IC regulators for power supplies p. 47
Transmitting data with digital ICs p. 58
Understanding read only memories p. 64
Project management, military style p. 27
Instrumentation—by the systems approach p. 73
For the first time you have the added dimension of variable persistence and storage in a low frequency scope for your dc to 500 kHz measurements. And, only variable persistence gives you completely flicker-free displays of all your low frequency measurements.

Four new models in the HP 1200 series have pushbuttons allowing selection of conventional, variable persistence and storage modes. Having one of these new all-solid-state scopes is like having three scopes in one!

You can select storage writing speed by pressing the STD pushbutton for >20 cm/ms. Press the FAST pushbutton for >½ cm/µs writing speed. Persistence is continuously variable from 0.2 second to 1 minute or longer in STD mode and 0.2 second to 15 seconds in FAST mode.

In STD mode, you can vary storage time from 1 minute to 8 hours—in FAST mode, from 15 seconds to 1 hour. And, because of the mesh storage technique used in the 8x10 cm internal graticule CRTs, you get bright displays without the loss of trace brightness caused by phosphor deterioration. The 1200 storage CRTs have a life expectancy comparable to HP conventional CRTs.

The new HP 1201A (cabinet) and 1201B (rack) models are dual trace storage scopes with 100 µV/cm deflection factor. Models 1207A and 1207B are single trace storage scopes with 5 mV/cm deflection factor. These new scopes have single-ended or differential input on all ranges, high common mode rejection ratio, complete triggering versatility, external horizontal input, dc-coupled Z-axis, beam finder—many of the features normally associated only with high frequency scopes.

For full details on the new HP dc to 500 kHz variable persistence and storage scopes in the 1200 series, contact your nearest HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

Prices: HP 1201A or 1201B 100 µV storage scopes, $1800; HP 1207A or 1207B 5 mV storage scopes, $1475.

HEWLETT PACKARD
OSCILLOSCOPE SYSTEMS

Now You Can Get Flicker-Free Variable Persistence and Storage In A Low-Cost, Low Frequency Scope!
Something New Has Been Added!

Improved SPRAGUE MONOLYTHIC® CERAMIC CAPACITORS

now have a phenolic terminal base

Type 7C Radial-lead Capacitors are made with alternate layers of sprayed ceramic dielectric material and screened metallic electrodes, fired into a solid homogeneous block and coated with a tough phenolic resin. Their new bossed terminal base construction provides these advantages: (1) No resin run-down on leads. (2) Uniform lead spacing is automatically maintained. (3) No dirt and moisture entrapment; degreasing fluid flows freely between capacitor and board.

<table>
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<tr>
<td>082 NPO</td>
<td>-55°C to +125°C</td>
<td>±60ppm/°C</td>
<td>50, 100, 200</td>
<td>51 pF to 0.024 µF</td>
<td>±20% to ±10%</td>
<td>±10% to ±5% to ±2%</td>
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<tr>
<td>075 N750</td>
<td>+25°C to +85°C</td>
<td>-75°C ±120 ppm/°C</td>
<td>50, 100, 200</td>
<td>0.001 µF to 0.002 µF</td>
<td>±20% to ±10%</td>
<td>±10% to ±5% to ±2%</td>
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<tr>
<td>067 X7R</td>
<td>-55°C to +125°C</td>
<td>Meets MIL-C-20 Char. UI</td>
<td>50, 100, 200</td>
<td>0.0018 µF to 1.5 µF</td>
<td>±20% to ±10%</td>
<td>±10% to ±5% to ±2%</td>
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<tr>
<td>023 Z5U</td>
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<td>±15%</td>
<td>50, 100, 200</td>
<td>0.01 µF to 3.3 µF</td>
<td>±20% to ±10%</td>
<td>±10% to ±5% to ±2%</td>
</tr>
</tbody>
</table>

Also made with axial leads, Monolythic® Ceramic Capacitors are available in four body formulations, including a newly-developed 075 ceramic material, as described in the adjacent chart.


SPRAGUE COMPONENTS
CAPACITORS
TRANSISTORS
RESISTORS
INTEGRATED CIRCUITS
THIN-FILM MICROCIRCUITS
PULSE TRANSFORMERS
INTERFERENCE FILTERS
PULSE-FORMING NETWORKS
TOROIDAL INDUCTORS
ELECTRIC WAVE FILTERS
CERAMIC-BASE PRINTED NETWORKS
PACKAGED COMPONENT ASSEMBLIES
BOBBIN and TAPE WOUND MAGNETIC CORES
SILICON RECTIFIER GATE CONTROLS
FUNCTIONAL DIGITAL CIRCUITS

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If George Gershwin had been a Viking design engineer, his creative talent would probably have generated many magnificent products.

At Viking, we have the talent of Gershwin at work every day, composing prolific concepts in precision wire wrap connecting devices—and just for your application.

Install our wire wrap connectors on your computer back panels, (or let us do it for you), and "Wrap Your Troubles in Dreams."

Write or phone for further information on our complete line of wire wrap products.
Project management, military style

To control the large Omega project, the Navy has delegated authority and responsibility to a project manager.

IC voltage regulators—Do-it-yourself power supplies

Not yet, say the users. Never, say the manufacturers of power supplies. But, now that you can get good regulators for $5, lots of people are buying them.

Transmitting data with digital ICs

New integrated circuits make it possible to transmit data under high noise conditions using a simple twisted pair of wires.

ROM at the top

From code conversion to microprogramming, the monolithic read-only memory proves to be a versatile component.

Instrumentation: The systems approach

Instead of performing isolated measurement tasks, instruments are taking on more and more of the complete data job.

IC Ideas

- Zero-beat detector
- IC-compatible crystal oscillator
- Tuned rf frequency divider
- Digital clock has adjustable pulse width

COVER

Because of IC voltage regulators becoming plentiful and priced right, designers now face a new make-or-buy decision for power supplies. When you should "roll your own" or buy complete power supplies is well covered in the article on page 47 by Steve Thompson, our western editor. Steve points out what is available in regulator units, both monolithic and hybrid, and their strong and weak points. Our cover has some good examples of products made by General Instrument, Bendix and Beckman.
There is only ONE authentic method to measure Phase Angle...

And this is it!

An original technique for the measurement of phase angle has been developed by Dytronics. It's recognized as an authentic "PRIMARY" technique. Measurements are dependent upon fundamental concepts, and not upon secondary considerations. The results...absolute unmatched performance. Hundreds of these instruments are in use throughout the world.

Dytronics also has Tunable Electronic Filters (d-c to lower radio frequencies) for separating frequencies.

For full details about these and other products, contact Dytronics Company, Inc., 4800 Evanswood Drive, Columbus, Ohio 43229.

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“The Pill”

for price control

We keep our promises! Last month we promised a low-priced industrial application DPDT TO-5 case relay with an internal transistor driver. We call this new contraption “THE PILL.” “THE PILL” contains a transistor driver and suppression diode, attaches externally to our DPDT industrial 712 relay to form the 712T ... and does double duty as a transapad.

The 712T combines the advantages of relay operation, i.e., high isolation, low contact resistance, double throw contacts, high current and overload capability with the low signal drive requirement offered by the transistor front-end.

It’s hermetically sealed; utilizes all welded construction; requires a turn on (trigger) power of only 200 microwatts or less depending on coil voltage; and may be driven directly from standard TTL or similar logic. The relay coil is paralleled with a diode to suppress transients.

The entire package is only 0.405 high by 0.370 in diameter (including “THE PILL”), and is available from stock at your local Teledyne Relay distributor or from the factory at the following price schedule:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>100</th>
<th>1,000</th>
<th>10,000</th>
</tr>
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<tr>
<td>Price</td>
<td>$12.50</td>
<td>$10.40</td>
<td>$ 9.25</td>
</tr>
</tbody>
</table>

We call our first price control PILL the 712T ... Look for an op-amp PILL in July for DO-IT-YOURSELF time delays and level sensing applications.

No blue sky promises from us ... just fast delivery for quick price relief.

Phone, wire or write for technical data.

TELEDYNE RELAYS
A TELEDYNE COMPANY
3155 West El Segundo Boulevard • Hawthorne, California
90250 Telephone: (213) 679-2205
In microwave diodes, nobody likes surprises. When you buy from Varian you know what you're getting: We build every lot of diodes to your specification and 100% inspect it to make sure that spec is met. There is no product sorting. You never get a diode that's been downgraded from a tougher specification. Our exclusive material selection, production and QA procedures insure the high yields necessary to guarantee you on-time delivery at the highest acceptance rate – bar none – in the industry. We make tuning diodes, multiplier, switching and step-recovery diodes, paramp and oscillator diodes, either Impatt or Gunn-effect type. We build them to a standard tolerance of ±10% or at special tolerances to ±3%. And we package them in any of over 30 different case configurations or deliver them in chip form. So get the diode you really need, every time, from more than 30 Electron Tube and Device Group Sales Offices throughout the world, or from our Solid State Microwave Project, Beverly, Massachusetts.

You get what you specify. Every time.
One electronic world

As recently as four years ago, the chief engineer for microelectronics of an impor­
tant French firm told me that American electronic magazines were being very in­
stuctive in publishing articles on integrated circuits. “But,” he remarked sadly, “we feel kind of hopeless when we find out that most of those circuits are available only in the United States.” He was referring, specifically, to the new TTL integrated circuits that had appeared in the U.S. market, and to the DTL 1cs that his American electronic engineer counterparts were using to good advantage to design the next generation of digital equipment.

This situation no longer exists. Your French, German, or Australian colleagues can today get the same circuits and components that are available to you, from thin-film resistors to high-level TTL integrated circuits. They pay only a slightly higher price than you do, and are catching up fast in learning how to use them.

To be sure, the technological gap that has accounted for the United States’ supremacy in electronics still exists, since most components are developed and manufactured here first. But that gap no longer has much effect on the availability of those components. Save for customs regulations (which are relaxing slowly), and thanks to the light weight of modern components, a manufacturer of integrated circuits or of crystal-can relays can air-freight his products just as easily to Amsterdam, Holland as to Amsterdam, N.Y.; as easily to Melbourne, Australia as to Melbourne, Fla. We are fast approaching “one world” (to borrow Wendell Wilkie’s visionary phrase)—the one world of electronics.

This was evident by comparing the recent IEEE Show, held in New York from March 24 to March 27, with the Salon International des Composants Electriques, held immediately afterward in Paris, from March 28 to April 2. Those American manufacturers who exhibited at both shows displayed almost exactly the same wares at each.*

What is the importance of this one electronic world to you? What difference does it make to you if the same components you use are available half-way around the globe? The difference is that, while the availability gap is evaporating, the salary gap is not. An hour of design work costs far more in the United States than anywhere else in the world. If talents and components are equal, it will be cheaper to produce certain types of electronic equipment elsewhere than here. You can see this trend already embodied in such popular items as the Sony-Tektronix 7-lb portable oscilloscope (designed and manufactured in Japan), in some Hewlett-Packard instruments (designed and manufactured in Germany), and in many IBM peripherals for the System 360 computer (designed and manufactured in several European countries).

The obvious way the American electronic engineer can stay competitive is to enlist the aid of the computer, as more and more of our readers are doing. As for our magazine, the unification of the electronic world will be reflected in our making available to you useful information, regardless of where it originates from. The new electronic world will have no place for chauvinism, or even provincialism. And it will be a world worth participating in.

Alberto Socobusty
Editor

*The European manufacturers who exhibited in Paris concentrated on “best selling” instru­ments such as counters, digital voltmeters, and digital panel meters, and on popular components, such as irrs, digital circuits, operational amplifiers, and voltage regulators, rather than on state­of-the-art items. The Paris show also featured a large percentage of “production” booths, particularly for printed circuits.

Have you noticed . . .

. . . the new columns in the last few issues of our magazine. One, called “Welcome” (page 54), gives you the latest information on new companies or new divisions in the electronics industry. Another, called “Product Seminars” (page 34), lists seminars sponsored by electronic companies for users of their products.
If you want better designs,

Fairchild MSI lets you design a system in the time you used to spend designing a circuit. A few MSI building blocks will do more work than a hundred ICs. We have versatile, compatible off-the-shelf devices that function like shift registers, counters, decoders, latching circuits, storage elements, comparators, function generators, etc. Just about all you need for any digital application. Like a scanning keyboard encoder:

If you'd like a simple method of converting keyboard switch closures to a binary code, you need only 5 of our CCSL building blocks and the logic diagram on the right. (Conventional design techniques would require about 30 conventional ICs to do the same job.) Besides simplicity, this design provides fast rollover, insensitivity to contact bounce, and eliminates ambiguity when several keys are depressed.

The two major elements of the design are a 64-position matrix and a six-bit synchronous counter. (The counter is composed of a 9316 four-bit binary counter and a 9020 dual JK flip-flop.) The three Most Significant Bits of the counter output address the 1-of-8 decoder (9301) forming one side of the matrix, sequentially driving its outputs "low". The three Least Significant Bits address the 9312 scanning multiplexer (the other side of the matrix), sequentially looking at its eight inputs. With this arrangement, all multiplexer inputs are scanned once for every change in the decoder output.

Each intersection of the decoder outputs and the multiplexer inputs can be used as a key position. If one of the keys is depressed, a "low" from the decoder is detected by the multiplexer and converted to a "high" on its negation output. This triggers a one-shot that inhibits the counter from advancing further and provides a "data ready" signal. The duration of the one-shot is set to cover any possible contact bounce. The output of the counter can now be used as the encoded signal, and the matrix can be arranged so that any key closure provides any binary code from 000 000 to 111 111.

The code that appears corresponds to the first key depressed. As long as that key remains down, the retriggerable one-shot continues to receive reset pulses that hold the counter at the count independently of any other switch closures on the board. Once that key is released, the counter resumes its scanning after the one-shot time period has run out.

The addition of a few more MSI elements would add even greater capability to this design. As an example, the addition of another 9312, 9316 and 9601 can result in a single serial binary PDM output group in response to each key depression. Additional control inputs could be used to restrict the range of the scan counter if only certain keys should be enabled in a certain mode as is the case in key punch machines. Addition of a 9304 Read-Only Memory would allow the selection of any code output with a single keyboard design. A single monolithic parity generator could be added to provide parity at very little additional cost. Or, you might want to add two Read-Only Memories to drive a character display and a normal output simultaneously.

Our universal CCSL logic blocks let you build circuits that you couldn't even consider with less complex or less flexible ICs. We now have 15 off-the-shelf MSI devices that you can use to lower costs and increase performance. More are on the way. Write for additional specs and application notes. We'll put you on our list for future mailings, too.
use fewer components.
LSI: Better late than never

Few are the companies that can deliver one year later than contracted for, yet still manage to please the customer (in this case the Avionics Lab at the Air Force's Wright-Patterson base). Texas Instruments, in delivering the hardware for the first system to make full use of large-scale-integration techniques, has pulled it off.

The integrated subsystems in question were 34 arrays: 16 arithmetic units, six input/output blocks, and 12 control-logic components. Average complexity of the transistor-transistor-logic devices was 200 gates per chip, well beyond the 100-gate threshold of LSI (see The Electronic Engineer, Feb. 1969, p. 53). These arrays replace over 1700 individual first-generation ICs in an updated version of an avionics computer. The equipment itself is a 16-bit machine with a 2-MHz clock rate, part of the Air Force's MERA radar system.

Countdown

Besides the obvious benefit of smaller size, the LSI approach imparted other advantages: a 50:1 savings in parts, a 6:1 reduction in interconnections, and a reliability improvement of 50:1. And it reduced the build time (for the computer) to half of what it used to take with standard ICs.

TI achieved a number of other objectives, all of which pertain to its ability to provide other customers with LSI products:

- The fabrication of standard LSI wafers that contain both flip-flops and various-input (1, 3, 5, and 7) gate circuits.
- The establishment of an automatic probe system that determines the exact location of every functional gate and flip-flop on a wafer.
- A working, computer-programmed, multi-level interconnect generator system for fast turnaround time.
- A compatible, 3-level metallization scheme that is applicable to other arrays.
- An automatic test program for checking array functioning.

Connect with this idea

Here is an idea from NASA that looks interesting. It is a non-arcing electrical connector concept. While the connector has not yet been built, R. E. Holmen of Douglas Aircraft, working under contract to Marshall Flight Center, believes it is a practical idea.

TI would not reveal if and when any of the arrays would be marketed on an off-the-shelf basis. But one company official was quick to point out, "We already have standard LSI products, such as 100-gate memories, and other arrays will be introduced later this year."

A decade of integrated circuit achievement. IC inventor Jack Kilby (center), Texas Instruments, holds the first all-IC "computer," a 1961 unit that demonstrated practicality of the IC concept. Flanking Air Force officials display portions of new all-LSI computer: at left is subsystem board composed of first-generation ICs; at right is a 250-plus gate array that replaces it.

A connector plug, as shown, will minimize or eliminate arcing during mating or demating. The plug has a high resistivity outer mating surface, such as a carbon rod with an inert binder. When the plug is inserted (Continued on page 13)
Five places for mil-spec connectors to lose wait.

Getting the Mil-C-26500 and Mil-C-26482 cylindrical connectors you need doesn’t take longer any longer.

Now you can get Elco cylindrical connectors, overnight, from any of our six stocking-and-assembling distributors. In any configuration. With from 2 to 61 contacts. Bayonet or threaded.

The connectors are the equal of any mil-spec-meeting cylindrical connector. Only, for you, they’re a little more equal. Because you can get them faster without paying extra for the privilege.

And the distributors are as willing and able a group of guys as you’ll ever deal with. Give the one closest to you a call; you’ll see what we mean.

For more information (like our new cylindrical connector catalog, for instance) or for direct factory assistance, write Elco Corporation, Pacific Cylindrical Connector Div. 2200 Park Place, El Segundo, Cal. 90245, or phone 213-675-3311. TWX 910-325-6602.
Up in the air for a reliable PCM telemetry system?

Look to MONITOR’s Space/data Team

MONITOR System’s A-100 PCM Telemetry Systems are currently flying in aircraft, missile, spacecraft and sounding rocket instrumentation applications. These high environment units provide state-of-the-art performance at extremely competitive prices. The A-100 PCM unit features:

- Extensive utilization of fully preconditioned microcircuitry for high reliability, small size, and low cost.
- Full compatibility with all IRIG PCM specification.
- True system flexibility—custom systems designed from proven building blocks.

Our down-to-earth engineering staff is available to provide expert assistance in defining and specifying your airborne instrumentation system. Call us and let us show you the most economical approach to solving your data handling problems. MONITOR’s total systems capability covering all phases of ground-based and airborne telemetry is at your disposal.

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A new idea in light beam deflection

Faster and faster memories are being sought by computer manufacturers. Many ideas and schemes are being tried. One of these is an experimental device that can switch the position of a light beam in 35 millionths of a second. This type of high-speed deflector has potential in optical memories to randomly position a laser beam for data recording and reading.

The deflector works on the principle of total internal reflection, which minimizes loss of light. A converging light beam entering a prism is totally reflected at a right angle to its original path and brought to a focus.

To change the position of this spot, a glass plate is moved into contact with the prism's reflecting surface. This effectively makes the prism larger. Light entering the prism now passes through the interface to the back of the plate and is reflected to a new focal position.

The glass plate is moved in and out of contact with the prism by a ceramic piezoelectric disk bonded to the plate. When a voltage (300 V) is applied to the disk, the ceramic material expands, causing the thin glass plate to bend away from the prism.

The disk need only move the plate about 35 x 10^-6 in. to prevent the light beam from crossing the boundary and entering the plate. Grooves ground into the plate allow it to bend more readily, and surface depressions promote a "peeling" action that makes lifting the plate easier.

At IBM's San Jose laboratories, prisms and plates have been combined to form multistage deflectors that produce high-quality images at several locations on a recording surface. Since the number of spots increases geometrically with additional prisms and plates, deflectors capable of addressing more than a thousand locations are feasible.

Development was done at IBM Systems Development Div. in San Jose, Calif.

(Continued from page 10)

into a receptacle, the high resistivity material limits current to below arcing level. As the contact mates further into the connector, less and less resistance is in series with the current, until contact is made with a good conductor.

The carbon rod can be very hard and should be machinable. Because this rod has very little shear strength, it needs an inert stiffener.

Light deflector switches a laser beam from one spot to another in 35 x 10^-6 seconds by moving a glass plate in and out of contact with a prism. Glass is moved with piezoelectric material.

By rapidly moving a glass plate in and out of contact with a prism you can vary the position of a light beam. The glass plate is mounted to piezoelectric material. Applying a voltage to the piezoelectric "driver" causes the material to change dimensions, thus moving the glass. The sketch shows the glass moved away from the prism. Deep groove in glass plate, and depressions, facilitate bending of glass away from prism. The gap is exaggerated in sketch.
Our new high energy silicon power transistors.
15 Amperes.
80 to 120 Volts.

The Delco Radio DTS-100 series. NPN. Triple diffused. Rugged.

All the experience gained from our very high voltage silicon power line has gone into the development of these new transistors.

They were especially designed for the extreme under-the-hood environment of our I.C. voltage regulator. We found these devices ideal for applications requiring high efficiency switching or high power amplification.

The Delco triple sequential diffusion gives the DTS-100 series the high energy reliability that's needed for very tough switching jobs—resistive or inductive. The 28-volt shunt regulator above, for example, is amply handled by the DTS-103 (V_{CEX} of 80 volts). For complete data on this circuit, ask for our application note No. 42.

In the direct coupled audio amplifier above right, the DTS-107 displays the excellent frequency response, gain linearity and transconductance of this family. This circuit is covered in our application note No. 43.

Our solid copper TO-3 package provides maximum thermal capacitance to absorb peak power pulses. Its low thermal resistance (0.75°C/W Max.) assures the extra reliability you expect from Delco.

Like more information? Just call us or your nearest Delco Radio distributor. All our distributors are stocked to handle your sample orders.

For Audio Amplification.

### Delco Radio

**Division of General Motors**

**Kokomo, Indiana**

**The Kokomoans Are in Power**

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**Table**

<table>
<thead>
<tr>
<th>IC Cont.</th>
<th>IC Pulsed</th>
<th>VCEX @ .5mA</th>
<th>VCEO @ .25mA</th>
<th>VCEO (Sus) @ 250mA</th>
<th>HFE @ 20A</th>
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<td>100</td>
<td>85</td>
<td>20-55</td>
<td>5</td>
<td>1.8</td>
</tr>
</tbody>
</table>
The revolutionary PhotoSCR

Will fire when it sees the whites of their eyes.

That much light is all the command this ultra-sensitive SCR needs to fire. Maximum light sensitivity is ten foot candles. Yet, its adherence to orders is so strict that you won't find a more stable device anywhere in the field. Even under charging currents that would overpower most other devices, it will hold its ground. Because its outputs are high, its gains are high, with peak currents up to one hundred times above those of other photosensitive semiconductors. You won't have to call in amplifiers for reinforcements. Watch how SSPI's PhotoSCR performs when it sees action in tape and card readers, level controls, optional encoders, meter relays, and watt-hour meters. SSPI has started a revolution. A call to Howard Wasserman now could mobilize SSPI's standing army of PhotoSCR's to join forces with you.

SOLID STATE PRODUCTS (SSPI) DIVISION OF UNITRODE CORPORATION
One Pingree Street, Salem, Massachusetts 01970 / Tel. (617) 745-2900
The EE Forefront is a graphical representation of the practical state of the art. You will find here the most advanced components and instruments in their class, classified by the parameter in which they excel.

**A word of caution**
Keep in mind the tradeoffs, since any parameter can be improved at the expense of others. If there is no figure-of-merit available, we either include other significant parameters of the same products, or we provide additional bar graphs for the same products.

Do not use these charts to specify. Get complete specifications first, directly from the manufacturers.

### INSTRUMENTS

#### Differential voltmeters (dc)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Accuracy ± % of reading</th>
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<tr>
<td>Fluke 885A</td>
<td>0.001</td>
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<tr>
<td>Fluke 895A</td>
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<td>Fluke 881A</td>
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<td>Medistor A-72</td>
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<tr>
<td>Prec. Standards 1002</td>
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#### General-purpose oscilloscopes

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<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-P 180A</td>
<td>50</td>
<td>$1,250</td>
</tr>
<tr>
<td>Tektronix 454</td>
<td>100</td>
<td>$1,200</td>
</tr>
<tr>
<td>Iwatsu SS211</td>
<td>150</td>
<td>$1,150</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>$1,100</td>
</tr>
</tbody>
</table>

#### Pulse generators

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Highest PRF MHz</th>
<th>Output pulse amplitude Volts (across 50Ω)</th>
<th>Offset voltage Volts</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-H Research 122</td>
<td>100</td>
<td>100</td>
<td>±15</td>
<td>$17</td>
</tr>
<tr>
<td>Datapulse 112</td>
<td>200</td>
<td>200</td>
<td>±50</td>
<td></td>
</tr>
<tr>
<td>Datapulse 113</td>
<td>250</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-H Research 129</td>
<td>500</td>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronetics PG-13</td>
<td></td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-P 214A</td>
<td></td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-H Research 5112</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMC SP-066</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### WWVB Receivers

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-P 117A</td>
<td>$1,300</td>
</tr>
<tr>
<td>Gertsch RLF-1</td>
<td>$875</td>
</tr>
</tbody>
</table>

#### REED RELAYS

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Contact voltage (peak) Volts</th>
<th>Contact voltage (peak) Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnecraft 102HV</td>
<td>10,000 (mA)</td>
<td>10,000 (mA)</td>
</tr>
</tbody>
</table>

←Circle 13 on Inquiry Card
### INTEGRATED CIRCUITS

#### Operational amplifiers

<table>
<thead>
<tr>
<th>Fairchild</th>
<th>Motorola</th>
<th>National</th>
<th>Radiation</th>
<th>Union Carbide</th>
<th>Transistor</th>
</tr>
</thead>
<tbody>
<tr>
<td>µA741C</td>
<td>MC 1539</td>
<td>LM101</td>
<td>RA 909</td>
<td>UC 4000</td>
<td>TEC7809</td>
</tr>
</tbody>
</table>

#### Voltage regulators

<table>
<thead>
<tr>
<th>NPC LA100</th>
<th>Fairchild µA723</th>
<th>Transistor TVR 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>National LM100</td>
<td></td>
<td>Motorola M1560R</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input bias current (typical) nA</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
</tr>
<tr>
<td>150</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>87</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

#### Power amplifiers

<table>
<thead>
<tr>
<th>Power output Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>111.11111111111111</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output current mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
</tr>
</tbody>
</table>

### SEMICONDUCTORS

#### Silicon power transistors (npn)

<table>
<thead>
<tr>
<th>Power dissipation Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 3 4 5 watts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collector current Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 80 100 (V_{CEO}=120V)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V_{CEX}-Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200 1400</td>
</tr>
</tbody>
</table>

#### Thyristors

<table>
<thead>
<tr>
<th>Forward current Amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 800 (1200V)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltage rise dv/dt-V/μs</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 200</td>
</tr>
</tbody>
</table>

### Zener diodes

<table>
<thead>
<tr>
<th>Noise level μV/√Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 3 2 (V_z=1.8V)</td>
</tr>
</tbody>
</table>

The Electronic Engineer • May 1969
Suffering from Pot Core tolerance pain?

(Take a powder and control it all the way).

Ferroxcube pot cores offer the magnetics designer extra performance and value because every step from powder formulation to final machining is under strait-jacket-tight control. And there are a lot of steps to be controlled: particle size, uniformity of properties, pressing, firing, grinding, testing. It takes precision all the way to give you pot cores with electrical tolerances that are the tightest in the business. That's why our pot cores are the choice of hard-nosed design engineers.

Ferroxcube pioneered ferrite materials. Out of this experience have come some proprietary contributions to the art of mass producing pot cores. These are reflected both in a wide variety of pot core sizes and a range of bobbins and hardware accessories. All with prices you can live with. Ferroxcube pot cores are stocked by distributors in your area. If you haven't yet designed around them and would like to experiment a bit before you buy, write for Bulletin 220-D. A quick scan will tell you which free sample pot core to ask us for.

Ferroxcube
Saugerties, New York

Can you get a complete D/A Converter system for $150?

Yes; ask for EDAC.

