached to a PC board are included. Malco, Chicago, IL

Epoxy powders
A four-page brochure contains information on epoxy powders, one of which pre-coats and cures at temperatures as low as 85 C. A graph depicts a method of application for each of the nine epoxy powders, along with temperatures, cure time and other characteristics such as shelf life, etc. Amicon, Polymer Products Div., Lexington, MA

Transducers
A 160-page book, “Transducers: Pressure and Temperature,” details the theory of transduction in general as well as the theory of operation of IC transducers in particular. It discusses their construction, includes a glossary of terms, discusses reliability, custom design and future products, and it includes design tables. National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051
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Microcomputer system
High performance n-channel microcomputer components and systems are described in a 12-page bulletin. The 15 support components described include four RAMs, six ROMs and pROMs and five peripheral circuits. Intel, Santa Clara, CA

CIRCLE NO. 370

Pushbutton switches
The Series 12000 minibutton pushbutton switch is described in a data sheet. Mechanical, electrical and environmental specifications, materials list, available codes list and price list and quantity discount are included. The Digitran Co., Pasadena, CA

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Electronic Design 25. December 6, 1974
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This multi-cam timer is one of a family of very versatile recycling timers that are available in single or recycling types with up to 20 control circuits. Control cams are independently adjustable from 2/3 to 98% of the total time cycles enabling the timer to be used as a programming device. And with supplied interchangeable gear and rack assemblies you can select from 700 time cycles ranging from 1/2 second up to 72 hours. All our timers are made to give you service far beyond what you'd reasonably expect. Our line consists of 17 basic types, each available in various mountings, voltages, cycles, circuits and load ratings...and with whatever special wrinkles you may need. Bulletin #206 tells all about our line of reliable Recycling Timers. Write for it or a catalogue of our entire line. If you have an immediate timer requirement, send us your specifications. Or for fastest service, call (201) 887-2200.

RECYCLING TIMERS Series RC

Audio Indicator “Systems”
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NEW SUB-MINIATURE TOGGLE SWITCH* FOR PRINTED CIRCUIT BOARDS
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- NO MOUNTING HARDWARE REQUIRED

A 2 & 3 Position Toggle (Actual Size)

CONTROL TOGGLE

28 VDC, 120 VAC

Contact Resistance .................................................. 0.025 ohms, max.
Ambient Temperature Range .......................... —20°C. to +70°C.
Weight ............................................................................. 0.06 ounce

PCB TOGGLE SWITCH SPECIFICATIONS
(available in 2 position or 3 position momentary and/or maintained)

<table>
<thead>
<tr>
<th>Volts</th>
<th>Load</th>
<th>Life (ops., min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 VDC</td>
<td>0.01 amp, res.</td>
<td>500,000</td>
</tr>
<tr>
<td>6 &amp; 12 VDC</td>
<td>1 amp, res.</td>
<td>100,000</td>
</tr>
<tr>
<td>28 VDC, 120 VAC</td>
<td>0.5 amp, res.</td>
<td>100,000</td>
</tr>
</tbody>
</table>

Pushbutton style also available in momentary action or latch-down, screwdriver-slot or snap-on button.

Send for technical bulletins

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A SUBSIDIARY OF CUTLER-HAMMER INC.
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Check these standard features:
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☐ Plated through PC board holes (component strength)
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☐ Pulse fired overvoltage protector with nuisance trip prevention
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MODEL 913—72

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AC coupled inputs (automatic rejection of up to 200 volts DC).
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Automatic high noise and harmonic rejection.
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MODEL 913H-72 — .025 thru 50,000 Hz.

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Quick Specs
- Input: 0 to -999mV
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- Power: +5VDC
- Output: Full parallel BCD
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- Counter: 0 to 10MHz count rate
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Even with three technologies on a single chip, the new CA3130 is simplicity itself. Which is why it costs only $0.75 at 1K (premium versions are also available). Among its principal features (values shown are typical):

**General Purpose**
- High open loop voltage gain: 110 dB
- Low input offset voltage: 8mV
- Low input current: 5pA
- Input offset current: 0.5pA

**FET input**
- Very high input impedance: 1500 MΩ

**Wideband**
- Unity gain crossover frequency: 15 MHz
- High slew rate: 10 V/μs
- Fast settling time: 1.2μs

**Micropower**
- 2.5 mW at 5V supply voltage

**High current**
- 22 mA output

A voltage swing to within 10 millivolts of either rail on a single power supply is now possible for the first time because of the CMOS output stage.

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