- Model EDAC-8-3, complete with internal reference and output amplifier: $150 (1-9)
- 8 to 11 bit models from stock
- Isolated grounds: no inter-system noise
- Only 0.4" high (and only 2 1/8" x 3 1/8" on your PC board)

**SYSTEM BLOCK DIAGRAM**

![System Block Diagram]

**DIGITAL/ANALOG CONVERTER MODEL**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>UNIT</th>
<th>EDAC-8</th>
<th>EDAC-9</th>
<th>EDAC-10</th>
<th>EDAC-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESOLUTION</td>
<td># of Bits</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>ACCURACY</td>
<td>% of F.S.</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>TEMP. COEFFICIENT</td>
<td>% of F.S./°C</td>
<td>0.01</td>
<td>0.0075</td>
<td>0.005</td>
<td>0.0025</td>
</tr>
<tr>
<td>SETTLING TIME</td>
<td>μs</td>
<td>5 typ.; 10 max.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT LOGIC</td>
<td></td>
<td>DTL or TTL, one line, one load per bit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CODING</td>
<td></td>
<td>One's complement, two's complement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RATED OUTPUT</td>
<td>Voltage Current</td>
<td></td>
<td>10</td>
<td>±10</td>
<td>±15</td>
</tr>
<tr>
<td>POWER SUPPLIES*</td>
<td>V</td>
<td>+5</td>
<td>+15</td>
<td>-15</td>
<td></td>
</tr>
</tbody>
</table>

*Output short-circuit proof!
Meet environmental requirements of Mil-Std-202C
*Also available for use with ±12V supplies.

**TEMPERATURE RANGE**

STORAGE: -55°C to +125°C
OPERATING: -25°C to +70°C (EDAC-8-3)

**PRICES (1-9):**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDAC-8</td>
<td>$200</td>
</tr>
<tr>
<td>EDAC-9</td>
<td>$250</td>
</tr>
<tr>
<td>EDAC-10-1</td>
<td>$300</td>
</tr>
<tr>
<td>EDAC-11-1</td>
<td>$400</td>
</tr>
</tbody>
</table>

**DDC**

DATA DEVICE CORPORATION
100 Tec Street, Hicksville, New York 11801 / (516) 433-5330

Circle 15 on Inquiry Card
The great digital systems kit!

step 3:

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These three new MINIVERTERS™ combine multiplexer, sample-and-hold amplifier and analog-to-digital converter with throughput rate choice of 90KHz, 135KHz or 180 KHz. And each unit goes faster when short cycled; for example, the 180 KHz MINIVERTER runs at 360 KHz with 8-bit resolution.

They come in 19" by 5¼" drawers only 17" deep. And that includes power supply, exhaust fan and input/output cable breakout. Mode selection, short-cycle and channel selection switches; data display indicators and other controls and indicators are available as options.

These new high-speed data acquisition instruments are more of the fast-moving products in our great digital systems kit for 1969. Write or call today. Raytheon Computer, 2700 S. Fairview St., Santa Ana, Calif. 92704. Phone (714) 546-7160. Ask for Data File DK-169.
to go into lucrative private practices in order to fulfill their own idealistic desires to help humanity by addressing the social and medical problems of modern medicine. Many of these researchers, after years of training and additional years of experience, receive salaries that would barely interest a starting engineer. Interestingly, these are the scientists who come up with the significant breakthroughs that open up whole new areas of medicine. These humanitarians are the Curies, the Jenneys, and the Salks of western civilization, and frequently they leave their children nothing more tangible than a legend.

"Is there an EE in the house?" didn't order engineers to march down to their local hospital and work full-time for nothing. The article merely needs of that physician and his colleagues a little thought. And it (polite, one hopes) asked those engineers who wish to spend a few hours a week helping these men to accept telephone calls and correspond with them from. So far, over 70 electronic engineers have written this magazine offering their services. Here are some of their comments:

"...I was deeply moved by the problem Doctor Levy has been having..." If it is at all possible, I would like to help." ...I would like to offer my assistance which might be of benefit to the medical profession." A medical electronics firm writes: "Our company policy is such that part of our responsibility in engineering is to help or work with any doctor who calls us for information. We have also found that we gain unlimited satisfaction from this policy." "I have just read the article in your magazine and would like to add my name to the list of available engineers." ...

If I am not able to help someone directly with electronic problems, I feel certain that one of my engineering friends in the numerous companies in this area certainly will be able to do some good. They cover just about every imaginable specialty you could ask for.

"I have just read the article in the November issue of The Electronic Engineer. Needless to say, I am moved by the letter of Dr. Levy and am anxious to join in similar efforts." I must say that Dr. Levy is a man of remarkable courage and knowledge. Indeed, the task of designing a disk interface is no small one. I also respect his problem of decoupling digital spikes from his low-level analog inputs. We are constantly faced with this problem in my discipline of hybrid computers. Finally, yes, I would be willing to help a physician at a nearby hospital clinic or research center if I can contribute. I could probably spend about 4-8 hours per week on my spare time. I can be reached at work any day or at home on Monday nights.

These are only a small sample of the letters that have come so far to the editorial office of The Electronic Engineer. Perhaps the most interesting one, from a medical engineer who has had considerable experience in medical electronics, was more inspiring than the article that elicited it. The letter was written by a Czechoslovakian engineer who escaped to the United States during the recent Soviet invasion. As a chief project engineer for 15 years at Prague Research Institute of Medical Electronics, the man has designed many special purpose medical instruments, such as a blood-circulation meter, a pulse-rate meter, and others. He writes a lengthy letter stating his qualifications, and then adds: "My favorite branch is physiology, especially physical culture research. Otherwise I am able and surely capable to cowork in other medical branches. I wish to contact you by phone, mail or perhaps by personal assistance." (signed) Vladimir Lorenz, 3816 Cabrillo Street, San Francisco, Calif. 94121.

The names of all volunteers, including those who would like to work full-time in the field of medical electronics, has been compiled into a list, which The Electronic Engineer will actively make available to organizations and publications that reach research and clinical physicians who are likely to desire help with their electronics. Already, the New York Academy of Medicine and Clinical Trends have requested copies of the list, and the former has expressed a desire to establish a clearinghouse for biomedical engineering information and aid.

Electronic engineers who are bothered by the nagging discomfort of altruism, by the symptoms of humanitarianism, are still more than welcome to send their name, address, telephone number and a brief description of their expertise to the editor of this magazine: Alberto Socolovszky, The Electronic Engineer, Chilton Co., 56th and Chestnut Streets, Philadelphia, Pa. 19131.

Roger Kenneth Field

---

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- **CESCO ELECTRONICS LTD.**
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  - New, Massachusetts (617) 906-7700

- **CLES ELECTRONICS SUPPLY, INC.**
  - Reading, Ohio (419) 615-6100

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- **ELECTRA DISTRIBUTING CO.**
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  - New York, New York (212) 829-9353

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  - Tulsa, Oklahoma (918) 587-9214

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- Dayton, Ohio (513) 296-8800
- Detroit, Michigan (313) 295-5391
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- Los Angeles, California (213) 250-8800
- Milwaukee, Wisconsin (414) 444-2840
- Minneapolis, Minnesota (612) 292-8800
- Rochester, New York (716) 244-8740
- Seattle, Washington (206) 762-4200
- Pomona, California (909) 624-6800
- Phoenix, Arizona (602) 272-7144
- Scottsdale, Arizona (602) 592-5524
- San Diego, California (714) 278-7400
- Seattle, Washington (206) 762-4200

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The reed switch is isolated in its glass container with a controlled atmosphere. It stays free of dust, damp and corrosion. There are no armatures, springs or pivots to wear. Life can easily exceed 100 million operations. Sensitivity is readily controlled. Speed is the next best thing to transistorized logic at a mere wisp of the circuit cost. Even RF switching is practical.

If you're not as familiar with reed switches as you should be, ask Hamlin. We sell more reed switches to more people than anyone else.

Send for our free switch lab. No big deal, just a reed switch and a magnet and a couple of catalog sheets. But with them, you may come up with machine, flow or systems control uses no other engineer has conjured up yet. Just write Hamlin, Inc. "Baghdad on the Lake," Lake Mills, Wisconsin 53551.

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We're in the business of extending man's senses.

Watch inbound traffic from outer space.
Talk safely in bits and pieces for 5,000 miles.
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Tune in the fleet with two million watts of RF power.
Control joint forces from an electronic command post 20,000 feet above the action.

Whatever the mission, no matter how impossible, how big, or how soon it's needed, LTV Electrosystems produces.
We can turn a mission concept into sophisticated hardware faster, better, at lower cost than just about anyone.

Our technological spectrum ranges from re-entry physics installations and international communications nets to high-reliability components. We have 15 production facilities countrywide and some of the best scientific and engineering minds anywhere.

Our mission: Extending man's senses.
What's yours?

See the opposite page for a listing of current professional opportunities at LTV Electrosystems.
JUNE

1 2 3 4 5 6 7
8 9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30


JULY

1 2 3 4 5 6 7
8 9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30 31


'69 Conference Highlights

WESCON—Western Electric Show and Conv., August 19-21; San Francisco, Calif.

NEREM — Northeast Electronics Research and Eng'g Meeting, Nov. 5-7; Boston, Mass.

Call for Papers

Nov. 5-7, 1969: Northeast Electronics Research & Eng'g Meeting (NEREM). Submit 35-40 word abstracts (3 copies) and 600-1000 word condensed versions (3 copies) before July 1, 1969 to Program Chairman, IEEE NEREM-69, 31 Channing St., Newton, Mass. 02158.

A new bulletin of professional opportunities at LTV Electrosystems.

Greenville Division
(Systems for strategic and tactical surveillance, reconnaissance, detection; tracking; command and control; airborne lighting systems; artificial intelligence; tactical warfare.)
Digital Systems Analysts
Digital Circuits Designers
Electro-Optics Systems Analysts
RF System Analysts
RF Circuit Designers
Scientific Programmers

Garland Division
(Long-range digital communications; fluid mechanical systems for aircraft, missiles, spacecraft; high-precision antennas; guidance and navigation systems; space systems.)
RF Circuit Designers
RF System Analysts
Digital Circuits Designers
Digital Systems Analysts
Antenna Design Engineers
Scientific Programmers

Continental Electronics
(This subsidiary company builds super-power RF transmitters for radio communications, broadcasting, re-entry physics radars, radio astronomy, nuclear accelerators.)
Transmitter Design Engineers
RF Circuit Designers
RF System Analysts

Memcor Division
Portable and stationary TACAN systems, tactical radio systems, gyro systems, nuclear controls, resistance products.)
Project Engineers (TACAN Systems)
Electronic Design Engineers
Instrumentation Engineers
Mechanical Engineers
Digital Systems Engineers

Call for Papers

LTV Electrosystems: extending man's senses.

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Like this solid logic circuit package, a key memory device in IBM's new Composer. The Composer electronically sets, justifies and corrects type for printing. It was developed at IBM Lexington, Kentucky, and is just one example of the electronic challenges and opportunities you'll find here.

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We have immediate openings for electrical engineers with a B.S. or M.S. degree. If you qualify, there are opportunities in several areas:

**Semiconductors:** You'd work with solid state semiconductor devices, optimizing their capabilities in practical applications.

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Grow with IBM

At IBM Lexington we produce a line of sophisticated office products: electric typewriters, dictating equipment, printers. And the line is constantly growing. In fact, we've been developing a major new product at Lexington on the average of one every 18 months.

Progress like this has made IBM a leader in the world's fastest growing major industry—information processing. Maybe your ideas can help solve some of the problems we face in electronics, and you can grow with us.

Write to us now

If you're interested, send your resume to Dave Evans, IBM Corporation, Department CE1019, New Circle Road, Lexington, Kentucky 40507.

An Equal Opportunity Employer
A case history

Project management, military style

To control the large Omega project, the Navy has delegated authority and responsibility to a project manager

By S. Peter Kaprielyan, Editor

After 15 years of long-range development, the Omega Navigation System was designated as a Project on June 18, 1965. Prior to this Captain Mavis X. Polk had served as the functional project manager of Omega—but was in charge of several other projects as well. Then, in May 1966, the Navy’s chain of command was reorganized, and Omega became one of the immediate beneficiaries: it was spotlighted as a project requiring intensified management under the direction of Admiral Galantin, Chief of Naval Material.

In current DOD parlance, “intensified project management” means the focusing of responsibility and authority in one individual—the project manager—who has executive and delegated authority over all phases of planning, direction, and control, and over all the resources allocated to the project. Thus, with the reorganization, Captain Polk became manager of the Omega Project exclusively, so that he could devote all his energies to the new navigation system.

Before a task or program is chartered as a Project by the Navy, it must qualify as a clearly definable task, within the compass of our national security objectives, and must meet these standards:

- national priority, or urgent military necessity
- top-level interest
- high cost—over $25 million for R&D or more than $100 million for production
- high degree of complexity
- multiple agency or service interest
- advanced technology
- high risk of slippage in schedule or cost overrun

Omega meets the above requisites by virtue of its significance, scope, and price tag.

Project authority and responsibility

Project management authority for Omega is delegated by the Chief of Naval Material through the project Charter. According to this Charter, the project manager directs the planning, control, and utilization of resources. He is responsible for establishing the system design interfaces, and meeting the system’s technical performance requirements. He also has directive authority over the project efforts of in-house and contractor organizations.

In cases where action is required beyond the authority granted him by the project Charter, the project manager must refer the action to the Chief of Naval Material, together with his recommendations for alternatives.

“We can look at this matter of authority another way,” explains Captain Polk. “The project Charter stresses that the project manager as a responsible executive is expected to act on his own initiative in matters affecting the project. Therefore he can assume, with some discretion, that he has authority in all areas affecting his project—unless he is expressly directed otherwise.”

Since the Omega system is global in scope, Captain Polk also has working relationships with many foreign countries. He is authorized through special agreements to work directly with his counterparts in those countries, on matters related to transmitter installations and operational tests.

Omega organization

The Omega Project Office, located just outside of Washington in Rosslyn, Va., is strictly a management organization that consists of eight professionals. Be-
sides the project manager, there are seven specialists in navigation systems operation, aircraft receivers, construction management systems, and electronics. Then, under the overall guidance and direction of the project manager, this staff works with specifically assigned people in the various naval Systems Commands (see Fig. 1).

As Captain Polk explains, "We utilize the people in the other parts of the Navy to give us the technical, contractual, and administrative assistance we need." Although these support personnel are not located in the Project Office, they are assigned to the project and are directed by the project manager. In all, there are about 55 persons assigned to Omega, including representatives of NASA, the FAA, the Air Force, the Army, and various foreign governments.

To staff the project, Captain Polk has the freedom to "shop" for the skills he needs among the Navy's contracting agencies. But selecting project personnel is not as easy a task for him as it usually is for the project manager in industry, who in many cases merely goes to upper management or to the personnel department and requests that certain persons be hired.

Navy managers, in contrast, must go through the merit promotion system. What Captain Polk does is let the Navy agencies know that he has at least one applicant in mind who is completely qualified—and he then asks them to find him the best applicant. "I have

---

**The Omega navigation system**

Omega is a hyperbolic (or circular) carrier phase measurement system. To get a navigational fix, the Omega receiver needs signals from three transmitting stations, which operate in the frequency band from 10 to 14 kHz, giving a wavelength of 16 miles. Based on phase difference measurement, the transmissions create a world-wide pattern of eight-mile grids, or lanes. By measuring the phase angle differences between any two pairs of the three signals, you can determine the position of a vessel with accuracy of, at worst, two miles.

The above drawing (right) shows how this works—but for simplification only shows two signals. What you see there for a position fix of two signals would be repeated with one of these two signals, plus a third signal, to determine your position "vertically" on this drawing.

To explain further, here is how the Omega receiver works: Suppose a ship is within range of stations A, B, and C. First a signal is received from A and stored in the receiver. Then a signal is received from B which when compared to that from A, results in display of a number on the receiver. That number represents one line of position on the Omega grid chart, available from the U. S. Naval Oceanographic Office. Finally, a signal is received from C which is then compared to the signal from either A or B to acquire a second numerical display from the receiver. This second line of position intersects with the first on the grid chart to mark the ship's position.

The four transmitting stations now operating are located in Norway, Hawaii, Trinidad, and Forrestport, N. Y. (the Forrestport station will soon be moved to the Northcentral part of the U. S.). The other four stations planned will be located in Japan, the Indian Ocean area (near Madagascar), Argentina, and Australia or New Zealand. When Omega becomes fully operational in 1972, the U. S. Coast Guard will assume the responsibility for operating the eight transmitting stations.
had it happen that I have gotten better applicants than the ones that I had in mind," he states. "I've taken them. But at least I have set a standard which I wouldn't drop below."

**Running the show**

Basically, Captain Polk set up a host of schedules to be maintained. There are overall schedules, and schedules for each of the facets his group is working on. Each contractor, in turn, has schedules.

To make his job simpler, and to keep on top of the project at all times, Captain Polk broke down the project into key **decision points**. For each of these decision points he assigned someone in his Project Office.

"It's darn hard for EEs not to get their hands dirty."

---

**Fig. 1. Project management organization for Omega.**

```
Secretary of the Navy
   Undersecretary
       Chief of Naval Operations
            Chief of Naval Material

Project Manager
   Omega
        Asst. Project Manager
             Technical Director

Logistics   Management   Aircraft Receiver   Construction   Electronics
   Coast Guard Liaison Electronics   Coast Guard Liaison Construction

Naval Supply Systems Command
   Naval Air Systems Command
       Naval Facilities Engineering Command
            Naval Electronic Systems Command
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Lockheed is an equal opportunity employer with unequaled opportunities.
Staff members are responsible for taking care of their particular aspects of the project, for informing the project manager what they have done, and for warning him if they are in trouble. Then a minimum of once a week the project manager gets a report from all of them—in the form of PERT charts, GANTT charts, Line of Balance, and so forth. These reports then go into the overall schedule as they affect the decision points. To ensure that each decision point is “covered” at all times, there is at least one person in the Project Office who stays informed on what another staff member is doing.

Captain Polk finds one of the hardest jobs in project management is charting all of the daily operations and changes. “To be perfectly honest with you,” he comments, “I have not been able to ascertain how to schedule and how to chart the day by day operations, because the decisions you make are bouncing back and forth. So what we've tried to do is put down the broad decision points—as broad as possible—and let the individuals responsible for them make sure that we come to these points.”

By delegating authority and responsibility for the various decision points to staff members, Captain Polk gives himself enough time to perform such key tasks as budget justifications, state department negotiations, and discussions with foreign countries. Above all, he does not get bogged down in details but can grasp the overall picture—and can thus make quick and wise decisions.

As far as actual management tools go, Captain Polk and his staff use PERT, GANTT, Line of Balance, and other forms of charts, although they don't endorse any one method. And since the scheduling of the project is fairly straightforward, they don’t use a computer system, except for standard accounting procedures and for technical assistance.

Communicating progress

Among the main functions of the Project Office are those of documentation and communication. It is the project manager’s responsibility to maintain complete documentation on training procedures, spare parts, equipment delivery, chronological history, working agreements, specifications, pertinent references, and reports.

To facilitate management decision-making, action, and support, both vertically and laterally, the Project Office issues various reports:

- an annual Technical Development Plan
- a semi-annual Project Master Plan
- a comprehensive verbal report to the Chief of Naval Material every six weeks, stating ten of the toughest problems facing the program, their nature, and their proposed remedies
- a monthly Program Evaluation Report summarizing the ten most critical items

“Besides these formal reports,” explains Captain Polk, “we have a meeting of all project managers in Admiral Galantin’s office each Monday afternoon, for informative off-the-record discussions. These man-to-man talks,” he says, “are known on occasion to become very spirited.”

What it means to the electronics industry

In the next six years, the Navy will spend about $100 million to outfit surface ships, submarine, and aircraft with Omega. Northrop Corp. and International Telephone & Telegraph are the only firms who have Navy contracts for receivers at the present time. Northrop is making a general purpose shipborne receiver and is also working on a contract for the developmental model of the airborne receiver. ITT is making a more sophisticated, special purpose surface receiver and a submarine unit as well.

Tracor, Inc. has a commercial receiver which it's selling to both commercial and military users, and Pickard & Burns Div. of Continental Electronics Mfg. Co. is making a receiver which is essentially the same as Northrop's surface receiver. Ryan Aircraft, now part of Teledyne, has also manufactured some receivers. Lear Siegler, along with the Naval Research Laboratories, made the prototype of the receiver that's under contract to Northrop, and is now working on an airborne receiver.

There are other companies working in the field too, and these will probably come out in the open just as soon as the Navy starts letting some additional contracts.

In summarizing its significance to industry, Omega’s project manager comments, “My Drew Pearson prediction is that it will have greater commercial use than it will Navy use... My own estimate is that we’re talking about a minimum of a billion-dollar receiver market worldwide—and probably as high as a three-billion-dollar market.”

EEs and project management

To make project management work, there must be one individual—the project manager—who can isolate himself from the details and thus concentrate on the total picture. But one of the greatest temptations to face project managers and their management staff is the urge to get involved in technical details to the extent that they slip into the role of project engineers.

As Captain Polk observes, “When an engineer tries to manage a big project, if he tries to remain the project engineer, the project runs into trouble. Almost without exception, we’ve gotten into trouble (with both contractors and project staff) on overruns, miscalculations, misdeliveries, because when a technical problem comes up the project engineer becomes so involved in it that the scheduling, the plans, the designs, the ordering of materials, and the other things you have to do to get out on time and within your budget are not accomplished.

“Electronic engineers,” he adds, “are one of the hardest groups to get to drop the technical involvement. . . . It’s darn hard for them not to get their hands dirty.”

(Editor's note . . . Here is a challenge to all of us—whether we're project managers, project engineers, or design engineers who plan on getting into management. Because of our training, we are used to working on technical details, and sometimes get bogged down in... Continued on page 32.
FOR ELECTRONIC ENGINEERS ON THE WAY UP...
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This Project Management course appeared originally in The Electronic Engineer and was devised for the engineer who wants to grow in his job and to help assure this the course was developed in collaboration with Booz, Allen and Hamilton, one of the largest management consulting firms in the world. Their experience includes the development of project plans and control systems for over 1,000 projects involving the expenditure of many billions of dollars.

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INFORMATION RETRIEVAL
Project management, Careers

Project management (concluded)

them. To be successful managers, as Captain Polk suggests, we must retrain ourselves to concentrate on the total view, and to leave the details to our fellow EEs who are working in the technical realm.)

As manager of a large electronics project, one of Captain Polk's first tasks was training the "obstructionist engineers" in his Project Office to concentrate on their management functions, and to keep the design work in the hands of the design engineers. Another problem was getting them out of the habit of explaining things in very technical terms. "Technical people," comments Captain Polk, "have to be able to explain to management people in the terms management understands. They've got to communicate." When he forced his staff to do this, he uncovered a few cases where an engineer himself didn't understand a problem, but had hidden this fact by using technical jargon.

Attributes of a project manager

Among the attributes Captain Polk considers vital for effective project management, he ranks first the ability to communicate with people, and to understand personalities and problems up and down the line of authority.

He also feels that for a project such as Omega, a basic technical orientation is a must for his Project Office—but that operational experience is the vital resource for solving the project's human engineering problems. For example, he has one person on his project team who is basically a navigator, and who looks at the equipment from the user's point of view. If he can misuse the equipment, it goes back to the drawing boards because there's a good possibility sailors will misuse it too.

Not a panacea

In the past few years, project management has received much fanfare—and has become perhaps the most common method for handling large electronic projects. But not everyone is convinced that it is the best way to handle such projects. Captain Polk, who has used the approach successfully for the Omega Navigation System, is himself not sure that it is the best way to go (although he feels it makes more sense in private industry, where there is more flexibility).

He summarizes, "To me project management in one respect means that our functional organization has broken down, that we couldn't take care of our work and had to set it up separately. I disagree with it on the basis that it takes away from the functional organization's capability, resources, priorities, and people. I don't know when we're going to get sophisticated enough—either in government or industry—to get away from project management. In the Navy, for example, if we would very critically, totally match our resources of people and money against what we have to do, we wouldn't need project management because we would have the resources to do the job."
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The ELECTRO ADAPTER

This new column lists product seminars that electronic companies offer to users of their products.


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"PDP-9 Programming," May 19-30 and June 16-27, Maynard, Mass. $500 (free for one person per computer purchase). Operation of the PDP-9 computer; the MACRO-9 assembler; utility programs; FORTRAN IV, the combining of FORTRAN IV and MACRO-9 programs, and the Science Library; the I/O monitor and related programming techniques; etc. Training Dept., Digital Equipment Corp., Maynard, Mass. 01754.

Circle 402 on Inquiry Card


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Circle 404 on Inquiry Card

"Repair and Maintenance Training Session," June 2-6 and July 7-11, Amsterdam, N. Y. Tuition-free. Covers EMC-25 and EMC-10 receivers, EFC-125 programmer, SPD-125 spectrum display, various antenna models, and FSS-250 spectrum surveillance system. Dale Samuelson, V.P., Fairchild Electro-Metrics Corp., 100 Church St., Amsterdam, N. Y. 12010.

Circle 405 on Inquiry Card

"Non-destructive Testing: Radiisotope Course," June 2-6, Cleveland. $300. Picker Industrial, Marketing Dept., 1688 Arabella Rd., Cleveland, Ohio 44112.

Circle 406 on Inquiry Card


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Circle 413 on Inquiry Card
“Project Management Seminar,” May 26-28 (Washington), June 23-25 (San Francisco). $300. Why project management; the project manager; the nature of electronic engineering projects; project management organization; project definition; network systems (PERT/CPM); project management functions and tools; work authorization; resource management; multi-project management; project management systems; time, cost, and performance evaluation; applications and problems; outlook for the future; case studies. Co-sponsored by The Electronic Engineer and Booz, Allen and Hamilton Inc. John E. Hickey, Jr., Seminar Coordinator, The Electronic Engineer, 56th and Chestnut Streets, Philadelphia, Pa. 19139.

“Modern Aspects of Control and Information Engineering,” May 26-June 6, Purdue Univ. $300. For engineers and scientists working in the field of guidance, estimation, and control. Short Course Programs, Room 116, Memorial Center, Purdue University, Lafayette, Ind. 47907.

“Pulse Code Modulation Telemetry Systems,” June 2-6, Purdue Univ. Theory and state of the art of telemetry systems for transmitting analog and digital data over noisy digital channels. Prof. Paul A. Wintz, PCM Telemetry Systems, School of Electrical Engineering, Purdue University, Lafayette, Ind. 47907.


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DESIGN FEATURES

IC voltage regulators—Do-it-yourself power supplies?

Not yet, say the users. Never, say the manufacturers of power supplies. But, now that you can get good regulators for $5, lots of people are buying them.

By Stephen A. Thompson,
Western Editor

Since National Semiconductor introduced the LM100 monolithic voltage regulator about 2½ years ago, there has been a proliferation of hybrid and IC voltage regulators in the ±40 V range. Generally, manufacturers have found them to be a good product, although Westinghouse and Raytheon no longer make them. Fairchild is selling more µA723 regulators than any other complex IC except its µA741 op amp. Some users buy regulators in 100,000-unit orders.

Regulators are readily available and have been accepted by builders of power supplies, computers, power conditioning equipment, avionics systems, and instruments of all kinds. Op amp users are good customers. In fact, Philbrick/Nexus makes a ±15 V unit, which it sells largely to its op amp customers. Applications range from the usual plus-or-minus series regulation, to current and voltage boosting, shunt regulation, and many more.

The success of these regulators is partly due to the fact that almost every piece of electronic equipment needs a regulated power supply. The predominance of ICs means that most of these supplies must have an output of 5 V or less. At this low voltage, diode drops are important, noise margins are very low, and the dynamic range that the designer has to play with is very small—he must control the supply voltage very accurately.

Choosing a regulator

The design engineer must evaluate each application separately. Some of the key parameters of commercial voltage regulators are compared in Figs. 1 through 5. Most of these products either have counterparts with negative voltage outputs or can be connected for negative outputs. Hybrid regulators are included; however, many of them consist of a monolithic IC regulator, with transistors added to get higher power dissipation and load currents. Other hybrid regulators have no monolithic ICs, they consist of discrete diodes and transistors plus thick-film resistors.

The designer should be aware of many things when choosing a regulator. In addition to low output impedance, the good ones have short circuit protection, overvoltage protection, high reliability, and come with good application notes.

Even though a low output impedance is mandatory in a regulator, we have not graphed this parameter because many spec sheets do not list it; those that do, specify operating points at varying frequencies. (Motorola is very proud of the fact that its typical \(Z_{out}\) of 25 mΩ is virtually flat with output voltage, so much so that until recently, load regulation did not even appear on its spec sheets.)

In fact, regulation is about the most difficult spec to compare. Figure 2 is a plot of those products where regulation was specified in the two most popular fashions—\% / \(V_{out}\) and \% (manufacturers also use \%/mA and mV). To insure that regulation comparisons rank with the labors of Hercules, the conditions under which the specs were made are as different as random fingerprints. In the midst of this chaos, Varadyne’s 0.005\% figure (typical) for its hybrid regulator is clearly the best—about an order of magnitude below anything reported in \%.
Regulator identification code

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Hybrids

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<td>LM500</td>
<td>MS</td>
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<tr>
<td>31.</td>
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<td>J series</td>
<td>MS</td>
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</table>

MS: MIL-SPEC temperature range (−55°C to +125°C)
C: Commercial grade (usually 0°C to +70°C)

Fig. 1: Regulated output voltage range of voltage regulators.

Fig. 2: Load regulation in %/Vmax and %.

Fig. 3: Maximum rated output current (Ia).

Fig. 4: Maximum power dissipation of regulators in free air @ 25°C.

Fig. 5: Cost of voltage regulators. Most prices are in quantities of 100.


Power and current capability are very important. Many users must add an external pass transistor to boost the output current. The higher the rated output of the regulator, the lower the β of the transistor can be to give the desired amperage. The high-power monolithic regulators incorporate a large series-pass transistor on the chip to give high currents, but this is questioned in National’s application notes by Bob Widlar, Director of Advanced Circuit Development, National shies away from it because IC packages can’t handle the power. Since the maximum junction temperatures for ICs are lower than those for discrete transistors, the heat sink for a power IC must be much larger than that for a regulator using a discrete pass transistor. In addition, Widlar feels that, when the pass-transistor is on the chip, variations in input voltage or load current cause gross variations in chip temperature. These temperature variations affect the control and reference circuits (located on the same chip) yielding poorer overall performance. He states that a good regulator should have an overall spec of 1%. That is—a total regulated voltage change of 1% when temperature, line, load, and so forth, are lumped together.

Regulators can defend themselves

By far, the most frequent cause of regulator failure is excessive dissipation in the series pass transistor. The most common method of protection is to limit the load current with a foldback current-limiting technique. For example, Fig. 6 shows the I-V short circuit characteristic of Beckman’s Model 806 hybrid regulator. When the output is shorted, the load current drops as the voltage is pulled down so that the regulator dissipates minimum power. The short circuit current may then be only a fraction of the full load current. Motorola Semiconductor protects its regulators against excessive power dissipation, or temperature, differently. Mr. Clay Tatom, who manages the firm’s linear IC product planning, thinks its system is more fundamental, because it uses temperature—rather than current—to protect against overdissipation (see Fig. 7).

It’s make or buy time again

Because IC regulators are now readily available and widely accepted, there may well be a shift in the make-or-buy decision by an engineer who needs a regulated power supply. Also, the system designer will seriously consider point-of-use regulation instead of central regulation. Both these ramifications have technical and economic aspects.

Until recently, everyone thought that he could build a power supply by throwing a transformer and rectifier bridge together—until he realized that he needed regulation. He could then either design, build, and tinker with his own circuitry, or buy a supply to do his job.

Today regulation is a component, like a transformer or a bridge. Armed with a catalog, the engineer can buy regulation in the range of ±40 V, 0.5 A using monolithics, or up to 5 A using hybrids. If he reads the application notes, he can boost his output into the 5 to 10 A range by adding a minimum of components and design. With the exception of power supply manufacturers in general, the consensus is that both the ICs and the application notes are good enough so that the average engineer can build a respectable supply with a minimum of discomfort.

Cost ranges between $3.50 and $6.50 for a commercial-grade regulator, up to $49 for a MIL SPEC unit, and prices have been dropping. Other cost factors are more subtle. Sometimes the choice is between two supplies, one being marginal, the other being too good for the job. Mike Markkula, product marketing manager for Fairchild’s linear integrated circuits, points out that now the engineer can get the voltage he wants without the agony of choosing between a $150 or $250 supply to get the tradeoff he needs.

According to Howard K. Cooper, Senior Vice President of the Semiconductor Division of Nucleonics Products Corp., a transistorized voltage regulator needs a sophisticated op amp, a stable reference, a good response time, and a good feedback loop. To design the circuit yourself you might need 20 resistors, ten capacitors, five transistors, tight temperature compensated
Computers—an outpost of resistance

Except in special cases, computer manufacturers have not yet adopted the local regulation scheme. Some consider it inconvenient, impractical, and expensive to break regulation up into a number like 1,000 small pieces when you compare it with a 100-A central supply. The problem is that the power dissipation of monolithics is limited. Hybrids are more interesting, but still unsatisfactory from a power standpoint. The power supply designer at a computer manufacturer suggests that if the monolithic regulator were built into a chip that you are already using (like a 10 flip-flop chip) then the scheme could be useful.

Jack Fort, manager of circuit design for National Cash Register, points out the problems of distributed regulation. First, it is difficult to supply local reference voltages, because each reference is slightly different, say 5.02 V as opposed to 4.98 V. One end of the reference is tied to what passes for ground. As loads change, ground loops can develop that change the references by changing the level of what you call ground. If, instead of local references, you provide a central one and ship the voltage around to each point, you have defeated one of the original purposes of local regulation—to get better noise immunity. If noise gets into the reference network, it goes everywhere.

Second, trying to divide the loads equally in a large system can be difficult. Each card may be able to handle 500 mA, but it can work out that one card requires 600 mA and another only 200 mA. The average is only 400 mA, but the division is unsatisfactory.

IBM uses central regulation for the great majority of their computers, while only 1% of the logic circuitry utilizes local regulation. John Roberts and George Allen of the IBM's Systems Development Division Labs, Kingston, N.Y., relate that these are cases where circuits require extremely tight tolerances and cannot be located close enough to a well-regulated supply. They consider it an expensive method, but in those cases technical demands override economic ones. IBM has an open mind on the subject of local regulation, but feels that no clear trend has yet developed. They consider that the most economical, reliable, and proven method today is to break the system and regulate it in several blocks, each serving a portion of the logic circuitry.

What do power supply manufacturers use?

All of these factors are important to power supply manufacturers, and there is much evidence that they are becoming large users of IC and hybrid regulators. Bendix and National both count power supply makers as large customers. Ed Renschler, section manager of linear IC applications at Motorola, believes that power supply companies will soon be buying potted regulators instead of making their own.

We contacted several power supply companies and asked them about the impact of these regulators on power supply users, and on themselves as users. There are hard-line manufacturers who say they are going down the line with discrete components. They believe that they can best understand and handle the problems of good regulation, and doubt whether the average engineer can build decent regulated supplies from application notes.

Others, like Sola Electric, find that the choice between designing their own or using ICs is just about a toss-up. Walt Hirschberg, Vice president in charge of product development at ACDC Electronics, points out that PC boards and discretes are still more economical. Such factors as heat sinks are more important than saved space. However, as control circuitry gets more involved and efficiency becomes more important, more ICs will probably be used in power supplies. At present, ACDC uses custom hybrids in a few units.

Hirschberg also feels that the average engineer can build simple regulation. When it comes to high-power reference devices, and a PC board. Assuming no shortages of parts, the circuit must be invented, tested and reviewed. All of this is now on one IC. With one component and a few holes in a broad, or socket, it's all over. Cooper concludes that while the IC regulator might cost the same as the discrete components, there is no assembly or design time. Actually, IC regulators still need several components outboard, but they are relatively easy to put together.
supplies, however, he will not design with ICs any more but turn to the power supply manufacturer.

Of 17 manufacturers contacted, only North Electric, Lambda Electronics, and Kepco use IC regulators in quantity in their supplies.

At the IEEE show in March, Lambda introduced a new line of power supplies that use IC voltage regulators. The regulator was designed by Lambda and manufactured by Motorola, using their computer aided design capability. Load regulation of the supplies is 0.01%.

Paul Birman of Kepco equates regulation with amplification. Amplification is easy to get, but temperature stability is more difficult. Kepco uses voltage regulator chips, even though they are more expensive than discretes, because their small size makes temperature uniformity and stability easier to achieve.

Actually, power supply makers are the ones who can benefit most from IC regulators, because they know more about regulation than the average user. We believe that many power supply manufacturers are using them primarily as error amplifiers to drive one or more series-passing transistors. As for the user, he will go to power supply manufacturers in proportion to the degree of sophistication required and the number of units he needs. Power supply manufacturers who have learned how to keep their costs down, will still be able to offer good supplies at a cost lower than most people can build them.

**Divide and conquer?**

Another class of potential regulator users, the digital systems designers, is faced with a decision about *distributed* vs *central* regulation. He can buy or build a well regulated central power supply and "bus" power throughout the system, or he can choose to have minimal regulation at the central supply and use ICs to regulate at the various points of use. The advantages of point of use regulation are many, but so are the mitigating circumstances.

The foremost advantage is that regulation is done as close as possible to the point of use. Distribution buses can be a severe headache for the system designer—a poor one degrades a good supply. He may have to use very low-resistance bus lines to keep voltage drops to millivolts, especially if he needs good regulation at any distance from the supply. Many users of big power supplies use remote sensing leads to insure that the regulated voltage is accurate at the load—rather than at the supply—but this can be done only when there is a single load.

Another important consideration is noise. Using central regulation, care must be taken to minimize noise in the common network, otherwise the busses will couple switching transients and hum to all points in the system. Individual regulators provide better immunity to noise pickup throughout the system because they remove noise at each load point.

Regulator manufacturers claim several other advantages, such as more reliability, less space, and better temperature coefficients than discretes. In addition, they say, if a system needs several different voltages, such as ±5, ±12, ±15, ±24 volts, etc., the exact voltage desired is available at the point you want it simply by specifying the correct regulator. Since each regulator is short circuit protected, a short in one card will not wipe out the power supply. If you consider the regulator as a component, the number of parts and interconnections in a circuit are reduced together with assembly and design time.

Cost can also be lower. Mike Markkula of Fairchild gives the following example. Suppose you need a 0.1% regulated, 5 V, 20 A supply. This might cost you $400 to buy. It will cost you under $50 to buy ten µA723's, plus $100 for a course supply. You should be able to buy the discretes needed to boost each regulator's capability to 2 A and put them together for well under the remaining $250. On the other hand, for 0.01% regulation, the cost situation shifts in favor of the power supply manufacturer.

Many digital systems designers buy the local regulation concept and are in the "designing in" stage. Electro Scientific Industries and Datcraft, for example, use course power, regulated at point of use, in some of their...
equipment. A spot survey of computer and avionics manufacturers, who would obviously be affected by the kinds of arguments above, uncovered the interesting views described elsewhere in this report.

Will regulators fly?

Avionics power systems pose a different set of problems. First, an aircraft manufacturer like McDonnell Douglas does not supply dc regulated voltage to the aircraft bus. According to Mr. W. B. Yopp, chief of electrical engineering, they supply power according to MIL-STD 704 which prescribes 3-phase 400 Hz ac for avionics systems, rectified to a nominal 28 V. (this voltage can vary from 19 to 29 V and still meet MIL-STD 704). This power is bussed around the aircraft; and the regulation problem is left for the equipment designer who must interface with the aircraft power bus.

J. Foutz, supervisor of computer engineering for the Data Systems Division of Autonetics, gave some insight into that side of the problem. The aircraft power system is well specified, and so is the unit (say, an airborne computer). The power supply always turns out to be a custom job, whether it is made or bought, because almost nobody makes power supplies that operate off a MIL-STD 704 input.

Autonetics uses a $40 regulator, adds about $40 worth of components and distributes regulated power around a particular unit. Unless extreme reliability is needed, the high cost of MIL-spec regulators makes point-of-use regulation very unattractive. However, several months ago Autonetics decided that there were enough good regulators on the market, and have designed their last one. From now on they will use monolithic regulators. Mr. Foutz cautions about applications notes: they tend to omit things, like the fact that most of them are bang-bang rather than frequency regulators; or that they are free running—which means that switching-type loads may latch the regulator on and destroy it.

Back to the drawing board

There are still formidable barriers to universal acceptance of point-of-use regulation. Almost everyone agrees it is a great idea to have it, but it will have to prove itself in each new situation. For a small number of loads, it is easy to distribute from a central supply. For a large number, it gets very complicated. In between, the idea is catching on.

Thanks . . .

. . . for the busy design hours they devoted in contributing to this report, to the gentlemen mentioned in the text and to Lyle Pittroff, Beckman Instruments; Dick Schomberg, Electro Scientific Ind.; Monte Lum, International Circuit Technology; Ken Kupferberg, Kepco Inc.; Jim Bright, North Electric; Jack O'Connell, Philbrick/Nexus; John Levin and Steve Rose, Power Designs Inc.; Rux Tucker, Sola Electric; L. J. Torn, Trygon Electronics; and Rene Cote, Varadyne.

INFORMATION RETRIEVAL
Wherever precision measurement calls for resistors with good stability, closely-controlled TC and low noise, you're apt to find Dale Metal Film. There are three good reasons: MIL-R-55182, MIL-R-10509 and MIL-R-22684. This versatility has turned a good source into a great one. Whether you want Established Reliability or just want to squeeze more precision into a pennies-per-part budget, Dale Metal Film is the answer.

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- **Resistance Range:** 10 ohms to 10 megohms, depending on size and TC.
- **Tolerance:** MIL-R-55182 = .1% (B), .25%, .5% (D), 1% (F); MIL-R-10509 = .1%, .25%, .5%, 1%; MIL-R-22684 = 2%, 5%.
- **Temperature Coefficient:** 11 standard TC's available in −55°C to +175°C range.

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The DO-4 is available in the following types: 1N3879 to 3883; 1N3889 to 3893; and 1N3909 to 3913. The DO-5 is available in these types: 1N1183 to 1190; 1N1193; 1N1195 to 1198; 1N248B to 250B; 1N3208 to 3214; and 1N3899 to 3903. Reverse polarity types are available in both packages.

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Circle 29 on Inquiry Card

Here we welcome new companies or new divisions in the electronics industry. If you want more information, just circle the appropriate numbers on the reader service card.

Ion implantation initiative. On February 20, the recently-formed KEV Electronics Corp. moved into new facilities in Wilmington, Mass., and commenced full-scale R&D and production activities. KEV’s goal: to make sophisticated semiconductors (discretes—not ICs) that cannot be made efficiently with diffusion. The process it will use: ion implantation.

Dr. William J. King, president and founder of the firm, is one of the pioneers of ion implantation in this country. He began working with the process while at Ion Physics Corp., a subsidiary of High Voltage Engineering.

KEV plans to produce special purpose diodes and transistor devices in which high resolution and uniformity are especially important. Its first product—expected to be available by early fall—will be a line of voltage-variable capacitors for military and industrial tuners, including those used in TV receivers and am and fm radios.

High-frequency devices—still under development—will make up its second product effort, but these will not be available for another 18 months or so. Further in the future is a line of junction field-effect transistors.

KEV will be working with silicon materials exclusively at first, but long range plans call for the development of devices using III-V and II-VI semiconductor materials such as gallium arsenide phosphide, gallium arsenide, indium antimonide, and indium arsenide.

Circle 414 on Inquiry Card

Control over telephone lines. The job of designing and manufacturing data communications systems has recently been tackled by Coherent Communications Systems Corp., Wyandanch, N.Y. At present, the Long Island firm is directing most of its efforts to its key product line—multifrequency control modules—which are designed to provide remote control switching or signalling over leased telephone lines. They will be used on facsimile transmission to select a particular machine speed, or to program all network receivers for the same speed. The modules are available in limited quantities.

Circle 415 on Inquiry Card

The Electronic Engineer • May 1969
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NOMEX®
Transmitting data with digital ICs

New integrated circuits make it possible to transmit data under high noise conditions using a simple twisted pair of wires.

By R. J. Widlar and J. J. Kubinec
National Semiconductor Corp., Santa Clara, Calif.

In cases where you must transmit digital data in a high-noise environment, you cannot use ordinary integrated logic circuits because they lack sufficient noise immunity. (Standard TTL or DTL have a noise immunity about 0.5 to 1 V). One way to solve this problem is to use high-noise immunity logic. This approach usually demands worse case logic swings of 30 V, which in turn requires high supply voltages. Further, considerable power is needed to transmit these voltage levels at high speed, especially if the lines must be terminated to eliminate reflections.

A better solution is to convert the ground-referred digital data at the transmission end into a differential signal and transmit this down a balanced, twisted-pair line (Fig. 1). At the receiving end, any induced noise, or voltage due to ground loop currents, appears equally on both ends of the twisted-pair line. A receiver which responds only to the differential signal from the line will reject large, undesired signals even with moderate voltage swings from the transmitter.

This article describes such a system. The transmitter provides a buffered differential output from a DTL or TTL input signal. A four-input gate is included on the input of the transmitter so that the circuit can also perform logic. The receiver detects a zero crossing in the differential input voltage and can directly drive DTL or TTL integrated circuits at the receiving end. It also has strobe capability to blank out unwanted input signals.

Both the transmitter and the receiver incorporate two independent units on a single silicon chip. Hence, you have either two complete transmitters or receivers on one chip.

Data transmission

The interconnection of the DM7830 line driver with the DM7820 line receiver is shown in Fig. 2. Except for the transmission line, the design is straightforward. Connections on the input of the driver and the output or strobe of the receiver follow standard design rules for DTL or TTL integrated logic circuits, i.e., 930 series DTL or series 54 TTL.

The transmitter, which has a typical differential output resistance of 15Ω, drives the twisted pair transmission line. These lines normally have a characteristic impedance of about 170Ω. The line is terminated at the receiving end, by a resistor on the receiver chip, to absorb reflections on the line. The transmitter will deliver a differential signal of ±3V into the transmission line while operating from a 5V supply, as is shown by the curves in Fig. 3.

At the receiving end, the terminating resistor is not normally connected directly across the output of the transmission line. Instead, an external capacitor is inserted in series with the resistor. The capacitor significantly reduces the power dissipation in both the line transmitter and receiver, especially in low duty
About the line driver and receiver...

The DM7830 line driver input interfaces directly with standard DTL or TTL circuits. It presents a load which is equivalent to a fanout of 3 to the circuit driving it, and it operates from the 5 V, ±10% logic supplies. The output can drive low impedance lines down to 50Ω and capacitive loads up to 5000 pF. The circuit is designed to clamp common mode transients coupled into the line, and short circuit protection is also provided. The integrated circuit consists of two of these drivers fabricated on a 41 x 53 mil-square die using the standard TTL process.

The line driver circuit closely resembles a standard TTL buffer. In fact, it is possible to use a standard dual buffer as a transmitter. But the DM7830 adds output current limiting to protect against shorts, and output diodes to clamp severe voltage transients that may be induced on the transmission line. Also, the circuit has internal inversion to produce the differential output, to reduce the time skew between the outputs and minimize radiation from the twisted pair lines.

LINE RECEIVER

The DM7820 receiver converts the differential output signal of the line driver into a single ended ground-referred signal to drive standard digital circuits on the receiving end. At the same time it must reject the common mode and induced noise on the transmission line. Two receivers are on one chip, 41 x 49 mil-square.

It was considered important that the receiver operate from the +5 V logic supply without requiring other supply voltages. This complicates design because the receiver must handle ±15 V input signals which are considerably greater than the operating supply voltage. However, the large common mode range over which the circuit must work can be reduced with an attenuator on the input of the receiver. In this design, the input signal is attenuated by a factor of 30. Hence, the ±15 V common mode voltage is reduced to ±0.5 V, which can be handled easily by circuitry operating from a 5 V supply. The differential input signal, which can go down as low as ±2.4 V in the worst case, is also reduced to ±80 mV. Hence, the circuit must be designed with a fairly accurate zero crossing detector. This necessitates using linear design techniques for the receiver circuit, even though it can be manufactured with standard digital processing.

Both the line driver and the receiver are available from National Semiconductor.
the voltage seen at the receiving end will be the output
60
Transmitter has four NAND inputs and drives the twisted
Fig. 1: When ground is used as a signal return as in Fig. 1a,
(b) Differential system
the receiving end . Hence, the noise immunity of
the transmitter-receiver combination must be equal to the
voltage at the transmitter plus any noise voltage induced
in the ground or signal line. The differential
transmission scheme in Fig. 1b solves this problem. Any
ground noise or voltage induced on the transmission lines
will appear equally on both inputs of the receiver. The re-
ceiver responds only to the differential signal coming out of
the twisted-pair line. It therefore rejects the noise and de-
livers a single-ended output signal referred to the ground at
the receiving end.

Fig. 2: Interconnection of the line driver and the line receiver.
Transmitter has four NAND inputs and drives the twisted-
pair line differentially from a low impedance source. C, pro-
vides dc isolation of the line terminating resistor in the
receiver to reduce power dissipation, and C, can be included
for the input resistance of the receiver.

Fig. 3: Output characteristics of the line driver under load
show the differential voltage delivered to the transmission
line for different characteristic impedances. Curves show
that the maximum current available from the driver is lim-
ited to prevent damage if transmission line is shorted.

cycle applications, by terminating the line at high fre-

Fig. 4: Output voltages versus output current for different
characteristic impedances (100 ohms and 50 ohms)
cquencies, but blocking steady state current flow in the
terminating resistor.

Since the line-termination resistor is included on
the receiver chip, precise resistor values cannot be
guaranteed without adversely affecting manufacturing
yields. Fortunately, relatively large mismatches be-
tween the line impedance and the termination resistor
do not adversely affect performance. Fig. 4 shows that
termination resistances which are a factor of two off the
nominal value (170Ω) do not cause significant reflec-
tions on the line. The lower termination resistors do,
however, increase line attenuation.

Fig. 5 gives the line-transmission characteristics with
various termination resistances when a dc isolation
 capacitor is used. The line is identical to that in the
previous example. The transient response is nearly
the same as the dc terminated line. The attenuation, on
the other hand, is much lower, being the same as an
untminated line. An added advantage of using the
isolation capacitor is that blocking the dc current from
the termination resistor reduces the average current

drain of the driver and the power dissipation in both
the driver and receiver.

As was the case with the termination resistance, the
value of the dc isolation capacitor is not too critical.
A good design guideline is to make the RC time con-
stant of the termination resistor/isolation-capacitor
combination 2 to 3 times the electrical line length.

When there is a difference in ground potential be-
tween the transmitter and receiver, the waveforms ob-
erved at the receiving end will be somewhat different
than those in Fig. 5. This difference comes about be-
cause the output resistance of the driver is not constant
under all conditions. The high output of the transmitter
looks like an open circuit to voltages reflected from the
receiving end of the transmission line which try to drive
it higher than its normal dc state. This condition exists
until the voltage at the transmitting end becomes high
enough to forward bias the clamp diode on the 5V
supply. Much of the phenomena which does not fol-
low simple transmission line theory is caused by this.
For example, with an unterminated line, the line ca-
pacitance is charged by the reflected signal to where the
clamp diodes are forward biased, increasing the signal
swing at the receiving end. This increase then decays
at a rate determined by the total line capacitance and
the input resistance of the receiver.

The abnormal behavior of the transmission lines
with non-zero common voltages is, however, of little
practical concern. It occurs only when a dc isolation
capacitor is used in series with the termination resistor,
and results in a received signal which is larger than
that which would be observed under normal conditions.

The power dissipated in the receiver is usually low.
However, with large common mode input voltages,
dissipation increases markedly, as shown in Fig. 6.
This is of little consequence with common mode tran-
sients, but the increased dissipation must be taken into
account when there is a dc difference between the
grounds of the transmitter and receiver. It is impor-
tant to note that Fig. 6 gives the dissipation for one
half the dual receiver. The total package dissipation
will be twice the values given when both sides are
operated under identical conditions.
Fig. 4: Transmission line response with various termination resistances shows that response degradation is small for relatively large mismatches. The line used was a twisted pair 150 ns long with a 170Ω characteristic impedance.

Fig. 5: Line response for various termination resistances when a series dc blocking capacitor is used. Capacitor increases signal swing and reduces power dissipation.

Fig. 6: Variation of internal power dissipation in the receiver with changes in common mode input voltage illustrates that dissipation can increase markedly for large dc ground differences between transmitter and receiver.

Fig. 7: Response time with and without an external delay capacitor (C₆ in Fig. 2). This capacitor gives added immunity to fast noise when only slow signals are expected.

Fig. 7 gives the response time, or propagation delay, of the receiver. Normally, the delay can be increased, by the addition of a capacitor between the response-time terminal and ground, to make the device immune to fast noise spikes that might be coupled differentially into the input. The additional delay obtained will generally be longer for negative going outputs than for positive going outputs.

Strobe capability is also provided on the receiver. With a logic zero on the strobe terminal, the output will be high no matter what the input signal is. With the strobe, the receiver can be made immune to any noise signals during intervals where no digital information is expected. The output state with the strobe on is also the same as the output state with the input terminals open, as would be the case when the transmitter was disconnected from the receiver.

**Results**

To summarize, the best termination is an RC combination with a time constant about equal to three times the transmission line delay. Even though its value is not precisely determined, the internal termination resistor of the integrated circuit can be used because the line characteristics are not greatly affected by this resistor.

An RC termination can cause problems only when the data transmission rate approaches the line delay and the attenuation down the line (dc terminated) is greater than 3 dB. This would correspond to more than 1000 ft. of twisted pair cable with No. 22 copper conductors. Under these conditions, the noise margin can disappear with low-duty-cycle signals. If this is the case, it is best to operate the twisted-pair line without a termination to minimize transmission losses. Reflections should not be a problem as they will be absorbed by the line losses.

**INFORMATION RETRIEVAL:**
Integrated circuits, Systems
Digital design
An important announcement
to the engineer
who is on the way up
in his company

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Because of a wide and enthusiastic response to the Project Management Series which has appeared in the pages of this magazine, the editors have arranged a series of professionally directed seminars which will take place in key cities throughout the country. These Seminars on the "Management of Engineering Projects" are open to all qualified engineers who wish to participate.

The purpose of the Seminars is to develop within each participant an improved capability to manage effectively both large and small electronic projects. The Seminars will provide the practical knowledge to those responsible for electronic projects to do a better job of planning and executing those projects. There will be particular emphasis on the methods used to reach an objective while remaining within the prescribed product specifications, budget and schedule. The tested methods used in the Seminars will help the individual electronic engineer or manager increase his personal skills, sharpen his capability and broaden his understanding of Project Management problems.

Electronics engineering projects require the use of new management concepts which are often difficult for the traditionally-oriented manager to understand and accept. Because they cut across many functional (specialist) and organizational lines, these projects do not fit comfortably within the lines of authority in the traditional organizational structure. Even more important, these projects are scheduled to achieve certain specified results at a particular point in time.

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The Electronic Engineer
From code conversion to micro-programming, the monolithic read-only memory proves to be a versatile component.

By John Linford, Manager, Computer Memory Systems, Applications Section, Motorola Semiconductor Products, Inc., Phoenix, Arizona

The monolithic read-only-memory is coming on strong. Available in both bipolar and metal-oxide-semiconductor forms, with bit capacities reaching into the thousands, the IC ROM is extremely versatile. It can handle all sorts of logic jobs, including detection, decoding, generation, distribution, and translation. Moreover, it can also serve as a complete arithmetic unit.

A read only memory (often called fixed-constant memory, non-alterable memory, or fixed-program memory) is a digital storage device containing information that cannot be altered during normal operation. Integrated circuit ROMS now on the market have information stored during the manufacturing process that cannot be electrically altered. When utilizing them, the system designer obtains the usual advantages of integrated arrays—such as increased system reliability, lower system cost, higher speed and reduced package count. In addition, the designer obtains a custom circuit without paying the full engineering and production tooling costs for an individual circuit. This is true because the storage pattern is inserted during a single step during processing; hence the user can obtain a given function at a price based upon the development of a single mask and the related processing. Thus, custom circuits become economically feasible with smaller production quantities. Another important plus for custom logic circuits built from ROMS is the short lead times involved.

Automatic mask generation can now generate the simple metal cut masks needed for ROMS, thus permitting some semiconductor houses to deliver circuits in 2 to 6 weeks.

Perhaps the biggest disadvantage of IC ROMS is the fact that the IC manufacturer must presently insert the storage pattern and hence the time required to change the pattern is longer than if the customer did the programming using other types of ROMS. Aware of this problem, some manufacturers have designed automated systems to generate the masks and the test pattern for a custom ROM. A turn around time of two weeks is the goal of this endeavor.

Mind your '1s' and '0s'

Standard wafers are processed with "1's" in all ROM locations. This standard processing includes passivation with a glass coating to protect the surface of the wafer. A masking operation now opens slots over the 128 metal link connections. The final photo-resist masking now etches away the bit links wherever a zero is desired. The cut mask needed for this information insertion can be generated automatically at reasonable cost.

Bipolar read-only memories with worst case access times of 50nsec are presently available with 128 and 256 bits. MOS ROM arrays with approximately 2µs access times are offered in sizes of 2048 bits and higher. Bipolar ROMS arrays with access times of 100nsec and bit capacities of 1024 bits are expected to be available by mid 1969. (Text continued on page 70)
Read-only memory

Block diagram and schematic

The versatile read-only-memory. This 128-bit integrated-circuit ROM generates as many as eight functions from a 4-bit binary code. The block diagram and schematic show enable inputs, address gates, decoder driver, array, and output buffers. The actual monolithic measures 88 by 85 mils. Each bit is initially in the logical '1' state, as established by the metal interconnection. The slots in the passivation mask determine which metal links will be removed to change the 1's to 0's.

The schematic shows a bipolar, 128-bit ROM (Motorola XC170) organized as an array of 16 words of 8 bits each. Four address bits provide binary coded inputs to select the desired word. The chip also contains four enable inputs useful for address expansion. A word line is enabled (in high or 1 state) when all enable inputs are driven high. With the connections as shown in the schematic word-line 0 will forward-bias the word-line buffer transistors Q_{w0} through Q_{w7}. The current from the word-line buffer transistors, Q_{w}, for example, will forward-bias the base-emitter junction of the bit-0 output buffer transistor Q_{b0}, producing a zero output. Under these conditions, the presence or absence of the metal link connections between the emitters of the word-line buffer transistors and the resistors connected to the base of the output transistors (between Q_{b} and R_{b} for bit 0) determines the presence of a stored "1" or a "0" for each bit. If the link is present and the output is low, a 1 is stored for that particular bit. Hence, the circuit is initially constructed with all 1's stored and is programmed for the desired 0's by etching away metal links.
From Hollerith...

Hollerith punched tape code for numerical control (An EDP card has 80 columns of this 12 bit code)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Hollerith Code</th>
<th>RS-358 Code</th>
<th>ROM # Used for Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bit positions)</td>
<td>Bits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>12-1</td>
<td>1000001</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>12-2</td>
<td>1000010</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>12-3</td>
<td>1000011</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>12-4</td>
<td>1000100</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>12-5</td>
<td>1000101</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>12-6</td>
<td>1000110</td>
<td>1</td>
</tr>
<tr>
<td>G</td>
<td>12-7</td>
<td>1000111</td>
<td>1</td>
</tr>
<tr>
<td>H</td>
<td>12-8</td>
<td>1001000</td>
<td>3</td>
</tr>
<tr>
<td>I</td>
<td>12-9</td>
<td>1001001</td>
<td>3</td>
</tr>
<tr>
<td>J</td>
<td>11-1</td>
<td>1001010</td>
<td>1</td>
</tr>
<tr>
<td>K</td>
<td>11-2</td>
<td>1001011</td>
<td>1</td>
</tr>
<tr>
<td>L</td>
<td>11-3</td>
<td>1001100</td>
<td>1</td>
</tr>
<tr>
<td>M</td>
<td>11-4</td>
<td>1001101</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>11-5</td>
<td>1001110</td>
<td>1</td>
</tr>
<tr>
<td>O</td>
<td>11-6</td>
<td>1001111</td>
<td>1</td>
</tr>
<tr>
<td>P</td>
<td>11-7</td>
<td>1010000</td>
<td>1</td>
</tr>
<tr>
<td>Q</td>
<td>11-8</td>
<td>1010001</td>
<td>3</td>
</tr>
<tr>
<td>R</td>
<td>11-9</td>
<td>1010010</td>
<td>3</td>
</tr>
<tr>
<td>S</td>
<td>11-10</td>
<td>1010011</td>
<td>2</td>
</tr>
<tr>
<td>T</td>
<td>11-11</td>
<td>1010100</td>
<td>2</td>
</tr>
<tr>
<td>U</td>
<td>11-12</td>
<td>1010101</td>
<td>2</td>
</tr>
<tr>
<td>V</td>
<td>11-13</td>
<td>1010110</td>
<td>2</td>
</tr>
<tr>
<td>W</td>
<td>11-14</td>
<td>1010111</td>
<td>2</td>
</tr>
<tr>
<td>X</td>
<td>11-15</td>
<td>1011000</td>
<td>2</td>
</tr>
<tr>
<td>Y</td>
<td>11-16</td>
<td>1011001</td>
<td>3</td>
</tr>
<tr>
<td>Z</td>
<td>11-17</td>
<td>1011010</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>0-1</td>
<td>0110000</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>1-1</td>
<td>0110001</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2-1</td>
<td>0110010</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3-1</td>
<td>0110011</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4-1</td>
<td>0110100</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>5-1</td>
<td>0110101</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>6-1</td>
<td>0110110</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>7-1</td>
<td>0110111</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>8-1</td>
<td>0111000</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>9-1</td>
<td>0111001</td>
<td>3</td>
</tr>
<tr>
<td>:</td>
<td>8-2</td>
<td>0111010</td>
<td>4</td>
</tr>
<tr>
<td>%</td>
<td>0-4</td>
<td>0100101</td>
<td>4</td>
</tr>
<tr>
<td>(</td>
<td>12-8-5</td>
<td>0101000</td>
<td>3</td>
</tr>
<tr>
<td>)</td>
<td>11-8-5</td>
<td>0101011</td>
<td>3</td>
</tr>
<tr>
<td>+</td>
<td>12-8-6</td>
<td>0101101</td>
<td>4</td>
</tr>
<tr>
<td>-</td>
<td>11</td>
<td>0101101</td>
<td>1</td>
</tr>
<tr>
<td>/</td>
<td>0-1</td>
<td>0101111</td>
<td>2</td>
</tr>
<tr>
<td>Space</td>
<td>No punches</td>
<td>0100000</td>
<td>2</td>
</tr>
<tr>
<td>BS</td>
<td>11-9-6</td>
<td>0001000</td>
<td>4</td>
</tr>
<tr>
<td>HT</td>
<td>12-9-5</td>
<td>0001001</td>
<td>3</td>
</tr>
<tr>
<td>LF</td>
<td>0-9-5</td>
<td>0001010</td>
<td>3</td>
</tr>
<tr>
<td>CR</td>
<td>12-9-8-5</td>
<td>0001101</td>
<td>4</td>
</tr>
</tbody>
</table>

NOTE: 8th bit is parity bit
...to punched tape

**Hollerith to RS-358 numerical control code**

### ROM 1
**Address-enable function** (These connections are made to the enable input)

\[(8) \oplus (9) \oplus ([11] \cdot (12) + (12) \cdot (11))]\]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Hollerith Code</th>
<th>ROM #1 storage location</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12-1</td>
<td>A&lt;sub&gt;1&lt;/sub&gt;, A&lt;sub&gt;2&lt;/sub&gt;, A&lt;sub&gt;3&lt;/sub&gt;</td>
</tr>
<tr>
<td>B</td>
<td>12-2</td>
<td>A&lt;sub&gt;0&lt;/sub&gt;</td>
</tr>
<tr>
<td>C</td>
<td>12-3</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>12-4</td>
<td>A&lt;sub&gt;0&lt;/sub&gt;</td>
</tr>
<tr>
<td>E</td>
<td>12-5</td>
<td>A&lt;sub&gt;0&lt;/sub&gt;</td>
</tr>
<tr>
<td>F</td>
<td>12-6</td>
<td>A&lt;sub&gt;0&lt;/sub&gt;</td>
</tr>
<tr>
<td>G</td>
<td>12-7</td>
<td>A&lt;sub&gt;0&lt;/sub&gt;</td>
</tr>
<tr>
<td>—</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>11-1</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>11-2</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>11-3</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>11-4</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>11-5</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>11-6</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>11-7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>one word unused</td>
</tr>
</tbody>
</table>

The Hollerith punched card code is popular in digital systems. But there are other codes—for example, the EIA RS-358 code for information interchange in perforated tape numerical control machines—and to go from one code to the other requires a translation. This is easy to achieve with read-only memories.

In the translating circuit below, the Hollerith code has 12 bits while the RS-358 is an 8 bit code. Since the output code from this translation is of 8 bit length, each word of a 16 word, 8 bit read only memory can make the translation to the output code. A problem arises in addressing the ROM from the 12-bit Hollerith code since the ROM is designed to be addressed with a straight 4-bit binary code. However, certain characteristics of the Hollerith code can be used to advantage in solving this problem. First note that only one of the bits in the group 1, 2, 3, 4, 5, 6, 7 is activated at a time. Hence, the input code can be compressed by reducing these 7 inputs into the 3-bit binary code indicated below:

### ROM 2
**Address-enable function** (Uses all 16 ROM words in ROM #2)

\[(8) \oplus (9) \oplus ([11] \cdot (12) + (12) \cdot (11))]\]

<table>
<thead>
<tr>
<th>Address Input</th>
<th>A&lt;sub&gt;0&lt;/sub&gt;, A&lt;sub&gt;1&lt;/sub&gt;, A&lt;sub&gt;2&lt;/sub&gt;, A&lt;sub&gt;3&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
</tr>
<tr>
<td>D</td>
<td>12</td>
</tr>
</tbody>
</table>

### ROM 3
**Address-enable function** (Uses 12 ROM words in ROM #3)

\[(5) \oplus (6) \oplus [8] + (8) \oplus (8)]\]

<table>
<thead>
<tr>
<th>Address Input</th>
<th>A&lt;sub&gt;0&lt;/sub&gt;, A&lt;sub&gt;1&lt;/sub&gt;, A&lt;sub&gt;2&lt;/sub&gt;, A&lt;sub&gt;3&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
</tr>
<tr>
<td>D</td>
<td>12</td>
</tr>
</tbody>
</table>

### ROM 4
**Address-enable function** (Uses 5 words in ROM #4)

\[(8) \oplus (9) \oplus (6) + (8) \oplus [9 + 2 + 6 + 4]\]

<table>
<thead>
<tr>
<th>Address Input</th>
<th>A&lt;sub&gt;0&lt;/sub&gt;, A&lt;sub&gt;1&lt;/sub&gt;, A&lt;sub&gt;2&lt;/sub&gt;, A&lt;sub&gt;3&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12</td>
</tr>
<tr>
<td>B</td>
<td>12</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
</tr>
</tbody>
</table>

Thus, by using only three 4-input OR gates, the input code is reduced to 8 bits (the original 12 less the 4 realized by the above compression). Furthermore, the address enable inputs of the ROM can be used to similar advantage permitting a block of characters and their Hollerith equivalents to be translated into RS-358 code by means of a single ROM.

In the case illustrated here, for example, ROM #1 converts 15 characters. The inputs 1, 2, 3, 4, 5, 6, 7 are compressed into three bits B<sub>0</sub>, B<sub>1</sub>, B<sub>2</sub>, that serve as three of the address inputs. Input 11 is the fourth address (A<sub>3</sub>), and (11 + 12) (0) (9) (8) (11) is the enable function. Hence, the Hollerith codes illustrated serve as the address inputs to the ROM, showing the word location where the desired RS-358 code can be stored.

The remainder of the character set can be divided in a similar manner and be arranged to address additional ROMs. This method can be expanded to translate from Hollerith to other output codes as well.
ROM applications: Decoding...

Decoder. Read-only memory converts BCD format into 1-out-of-8 code. The three binary-coded inputs drive address lines A2, A1, and A0. Address line A0—as well as "chip enable input"—may be used for enable gating. A logical '1' stored in the memory results in a low output for the corresponding bit output; hence inverters will be required for applications that need high output states. If the storage pattern is inverted—'1's replace '0's and '0's replace the '1's—these extra inverter stages aren't necessary, but the utility of the chip enable inputs is lost. For such a setup the enable inputs must be connected "high" to permit outputs to remain low when not selected. With eight additional ROM chips configured in like fashion a one-out-of-sixty-four decoder subsystem is achieved.

ROM data distributor routes inputs to one of N outputs as directed by the address on the control lines (1-of-8 distribution is shown). If the data line (address input line A0 in decoder above) is in the '1' state, the output line specified by bits A2, A1, A0 contains a '1'. Here eight memory chips distribute 8 bits of data to the one register, specified by the selection bits, out of the eight registers. If, instead of registers, eight output lines were the ultimate destination, the wired-OR output feature of the ROM could be connected in common to achieve this. Such a matrix, which resembles a crossbar switching system, may have its interconnection system generated in two ways: a basic storage pattern like that of the decoder above can provide external control (with the chip outputs wired accordingly), or internal (to the ROMs) control, whereby a separate pattern is generated for each storage chip.

Detection of single errors in a binary word with the Hamming code. This code adds parity bits to the original word to locate erroneous bit number. One read-only-memory chip generates the three parity bits P1, P2, and P4, as a function of the four data bits, which serve as address bits. Each of the 16 memory locations is programmed to contain the proper parity information for P1, P2, and P4, for the corresponding combinations of input variables. Errors are detected by comparing the generated parity bits with the transmitted parity bits; the comparator output identifies the erroneous data bit. Note that only three of the eight storage bits are required to generate P1, P2, and P4, for the four message bits: bit 0 is a simple odd parity bit. Bits 4-7 are designed for use with longer message words.
Binary to 16-segment alphanumeric decoder. The ROM translates a 6-bit binary word into a code used to drive the 16 lamps of the indicator. Dots in storage pattern indicate a bit location in which a '1' is stored. Since only five 128-bit ROMs are used for translation, we use two ROMs to generate the alphabetic characters A to P, two more ROMs for Q to Z, and one ROM for symbols 0 through 9, restricted to 7 of the segments in the right half of the indicator. When an ROM output bit number is connected to the segment listed directly above each bit, the patterns programmed into the two ROMs will illuminate the symbols corresponding to each row. For example, the display of symbol A requires illumination of segments A, B, C, G—controlled by ROM #1—and A', B', F', G', controlled by ROM #2. Thus, one stored word in each of two ROMs is used to display the symbol A.

Logic function generator employs two ROMs as an arithmetic unit. Here a 256-word, 4-bit read-only-memory provides eight different functions over two input bits. Registers A and B each feed 2 bits into the memory. A 3rd input provides the carry, borrow, etc., command from the previous element in an iterative parallel machine, or from a storage element of a serial machine. Three additional address inputs (256 = 2^8) are available for function specification. A set of typical & functions would be ADD, SUBTRACT, WORD ZERO, PARITY, AND, OR, EQUAL, and EXCLUSIVE-OR. Others can also be accommodated. For example, a single input high function: \( F = A + A_1 + A_2 + A_3 \), a single input low function: \( F = A' + A_1 + A_2 + A_3 \), a 4-input exclusive-OR: \( F = A + A_1 + A_2 + A_3 + A_4 \), all inputs high: \( F = A + A_1 + A_2 + A_3 \), all inputs low: \( F = A + A_1 + A_2 + A_3 \). For each of the function specification combinations, the ROM can be programmed to provide the appropriate outputs on \( F_1 \), \( F_2 \), and the carry output.

The Electronic Engineer • May 1969
...ROM applications: arithmetic...

Detection of the right most (least significant) bit, performed with read-only-memory. The pattern for chip A indicates that if address input lines to a particular chip possess all zeroes, then the next chip in the chain is enabled. Hence, the first chip with a '1' on any of its address inputs will control the output. The circuit is iterative, with each cell different from the next. The output consists of the original word with the rightmost 1 zeroed. The new word can then be examined for the next right-most 1, or otherwise processed. Each chip must calculate the right-most 1 address if enabled, and also furnish bits for the new 16-bit word. Chip A—since it is the rightmost chip—merely removes the right-most 1 if it exists in the first four bits, and furnishes 4 bits for the new word. The pattern: if address input A0 is enabled (all bits examined by cells to the right of this cell are zero), then the chip output for bits 3-6 should be the input address with the rightmost 1 bit zeroed. If input A0 is zero, the present input passes on to the output without alteration.

Sequence generator uses a 16-word, 8-bit read-only-memory. The 4-bit binary counter addresses each of the 16 words in sequence. The code used for each 8-bit word depends on the number of different operations to be performed. Thus if only 8 distinct operations are required, a 1-out-of-8 code would be used. A translation stage employing other ROM chips can be used to convert the storage code to a 1-out-of-N code if additional operations are required. The same scheme works for longer sequences that are multiples of eight. This expansion is based on the ROM's chip-enable inputs and wired-OR capabilities.

The smaller bit size ROMs will find their greatest use in code conversion functions. On the other hand, the larger size ROMs will find considerable use in sequence generation. Such applications utilize the code translation function of a ROM cell. In addition, by sequential addressing of ROM words we can generate sequences of coded information.

Since the generation of sequences is a basic concept to digital systems, ROMs can be used to generate the control sequences within both stored-programs and wired-program machines. In a stored-program machine, sequences appear in various levels of the system structure. Two such examples are sequences of instructions (subroutines), and the gating sequences necessary to
Microprogrammer uses a read-only memory technique to manipulate computer data. An instruction has been read from the memory and gated into the instruction register. The operations code (OP CODE) of the instruction causes a certain section of the instruction sequence store (the ROM) to be addressed. The sequential counter is now activated, gating the first word within the addressed section into the microinstruction register. The micro-instruction sets a basic operation (such as a gating function) within the arithmetic section of the computer. The sequential counter then advances and a second micro-instruction is read-out. With this approach, the arithmetic unit alters the sequence within an instruction or the normal sequence of instructions. Instructions may be altered and new instructions added by replacing that particular section of the micro-instruction sequence store. Thus, we modify only a small portion of the control logic to make alterations—as contrasted with the total modification required by the control logic of a conventional machine.

Microprogramming

Instruction store

Memory address register

Instruction register

OP Code

READ ONLY MEMORY

Code selects 1 of N sequences

Sequential counter

Typical sequence

0 0 0 0 0 0 0 1
0 0 0 0 0 0 1 0
0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0

Micro-instruction register

INSTRUCTION SEQUENCE GENERATION

Request next instruction

Enable

Modify sequence

Basic operation hardware

ARITHMETIC UNIT

FINISHED SEQUENCE

Modify sequence

Basic operation hardware

Enable

Finished sequence

INFORMATION RETRIEVAL:
Computers, Digital design, Semiconductors, Integrated circuits, Systems
Anyone can think small.

Frankly, we had something bigger in mind.

We built our second generation DPM* to fit into seven square inches of panel. That's less than any other digital panel meter requires. But we didn't stop there. The Model 1290 mounts completely from the front of the panel. The entire chassis pulls out from the front for servicing or replacement. Even the Nixie** tubes are pluggable! Think of the convenience in continuous systems operation. Despite the smaller package, Model 1290 has all the features our original DPM is so widely acclaimed for—3-digit plus 100% overrange display, 0.1% ±1 digit accuracy, circularly polarized window filter, dual slope integration, full-buffered storage display and BCD output. Many of these standard Weston features are still "optional at extra cost" on competitive units. Our new compact is styled for tomorrow, available today, and priced below $200 in quantity. Anything else in the industry is just small talk. WESTON INSTRUMENTS DIVISION, Weston Instruments, Inc., Newark, New Jersey 07114. 

*U.S. Pat. #3,051,939 and patents pending.
**Registered trademark, Burroughs Corp.
Instrumentation: The systems approach

Instead of performing isolated measurement tasks, instruments are taking on more and more of the complete data job.

Two bywords which summarize the approach today's electronic components are taking—integration and systems-orientation—also reflect the latest trends in instrumentation. Instead of isolated measuring tasks, instruments are performing a host of related functions, taking on more and more of the complete data job.

This systems trend has had a big impact on data gathering, data analysis, and data use. It is changing the engineer's role in that closed loop. He now requires new guidelines to evaluate and apply instruments.

There are many factors he must take into account: How do all the separate instruments interrelate in a system? What are the advantages and limitations of the systems approach? Which will best suit him—programming features or manual control? What is the computer's role? And many, many others.

Evolution, not revolution

The systems push isn't radically new; it has been evolving for more than a decade. Today, instrument systems account for about 15% of all instrument business. By the mid-1970s its share may well be 50%. And manufacturers are pleased to admit systems activity comes as an addition to the traditional business, not at its expense. However, some feel systems growth will eventually hurt individual instrument sales.

A marketing official of Teradyne believes "the real systems trend involves the extent to which the manufacturer is responsible for seeing that all the parts work together. It means designing the entire system electrically and mechanically, and marketing it as a unit." Others submit the approach is characterized by systems-like features (such as programmability) added to individual instruments.

Whereas many instrument systems in the past were designed by users, more today are being built by manufacturers: instrument firms; systems firms; even computer companies; and conglomerates in all three areas.

Barton A. Weitz, product marketing manager at Dana Laboratories Inc., maintains the systems trend is reflected by the nature of the building blocks used. "The number of different blocks required is decreasing
Sample and hold

A representative sampling of individual system-type instruments, small computers, and data systems is compiled on these and the following pages. Information includes price, maker and model number, and salient features. Equipment is classified into instrument class (e.g., DVMs, computers, data-acquisition systems, etc.). The data is merely a rough guide to off-the-shelf hardware. EE’s editors suggest you write to the various manufacturers to obtain full information.

and more of the calculating and control functions are being handled by one instrumentation computer,” he argues.

Detailed examinations of these and other issues will be presented in a forthcoming series of articles. For your immediate concern, we have compiled charts that will show you a sampling of the hardware available for systems use. They may also be used to help you evaluate individual equipment and instrument complexes.

For good measure

The following is a checklist of items to consider before you purchase an instrument. They reflect the systems thrust, and will help you get full value for your measurement dollar.

- How much of the complete measurement job (beyond mere “reading”) does the instrument provide?
- How easily does it interface, electrically and mechanically, with other associated instruments?
- Does it combine the features and capabilities of two or more older instruments, to ease the measurement task?
- Can it measure systems variables as well as component and circuit parameters?
- Is the data generated in a directly usable form?
- In terms of dials, controls, adjustments, calibration, and so forth, is the equipment easier to operate?
- Does it have provision for environmental testing?
- Will it save time and labor, freeing skilled personnel for more vital work?
- How easily can it be controlled automatically, such as by a computer or control mechanism?
- How difficult will the programming be?
- Is there a more-universal, less-costly system available to do the job you intend for an instrument ‘hodgepodge’?
- What kind of assistance does vendor offer?
- Does the instrument have both analog and digital capabilities?
- Can operation be manual, as well as automatic?
- How easily can the gear be modified (e.g., by plug-in modules or circuit boards) to suit it to tasks?
- What are the relative costs of building your own system as against purchasing one?
<table>
<thead>
<tr>
<th>MINIMUM PRICE ($)</th>
<th>MAKER &amp; MODEL #</th>
<th>DATA WORD SIZE (BITS)</th>
<th>MEMORY SIZE (E denotes Expandable)</th>
<th>MEMORY SPEED (µsec)</th>
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## PROGRAMMERS

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<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>TYPE</th>
<th>FOR</th>
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<tbody>
<tr>
<td>325</td>
<td>Tektronix 263</td>
<td>CRO-Control</td>
<td>6 Measurements</td>
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<tr>
<td>375</td>
<td>Monsanto 570A</td>
<td>General</td>
<td>1-10 Programs 64 bits/Prog.</td>
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<tr>
<td>1200</td>
<td>HP 6933A</td>
<td>D to A Interface</td>
<td>18 Lines, Analog Program</td>
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<tr>
<td>1550</td>
<td>Tektronix R250</td>
<td>Power supply Pulse Gen.</td>
<td>Auxil. Prog. Patch Panel</td>
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<tr>
<td>1600</td>
<td>Tektronix 262</td>
<td>CRO-Control</td>
<td>8 Meas.</td>
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<tr>
<td>2175</td>
<td>Jerrold PC-6</td>
<td>Event</td>
<td>FCC Freq. Tests</td>
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<tr>
<td>4000</td>
<td>Tektronix 240/R240</td>
<td>CRO-Control</td>
<td>Storage, Branching, Ser to Par Conv.</td>
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<tr>
<td></td>
<td>Moore series 575C</td>
<td>A &amp; D</td>
<td>Pressure</td>
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## SCANNERS, MULTIPLEXERS

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>NO. OF CHANNELS</th>
<th>OUTPUT</th>
<th>DISPLAY DIGITS</th>
<th>INPUT RATE</th>
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<tbody>
<tr>
<td>825-1550</td>
<td>Scanivalve Aerospace line</td>
<td>48</td>
<td>BCD &amp; 0-30mV</td>
<td>—</td>
<td>0-10,000 psia</td>
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<tr>
<td>1975</td>
<td>HP 2901A</td>
<td>25  3-wire inputs</td>
<td>Programmed</td>
<td>2</td>
<td>12 chan/s</td>
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<tr>
<td>2000 up</td>
<td>Non. Lin. Syst. 2300 series</td>
<td>32</td>
<td>BCD</td>
<td>3</td>
<td>2.5ms/Chan; 1µV-750 V</td>
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<tr>
<td>2150-4875</td>
<td>Scanivalve 48CBM</td>
<td>48-576</td>
<td>BCD &amp; 0-30 mV</td>
<td>—</td>
<td>0-500 psia</td>
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<tr>
<td>2575-19,150</td>
<td>Scanivalve 64CBM</td>
<td>64-768</td>
<td>BCD &amp; 0-30 mV</td>
<td>—</td>
<td>3-15 psig</td>
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<tr>
<td>2975</td>
<td>Beckman 3701</td>
<td>10</td>
<td>8 bits</td>
<td>—</td>
<td>320 bits</td>
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<tr>
<td>3500</td>
<td>GR 1770</td>
<td>100</td>
<td>—</td>
<td>—</td>
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<tr>
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<td>4475</td>
<td>HP 2515A</td>
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<td>BCD</td>
<td>—</td>
<td>10 meas/ms</td>
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<tr>
<td>5100</td>
<td>HP 2911 A,B,C</td>
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<td>Prog.</td>
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<td>30 chan/s</td>
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<td>6975</td>
<td>Beckman 3700</td>
<td>100</td>
<td>100mV-10 V</td>
<td>4</td>
<td>5,000 samp/s</td>
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CONVERTERS

<table>
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<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>TYPE</th>
<th>OUTPUT</th>
<th>LINEARITY</th>
<th>INPUT RATE OR CAPACITY</th>
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<tbody>
<tr>
<td>250</td>
<td>EAI 6203</td>
<td>ac to dc</td>
<td>4 DEC</td>
<td>0.2</td>
<td>20 Hz-100 kHz</td>
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<tr>
<td>250</td>
<td>Dig. Equip. Corp. A613</td>
<td>D to A</td>
<td>...</td>
<td>...</td>
<td>12 bits</td>
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<tr>
<td>450</td>
<td>Beckman 4027</td>
<td>A to Bin.</td>
<td>10 Bits</td>
<td>0.1</td>
<td>10/s.</td>
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<tr>
<td>495</td>
<td>Beckman 4060</td>
<td>Bin to Dec</td>
<td>4 BCD</td>
<td>...</td>
<td>13 bits</td>
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<tr>
<td>650</td>
<td>Monsanto 503A</td>
<td>D to A</td>
<td>1 mA</td>
<td>0.25</td>
<td>BCD</td>
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<tr>
<td>755</td>
<td>Gen. Radio 1136</td>
<td>D to A</td>
<td>1 mA, 0.1 V</td>
<td>0.1</td>
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<tr>
<td>2250</td>
<td>HP 2410B</td>
<td>ac, Ω to dc</td>
<td>0-1 Vdc</td>
<td>...</td>
<td>10^7 Ω, 0-750V</td>
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<td>2400</td>
<td>HP 3461A</td>
<td>ac, dc Ω to d</td>
<td>...</td>
<td>.004</td>
<td>5 ranges</td>
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<tr>
<td>2900-3100</td>
<td>Interdata 7-750 series</td>
<td>A to D</td>
<td>8-12 bits</td>
<td>...</td>
<td>64 channels</td>
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<tr>
<td>---</td>
<td>Moore Synchro</td>
<td>D to A</td>
<td>3-15 psi</td>
<td>0.1</td>
<td>1</td>
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<tr>
<td>---</td>
<td>Non Lin. Syst. 2610</td>
<td>Serial</td>
<td>6 Digits 7 options</td>
<td>...</td>
<td>18 characters</td>
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<td>Computer</td>
<td>.05</td>
<td>10-13 bits 256 chars.</td>
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<td>Comp.</td>
<td>.05</td>
<td>10-13 bits 48 chan.</td>
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<td>Comp.</td>
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<td>10-13 bits</td>
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<td>±10V</td>
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<td>8-12 bits</td>
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<td>A to D</td>
<td>Bin.</td>
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* A = Analog; D = Digital; Bin = Binary; Ω = OHMS; DEC = Decimal; BCD = Binary-Coded/Decimal

DIGITAL VOLTMETERS

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<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>ACCUR. (%)</th>
<th>RANGES</th>
<th>TYPE *</th>
<th>DISPLAY (Full Digits)</th>
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<td>240</td>
<td>EAI 6201</td>
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<td>DC; V</td>
<td>3</td>
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<td>–</td>
<td>DC</td>
<td>–</td>
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<td>389</td>
<td>Darcy DM 330</td>
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<td>DC &amp; AC; V, A, Ω</td>
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<td>PRICE ($)</td>
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<td>ACCUR. (%)</td>
<td>RANGES</td>
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<td>DISPLAY (Full Digits)</td>
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<td>Heath EU805A</td>
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<td>DC; V</td>
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<td>DC</td>
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<td>1850</td>
<td>DTC 326</td>
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<td>10</td>
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<td>Systr.-Donn. 6413 Series</td>
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<td>4</td>
<td>DC; V, f</td>
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<tr>
<td>1900</td>
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<tr>
<td>1,950 up</td>
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<td>6</td>
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<tr>
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<tr>
<td>2390</td>
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<td>2485</td>
<td>Fluke 9500A</td>
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<td>AC</td>
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<td>2575</td>
<td>Fairchild 7100A</td>
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<tr>
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<td>4</td>
<td>DC; V</td>
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<td>4100</td>
<td>HP 2401C</td>
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<tr>
<td>4100-5300</td>
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<td>Fairchild 7200</td>
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<td>DC &amp; AC</td>
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<td>4600</td>
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<td>4</td>
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<td>5</td>
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*V=VOLTAG E; A=CURR E NT; Ω=OHMS; R=RATIO; f=FREQUENCY; T=TIME OR PERIOD
### OTHER DIGITAL METERS*

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>ACCUR. (%)</th>
<th>READS (Full Digits)</th>
<th>MEASUREMENT TIME</th>
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<tbody>
<tr>
<td>175</td>
<td>API 4301</td>
<td>0.1</td>
<td>DC; mV, V, A</td>
<td>3 1/5 s</td>
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<tr>
<td>199</td>
<td>DTC, DT-340</td>
<td>0.1</td>
<td>DC; V, Ω, R</td>
<td>3 1 s</td>
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<tr>
<td>245</td>
<td>Honeywell, VT-100</td>
<td>0.2</td>
<td>DC; V, Ω, R</td>
<td>3 1 s</td>
</tr>
<tr>
<td>225-300</td>
<td>Time Syst. Corp. 701,3,4,11</td>
<td>0.1</td>
<td>DC; mV, V, A</td>
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<tr>
<td>245-320</td>
<td>Time Syst. Corp., 700,710</td>
<td>0.1</td>
<td>DC; V, Ω, V, A</td>
<td>3 0.2 s</td>
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<tr>
<td>295-395</td>
<td>Syst.-Donn., 9000 series</td>
<td>0.1</td>
<td>DC; V, Ω, V, A</td>
<td>3 1/6 s</td>
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<tr>
<td>340</td>
<td>EA1, 6200</td>
<td>—</td>
<td>DC &amp; AC; V, f, T</td>
<td>3 0.2 s</td>
</tr>
<tr>
<td>345,395</td>
<td>Beckman, 4025, 4026</td>
<td>0.1</td>
<td>DC; V, A</td>
<td>3 0.2 s</td>
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<tr>
<td>350</td>
<td>Triplet, 500</td>
<td>0.1</td>
<td>DC &amp; AC; mV, V, A</td>
<td>3 1/6 s</td>
</tr>
<tr>
<td>375</td>
<td>DTC, DT-360</td>
<td>0.1</td>
<td>DC &amp; AC; V, A, Ω</td>
<td>3 0.2 s</td>
</tr>
<tr>
<td>550</td>
<td>HP 4260A</td>
<td>—</td>
<td>Impedance Meter</td>
<td>3 —</td>
</tr>
<tr>
<td>1575</td>
<td>Keithley 418A</td>
<td>2.0</td>
<td>Picoamp meter</td>
<td>5 4 s</td>
</tr>
<tr>
<td>2450</td>
<td>Keithley 419</td>
<td>1.5%</td>
<td>Picoamp meter</td>
<td>4 0.3 s</td>
</tr>
<tr>
<td>2500</td>
<td>Boonton 700A</td>
<td>0.25</td>
<td>Capacitance and inductance meter</td>
<td>4 0.3 s</td>
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<tr>
<td>—</td>
<td>DTC DVX-315A</td>
<td>0.003</td>
<td>DC; V, Ω, R</td>
<td>5 —</td>
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<tr>
<td>—</td>
<td>Simpson 2800</td>
<td>0.1</td>
<td>DC; V, A</td>
<td>3 0.2 s</td>
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*Panel type unless otherwise indicated.

### DIGITAL FREQUENCY METERS

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>RANGE</th>
<th>ACCUR. (%) OR RESOL.</th>
<th>DISPLAY (FULL DIGITS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>425</td>
<td>Beckman 4038</td>
<td>10⁶ events/sec 10 Hz-1 MHz</td>
<td>0.01</td>
<td>4</td>
</tr>
<tr>
<td>450</td>
<td>Beckman 4038</td>
<td>10⁶ events/sec 10 Hz-1 MHz</td>
<td>0.01</td>
<td>4</td>
</tr>
<tr>
<td>1000</td>
<td>Syst.-Donn. 6013</td>
<td>2 Hz-5 MHz</td>
<td>—</td>
<td>4</td>
</tr>
<tr>
<td>1450</td>
<td>Syst.-Donn. 6014</td>
<td>0.2 μs - 10⁶s, 0-10 MHz</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>1650</td>
<td>CMC 738</td>
<td>10 Hz-100 MHz</td>
<td>—</td>
<td>7</td>
</tr>
<tr>
<td>4650</td>
<td>Syst.-Donn. 6316</td>
<td>0-100 MHz</td>
<td>0.01</td>
<td>7</td>
</tr>
<tr>
<td>4750</td>
<td>HP 5240A</td>
<td>0.3-12.4 GHz</td>
<td>1 count</td>
<td>8</td>
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### DIGITAL COMPARATORS

<table>
<thead>
<tr>
<th>PRICES ($)</th>
<th>MAKER, MODEL #</th>
<th>TYPE</th>
<th>RANGE</th>
<th>ACCUR. (%)</th>
<th>OPER. SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>475</td>
<td>Beckman 4070</td>
<td>Dig. limit</td>
<td>4 Dec</td>
<td>—</td>
<td>100 μs</td>
</tr>
<tr>
<td>540-925</td>
<td>Auto Dyn. 66 series</td>
<td>Dig. limit</td>
<td>4-8 Dig.</td>
<td>—</td>
<td>1 μs</td>
</tr>
<tr>
<td>795</td>
<td>Monsanto 504A</td>
<td>Dig. limit</td>
<td>5 Dig.</td>
<td>—</td>
<td>1 μs</td>
</tr>
<tr>
<td>850</td>
<td>Monsanto 104A</td>
<td>Dig. limit</td>
<td>5 Modes, 1-10 V</td>
<td>&lt;1%</td>
<td>&lt;1 μs</td>
</tr>
<tr>
<td>1625</td>
<td>GR 1781</td>
<td>Dig. limit</td>
<td>11 digits</td>
<td>0.1</td>
<td>—</td>
</tr>
<tr>
<td>1800</td>
<td>HP 3434A</td>
<td>Dig. limit</td>
<td>100mV-1000 V, 1K-10 M Ω</td>
<td>0.02</td>
<td>0.2s</td>
</tr>
<tr>
<td>2000</td>
<td>Non Lin. Syst. 5510</td>
<td>Dig. limit</td>
<td>6 Dig.</td>
<td>—</td>
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</table>

(Digital comparator listing continued on following page.)

The Electronic Engineer • May 1969
### Digital Comparator Listing

<table>
<thead>
<tr>
<th>Price ($)</th>
<th>Maker, Model #</th>
<th>Type</th>
<th>Range</th>
<th>Accuracy (%)</th>
<th>Operation Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2650</td>
<td>HP 2539A</td>
<td>Dig. limit</td>
<td>12 compar.</td>
<td>–</td>
<td>&lt;3 ms</td>
</tr>
<tr>
<td>4975</td>
<td>GR 1681</td>
<td>Imped.</td>
<td>2 Ω - 20 M Ω, 20 pf-800 μF</td>
<td>0.005</td>
<td>0.5s</td>
</tr>
<tr>
<td>4975</td>
<td>GR 1680</td>
<td>Cap Bridge</td>
<td>0.01 pF-1000 μF</td>
<td>0.1</td>
<td>0.25-50 s</td>
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<tr>
<td>–</td>
<td>Marconi TF2412</td>
<td>Dig. limit</td>
<td>5-9 Dig.</td>
<td>–</td>
<td>25 μs</td>
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### Digital Counters, Timers

<table>
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<tr>
<th>Price ($)</th>
<th>Maker, Model #</th>
<th>No. of Full Digits</th>
<th>Range</th>
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<tbody>
<tr>
<td>70-110</td>
<td>Janus 6011 series</td>
<td>5</td>
<td>500 mV-30 V, 0-3 MHz</td>
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<tr>
<td>120</td>
<td>Wang IC-1</td>
<td>4</td>
<td>1-9999 items</td>
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<tr>
<td>275</td>
<td>EAI 6202</td>
<td>3</td>
<td>0-10 MHz 1 μs - 1000 s</td>
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<tr>
<td>325-395</td>
<td>Eldorado 200 series</td>
<td>4-5</td>
<td>100 KHz-15 MHz</td>
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<tr>
<td>345</td>
<td>Monsanto 103A</td>
<td>4</td>
<td>5 MHz-12.5 MHz</td>
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<tr>
<td>345-395</td>
<td>Time Syst. Corp. 410 series</td>
<td>5-6</td>
<td>2 Hz-2MHz</td>
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<td>375</td>
<td>Beckman 4050</td>
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<td>1Hz-12.5 MHz</td>
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<td>Simpson 2724</td>
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<td>Simpson 2725</td>
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<td>5Hz-20MHz</td>
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<td>550-1650</td>
<td>Eldorado 1600 series</td>
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<td>25-500 MHz</td>
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<td>575</td>
<td>Monsanto 100A</td>
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<td>5Hz-12.5 MHz</td>
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<td>595</td>
<td>Itron 650</td>
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<td>0-20 MHz</td>
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<td>675</td>
<td>Monsanto 101A</td>
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<td>5Hz-12.5 MHz</td>
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<td>Monsanto 505A</td>
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<td>24 Hr. clock</td>
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<td>CMC 608</td>
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<td>2Hz-15 MHz</td>
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<td>750-1975</td>
<td>Syst.--Donn. 7000 series</td>
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<td>0-12.5 MHz</td>
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<td>5Hz-8MHz</td>
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<td>Monsanto 106A</td>
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<td>5Hz-5MHz</td>
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<td>950-1050</td>
<td>HP 5331A, B</td>
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<td>0-10 MHz, 10 μs-1s</td>
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<td>Eldorado 1400 series</td>
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<td>Time Syst. Corp. 300</td>
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<td>CMC 608</td>
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<td>0-20 MHz</td>
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<td>1200-1425</td>
<td>Ortec 708 series</td>
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<td>0.15 - 11 days</td>
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<td>1285</td>
<td>Monsanto 110 A</td>
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<td>0-50 MHz</td>
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<td>2Hz-300 KHz</td>
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<td>HP 5325A</td>
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<td>0-12.5 MHz</td>
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<td>Syst.--Donn. 153</td>
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<td>3-3 GHz</td>
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<td>1370 up</td>
<td>Non. Lin. Syst. 2200 series</td>
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<td>24 hr., 100 and 400 day clocks</td>
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<td>MAKER, MODEL #</td>
<td>NO. OF FULL DIGITS</td>
<td>RANGE</td>
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<td>1 Hz-10MHz</td>
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<tr>
<td>1650</td>
<td>Syst.-Donn. 6034</td>
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<td>0-10 MHz, 0.2 µs - 10⁶s</td>
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<td>HP 5590A</td>
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<td>Time Syst. Corp. 210</td>
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<td>0.1 Hz-20 MHz</td>
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<td>GR 1159</td>
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<td>0.6 Hz-20 MHz</td>
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<td>HP 5323A</td>
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<td>0.125 Hz-20 MHz</td>
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<td>Syst.-Donn. 7036</td>
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<td>0-500 MHz</td>
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<td>2480-3100</td>
<td>HP 5245L, M</td>
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<td>2495</td>
<td>Monsanto 1510A</td>
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<td>0.3 GHz</td>
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<td>2750</td>
<td>Nanosec. Syst. 1714</td>
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<td>0-500 MHz</td>
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<td>Monsanto 1500A</td>
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<td>0-125 MHz</td>
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<td>0-100 MHz</td>
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<td>3350</td>
<td>Syst.-Donn. 6038</td>
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<td>0-100 MHz</td>
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<td>0-12.4 GHz</td>
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<td>11</td>
<td>0.01 Hz-320 MHz</td>
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<td>Beckman 6148</td>
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<td>0-100 MHz</td>
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<tr>
<td>-</td>
<td>HP 5323A</td>
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<td>0.125 Hz-20 MHz</td>
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</table>

**DIGITAL RECORDERS**

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>COLUMN CAPACITY</th>
<th>PRINT RATE</th>
<th>INPUT</th>
<th>OUTPUT</th>
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<tbody>
<tr>
<td>750-775</td>
<td>HP565A</td>
<td>11</td>
<td>5 lines/s</td>
<td>10-line DEC code</td>
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<tr>
<td>1085</td>
<td>HP562A</td>
<td>11</td>
<td>5 lines/s</td>
<td>4 or 10-line BCD</td>
<td>---</td>
</tr>
<tr>
<td>1150-1135</td>
<td>HP561B</td>
<td>11</td>
<td>5 lines/s</td>
<td>10-lines DEC code</td>
<td>---</td>
</tr>
<tr>
<td>1199</td>
<td>Beckman 3725</td>
<td>---</td>
<td>20 samp./s</td>
<td>---</td>
<td>4 Dig.</td>
</tr>
<tr>
<td>1760-3035</td>
<td>TI-170</td>
<td>---</td>
<td>---</td>
<td>Pressure G&amp;GES</td>
<td>Printer, Computer</td>
</tr>
<tr>
<td>2700-4800</td>
<td>Ampex SP-700</td>
<td>33 Chan.</td>
<td>2.75 in./s</td>
<td>0-5Hz, 0.2-5 kHz FM, voice</td>
<td>Tape</td>
</tr>
<tr>
<td>10,354</td>
<td>Beckman 3710</td>
<td>---</td>
<td>20 samp./s</td>
<td>---</td>
<td>4 Dig.</td>
</tr>
<tr>
<td>11,934</td>
<td>Beckman 3720</td>
<td>---</td>
<td>5 samp./s</td>
<td>---</td>
<td>4 Dig.</td>
</tr>
<tr>
<td>17,475</td>
<td>Beckman 3730</td>
<td>---</td>
<td>100 samp./s</td>
<td>---</td>
<td>4 Dig.</td>
</tr>
<tr>
<td>21,500</td>
<td>Beckman 3750</td>
<td>---</td>
<td>5000 samp./s</td>
<td>---</td>
<td>4 Dig.</td>
</tr>
<tr>
<td>22,500</td>
<td>Beckman 3740</td>
<td>---</td>
<td>1000 samp./s</td>
<td>---</td>
<td>Computer</td>
</tr>
<tr>
<td>---</td>
<td>Janus 4120</td>
<td>---</td>
<td>---</td>
<td>14 DEC.</td>
<td>BCD Record,</td>
</tr>
<tr>
<td>---</td>
<td>HP 50508</td>
<td>18 Col.</td>
<td>20 lines/s</td>
<td>Voice Counter</td>
<td>16 col. paper</td>
</tr>
</tbody>
</table>
## DATA PRINTERS

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>INPUT</th>
<th>CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>760 up</td>
<td>Hickok PR4900</td>
<td>BCD</td>
<td>10 col.</td>
</tr>
<tr>
<td>995</td>
<td>Beckman 3115</td>
<td>BCD</td>
<td>9 Digits, 2 Lines/s</td>
</tr>
<tr>
<td>1675-1935</td>
<td>GR 1137A</td>
<td>BCD</td>
<td>12 Col.</td>
</tr>
<tr>
<td>1700</td>
<td>Non Linear Syst. 2504</td>
<td>BCD</td>
<td>12 Col., 2-6 lines/s</td>
</tr>
<tr>
<td>1900</td>
<td>HP 5050B</td>
<td>BCD</td>
<td>18 Col. 20 lines/s</td>
</tr>
</tbody>
</table>

## DIGITAL SOURCES/GENERATORS (FREQ SYNTH, TONE, PULSE, POWER, WAVEFORM, SWEP, VOLTAGE)

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>RANGE</th>
<th>INCREM</th>
<th>V OUT</th>
<th>ACCURACY, PURITY OR DISTORTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Exact 200</td>
<td>2 µs-1 s</td>
<td>2µs</td>
<td>10-30V</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>425</td>
<td>HP 6181B</td>
<td>250mA @ 100 V</td>
<td>1mA</td>
<td>250mA</td>
<td>100 ppm</td>
</tr>
<tr>
<td>425</td>
<td>HP 6177B</td>
<td>50 mA @ 50 V</td>
<td>1mA</td>
<td>500mA</td>
<td>100 ppm</td>
</tr>
<tr>
<td>595</td>
<td>Monsanto 3100A-016</td>
<td>0-1.3 MHz</td>
<td>0.01 Hz</td>
<td>-20dBm</td>
<td>---</td>
</tr>
<tr>
<td>650</td>
<td>HP 3300A</td>
<td>0.01Hz-100 kHz</td>
<td>1%</td>
<td>35V</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>750</td>
<td>HP 1900A</td>
<td>25 Hz-25 MHz</td>
<td>15ns</td>
<td>---</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>770</td>
<td>HP 8003A; option 0</td>
<td>10 ns-2s</td>
<td>30ns</td>
<td>5V</td>
<td>4%</td>
</tr>
<tr>
<td>995</td>
<td>Wavetek 150</td>
<td>0.01 Hz-1 MHz</td>
<td>1 Hz</td>
<td>10V</td>
<td>3%</td>
</tr>
<tr>
<td>1195</td>
<td>Wavetek 155</td>
<td>0.01 Hz-1 MHz</td>
<td>1 Hz</td>
<td>10 V</td>
<td>3%</td>
</tr>
<tr>
<td>1250</td>
<td>Monsanto 300A</td>
<td>50 ns-200 ms pulses</td>
<td>25 ns</td>
<td>0.2-10 V</td>
<td>---</td>
</tr>
<tr>
<td>1285</td>
<td>Data Royal F270A</td>
<td>0.01 Hz-1.1 MHz</td>
<td>0.1%</td>
<td>16 V</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>1295</td>
<td>HP 8717A</td>
<td>0.032 V @ 500 mA</td>
<td>0.01</td>
<td>---</td>
<td>4%</td>
</tr>
<tr>
<td>1435</td>
<td>Data Royal F280A</td>
<td>0.01 Hz-1.1 MHz</td>
<td>0.1%</td>
<td>16 V</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>1600</td>
<td>HP 6130B</td>
<td>50V @ 1A</td>
<td>1 mV, 10mV</td>
<td>-10 to +10 V</td>
<td>0.2-2mV</td>
</tr>
<tr>
<td>1600</td>
<td>HP 8690B</td>
<td>400 kHz-40 GHz</td>
<td>1%</td>
<td>5-40 mW</td>
<td>1%</td>
</tr>
<tr>
<td>1975</td>
<td>HP 8601A</td>
<td>0.1-11u MHz</td>
<td>0.01%</td>
<td>-2-110 dBm</td>
<td>1%</td>
</tr>
<tr>
<td>2250</td>
<td>HP 675A</td>
<td>10 Hz-32 MHz</td>
<td>1 kHz</td>
<td>13 dBm</td>
<td>---</td>
</tr>
<tr>
<td>2495</td>
<td>DTC DF120</td>
<td>0.2MHz</td>
<td>1 Hz</td>
<td>2V</td>
<td>&lt; 30dB</td>
</tr>
<tr>
<td>2530</td>
<td>Datapulse 110FP</td>
<td>5 Hz-50 MHz</td>
<td>10 ns</td>
<td>10V</td>
<td>---</td>
</tr>
<tr>
<td>2650</td>
<td>HP 3722A</td>
<td>150 µHz-50 kHz (noise)</td>
<td>0.003Hz</td>
<td>10V</td>
<td>---</td>
</tr>
<tr>
<td>2995</td>
<td>Wavetek 157</td>
<td>100 µHz-1MHz</td>
<td>1Hz</td>
<td>10V</td>
<td>3%</td>
</tr>
<tr>
<td>3450</td>
<td>Datapulse 110FP/G2</td>
<td>5 Hz-50 MHz</td>
<td>10 ns</td>
<td>10V</td>
<td>---</td>
</tr>
<tr>
<td>3950</td>
<td>Monsanto 3100A</td>
<td>0-1.5 MHz</td>
<td>0.01 Hz</td>
<td>-20 dBm</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>4775-5395</td>
<td>Dana series 7000</td>
<td>0-11 MHz</td>
<td>0.01 Hz</td>
<td>1V</td>
<td>90 dB</td>
</tr>
<tr>
<td>6120</td>
<td>Datapulse 110FB/A2</td>
<td>5 Hz-50 MHz</td>
<td>10 ns</td>
<td>10V</td>
<td>---</td>
</tr>
<tr>
<td>6500</td>
<td>HP 5105A</td>
<td>100 kHz-500 MHz</td>
<td>0.1 Hz</td>
<td>---</td>
<td>&lt; 1%</td>
</tr>
</tbody>
</table>

(Digital sources listing continued on following page.)
(Digital sources listing continued from previous page.)

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>RANGE</th>
<th>INCREM</th>
<th>V&lt;sub&gt;OUT&lt;/sub&gt;</th>
<th>ACCURACY, PURITY OR DISTORTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>7200</td>
<td>HP 5102A</td>
<td>50 Hz-1 MHz</td>
<td>0.01 Hz</td>
<td>1 V</td>
<td>&gt; 74 dB</td>
</tr>
<tr>
<td>7800</td>
<td>HP 5103A</td>
<td>50 Hz-10 MHz</td>
<td>0.1 Hz</td>
<td>1 V</td>
<td>&gt; 64 dB</td>
</tr>
<tr>
<td>8150</td>
<td>HP 5100B</td>
<td>0-50 MHz</td>
<td>0.1 Hz</td>
<td>1 V</td>
<td>&gt; 90 dB</td>
</tr>
<tr>
<td>9750</td>
<td>HP 5105A</td>
<td>100 kHz-500 MHz</td>
<td>1 Hz</td>
<td>0 dBm</td>
<td>&gt; 90 dB</td>
</tr>
<tr>
<td>...</td>
<td>Wavetek 150 CP</td>
<td>1.2 - 12 kHz</td>
<td>1%</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>GR1164</td>
<td>10 kHz-70 MHz</td>
<td>10 Hz</td>
<td>...</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>...</td>
<td>Rohde &amp; Schwarz SMDH</td>
<td>0-50 MHz</td>
<td>1 Hz</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>Fluke 644A</td>
<td>0-40 MHz</td>
<td>1 Hz</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>Adret 300</td>
<td>6.1 Hz-2 MHz</td>
<td>0.1 Hz</td>
<td>10 µV-1 V</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>Freq. Eng. Labs. 700A</td>
<td>12-2.4 GHz</td>
<td>...</td>
<td>...</td>
<td>&gt; 70 dB</td>
</tr>
<tr>
<td>...</td>
<td>Microdot 412-525</td>
<td>400 MHz-2.35 GHz</td>
<td>0-300 kHz</td>
<td>0.1 µV-1 V</td>
<td>0.0003%</td>
</tr>
<tr>
<td>...</td>
<td>Wavetek 1001</td>
<td>500 kHz-300 MHz</td>
<td>100 kHz</td>
<td>1 V</td>
<td>30 dB</td>
</tr>
<tr>
<td>...</td>
<td>Wavetek 1501</td>
<td>450-930 MHz</td>
<td>5 MHz</td>
<td>0.5 V</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>Chronetics 1012</td>
<td>0-20 MHz</td>
<td>40 ns</td>
<td>9.9 V</td>
<td>&lt; 5%</td>
</tr>
</tbody>
</table>

**WORD GENERATORS**

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>WORD LENGTH</th>
<th>BIT RATE</th>
<th>OUTPUT CHANNELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>680-7460</td>
<td>Datapulse 200 series</td>
<td>1-100 bits</td>
<td>1 Hz-15 MHz</td>
<td>6-12V multi</td>
</tr>
<tr>
<td>2495</td>
<td>Datapulse 310 series</td>
<td>70 ns-5µs</td>
<td>0-10 MHz</td>
<td>Dual pulse</td>
</tr>
<tr>
<td>3500-4500</td>
<td>Eldorado 600 series</td>
<td>8 digits</td>
<td>1 ns-10 ns</td>
<td></td>
</tr>
<tr>
<td>3600</td>
<td>TI 6360</td>
<td>1-100 bits</td>
<td>10 MHz</td>
<td>1</td>
</tr>
<tr>
<td>3800</td>
<td>TI 6351</td>
<td>3-16 bits</td>
<td>10 MHz</td>
<td>3</td>
</tr>
<tr>
<td>4150</td>
<td>TI 6358A</td>
<td>1-100 bits</td>
<td>10 MHz</td>
<td>1</td>
</tr>
</tbody>
</table>

**DIGITAL CALIBRATORS**

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>RANGES</th>
<th>STEPS</th>
<th>OUTPUT</th>
<th>ACCUR. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1150</td>
<td>Cohu 324AN</td>
<td>1-100 V</td>
<td>10µV</td>
<td>1±122</td>
<td>0.003</td>
</tr>
<tr>
<td>3000</td>
<td>Fluke 3330A</td>
<td>10-1000 V</td>
<td>1-100 mA</td>
<td>1000V</td>
<td>0.005</td>
</tr>
<tr>
<td>4500</td>
<td>HP 745A</td>
<td>10 Hz-110 kHz</td>
<td>1 mV-100µV</td>
<td>0.1 mV-100 V</td>
<td>0.02</td>
</tr>
<tr>
<td>5000</td>
<td>Cohu 326</td>
<td>1-1000V</td>
<td>100µV</td>
<td>0±1111V</td>
<td>0.003</td>
</tr>
<tr>
<td>...</td>
<td>Cohu 313</td>
<td>1-1000V</td>
<td>10µV</td>
<td>0±1111V</td>
<td>0.01</td>
</tr>
<tr>
<td>...</td>
<td>Microdot 1203</td>
<td>200 Hz-2.35 GHz</td>
<td>...</td>
<td>0.1 µV-1V</td>
<td>0.0008</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>FUNCTION, CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>890-9950</td>
<td>Julie RVD, A10, SM, VOR series</td>
<td>Automated/programmable test sets. Cover 1 ppm accuracy of dc voltage, current, resistance, ratio. Includes sources, dividers, bridges, balancers, loggers, printers</td>
</tr>
<tr>
<td>895</td>
<td>Luft 77-P</td>
<td>Master controllers. Controls, automates operations. Also for data acquisition</td>
</tr>
<tr>
<td>975</td>
<td>Julie PRB-205S</td>
<td>Primary resistance measuring system. 0.00001% accuracy. Self-calibrating.</td>
</tr>
<tr>
<td>3000 up</td>
<td>HP 2310 elements</td>
<td>A-to-D subsystem for data acquisition and control. 16-64 inputs. Includes pacer, computer-interface</td>
</tr>
<tr>
<td>5000 up</td>
<td>HP 8410A</td>
<td>Network analyzer. Full characterization; 0.11-12.4 GHz; direct readout</td>
</tr>
<tr>
<td>5000 up</td>
<td>Vidar Vicom line, 5200 series</td>
<td>Systems for telecommunications, FM multiplex recording, data logging. 70 channels. 20 signals per track. High and low levels. Processor controlled.</td>
</tr>
<tr>
<td>5000-30,000</td>
<td>Honeywell PDC-100</td>
<td>Power demand control systems. Cyclical control of 4 M Watts or less. Programmable.</td>
</tr>
<tr>
<td>6000 up</td>
<td>Vidar 5400 series</td>
<td>Digital data acquisition systems. To 1000 channels; 36 samples/s. Portable, programmable.</td>
</tr>
<tr>
<td>7000 up</td>
<td>NLS S-1, S-2</td>
<td>Portable multifunction data acquisition systems. 200 3-wire inputs. 4 readings/s.</td>
</tr>
<tr>
<td>8980-14,925</td>
<td>HP 2010 K, L</td>
<td>Data acquisition system to measure, display, and record analog inputs. Can perform in noisy environments.</td>
</tr>
<tr>
<td>9500</td>
<td>Automation Dynamics AC410</td>
<td>Automatic logic circuit tester. 3000 ckt/s. Includes memory, printer.</td>
</tr>
<tr>
<td>9950 up</td>
<td>Non-Linear Systems S-1 series</td>
<td>Portable multifunction data acquisition systems. AC and DC, resistance and ratio. To 10003-inputs. Includes switching, timing, programmer, comparator, printer, recorder, computer interface. For temperature, gage, pressure, flow, component, linearizer, communication, control, monitoring, and performance measurements.</td>
</tr>
<tr>
<td>10,000-23,000</td>
<td>HP 2300 series</td>
<td>Computer systems for data acquisition and control. Include computer, teleprinter, reader, and interface subsystem.</td>
</tr>
<tr>
<td>10,000 up</td>
<td>GR 2990-9138, 9</td>
<td>Automatic capacitance and leakage measuring system. For component quality control.</td>
</tr>
<tr>
<td>10,000 up</td>
<td>Automation Dynamics series 363</td>
<td>Universal automated logic test system. Dynamic static testing. Includes computer, interfacers, software. 400 ckt/s.</td>
</tr>
<tr>
<td>10,354 up</td>
<td>Beckman 3700 series</td>
<td>Data acquisition recording system. 100 inputs; 5000 samples/s. rate. Automatic ranging; universal output modes.</td>
</tr>
<tr>
<td>10,555</td>
<td>HP 5561A</td>
<td>Nuclear counting system with sample changer.</td>
</tr>
<tr>
<td>11,405-13,825</td>
<td>HP 2012 series</td>
<td>Data acquisition system. Handles 10-1000 3-wire channels.</td>
</tr>
<tr>
<td>11,950</td>
<td>HP 5401A</td>
<td>Multichannel analyzer; 20 MHz range, expandable memory, 1024 channels. Contains CRO, processor, A/D converter, interface.</td>
</tr>
<tr>
<td>12,000-28,250</td>
<td>TEK S-3110, S-3120</td>
<td>Digital measurement system for dynamic testing of assemblies, circuits, components. Includes programmer, memory, tape reader. Can store 1600 measurements.</td>
</tr>
</tbody>
</table>

(Instrument systems listing continued on following page.)
<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>FUNCTION, CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>13,850</td>
<td>TEK S-3111</td>
<td>Digital measurement system for dynamic testing of assemblies, circuits, components. Includes programmer, memory, tape reader.</td>
</tr>
<tr>
<td>&lt;25,000</td>
<td>HP 5481A</td>
<td>Signal averager. Includes analyzer and computer, all interfaces and software.</td>
</tr>
<tr>
<td>25,000</td>
<td>Honeywell SPEC-Purpose</td>
<td>Programmed batch blending system. Card readers, digital dial, or sequence selectors control blending of 5-20 ingredients cyclically.</td>
</tr>
<tr>
<td>30,000 up</td>
<td>IBM 1800</td>
<td>Data acquisition and control system. 20,000 samples/s. A&amp;D inputs and outputs.</td>
</tr>
<tr>
<td>30,300</td>
<td>GR 1921</td>
<td>Real-time analyzer. 3.15 Hz-80 kHz. Computer.</td>
</tr>
<tr>
<td>30,000-70,000</td>
<td>HP 5405A/5406A</td>
<td>Analyzer systems. Single and multi parameters. Contains A/D converter, display, analyzer, software-controlled memory.</td>
</tr>
<tr>
<td>35,000-42,500</td>
<td>Redcor 686 series</td>
<td>Data acquisition system. 60,000 samples/s. Includes computer software.</td>
</tr>
<tr>
<td>40,000</td>
<td>Singer EMA-910</td>
<td>Digital measurements system. 1600 meas. storage; 100 meas./s. Dynamic. Programmed.</td>
</tr>
<tr>
<td>42,500</td>
<td>TEK S-3130</td>
<td>Field strength measurement and surveillance system. 1-26.5 GHz. Programmable.</td>
</tr>
<tr>
<td>47,600 up</td>
<td>Teradyne T200 series</td>
<td>Digital measurement system for dynamic testing of assemblies, circuits, components. Includes programmer, memory, tape reader. Can store 1600 measurements.</td>
</tr>
<tr>
<td>48,500 up</td>
<td>Teradyne J259 series</td>
<td>Computerized semiconductor test system. Includes computer, software.</td>
</tr>
<tr>
<td>53,000</td>
<td>EAI Pace</td>
<td>Computer-operated circuit test systems. DC measurements on components, circuits, boards, modules. Includes software, computer.</td>
</tr>
<tr>
<td>54,000 up</td>
<td>HP 9500A</td>
<td>Analytical lab data processing system. Includes computer, interfacers, teletype.</td>
</tr>
<tr>
<td>75,000-95,000</td>
<td>HP 8540A</td>
<td>Computer-controlled stimulus/response test system. For components, modules, assemblies. DC-500 MHz. Includes computer, teleprinter, interfacers.</td>
</tr>
<tr>
<td>86,000 up</td>
<td>HP 2060A</td>
<td>Automatic network analyzer. Full characterization; 0.11-12.4 GHz. Includes computer control.</td>
</tr>
<tr>
<td></td>
<td>Stoddart Series VII</td>
<td>Logic module test system. Includes computer, teleprinter, punched tape reader. Can perform 10,000 tests/s.</td>
</tr>
<tr>
<td></td>
<td>EAI Quad series</td>
<td>Automated RFI/EMI data acquisition for 20 Hz - 10 GHz. Includes programmer.</td>
</tr>
<tr>
<td></td>
<td>Microdot 1204</td>
<td>Lab mass. Spectrometers and gas analyzers. Analysis, process control, materials studies.</td>
</tr>
<tr>
<td></td>
<td>Microdot 4221, 1203</td>
<td>RF power calibrator system. 10 MHz-2.2 GHz.</td>
</tr>
<tr>
<td></td>
<td>Sanders Assoc. BFN</td>
<td>FM calibrating system. 10 MHz-18 GHz. For receivers, transmitters.</td>
</tr>
<tr>
<td></td>
<td>Sanders Assoc. BEH</td>
<td>TWT test station. 1.7-12 GHz. Programmed. Covers amplifiers, oscillators, other microwave devices.</td>
</tr>
<tr>
<td></td>
<td>E-H Research Labs. 8321</td>
<td>Programmable test station for radar, communications equipment. 1.7-8.0 GHz. Printer output.</td>
</tr>
<tr>
<td></td>
<td>Marconi Autotest</td>
<td>Automatic core test system. Programmed. 130,000 cores/hr.</td>
</tr>
<tr>
<td></td>
<td>Anadex CD-2381Q</td>
<td>Programmable system for communications devices. 20 Hz-150 MHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data acquisition and logging system. For multi-channel automatic scanning; 60 channels. Programmable.</td>
</tr>
</tbody>
</table>

(Instrument systems listing continued on following page.)

The Electronic Engineer • May 1969
(Instrument systems listing continued from previous page.)

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>FUNCTION, CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>195-467</td>
<td>GR 2990-9116</td>
<td>Automatic measuring system. For measuring temperature, time, device change events. Card punch output.</td>
</tr>
<tr>
<td>195-1448</td>
<td>Boonton 001-5, 171K</td>
<td>Test systems for unleaded (chip) components. 10,000 pieces/hr. Programmed.</td>
</tr>
<tr>
<td>2370-17,895</td>
<td>Servo Corp. 887/889 series</td>
<td>High-power microwave swept leveled system. 1-18 GHz; 7-14 watts.</td>
</tr>
<tr>
<td>145</td>
<td>Honeywell 7899</td>
<td>Automatic signal spectrum analysis and display. For EMI/RFI measurements, 20 Hz-1GHz. Programmed.</td>
</tr>
<tr>
<td>145</td>
<td>ESI Model 70</td>
<td>Meter calibration systems. Programmable. Calibrates deflection meters.</td>
</tr>
<tr>
<td>145</td>
<td>ESI 721, 951, 1071</td>
<td>Automatic data acquisition systems. Cover temperature, ac and dc ratios, computer compatible.</td>
</tr>
<tr>
<td>145</td>
<td>Raytheon Multiverter</td>
<td>Data acquisition and processing system. 96 channels. Contains multiplexer, sample and hold amplifiers, A/D Converter, power supplies.</td>
</tr>
<tr>
<td>145</td>
<td>Ballantine series 3570</td>
<td>Digital measuring systems for broadband ac voltage measurements. 30 Hz-10 MHz. Computer controllable.</td>
</tr>
<tr>
<td>145</td>
<td>Panoramic HCA-1</td>
<td>Alarm systems control unit for communications. Facility monitoring. 60 kHz-3.1 MHz.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>COUNTS/TURN OR RANGE</th>
<th>BITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>195-467</td>
<td>Baldwin 260 series</td>
<td>5000</td>
<td>14</td>
</tr>
<tr>
<td>195-1448</td>
<td>Baldwin 200 series</td>
<td>5000</td>
<td>14</td>
</tr>
<tr>
<td>495-6500</td>
<td>Baldwin 670-690 series</td>
<td>10-50,000</td>
<td>17-20</td>
</tr>
<tr>
<td>2370-17,895</td>
<td>Baldwin 500 series</td>
<td>36,000</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Baldwin 87-A series</td>
<td>1024</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Moore 7800 series</td>
<td>3-30 psi</td>
<td>1-50 mA dc</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-5 to +5 V dc</td>
</tr>
</tbody>
</table>
### MISCELLANEOUS

<table>
<thead>
<tr>
<th>PRICE ($)</th>
<th>MAKER, MODEL #</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>455-655</td>
<td>Dana series 2800</td>
<td>Guarded diff. data amplifiers</td>
</tr>
<tr>
<td>470-3250</td>
<td>Wang 320</td>
<td>10-14 Dig. calculations (gen', trig, log, exp.)</td>
</tr>
<tr>
<td>675 up</td>
<td>Simpson 2700</td>
<td>Digital System Unit (DVM, ranging modules)</td>
</tr>
<tr>
<td>1050</td>
<td>HP 8707A</td>
<td>400 kHz - 40 GHz rf sweep &amp; control</td>
</tr>
<tr>
<td>1200</td>
<td>HP 2411A</td>
<td>Guarded data amplifier</td>
</tr>
<tr>
<td>1250</td>
<td>Heathkit EU-805A</td>
<td>Universal dig instrument (DVM, counter, compar, timer, memory)</td>
</tr>
<tr>
<td>1550-1650</td>
<td>Tektronix 3S, 3T series</td>
<td>Programmable CRO sampling plug-ins</td>
</tr>
<tr>
<td>1595</td>
<td>Beckman 310B</td>
<td>Analog to Teletype coupler</td>
</tr>
<tr>
<td>1790</td>
<td>Julie RVD-106</td>
<td>Programmable divider</td>
</tr>
<tr>
<td>2250</td>
<td>HP 8406A</td>
<td>1-1000 MHz vector voltmeter</td>
</tr>
<tr>
<td>2500</td>
<td>Wang 379-8</td>
<td>Universal Interface (Dig. instrum. to counter)</td>
</tr>
<tr>
<td>2950</td>
<td>HP 8441A</td>
<td>Preselector Bandpass Filter</td>
</tr>
<tr>
<td>3050</td>
<td>HP 155A/1550A</td>
<td>Program Oscilloscope</td>
</tr>
<tr>
<td>3200</td>
<td>HP 3690A</td>
<td>20 Hz-620 kHz Spectr. Analyz.</td>
</tr>
<tr>
<td>3700</td>
<td>HP 5260A</td>
<td>13-12.4 GHz Freq. Divider</td>
</tr>
<tr>
<td>3800</td>
<td>HP 2801A</td>
<td>0.0001°C Resol. Quartz Therm.</td>
</tr>
<tr>
<td>4450</td>
<td>HP 4470A</td>
<td>Transistor Noise Analyzer</td>
</tr>
<tr>
<td>5000</td>
<td>HP 3370A</td>
<td>Gas Chromatograph Digital Integrator</td>
</tr>
<tr>
<td>5500</td>
<td>HP 8051A</td>
<td>1-400 series Loudness Analyser</td>
</tr>
<tr>
<td>8950</td>
<td>HP 8054A</td>
<td>Real Time Audio Spect. Analyzer</td>
</tr>
<tr>
<td>9950</td>
<td>HP 5480A</td>
<td>0-50 kHz Sig. Analyzer</td>
</tr>
<tr>
<td>125000 up</td>
<td>TI 553</td>
<td>Computer Controlled Dynamic Test System</td>
</tr>
<tr>
<td></td>
<td>Non. Lin. Syst. X-5</td>
<td>Digital Pressure Meter</td>
</tr>
<tr>
<td></td>
<td>Datawest 380</td>
<td>128 Channel High Speed A to D Interface</td>
</tr>
<tr>
<td></td>
<td>Marconi DA1444</td>
<td>Controller for programmable instruments</td>
</tr>
<tr>
<td></td>
<td>Hickok DMS 3200</td>
<td>Digital Measuring System Modules</td>
</tr>
</tbody>
</table>

### INFORMATION RETRIEVAL

Instruments and measurements, Computers and peripherals, Data acquisition and processing, Systems design
What this country needs is a good nickel cigar...

and a $\frac{3}{8}$ square industrial cermet trimmer.

Helipot has the trimmer for $3.50 list...
now available in local stock.

(But you'll have to find the cigar.)
Zero-beat detector ........................................... 916
IC-compatible crystal oscillator ............................. 917
Tuned rf frequency divider ................................... 918
Digital clock has adjustable pulse width ................... 919

Vote for the one you like best.

Send us practical, reproducible ideas that are original with you and have been implemented with linear or digital ICs.

- If we publish your idea you win a check for $25.00.
- If our readers vote yours the best of the issue in which it appears, you have your choice of a Simpson 270 or a Triplett 600 multitester.
- After 12 issues our readers will vote on the best idea for all 12 issues. The winner gets his choice of either a Hewlett-Packard 1206A or a Tektronix 310A oscilloscope.

Submit your IC Ideas to:
Alberto Socolovsky
Editor
THE ELECTRONIC ENGINEER
Chestnut & 56th Sts.
Philadelphia, Pa. 19139

Here's how you voted

The winning Idea for the December 1968 issue is, "Regulated supply has two outputs."

Don Purland, our prizewinning author, is a Project Engineer at the Controls Division of Research Inc., in Minneapolis, Minn. Mr. Purland selected the Triplett 600 TVO multitester as his prize.
you can put all your eggs in one basket

From logic diagram to logic drawer . . . (24 positions . . . and wire-wrappable) . . . that's INTERDYNE's total service concept!

We start with your logic design processed through our computer based design automation programs. Your logic is allocated then partitioned onto INTERDYNE's Modu-Wrap boards. Placement of the boards is optimized, and a pin-vs-signal assignment list is created. Next, we manufacture the modules—a rugged steel chassis 5.8" wide in whatever length you require, with a 90-pin connector at one end, and row after row of—you name it—14-, 16-, or 24-pin sockets, transistor holders, printed circuit card connectors, component posts, etc.—all neatly packaged with superbly unique power and ground distribution planes. If you prefer, you can by-pass our design automation and create your own modules from our list of available configurations. And, "to wrap it up," we have five fully automatic wire-wrap machines. Each card, and the drawer back panel, are wire wrappable. If you need the flexibility of direct entry packaging and want fast delivery, you'll want to know more about INTERDYNE's Inter-Wrap. Let us show you how you can put all your eggs in one basket. Ask for the MW 2900/5800 Series Brochure and information on the MW 5824 Logic Drawer. Circle Number 115 on the Reader's Service Card.

INTERDYNE
2217 Purdue Avenue
Los Angeles, California 90064
(213) 477-6051
916 Zero-beat detector

Tim K. Aaltonen
ARZ Assoc., New Rochelle, N. Y.

Keep this circuit in mind if you have to adjust two frequencies to within several cycles of each other. The particular problem was to zero-beat two 15-kHz signals to within ±5 Hz, quickly and accurately. A dual-trace scope was not accurate enough, while a counter took too long for production-line use.

How to do it? A two-bit comparator solved the problem. It detects a zero-beat between two frequencies. When they match within a few cycles, the lights blink slowly on and off.

The circuit accepts signals of up to 5-V peak amplitude, and is relatively insensitive to amplitude.

917 IC-compatible crystal oscillator

Albert W. Weggeman
Texas Instruments, Austin, Tex.

Here's an inexpensive, reliable, and accurate clock oscillator. Its output is compatible with the type of logic you use to build it.

Resistors $R_1$ and $R_2$ temperature-stabilize the NAND gates (T. I. SN7400N). They also ensure that the gates are in a linear region for starting. Capacitor $C_1$ is a dc block; it must have less than a 10-Ω impedance at the operating frequency.

The crystal, which sets the circuit's accuracy, runs in a series-resonant mode. So its series resistance must be low; AT-cut crystals for the 1- to 10-MHz range work well.

The output waveshape has nearly a 50% duty cycle, with chip-limited risetimes. The circuit starts well from 0° to 70°C.
918 Tuned rf frequency divider

Del Crowell
Philco-Ford, Palo Alto, Calif.

You can use this circuit to divide by two, up to 100 MHz. It has 10-11 dB gain with limiting, and a 15 dBm max. output level. From $-30^\circ$ to $75^\circ$C, the output variation is less than $\pm 1$ dB.

When you drive the Motorola MC1550G into its limiting region in this circuit, it becomes a monostable multivibrator. The base terminal is left open to allow switching. The feedback capacitor, $C f$, should have a value that ensures switching at levels about 10 dB lower than your normal input.

The tuned input and output reduces broadband noise as well as harmonically related spurious signals ($f_1 - f_2$, and so forth). All such spurs are more than 35 dB down.

919 Digital clock has adjustable pulse width

M. R. Rawlings
Collins Radio, Dallas, Tex.

A single Sylvania SG143 NAND gate, an SG83 dual pulse-shaper, and two capacitors give you a clock with adjustable pulse width.

The capacitors, with the SG83's internal resistors (4 kΩ), set the time constant for each phase. (A variable resistor in series with each internal resistor would give you continuous control.)

Total period is the sum of the pulse widths, which are: $T_1=C_1R_a/3$, and $T_2=C_2R_b/3$. The circuit is self-exciting, and has a frequency range in excess of 5 MHz.

(Note: This circuit is a variation of one recommended by Sylvania in their New Product Report on the SG80. That circuit's pulse width is fixed at only 20 ns. The author's variant, on the other hand, gives you any width that you need.)
Whether you want a wave analyzer or a spectrum analyzer, the ambidextrous HP 3590A does the job. This flexibility is achieved through the use of automatic amplitude ranging, electronic frequency sweeping, and linear or log X-Y outputs for graphic display.

But this dual capability is only the start of the HP 3590A's measuring ability. Add to this versatility the >85 dB dynamic range, highly selective bandwidths, ac and dc programmability, and a frequency range of 20 Hz to 620 kHz. The sum of all these improvements is increased performance and accuracy at speeds previously unattainable. Why settle for less? With the HP 3590A, you get the measurements you want—when you want them—faster and easier.

To provide the additional advantages of a special balanced input with selectable terminating impedances of 75, 135, 150, and 600 Ω—the new HP 3591A selective voltmeter is now available. Multiply this highly useful input capability by the fact that the 3591A is calibrated to indicate properly in either dB or dBm regardless of the terminating impedance selected. One result—an analyzer capable of making noise and level measurements on balanced voice frequency circuits, or on carrier systems up to 120 channels. And this example is only one of the many applications of an instrument designed with you in mind.

Wave Analyzer or Spectrum Analyzer?
The HP 3590A is both!

The 3590A mainframe is $3200. The 3591A mainframe is $3350. Three plug-ins are available: 3592A low cost slave and program unit when used in second 3590A, $80; 3593A with 3-digit mechanical display, $1100; 3594A with 5-digit electronic counter frequency display, $1600.

To get complete information on either the HP 3590A or the HP 3591A, call your local HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT PACKARD
SIGNAL ANALYZERS

The Electronic Engineer • May 1969

Circle 35 on Inquiry Card
Recommended reading for today's components buyer

North Electric is pleased to present a Full Line Components Catalog featuring their standard line of components. The catalog offers detailed information on the North Crossbar Switches, Connectors, Rotary Stepping Switches, Telephone-Type Relays—and, explains how you can benefit from North's 83 years experience building precision quality components for the electronics industry. Send for your copy today.
Feature article abstracts

Published information is vital to your job.
To save time in finding this information, we have abstracted the important technical features from eight electronic engineering publications.

Should any of these articles interest you, contact the magazine—names and addresses are listed below.

Reprints of articles with an asterisk are available free.

Save this section for future reference.

Circuit Design

Designing low-current MOS systems, Burt N. Mitchell, National Semiconductor. "EEE," Vol. 17, No. 3, March 1969, pp. 66-72. This article is not on "low-current MOS systems," but rather on how to drive the clock inputs of multiple-phase shift registers. Such registers—being capacitive and operating fast and at relatively high voltages—draw too much current to be driven by a metal-oxide bipolar IC. The author describes a hybrid circuit that his company has designed to solve that problem, and explains how to use it as an interface between TTL gates (the scheme applies also to DTL and two-phase-coded dynamic MOS shift registers).

Tackle your switching circuit designs, Delbert Johnson, De Forest, Inc. "Electronic Design," Vol. 17, No. 7, April 2, 1969, pp. 70-73. The designer describes an easy-to-use technique that can replace conventional worst-case methods of designing transistor switching circuits. It provides optimum coupling between stages and an optimum collector load for the driving stage. With it, you can almost arbitrarily select the reverse-bias potential for the base of the transistor that is QP8. Thus, you can include noise and drift in the design. The method can be used for silicon or germanium devices at any power level.

Speed network analysis with topology, John F. Deblanco, Honeywell Computer Control Div., "Electronic Design," Vol. 17, No. 7, April 1, 1969, pp. 56-61. With topological circuit analysis you don't have to write network equations or evaluate network matrices. But if the networks contain active components (such as transistors), the topological analysis method becomes quite complicated. It's easy to see why this method has had limited application. Now, however, there is a new technique that handles active nets easily and allows you to analyze your circuits almost by inspection.

A sinusoidal voltage-controlled oscillator for integrated circuits, Alan B. Grebene, Signetics Corp., "EEE Spectrum," Vol. 6, No. 3, March 1969, pp. 79-82. Since design parameters are dependent upon passive-component ratios only, the circuit described in this article is ideally suited for the loose absolute-value tolerances that are exhibited by the diffused components of ICS. This circuit is an inductorless near-harmonic voltage-controlled oscillator (VCO) that utilizes a compensated Wien-bridge topology with a voltage-controlled Miller integrator as the tuning element. It has a two-tone control range for frequencies up to 10 MHz with less than a 1-dB amplitude variation and less than a 10% total harmonic distortion over the entire control range.

Communications

*Transmitting data with digital ICS, R. J. Widlar and J. J. Kubinac, National Semiconductor, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 58-67. Often digital data (from a computer or telemetering equipment, etc.) must be sent in a high noise environment. Ordinary integrated logic circuits cannot be used on interface devices because they do not have sufficient noise immunity. Noise on wires, such as telephone lines, could be misread as digital information or it could mask digital information on the line. This article describes the operation and use of integrated circuits, and gives design information for overcoming noise on twisted-pair lines.

Power requirements for deep-space telecommunications, M. H. Brockman and E. C. Posey, California Institute of Technology. "EEE Spectrum," Vol. 6, No. 3, March 1969, pp. 95-99. Scientific exploration of the solar system through the use of deep-space probes is basically dependent on adequate telecommunications link between the spacecraft and the earth stations; a key factor is the need for high-power transmission capability. The answer seems to lie with high-power transmitters (earth-based) that have output in the 1000-GW range.

Components

*What is happening in chip capacitors, Robert H. Cushman, Eastern Ed., "EDN," Vol. 14, No. 6, Mar. 15, 1969, pp. 81-84. Monolithic ceramic capacitors have shown continuing progress. For example, you can now expect to get 1 µF in a 0.1-in. cube. Besides the ceramics, other types are discussed. There are several curves to help place the chip capacitor milieu in perspective.
Computer Hardware

*ROM at the top. John Liefeld, Motorola, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 44-53. Read-only memories are used to store information of a reference nature. For instance, this data could be a program for a large computer, or a series of names and addresses for a subscription service. The article discusses versatile integrated circuit memories that can be used for read-only applications such as decoders, sequencers, and arithmetic logic units, in addition to arithmetic functions. After a description of these memories, the reader will learn how to apply them to his needs.

Optical Techniques Light the Way to Mass Storage


Cryoelectric Memories: Best Hope for Large and Fast Mass Storage, G. B. Gange, RCA Labs, "Electronics," Vol. 42, No. 6, March 16, 1969, pp. 108-118. Cryoelectric memories, capable of storing a billion bits in a square inch at -40°C, are stepping into the spotlight to challenge magnetic memory systems for the vital mass-storage job. Densities of 100 million bits per square inch are achievable—100 times that of drums, disks and other magnetic equipment. The authors discuss advantages and limitations, the place of optical memories compared to other memories, including semiconductor type, characteristics, construction, and typical performances.

Testing Dilemma—How Much Is Enough?

Interface TTL directly with MOS dynamic circuits, Dale Mrozek, National Semiconductor, "IEEE Transactions on Electron Devices," Vol. ED-16, No. 3, March 1969, pp. 358-361. Low-voltage threshold processing of MOS circuits eliminates the problem of MOS-TTL interfacing problems. The new 2-V threshold levels mean, however, that the threshold voltage is now dependent on the device's temperatures approaching absolute zero. Although largely in the experimental stage, the technique has promise faster speed, less noise, better linearity, and greater bit capacities than semiconductor and magnetic memory elements. The article presents the state of art, provides the tutorial base needed to understand functioning, and discusses physical and design trends of cryoelectric elements.

MOS Characteristics Induce Other Design Concepts

*IC Voltage Regulator—Do-It-Yourself Power Supply, B. L. Perot, Associate Editor, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 47-52. With the widespread use of integrated circuits, the question of IC voltage regulator design engineers are now raising this question: "Should we buy a separate power supply or should we throw in a couple of rectifiers and then use an integrated circuit voltage regulator to power our equipment?" "Not yet," think the computer designers who put this question to. "Never," say the power supply manufacturers. Yet, the simplicity of integrated circuit voltage regulators is present in power supplies. The reason is explored and discussed in this very timely article.

The Economical Fuel Cell, Galen R. Fyshinger, U.S. Army Electronics Command, "IEEE Spectrum," Vol. 6, No. 3, March 1969, pp. 83-90. One of the first applications of economically competitive fuel cells is expected to be as a battery charger, either for recharging discharge cells or for use in an auxiliary battery, for use in hybrid configurations. With the fuel-cell-battery hybrid system, a number of fuel cells and their service can be used. The wide range of lightweight portable equipment at low development costs.

Test and Measurement

Instruments win top billing with more ICs and digital devices, Don Day, Assistant Editor, "EDN," Vol. 42, No. 5, March 3, 1969, pp. 49-56. Electronic test equipment business is expected to climb rapidly. The reason is explored and discussed in this very timely article.

Component and Chips for ICs, Sidney C. Silver, Associate Editor, "Electronic Products," Vol. 11, No. 12, Mar. 15, 1969, pp. 18-31. Read-only memories are used to store information of a reference nature. For instance, this data could be a program for a large computer, or a series of names and addresses for a subscription service. The article discusses versatile integrated circuit memories that can be used for read-only applications such as decoders, sequencers, and arithmetic logic units, in addition to arithmetic functions. After a description of these memories, the reader will learn how to apply them to his needs.

Microfilm self-scanned mosaic sensors, P. K. Weinberger, W. S. Fischbacher, and R. E. Cross, L. M. Warrington, RCA Labs, "IEEE Spectrum," Vol. 6, No. 3, March 1969, pp. 62-68. The development of practical solid-state image sensors is expected to introduce a new class of devices with applications extending considerably beyond those of today's camera tubes. Though still being developed, camera tubes for electronic and price, solid-state sensors offer some important advantages, such as compactness, geometric accuracy of scan, and versatility of addressing not possible with electron beams. This article discusses the operation of the most common self-scanned sensor types, and gives their relative advantages and disadvantages. It also covers two general sensor designs that use a monolithic silicon approach and a thin-film photodiode approach.

Integrated Circuits

Test and Measurement

*Instrumentation: The Systems Approach, Staff Report, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 73-87. Fewer and fewer instruments now operate on a stand-alone basis. Instead, the trend towards system-orientation, whereby a total measurement task is performed by compatible instruments, is growing. This requires new design techniques and details the characteristics of off-the-shelf hardware suited to system and entire measurement systems.

Semiconductors

Semiconductor Forum on SCR—Part 2, Michael Perugli, Contrib. Ed., and George Flynn, Sr. Assoc. Ed., "Electronics," Vol. 11, No. 12, Mar. 15, 1969, pp. 44-53. SCR characteristics are reviewed. The future of the thyristor family of devices is explored in a new class of thyristor devices. The future of the thyristor family of devices is explored in a new class of thyristor devices, especially those of low-voltage medium-current ratings. The discussion concludes with the thought that economics is the key to success, and that, for the break to succeed, a new class of thyristor devices should be developed.

Just How Obsolescent Are You? Tom Stephenson, Western Editor, "EDN.," Vol. 14, No. 4, Feb. 15, 1969, pp. 66-71. Single-shot measurements let you test simple and complex devices at high speeds, with negligible heating effects. And such measurements can be automated. The author stresses the point that to get the several hundred megahertz bandwidth you need, the instrumentation's signal-handling portion must be able to handle a low-inherence transmission line. Voltage and time measurement in such circuits is described.

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Avco effectively checks integrity of circuit boards with GAF industrial x-ray film.

Use of multilayer printed circuit boards enables Avco Electronics Division, Cincinnati, Ohio, to turn out smaller and more efficient military radio equipment. And GAF industrial 'H-D' Monopak™ x-ray film helps them get the job done right.

As part of a strict quality control program, Avco subjects each space-saving multilayer circuit board to exhaustive radiographic examination to assure faultless performance and long life. Both the front and back of each 5-layer board are x-rayed to see if there are any circuit breaks, missing components, bridging, misplaced resistors, rotated transistors, etc. and to check if the laminated parts are properly aligned.

For such exacting work, a film is needed to provide outstanding image definition and sharpness... which is why they use GAF industrial 'H-D' Monopak™ x-ray film. Industrial 'H-D' is an ultra-fine-grain, very high contrast film designed to yield high image definition even when radiographing minute subjects and very thin materials.

GAF offers you a complete line of industrial x-ray products with a wide range of speed, grain and contrast characteristics. Find out how GAF x-ray films and matched chemistry can best serve you. Contact your local GAF X-ray Representative. Or write GAF Industrial X-ray Marketing Dept., GAF Corporation, 140 West 51 Street, New York, New York 10020.
AC Digital/Analog Conversion.

11 Bit Resolution, 1/2 Bit Accuracy, In 3.2 Cu. In.

The Model D/A 011 (patent applied for) is unique in its design, combining a previously unmatched level of resolution and accuracy in a small package.

It employs a combination of transformer windings and MOS integrated circuits. It is fully compatible with DTL and TTL computers. No voltage level offset is required. Specifications for the D/A 011 are shown below. Why not let us show you how it, and related units, can help solve your interface problems. Use the handy reader service number below or write or call, Electronic Products Division, The Perkin-Elmer Corporation, 131 Danbury Road, Wilton, Conn. 06897. (203) 762-6574.

ADDITIONAL SPECIFICATIONS—MODEL D/A 011

Input Voltage — ±3.5 volts 400 CPS
Input Impedance — 90KΩ Minimum
Output Impedance Without Amplifier — 2000Ω Maximum
Operating Temperature — -55°C to +125°C

Logic Level (on) — +5 Volts DC
Logic Level (off) — 0 Volts DC
Channel Switching Time (typical) — 1µs
Weight — 3 oz.
NEW PRODUCTS

Leverwheel switches give fast action

In this era of great technological advances particularly, in the solid state area, we tend to overlook "mundane" devices such as, in this case, selector switches. However, somewhere along the line a human must control or put information into equipment. With this thought in mind, Cherry Electrical Products Corp. has made a giant step forward with their leverwheel rotary switches.

You can go from zero through nine in only 60° of rotation, and there is very positive detent action at each number.

This switch is a take-off of the 360° rotation type thumb wheel switches. But with this device, you can locate a position about twice as fast as you can with a normal thumb wheel type switch. Also, it eliminates the decision factor a user faces when, say, he is at position 4 and wants to move to position 8. Here the question is, "shall I push the wheel up or down to get to the next number fastest?" In the lever action switch this need for decision is eliminated. Physically and psychologically, with the 360° thumb wheel type switch, you are inclined to push the wheel in a downward position, which can, in many cases, make it much slower to reach your switch position.

In some cases, you may want to position the switch at the zero position, as perhaps a form of reset before selecting your number. With a lever switch this is a very rapid positive action.

The lever wheel switches come in two sizes: the subminiature size designated L-20 and the miniature size designated either L-20 or L-20, contingent on whether you want a front or back panel mounting switch. Incidentally, the subminiature switch mounting is only from the panel back.

Presently, the leverwheel switches are available with seven standard codes. As an example, codes cover such types as 10-position decimal, BCD complement, BCD plus even parity or BCD plus odd parity.

These switches terminate in a gold plated printed circuit board and they may be stacked together in any number of units. Switches have max rating of 240 V ac or dc, 0.5 A (12 W) per circuit.

In case you have any need or preference for the standard type thumb wheel rotary switches, Cherry Electric also has these in their product line. They are the same basic configuration as the leverwheel rotary switches, but they are available in 10 standard codes. For more information, contact Cherry Electrical Products Corp., 1650 Old Deerfield Rd., Highland Park, Ill. 60035. (312) 831-2100.

Circle 286 on Inquiry Card

Leverwheel rotary switches can be used singularly, or ganged together. Only 60° of lever movement is needed to go from 0 to 9.

Thumbwheel and leverwheel rotary switch codes

<table>
<thead>
<tr>
<th>Code</th>
<th>SUBMINIATURE</th>
<th>SUBMINIATURE</th>
<th>MINIATURE</th>
<th>MINIATURE</th>
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<tbody>
<tr>
<td></td>
<td>Mounting</td>
<td>Mounting</td>
<td>Mounting</td>
<td>Mounting</td>
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<tr>
<td></td>
<td>Front</td>
<td>Back</td>
<td>Front</td>
<td>Back</td>
</tr>
<tr>
<td>10 Position Decimal</td>
<td>T20-01A</td>
<td>T11-01A</td>
<td>T10-01A</td>
<td>L20-01A</td>
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<tr>
<td>BCD (Binary Coded Decimal)</td>
<td>T20-02A</td>
<td>T11-02A</td>
<td>T10-02A</td>
<td>L20-02A</td>
</tr>
<tr>
<td>Hex Decimial</td>
<td>T20-03A</td>
<td>T11-03A</td>
<td>T10-03A</td>
<td>L20-03A</td>
</tr>
<tr>
<td>BCD Complement</td>
<td>T20-04A</td>
<td>T11-04A</td>
<td>T10-04A</td>
<td>L20-04A</td>
</tr>
<tr>
<td>BCD + Comp. + 2 Comm.</td>
<td>T20-05A</td>
<td>T11-05A</td>
<td>T10-05A</td>
<td>L20-05A</td>
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<tr>
<td>BCD + Even Parity</td>
<td>T20-06A</td>
<td>T11-06A</td>
<td>T10-06A</td>
<td>L20-06A</td>
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<tr>
<td>BC Octal</td>
<td>T20-07A</td>
<td>T11-07A</td>
<td>T10-07A</td>
<td>L20-07A</td>
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<tr>
<td>Hex Decimial + Comp.</td>
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<td>T11-08A</td>
<td>T10-08A</td>
<td>L20-08A</td>
</tr>
<tr>
<td>Hex Decimial + Comp. + 2 Comm.</td>
<td>T20-09A</td>
<td>T11-09A</td>
<td>T10-09A</td>
<td>L20-09A</td>
</tr>
<tr>
<td>BCD + Odd Parity</td>
<td>T20-10A</td>
<td>T11-10A</td>
<td>T10-10A</td>
<td>L20-10A</td>
</tr>
</tbody>
</table>

The Electronic Engineer • May 1969
A complete digital panel meter

In case you haven't been keeping track, the trend in panel meters is definitely toward digital readouts, and for many obvious reasons: accuracy, ease of reading by non-technical people, compatibility with digital equipment and so forth. The latest entry in the field is Triplett, who make the claim of “total capability” for their DPM.

It may seem strange that a company like Triplett was slow in producing such a unit. But there's a good reason for the delay—they spent much time surveying what is available, and what is needed now and in the future. Then they designed their panel meter accordingly. The result: a DPM with standard features that are extra-cost accessories on other panel meters.

Looking over its specs, you'll find that the Model 5000 is a 3½-digit DPM with nonblinking display (six readings per second), moveable decimal point, and automatic polarity and overrange (O/R) indication. It has a 100-mVdc sensitivity, a 100-mV resolution, and an accuracy of ±0.1% full range ±1 digit. Dual-slope integration gives stability and long life.

The Triplett unit has both binary-coded-decimal (BCD) and decimal outputs to drive remote display or printer units. (You do not need converters to operate remote display devices.) A 1000-MΩ input resistance reduces loading and improves the reading accuracy.

Common-mode rejection is 80 dB, so you can make floating measurements with good accuracy. Series-mode rejection is 40 dB. To service the DPM, you simply remove the bezel and take out the chassis through the front panel; the case itself remains mounted to the panel.

Ranges presently available are ac or dc volts from 0.1 to 1000 V, and dc currents from 1 µA to 10 A (the circuit drop is 100mV). The ac version costs slightly more than the dc unit.

Some other features of the new digital panel meter are: automatic zero; display hold provisions; overload protection to 1 kV; and a built-in 8-W ac power supply. The supply is regulated, and operates from 115-Vac, 60-Hz lines. All calibration controls are accessible at the front of the panel. The DPM has an all-metal case for rf shielding. These features, plus others, are at the standard price.

The Model 5000 operates between 0° and 50°C. It measures 2.75 x 4.5 x 5.5 in., and weighs less than 6.5 lbs. User price is $360. For more information, contact Marketing Dept., Triplett Electrical Instrument Co., Bluffton, Ohio 45817. (419) 358-5015.

Circle 284 on Inquiry Card

Digital panel meter has many built-in features that are accessories on others. This unit has both BCD and decimal outputs for driving remote displays or a printer.

Rotary switch has pushbuttons

This is the year for improvements in rotary-type, thumbwheel switches. And one of the latest such improvements does away with the thumbwheel itself!

Chicago Dynamic Industries has a new switch that looks a lot like others at first glance. But there is no thumbwheel; instead, there is a push-button at its top and bottom. You push one of the buttons to add a digit, you push the other to subtract one. This eliminates the decision factor of the normal thumbwheel switch—which way to go to get to the next number.

Series MPB/AS-27000 is available in decimal, binary, and binary-with-complement outputs, and with internal lighting if desired. Special codes are available, too.

Terminations at the back of the switch are plain or funneled, as specified. Precision metal contacts are silver, gold, or palladium. The switches can carry 2 A max. at 115 Vac, and have a 0.1-Ω contact resistance. Operating temps. range from −55°-85°C.

As with most switches of this type, you can stack them together.

The MPB/AS-27000 costs about $14 per module, with a 3- to 4-week delivery cycle. For more information, contact J. C. Koci, Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago, Ill. 60614. (312) 935-4600.

Circle 285 on Inquiry Card
American born.

With the exception of apple pie, there's nothing quite so American as C & K Subminiature Switches. They're designed in the U.S. They're made in the U.S. With all the finest materials fifty states can supply.

So, naturally they cost more—right?
Wrong.

Our subminiature pushbutton and toggle switches cost less than comparable imports.

Trust what you buy. Order your subminiature switches—pushbutton or toggle with 1, 2, 3 and 4 poles—from C & K Components.

(In price, and in dependability, we speak your language.)

Call or write for quantity prices:

C&K COMPONENTS, INC. 103 Morse Street
Watertown, Massachusetts 02172 tel: (617) 926-0800
Our new printer is designed for original equipment manufacturers. It makes it easier for computers to talk to people and easier for people to talk back to their computers.

It's the UNIVAC® 0769 Incremental Printer. It's a low-speed asynchronous device that can print at a rate of up to 25 characters per second. Making it a pretty fast low-speed printer.

Its basic simplicity of design makes it very flexible. For example, you can use it with a keyboard as a remote input device to a central processor.

Or it can be a low-speed output printer. Or an integral part of a communications terminal. Or part of a magnetic-tape data recording system.

It has a changeable font. So if your customers suddenly decide to talk to their computers in mathematical symbols, they can.

The UNIVAC 0769 can handle up to 132 print positions. 52 positions more than you usually get.

It has an ink-impregnated roller that takes only a few seconds to change. And we designed it to produce an original and five good clean copies.

We're offering the 0769 to OEM customers as a basic mechanism, without controlling electronics, power supplies or cabinetry. We can also supply intimate electronic circuits for the 0769, primarily amplifiers and drivers, on a single plug-in printed circuit assembly.

If all this sounds interesting, write to Univac, OEM Marketing Department, P.O. Box 8100, Philadelphia, Pennsylvania 19101.

We offer Readers, Punches, Printers, Communication Terminals, Graphics, Memory Devices and, of course, a little therapy.
New interconnection system gives 3-D density

V-shaped spring contact enables connector size reduction without sacrificing reliability.

In this age of microminiaturization, it's often not feasible to use conventional interconnection techniques because they are too large. There may not be enough space for the connector; or the longer circuit length, with its unmatched impedance, may be unacceptable.

V-spring the key

A new high-density interconnection technique for parallel, perpendicular, or in-line mating promises to solve these problems. Designated the A-MP Microelectronic Connection System, it is built around an unusual receptacle contact that has two diametrically opposed V-shaped spiral springs. These springs, which deflect at right angles to the mating male pin, are stamped and formed from 0.004 in. beryllium copper. They are only 0.065 in. long with an outside diameter of 0.030 in. and are gold over nickel plated (as are the male pins).

Despite their compact size, the receptacle contacts can produce normal contact forces of over 100 grams for each of their two springs. When the mating pin contact is inserted into the receptacle, the spiral spring deflects in a plane perpendicular to the mating axis, making it possible for the overall length of the contact to be short while the springs are still long enough to function without excessive permanent deformation.

When housed in plastic (diallyl phthalate, epoxy or filled polyamide resin) blocks, the dimension in the direction of mating can be as small as 0.350 in. from wire termination to wire termination across the connector halves. This is especially advantageous in applications where the impedance mismatch (or length of the unmatched area) through the interconnection must be minimized. The short 0.065 in. receptacle contact length makes this possible.

Alignment not a problem

A serious drawback of many miniaturized units is that the connector halves must be perfectly aligned during mating to avoid damage to the pins. However, with this system, the angular displacement of the pin (without damage to the spring) is limited only by the inside geometry of the front and rear of the receptacle. This feature, along with the "float" of these terminals in their housings, makes it unnecessary for connector halves to be perfectly aligned.

Contacts can be terminated by crimping, welding or soldering. The pin and receptacle terminals snap into place in their respective housings and can be easily replaced if necessary.

Convenience an advantage

The housings can be mounted (and mated) without accessory hardware. One version can be stacked end-to-end without interrupting the 0.050 in. and 0.025 in. grid spacing. This is important on computer memory frames and other applications where it wouldn't be convenient to have one connector handle a large number of terminations. Another important application would be where it's necessary to plug a series of small connectors, side by side, into a single larger one.

A variety of configurations is available with contacts on 0.050 in. (true) and 0.025 in. (staggered) grids, including a full 16-position connector only 0.437 in. long. For more information contact AMP Incorporated, Harrisburg, Pa. 17105 (717) 564-0101.

Circle 222 on Inquiry Card

Key to the small size of the new connector system is the female contact at the left. Its two integral "V" shaped springs deflect at right angles to the mating pin contact, producing two points of electrical contact. As the deflection takes place entirely in a plane perpendicular to the mating axis, the overall contact length can be short.

By contouring the ends of the connector housings, they can be stacked end-to-end without interrupting the grid spacings.
Low cost, thin-film Hall generators

A new thin-film process brings down the price of Hall-effect generators—the payoff of three years of research by F. W. Bell, Inc.

The Ohio firm says that the low prices will open up high-volume applications for these devices in such things as brushless dc-motors, automobile ignition systems, position sensors, and so forth.

There are three basic types: Model FH-300, a 0.1 x 0.125 in. flip-chip device; Model FH-301, the same size as the 300, but with conventional wire leads; and the FH-302, which has a flexible pc lead strip with contacts on 0.1 in. centers. (If needed, you can have pc conductor patterns to suit your particular application.)

Second generation op amp is premium quality

Looking for a high quality, general purpose op amp? Then you may be interested in this new hybrid unit.

The 207 is a Bell & Howell item (Control Products Div.), marketed for that company by Data Device Corp. Its input characteristics are markedly improved over those of the 007, an 18-month-old predecessor.

For example, the initial voltage offset (max.) was 1 mV on the 007; it's 0.2 mV on the 207. Similarly, the voltage drift is a low 5 µV/°C; max., down from the original 20. And the input bias current is half: 150 nA max. for the 207.

GOLD-BEARING EPOXY

Is highly conductive.

Single-component epoxy compound contains pure gold powder. Conductivity of Epo-Tek 441 is uniform and highly reproducible. Volume resistivity is held to 0.0001 to 0.0005 Ω cm. The material is a smooth paste which is used directly from the jar. It can be used to attach chips in hybrid circuits, and for other applications where a gold epoxy is highly desirable or mandatory. Epoxy Technology, Inc. (617) 926-1949.

GUNN DIODE OSCILLATOR

X-band YIG tuned.

Model OX-100 electrically tunable oscillator provides 10 mW min. of fundamental rf pwr. with 6 dB max. pwr. variations over 8 to 12 GHz freq. range. Incidental FM, 10 kHz Pk-Pk; spurious outputs, -50 dB; harmonics, -30 dB; linearity, +0.1%. It is well suited for local osc. and freq. diversity master osc. applications. Physical Electronics Laboratories. (415) 323-9092.

FREQUENCY STANDARDS

1, 2, 2.5, 3, 4, 5, or 10 MHz out.

Model YH-522-1 standard has a cast aluminum internal cavity for its oven housing which gives good temperature stability and mechanical immunity to shock and vibration.

Level: 1 V rms min. into 1000-Ω
Stab: > ±1 x 10⁻⁹/day after 30 days initial aging.
Freq: < ±1 x 10⁻⁸ over 0° to 55°C
Input: ±28 Vdc ±1% reg.
Greenray Industries, Inc.

The Electronic Engineer • May 1969
**CTS cermet resistor networks**

...with

**NEW 16-lead dual-in-line package**

- Add more circuitry...up to 16-lead dual-in-line packages...with these new CTS space-saver cermet resistor networks. Specifically designed to simplify automatic insertion and reduce your assembly costs. Easy to hand mount, too.

**Series 760 DIP Resistor Networks** provide...14 or 16 lead packages...up to 15 resistors per module with an infinite number of circuit combinations...extremely good environmental specifications...5 lbs. pull strength on leads...and are available with or without active devices...lead spacing, .125".

**Check CTS low prices and fast delivery schedule...**2 weeks for prototypes; 4-6 weeks for production quantities. See the prices listed below!


---

**SERIES 750**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>4-pin 5 resistors</th>
<th>6-pin 5 resistors</th>
<th>8-pin 7 resistors</th>
<th>9 resistors (14 pin module)</th>
<th>11 resistors (14 pin module)</th>
<th>13 resistors (14 pin module)</th>
<th>15 resistors (16 pin module)</th>
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<tbody>
<tr>
<td>10,000</td>
<td>14.4¢ ea.</td>
<td>19.5¢ ea.</td>
<td>24.5¢ ea.</td>
<td>41¢ ea.</td>
<td>43¢ ea.</td>
<td>45¢ ea.</td>
<td>55¢ ea.</td>
</tr>
<tr>
<td>piece</td>
<td>(4.6¢/resistor)</td>
<td>(3.9¢/resistor)</td>
<td>(3.5¢/resistor)</td>
<td>(4.5¢/resistor)</td>
<td>(4¢/resistor)</td>
<td>(3.5¢/resistor)</td>
<td>(3.7¢/resistor)</td>
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<tr>
<td>price</td>
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<td>19.5¢ ea.</td>
<td>24.5¢ ea.</td>
<td>41¢ ea.</td>
<td>43¢ ea.</td>
<td>45¢ ea.</td>
<td>55¢ ea.</td>
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<tr>
<td>1,000</td>
<td>28.8¢ ea.</td>
<td>39.0¢ ea.</td>
<td>49.0¢ ea.</td>
<td>82¢ ea.</td>
<td>86¢ ea.</td>
<td>90¢ ea.</td>
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<td>price</td>
<td>(4.6¢/resistor)</td>
<td>(3.9¢/resistor)</td>
<td>(3.5¢/resistor)</td>
<td>(4.5¢/resistor)</td>
<td>(4¢/resistor)</td>
<td>(3.5¢/resistor)</td>
<td>(3.7¢/resistor)</td>
</tr>
</tbody>
</table>

Prices shown are ±2½% tolerance, ±250 ppm/°C from 50 ohms through 1 megohm standard TC. (Also based on circuits with all resistors screened simultaneously on one side of the substrate.)
NEW MICROWORLD PRODUCTS

THICK- FILM RESISTOR NETWORK
Sets current-source levels.

Model 813 is for use with Fairchild’s µA722 10-bit current source. Operates -20° to 85°C. There are three application resistors for output buffer scaling, and one for output offsetting for bipolar uses. $14 ea., 100-199. Beckman, Helipot Div., (714) 871-4848.

Circle 201 on Inquiry Card

D/A LADDER SWITCHES
For use with R-2R ladder networks.

Each unit is a single-bit, series-shunt switch and driver circuit. Type CMDA1 works from DTL/TTL logic, with a -10 V reference. $19.50 ea., 1-99 pcs. Crystalonics, (617) 491-1670.

Circle 202 on Inquiry Card

LADDER NETWORK
For 12- and 10-bit applications.

Designed for Fairchild's 3751 A/D converter, the M3019 R-2R ladder has an accuracy better than 1/2 LSB. Tracking TCR is less than 1 ppm/°C over military temperatures. Package is 0.6-in. dip, 560 ea., 100 pcs. Megadyne Industries, (716) 328-4242.

Circle 203 on Inquiry Card

MOS READ-ONLY MEMORY
Arranged as 256 x 4-bit words.

For code conversion, random logic synthesis, table look-up, and so forth. Gate protection diodes on all inputs. Needs no clock. Operates in less than 1 µs. DTL/TTL-compatible. MM421 (-55° to 125°C). $72 ea., 100-999 pcs. National Semiconductor, (408) 245-4320.

Circle 204 on Inquiry Card

MONOLITHIC AC AMPLIFIER ARRAY
Four independent amplifiers on a single substrate.

Features include 2 dB noise figure, 53 dB voltage gain, 2 Vrms out, 300 kHz open-loop BW. The CA3048 is a 16-pin dip, runs from a single-ended supply, and is specified from -25° to 85°C. $2.45 ea., 1000-up. RCA/Electronic Components, (201) 485-3900.

Circle 205 on Inquiry Card

LOGARITHMIC ELEMENTS
Both log and antilog functions.

These devices have an input range of 10 pA to 1 mA. Output is 60 mV/decade. Two independent sections have $V_a$ matched to 0.2 mV at 10 µA. Model L1-P is for positive inputs, L1-N for negative. $37.50 ea., 1-9 pcs. Data Device Corp., (516) 433-5330.

Circle 206 on Inquiry Card
ULTRASONIC OR THERMOCOMPRESSION BONDER
For flip-chips on substrates to 4 in.

Bond characteristics are controllable and repeatable. Critical adjustments programmed and preset. Model 8-149-01 has gross manipulation; x, y, and rotational micro-manipulator also. Split optics. About $10,000. Unitek, Weldmatic Div. (213) 359-8361.
Circle 207 on Inquiry Card

VERTICAL SIDEWALL MICROCIRCUIT CASE
For substrates to 1 x 1 in. and 0.75 x 1.5 in.

Kovar cases meet MIL-STD-883, MIL-STD-202; have 10 to 40 leads in opposing or triangular patterns. Terminal seals of borosilicate glass. Copper-clad Kovar option for cold-welding packages. $2.62 ea., 1000 pcs. Tekform Products, (714) 630-2340.
Circle 208 on Inquiry Card

MECHANIZED IC HANDLER
For testing in ambient environment.

Model 8024 handles 5000 tcs per hour, in carriers, for production/QA testing. Basic set-up includes magazine input, pneumatic transfer to test-position, and “ready-to-test” contact closure for tester. About $2500. Delta Design. (714) 465-4141.
Circle 209 on Inquiry Card
NEW LAB INSTRUMENTS

PEAK RF LAB STANDARD WATTMETER
For 50-Ω, pulsed transmission systems.

Self-contained Model 4345 samples reflected or forward power. Taut-band meter shows peak power, 250 W to 5 kW, 950-1300 MHz. Accuracy ±6% of reading at 25 calibrated points. Less than 1.08 insertion VSWR. Changeable connectors. Bird Electronics, (216) 248-1200.

Circle 210 on Inquiry Card

WIDEBAND OSCILLOSCOPES
To 200 MHz in real-time.

Model SS-112 has a 100-MHz bandwidth, while Model SS-211 is a 200-MHz unit. Both have 10 mV/cm sensitivity, 6 x 10 cm display. A FET probe has 1.75-ns rise-time. The SS-211 is $3120. Made by Iwatsu Electric, Tokyo. Sold by E-H Research, (415) 834-3030.

Circle 211 on Inquiry Card

NOISE SPIKE DETECTOR FOR SCOPES
Converts short duration spikes to square-wave output.

Plugged between scope and probe (BNC connectors), Scopac S-1 detects random, widely-spaced spikes with PRFs from 0.1 to 5 MHz. Threshold control sets minimum detectable level, ±0.1-1 V. Pulse input, 10 V max. $95. Travis Electronics, (617) 332-7447.

Circle 212 on Inquiry Card

11-MHZ SYNTHESIZER HAS 1-HZ STEPS
Digital control, crystal accuracy, spectral purity.

Series 7000 can be remotely controlled with TTL logic, using 1-2-4-8 code. Model 7010 is the basic unit; the 7020 adds analog search and an output attenuator. Model 7030 has analog search and VLF out. From $4775. Dana Labs., (714) 833-1234.

Circle 213 on Inquiry Card

The only total portable, laboratory quality oscilloscope.

And only $665.

Goes anywhere you need it. And at $665, there's no need for scope sharing. Operates from optional internal battery or 110/220 vac 50 to 400 Hz line. Compact 8½" x 9" x 15" size, weighs less than 20 lbs.

Features include: 20 MHz bandwidth; 17 ns rise time; 18 sweep speeds; internal voltage calibrator; and triggering stability over 30 MHz.

Write for Bulletin TIC 3316 to Motorola Communications & Electronics Inc., 4501 W. Augusta Blvd., Chicago, Ill. 60651.

MOTROLA
Precision Instrument Products

Circle 44 on Inquiry Card
when size makes the difference

Adlake makes the size

Adlake's new AWCM and AWDM Mercury Wetted Contact Relays — Sub-Miniature in size for printed circuit board use (see diagram) provides the answer to the high component density question. Small in size, yet made to Adlake's stringent quality requirements. Depend on Adlake's reliability and this new product to help solve your space problems. Available as contact Form C or contact Form D.

Write, please, for BULLETIN No. MW 5.

THE ADAMS & WESTLAKE COMPANY
A SUBSIDIARY OF ALLIED PRODUCTS CORPORATION
ELKHART, INDIANA 46514 • 219-264-1141 • TWX 219-522-3102 • TELEX 25-8458 • CABLE ADLAKE
Mercury Relays / Architectural Products / Transportation Equipment / Doors and Entrances / Contract Manufacturing
Circle 45 on Inquiry Card
What makes low-cost Dialight readouts so reliable and easy-to-read?

Reliable because of simple module construction and long life lamps. Designed for use with neon or incandescent lamps to meet circuit voltage requirements. Easy-to-read from any viewing angle. 1" high characters are formed by unique patented light-gathering cells, and may be read from distances of 30 feet. Sharp contrast makes for easy viewing under high ambient lighting conditions.

Dialight Readout Features
1. Operate at low power.
2. 6V AC-DC, 10V AC-DC, 14-16V AC-DC, 24-28V AC-DC, 150-160V DC or 110-125V AC.
3. Non-glare viewing windows in a choice of colors.
5. Available with universal BCD to 7 line translator driver.
6. Can be used with integrated circuit decoder devices now universally available.
7. Caption modules available; each can display 6 messages.

Send for catalog
Catalog-folder contains complete specifying and ordering data on numeric and caption modules, translator drivers, mounting accessories. Dialight Corporation, 60 Stewart Avenue, Brooklyn, New York 11237. Phone: (212) 497-7600.

DIALIGHT

Circle 46 on Inquiry Card

NEW LAB INSTRUMENTS

AUTOMATIC RELAY TESTER
Cycles to five operations a second.

Models R-4, R-5, R-6 test dry-circuit and pull-in (sensitivity adjustable to 10 µV or dry test). Wide range current/voltage for actuation/contact tests. Counters show faults/total cycles. Fleetwood Labs, (914) 235-0831.

Circle 223 on Inquiry Card

DIGITAL PICOAMMETER
Three digits resolve to 10⁻¹³ A.

Model 440 has 9 ranges: 10⁻² to 10⁻¹⁰ A f.s. Accuracy, ±0.5% on sensitive ranges, ±0.2% on others. 100% over-ranging, auto polarity and overload indication. Recorder output; printer output optional. $995. Keithley Instr., (216) 248-0400.

Circle 224 on Inquiry Card

DIGITAL DATA GENERATOR
Bit rates from 1 Hz to 125 MHz.

Model WG-100 has output of two 16-bit (or one 32-bit) words. Return-to-zero, nonreturn-to-zero formats. Provides logical complement. Rise/fall times, 1 ns. Output, 5 V/50Ω. Width, 2 ns-20 ns. $11,950. Tau-tron, (617) 458-6871.

Circle 225 on Inquiry Card

The Electronic Engineer • May 1969
MICROWAVE COUNTER
Measures 300 MHz to 3 GHz.

Circle 226 on Inquiry Card

REAL-TIME DIGITAL CLOCK
Shows hours, minutes, and seconds.

Preselect timed command pulses to occur at one of 70 intervals from 1 s to 25 h. Controls set starting time, select time of day or totalize mode. Nine-digit version shows days or manually-set data. Vidar, (415) 327-6340.
Circle 227 on Inquiry Card

PRESETTABLE COUNTERS
Models with up to six digits.

Signals generated by broken light path, magnetic field, etc. trigger these sensing counters. Dial in desired count, unit resets at that point. Counts to 50-kHz max. rate. Timed output signal. Numerics Corp., (617) 851-7229.
Circle 228 on Inquiry Card

The high performance, sensibly priced PULSE GENERATOR you've been looking for is here! Meet the Model PG-11: 10 Hz to 20 MHz.
$\pm15$ volts at maximum or any other rep rate. Rise time typically $3\text{ ns}$ at full amplitude. Single or double pulses, manual one-shot, pulse bursts. Synchronous or asynchronous gating. Triggering, DC to 20 MHz. Continuously variable rep rate, width, delay, amplitude.
Clean pulses: total distortion at full amplitude from all sources is less than 5%. All solid state. Optional rack adapter for mounting one PG-11, or mounting two PG-11's side by side in 3-1/2" of rack height. Bench model dimensions are 4" h x 8-1/2" wd x 9-1/2" d; weight 7 pounds, net. Full year guarantee. Available from stock.

Write or phone your nearest Representative (eem) for literature, a prompt demonstration or both.
Chronetics, Inc. 500 Nuber Avenue, Mt. Vernon, N.Y. (914) 699-4400. In Europe: 39 Rue Rothschild, Geneva, Switzerland (022) 31 81 80.

Circle 47 on Inquiry Card
T1007 is world's most sophisticated, flexible transfer function and mechanical impedance analyzer

For the first time, a transfer function and mechanical impedance analyzer is available which provides direct analytical solution of problems in vibration and fatigue, quieting studies, structural resonance, chatter, flutter and foundation design and isolation.

The new MB T1007 accepts and analyzes all data—sine and random as well as transient signals. It rejects all extraneous uncorrelated inputs, regardless of frequency or amplitude by effective use of cross-correlation techniques. The analyzer is therefore capable of obtaining transfer functions in the presence of noise or multiple inputs.

A primary application of the T1007 is simplifying the analysis of complex mechanical systems. Systems can be subdivided and regrouped conceptually and the dynamic effect of inserting a new component at any point can be predicted with great accuracy. The resulting distribution of forces and motions can then be determined easily.

The T1007 frees the design engineer and the data analyst from the need to simulate real time conditions. For example, it is possible to utilize data recorded directly from transducers mounted in an operating unit such as a motor vehicle or machine tool.

The full performance capabilities, as well as a complete description of all T1007 components, is contained in Bulletin 251.

Log Converter allows direct linear db plotting of signals with up to 50 db variations

The N404 Log Converter provides a dc output proportional to the logarithm of wideband voltage inputs from any source and is intended for use with galvo, X-Y, level, or tape recorders. It features a wide frequency range of 5 Hz to 10 kHz.

The N404 is part of the exclusive Zero Drive* data acquisition and conditioning system introduced by MB. It is a modular unit with self-contained power supply and isolated input/output signal path. A standard 19-inch rack can accommodate 12 units occupying a rack height of only 3½ inches. Price of the N404 is $250.00.

Hurst Performance uses PM Shaker for shifter test

Shown here is an MB PM50 shaker rated at 50 lbs. force being used by Hurst Performance Inc., of Warminster, Pa., to random audit Hurst shifters. The test is designed to simulate the vibration experienced by the shifter while selecting gears in a moving vehicle. The unit shown on the shaker is Hurst's latest patented four speed shifter currently supplied to Pontiac Motor Division for use in certain high performance cars.

MOS CLOCK

To 10-MHz rate.

Model SQ532 gives 2- or 4-phase outputs. Level control to —30 V with 0 to —4 V offset. Each phase has extended driver probe: swings 0 to —30 V in 20 ns against 100 pF. TTL write-gate, output strobe. Adar Assoc., (617) 623-3131.

Circle 229 on Inquiry Card

SAMPLING HEAD

Switch selects ac or dc coupling.

Type S-5 is low-noise (500 µV) with 1-ns risetime, and 1-MΩ/15-pF input. P6010 passive x10 probe (included) raises input impedance, has 20 mV to 2V/div. sensitivity. Max. dc input, ±100 V, $315 f.o.b. Tektronix, (503) 292-2611.

Circle 230 on Inquiry Card

MILLIMETER-WAVE SWEEPER

40-90 GHz with two plug-in heads.

Model 740 system has wide-range two. Heads span 40-62 GHz (20mW avg.), 60-90 GHz (5 mW rated). Power supply has voltage sequencing; simplified supply option if sweeping not needed. $10,500. Micro-Now Instr., (312) 282-0846.

Circle 231 on Inquiry Card
NULL DETECTOR
Fully floating and guarded input.

Model A-65C also has isolated recorder output. Full-scale ranges 10 \( \mu \text{V} \) to 100 Vdc, \( \pm 3\% \) accuracy. Resolution to 0.1 \( \mu \text{V} \); noise level is \( \pm 50 \text{nV} \). Stays zeroed at any source-impedance. Battery/line operation. $295. Medistor Instr. (206) 784-8141.

Circle 232 on Inquiry Card

TRANSFER STANDARD
Has 0.001\% accuracy without tables.


Circle 233 on Inquiry Card

VOM WITH FET CIRCUITS
Constant-impedance 10-MΩ dc input.

Battery-operated Model 310-FET measures 0.3-600 Vdc in 6 ranges; 3-600 Vac (5kΩ/V); 0-1.2 mA; resistance to 5 MΩ. Battery self-test position. Size 2.75 x 4.25 x 1.125 in., 14 oz. User Net, $70. Triplett, (419) 358-5015.

Circle 234 on Inquiry Card

The Electronic Engineer • May 1969

For Extreme Processing Temperatures to 1400°F
E-I SUPER STRENGTH CERAMIC-TO-METAL NEW! SEALS

Vacuum-tight, hermetically-sealed components offer exceptional resistance to shock, vibration and corrosion, and conform to all ASTM F-18-64 requirements.

- Superior dielectric properties
- Maximum rigidity and durability
- Withstand extreme thermal stresses
- Miniaturization and design standardization

These E-I components are specifically designed to provide maximum reliability under severe environmental conditions. For example, they withstand repeated heat cycling up to 1400°F, and thermal shock comparable to electron tube processing.

E-I alumina insulated, ceramic-to-metal seals can be economically produced from hundreds of stock designs; where special configurations are required, E-I sales engineers will make recommendations from your blueprints or sketches.

Electrical Industries
A Division of Philips Electronics and Pharmaceutical Industries Corp.
Murray Hill, N. J. 07974—Tel.: (201) 464-3200

Circle 48 on Inquiry Card 113
filter magic? 
watch envelope-delay problems disappear!

High-speed data transmission demands Reeves-Hoffman Hi-Fidelity crystal filters with advanced control of envelope delay combined with optimum selectivity!

Available at most IF frequencies
Our Hi-Fidelity crystal filters minimize envelope-delay distortion, and eliminate the need for discrete equalizers.

Describe your requirement
Reeves-Hoffman designs to your specifications. Call, TWX, or write today for delivery and price.

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**DIGITAL PANEL METERS**
Range: 100 mV-100 V, 1 µA-100 mA.

Ten versions of 3-digit DPMs all feature 100% overrange, no-blink display, BCD outputs, programmable decimal points, accuracies of 0.1% of reading ±1 digit. Operate 0° to 60°C. Series 510 are 4 in. deep. Datascan, (201) 478-2800.

Circle 235 on Inquiry Card

**MICROWAVE SYNTHESIZER**
From 1 to 12.4 GHz.

Select frequencies manually, or by 4-wire BCD +5 V to each digit. Stability, 1 x 10⁻⁸/day. Power out, 15 mW min. in each of 4 bands. Harmonics, −20 dB, other spurs, −60 dB. Uses external VCO. Model 300A. Micro-Power, (212) 726-4060.

Circle 236 on Inquiry Card

**UNIVERSAL POWER SUPPLY**
Regulated ac and dc outputs.

Both ac and dc outputs are superimposed over a 50-dB noise-level filtering. Regulation is 5 mVdc, and 0.25% ac. Outputs are 0-140 Vac, 0-8 Vdc. 500 VA. Fully metered. Model P-5505 costs $875. Wanlass Instruments, (714) 546-1811.

Circle 237 on Inquiry Card

The Electronic Engineer • May 1969
ELECTRONIC GALVANOMETER
For null-reading in dc systems.

Type E11.501 has 10 µV/div. sensitivity (250 µV f.s.) and 3 s response time. Common-mode rejection more than 140 dB at dc, 50/60 Hz. Input resistance, 9 kΩ. 5-V overload protection. Battery operated. $135. Voltron, (213) 681-2751.

Circle 238 on Inquiry Card

LOGARITHMIC RF AMPLIFIER
Spans 400 kHz to 130 MHz.

Model 6001 accepts −70 to +20 dBm inputs. Linear output is detected, accurate to ±3 dB. Expand control increases sensitivity. Offset switch for high-resolution measurements. Meter reads in dBm. Telonic, (317) 787-3231.

Circle 239 on Inquiry Card

NEW OPTION FOR DPM
Automatic peak or null retention.

In peak-retention mode, reading changes only when previous value is exceeded. In null mode, reading is changed only for lesser value. All digital circuitry. For Models 3410, 3400, or 3310. Option 09. $175. Electro-Numerics, (408) 248-5020.

Circle 240 on Inquiry Card

We'll tear your memory costs to bits.

Spec by spec. $300 a unit.

Our low cost delay line memory system challenges any other memory system. Including any you are using now, or may be considering. You name the specifications.

This Digital Devices memory system is suited for buffering limited message keyboards, installation in peripheral equipment and more complex buffering units, interfacing with communications networks, incorporation in CRT displays and similar applications.

These versatile memory systems include the recirculation and control circuitry necessary for the complete memory function. They store up to 20,000 bits at 2.5 MHz. The systems hold storage indefinitely until cleared and can be loaded and unloaded at rates compatible with communications links or peripheral equipment.

Operating environment ranges from 0° to 70°C and atmospheres to 100% humidity. The compact units measure from as small as 6" x 7" x 3" to 12" x 12" x 2".

There are five basic models available – each adaptable quickly and reliably to your exact specifications. And best of all, each delivers more for less money. Some units cost as little as $300.

Let us take on your memory requirements. Send us your specifications and we’ll give you a quote. You can even send us your present memory costs and we’ll see if we can beat them. Spec by spec. Digital Devices Division, Tyco Laboratories, Inc., 200 Michael Drive, Syosset, Long Island, New York 11791.
**PLASTIC TRANSISTORS**

Package is only $\frac{5}{8} \times \frac{1}{2} \times \frac{3}{8}$ in.

Two pairs of low cost encapsulated silicon transistors are for use in 20 and 35 W complementary audio amplifiers. The NPN MJ2801 and PNP MJE105 are 5 A transistors for use in amplifiers delivering up to 20 W. The NPN MJE2901 and PNP MJE2901 are 10 A transistors for use in amplifiers with outputs of up to 35 W. Motorola Semiconductor Products Inc. (602) 273-6900.

Circle 241 on Inquiry Card

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**GLASS FOAM**

Can be used to 1000°F.

Eccofoam LM-46A is a unicellular, low density (0.330 g/cc), low loss (0.007 at 8.6 GHz), low dielectric constant (1.54 at 8.6 GHz) glass foam that is completely impervious to moisture. Applications include radomes, transmission line windows, dielectric supports in vacuum, non-tracking insulator for HV antennas, and as waveguide dielectric. Emerson & Cuming, Inc. (617) 828-3300.

Circle 242 on Inquiry Card

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**C-BAND YIG FILTER**

Two stages.

Model C2202 operates from 4.0 to 8.0 GHz. Guaranteed performance (per 2-stage channel) includes 2.5 dB insertion loss, a 3 dB bandwidth of 30 to 50 MHz (depending on customer's requirements), > 60 dB off-resonance isolation, 1.5 dB combined pass-band-spurious and ripple, and an rf limiting level > ±18 dBm. Advanced Microwave Laboratories. (408) 245-5770.

Circle 243 on Inquiry Card
MINIATURE TRANSFORMERS
For core memory and transistor uses.

Features include miniature ferrite toroids, winding to winding ins. res. 10,000 MΩ, and low leakage. Model PT 1851 is 0.500 x 0.350 x 0.250 in. with channelled base. Model PT 1838 is 0.365 x 0.235 x 0.280 x 0.325 in. and is adaptable to PC boards where axial leads are preferred, or drop-in type leads are needed. Valor Electronics, Inc. (714) 540-9261.

Circle 244 on Inquiry Card

POWER SUPPLIES
Output ripple is only 0.5 mV RMS.

New Power-Pact series of miniature supplies features 0.01% reg. plus front-panel control and metering of output voltage and current-limiting level. Five models are available with outputs of 10, 20, 50, 100, and 150 V at 20 W. Case dimensions are 2½ in. high by 5 in. wide by 5 in. deep. Pacific Radionics. (408) 379-3280.

Circle 245 on Inquiry Card

HIGH POWER BALUNS
Efficiency is 97% or better.

This series of baluns, which includes models up to 200 kW average power, permits use of either balanced or unbalanced line between transmitter and antenna. Frequency range is 1.5 - 34 MHz with impedances of 50, 75, 200, and 600Ω and insertion VSWR of <1.2:1. The baluns are available either dry or oil filled. Electro Impulse, Inc. (201) 741-0404.

Circle 246 on Inquiry Card

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FUSEHOLDERS OF UNQUESTIONED HIGH QUALITY

SUB-MINIATURE FUSES
Ideal for space tight applications, light weight, vibration and shock resistant. For use as part of miniaturized integrated circuit, large multi-circuit electronic systems, computers, printed circuit boards, all electronic circuitry.

TRON Sub-miniature Pigtail Fuses — Body size only .145 x .300 inches. Glass tube construction permits visual inspection of element. Hermetically sealed. Twenty-three ampere sizes from 1/100 thru 15.

BUSS Sub-miniature GMW Fuse and HWA Fuseholder Fuse size only .270 x .250 inches. Fuse has window for visual inspection of element. Fuse may be used with or without holder. 1/200 to 5 amp. Fuses and holders meet Military Specifications.

Write for BUSS Form SFB

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THE COMPLETE LINE OF SMALL DIMENSION FUSES
For the protection of all types of electronic and electrical circuits and devices . . .

... includes dual-element "slow-blowing", single-element "quick-acting" and signal or visual indicating types . . . in sizes from 1/500 amp. up.

For special fuses, clips, blocks or holders, our staff of fuse engineers is at your service to help in selecting or designing the fuse or fuse mounting best suited to your requirements.

Write for BUSS Form SFB
CABLE ASSEMBLIES
For subsystem interconnection.

This new family of signal transmission line component assemblies transmit digital pulses through precisely controlled parallel wire cables. Cables are made with TFE Teflon insulation and silver-plated copper conductors. Characteristic impedance can range from 50 to 300 Ω. W. L. Gore & Associates, Inc. (302) 368-0651.

Circle 247 on Inquiry Card

DIRECTIONAL COUPLERS
For 1.0 - 12.4 GHz freq. range.

Series 234 couplers are available in five degrees of coupling from 3.0 to 20 dB, with coupling deviation across the freq. band < ±0.5 dB for the 3 dB model and < ±1 dB for all others. Directivity is 10 dB min., typically 15 dB, and VSWR is 1.30. I-Tel Inc. (301) 946-1800.

Circle 248 on Inquiry Card

MINIATURE DC RELAYS
Choice of Form A, B, C or D contacts.

The 900 Series relays offer a choice of Form A, B, C or D contact arrangements in pole sizes from one Form A through eight Form D. Six different contact types are available for loads from dry circuit to 10 A with coils from 3 Vdc to 115 Vdc. Parelco, Inc. (714) 493-4507.

Circle 249 on Inquiry Card

SNAP-ACTION SWITCH
For solid state use.

Gold "Crosspoint" contacts are used on E53 series low torque switch. The contacts deliver high force per unit area (contact pressure) and low susceptibility to contact closure interference from foreign particles (as compared with conventional ¼-in. dia. contacts). Cherry Electrical Products Corp. (312) 831-2100.

Circle 250 on Inquiry Card

BALUN TRANSFORMERS
Feature small size.

New actafiler broad-band transformers are for low impedance operation on transmission lines, balanced to unbalanced. Only 0.650 in. long, 0.500 in. wide and 0.700 in. high, they have an open circuit inductance of 350 µh, minimum, and a low leakage ind. of 0.5 µh. PCA Electronics, Inc.

Circle 251 on Inquiry Card

DE-SOLDERING TOOL
Works on compressed air.

Suction is created by way of the “Venturi” principle, in the “bit” of the tool. The result is a continual cleaning of the tool itself by the high pressure air flow. An ordinary foot pump may be used if a compressed air line is not available. Hunter Associates. (201) 672-0423.

Circle 252 on Inquiry Card

DIL EXTRACTION TOOL
Saves time and trouble.

Each of the 4-sides of this tool is a different size to accept any 14 or 16 lead DIP package. DILET-1 helps keep IC leads from becoming bent or twisted; often precludes later time and trouble of straightening in the event leads must be re-inserted. Molded from red polycarbonate. Robinson-Nugent Inc.

Circle 253 on Inquiry Card

REED SWITCH
Bounce minimized.

Blades of this magnetic reed are twisted from their normal planes. The closing and opening action is described as sliding or wiping. Bounce of the Tiny TwisterPP is about 70 µs (std. about 1 ms) and initial contact resistance, 0.100 Ω. Gordos Corp. (201) 743-6800.

Circle 254 on Inquiry Card

DPDT RELAY
Pick-up sensitivity is 200 mW.

Model 3114 Trimpot® subminiature relay is only 0.23 x 0.5 x 0.4 in. It has an oper. temp. range of -65° to +125° C, a coil resistance range of 45 to 980Ω and a contact rating of 2 A at 28 Vdc; 150,000 cycles min., with relay case grounded. Resistance tol. is ±10%. Bourns, Inc. (714) 684-1700.

Circle 255 on Inquiry Card
VOLTAGE BAND MONITORS
Protect equipment.

VB series monitors have SS voltage sensors that determine pre-selected under or over voltage conditions and de-energize an internal control relay if these limits are exceeded. The monitor can be used to sound an alarm, light warning lights, or shut down the equipment. A time delay accommodates start-up transients. Diversified Electronics, Inc. (812) 424-2288.

Circle 256 on Inquiry Card

NULL SENSING RELAYS
Replace more complex components.

Internal reed switch load contacts respond to phase reversals of input signal. These hybrid modules can often replace more complex, costly, and frequently less reliable components commonly used for transducer sensing, servo-positioning, or sensing and regulating motion displacement in process and machine control systems. Sensitak Instrument Corp. (603) 627-1432.

Circle 257 on Inquiry Card

DC POWER SUPPLIES
Regulation is 0.25%.

The E series modulator supplies combine an FET with a temp. compensated zener diode to provide a stable reference source. Models are available from 5 to 300 V with currents from 0.25 A. Short circuit protection is accomplished by a circuit that reduces the output to essentially zero within 2 µs. Universal Electronics Co. (213) 393-9219.

Circle 258 on Inquiry Card

Degrease with ease...
Spray gunk away with MS-180

MS-180 is a Freon® TF degreasing system conveniently packaged in aerosol cans. Use it in maintenance and on the line to spray grease and dirt away quickly from assemblies, components, connections. It's non-flammable and non-conductive (safe to apply while equipment is operating if you want to save even more time). MS-180 Degreaser is available in 16-oz. cans for plant use and in 6-oz. cans for field maintenance kits. Try MS-180 free. Write on company letterhead for a sample. We'll be big about it and send you the 16-oz. size.

Miller-Stephenson Chemical Co., Inc.
Route 7, Danbury, Conn.

Circle 52 on Inquiry Card
Plugs directly into your PC board!

Printact

Latching and Non-Latching MAGNETIC RELAYS

Printact Relay Division, Executone, Inc., Box 1430, Long Island City, N.Y. 11101

Circle 53 on Inquiry Card

Ammeter Insertion Jack

Designed for flush mounting behind panels up to 1/8" thick. 50 ampere rating... matching plug available.

Plugs and Receptacles

Permit full use of all power supplies at all points. Choice of Socket Receptacle and Pin Plug or Pin Receptacle and Socket Plug. Sizes up to 250 amp.

Write today for full particulars to:

STANDARD ELECTRIC TIME CORP.
# LOGAN STREET • SPRINGFIELD, MASS. 01101

Circle 54 on Inquiry Card

The Electronic Engineer • May 1969
X-BAND OSCILLATOR
RF output is 250 mW.

Model 44010H oscillator features direct dc-to-microwave conversion and has a silicon avalanche diode as the active element. It achieves an rf output of 250 mW min. from a dc supply voltage of 60-80 V at about 100 mA. Frequency range is 8.0 to 12.4 GHz. Hughes Electron Dynamics Div. Circle 262 on Inquiry Card

WIRE WOUND RESISTORS
Low TC and high stability.

The economy line series “E” precision resistors have low temperature coefficients (std = ±10 ppm/°C), high stab., and close tolerances (±1.0%, 0.5%, 0.25%, and 0.1%). Wattage rating is 60°C amb. and is derated to 0 at 105°C. RCL Electronics, Inc. (201) 763-2820. Circle 263 on Inquiry Card

POWER RESISTOR
Used for sensing and as current shunt.

This resistor dissipates high power while maintaining low resistance values at precision levels. SPR-390 has a range of from 0.001 Ω to 0.005 Ω with a temp. coeff. of ±50 ppm/°C from +25° to +125°C. Standard tol. is 1%. Special Resistor Dept., Wire-wound Div., Dale Electronics, Inc. Circle 264 on Inquiry Card

voltage and temperature measurement with...

DIGITEC

series 251 & plug-in modules

Your lab can be fully equipped, economically, using the 251 main frame and a wide variety of plug-in modules. Data acquisition capability of the 251 offers unlimited flexibility when used with Digitec system components.

MAIN FRAME: .................. $445
0.05% DVM PLUG-IN. ............... $150
±10, 100, 1000 VDC model 251
±100, 1000 VDC model 251-1

0.05% DVM PLUG-IN. ............... $250
±100, 1000 VDC model 251-3

0.01% DVM PLUG-IN. ............... $350
±1000 VDC, model 251-4

-22° to +122°F. ................... $250
Accuracy: ±0.3°F model 251-1
Thermistor Probes available

-30° to +50°C. .................... $295

0° to +100°C model 551-2
Accuracy: ±0.2°C Thermistor Probes available

-148° to +740°F. .................. $295

Accuracy: ±0.4°F model 551-3
Platinum Resistance Probes available

-100° to +600°C. .................. $295

Accuracy: ±0.4°F model 551-4
Platinum Resistance Probes available

DIGITEC by UNITED SYSTEMS CORPORATION

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Stocking Representatives Throughout the World

The Electronic Engineer • May 1969

Circle 55 on Inquiry Card 121
HOW ELSE WOULD YOU DO IT...?

Many of the leading manufacturers of power tubes (and other electronic components) rely on Tempilaq™ to determine operating-temperature characteristics of their products... recommend it to their customers as a practical and accurate means of monitoring.

Here is what some original equipment manufacturers say about Tempilaq™ in their technical literature:

- "Considering the importance of tube temperatures, every design engineer should familiarize himself with the use of Tempilaq™ or some other similar substance. Measurements of this kind yield basic information sometimes obtainable in no other way."
- "Cooling of power tubes, inductors and other components under operating conditions needed to be carefully evaluated. Tempilaq™ temperature indicators proved to be a practical method of checking the operating temperature of these critical items."
- "Your products are officially recommended in our Service Bulletin to insure proper operation of our tubes... as well as being extensively employed in our production and research facilities."
- "The maximum seal temperature of 250°C is a tube rating and is to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq™."

Tempilaq™...a simple quick-drying coating, can be applied to glass and other smooth surfaces—frequently provides the only practical means of determining temperatures of electronic tubes and other components.

- 103 certified temperature ratings, available in closely spaced intervals.
- Accuracy within one percent of the stated rating.
- Response delay of a thin coating; a few milliseconds.
- Change of appearance on melting irreversible.

Write to: ADVERTISING DIVISION
Tempilaq DIVISION OF BIG THREE INDUSTRIAL GAS & EQUIPMENT CO.
112 WEST 22nd Street, NEW YORK, N. Y. 10011
Phone: 212-675-6610 TWX: 212-640-5478

Circle 56 on Inquiry Card

Every Engineer or Draftsman should have the NEW BY-BUK CROSS REFERENCE GUIDE P-45 (supersedes By-Buk Catalog No. P-42)

to better printed circuit drafting.

This FREE 24 page booklet contains color-coded standard MIL-SPEC SIZES and design standards... plus a newly added numerical index for easy reference to over 2000 pre-cut tapes, pads, shapes, transistor tri-pads, spaced IC terminal pad sets and other drafting aids for faster, more accurate, distortion-free printed circuit master drawings.

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4326 West Pico Blvd. • Los Angeles, Calif. 90019 • (213) 397-3511

Circle 57 on Inquiry Card

EE NEW PRODUCTS

CONTROL KNOB

For control-panels.

Model #568 knob, is available with or without a 1½ in. dia. skirt. Skirt comes in spun or bright aluminum and can be lithographed, etched, or debossed. The plastic grip can be furnished clear or in colors. Westmoreland Plastics.

Circle 265 on Inquiry Card

PRECISION POTS

In servo or bushing mounts.

Conductive plastic track of these 30 pots reduces wear-effect for improved reliability. Other advantages are its greater accuracy with resulting lower noise level and smoother control. Minimum no-load oper. life of the servo type pots is 20,000,000 revolutions. Resistance is from 1000 to 50,000Ω. PIC Design Corp. (516) 593-6470.

Circle 266 on Inquiry Card

HV RECTIFIERS

Feature integral heat sinks.

Two new medium power rectifier modules (J531 and J532) dissipate 10 and 20 W respectively in free air (25°C). They may be assembled into many configurations of rated voltage and current. With a ¾ in. min. space between modules they will operate at rated current in 25°C amb. air. Solidtron Devices, Inc. (914) 359-5650.

Circle 267 on Inquiry Card
PLASTIC MOLDING MACHINE

Fully automatic.

Unisetter 4 transfer molding machine is for production and laboratory use. Small, fast, rugged, and simple to operate, it can be used for molding small precise and intricate parts from thermosetting resins. Schriever Design Co., Inc. (203) 929-5331.

Circle 268 on Inquiry Card

CHIP RESISTORS

For hybrid circuits.

CR05 thick film chip resistors are 0.050 x 0.050 x 0.012 in. Resistance range is 1 Ω to 2 MΩ, temp. coef. -55°C to 125°C ±200 ppm, and diss. 1/10 W at 125°C. The CR05 has a glass seal overcoat, while land areas are platinum-gold. They are available with tolerances of 1, 2, 5, 10 and 20%. EMC Technology, Inc. (215) 563-1340.

Circle 269 on Inquiry Card

MICROWAVE OSCILLATOR

Cavity stabilized

New wide-band mechanically tunable, fundamental freq. SS oscillator can be tuned over the 3-4 GHz freq. range with a single adjustment. Model FS-31A has a min. power output of 10 mW. Frequency stab, is > ±0.05% over the temp. range of -30°C to +70°C. Frequency Sources, Inc. (617) 774-0577.

Circle 270 on Inquiry Card

The Heath/Solartron CD-1400 is more than a portable, general-purpose, true dual-beam oscilloscope: it is a fully modular system of vertical amplifiers and time bases to fill your measuring requirements with unmatched flexibility. The 5" CRT, coated with P31 phosphor, operates at 4 kV to give you high resolution and bright displays. Viewing area of the graticule is 8 by 10 cm. Separate gun assemblies, positioned vertically to minimize geometric distortion, have separate focus and brilliance controls. Available in factory assembled and tested form only.

The CD-1400 shown above with two CX-1441 Wide-Band Amplifiers and a CX-1443 General Time Base and X Amplifier features:
- DC to 15 MHz bandwidth
- 24 ns rise time
- 9 sensitivity ranges from 100 mV/cm to 50 V/cm (10mV/cm, DC to 750 kHz with switched x10 gain)
- 18 calibrated sweep ranges from 0.5 us/cm to 200 ms/cm in a 5, 2, 1 sequence (a continuous uncalibrated coverage up to 500 ms/cm gives a 5 s sweep)
- ±5% accuracy
- x1 to x5 expansion
- Int, Ext, +, −, Normal, Auto, HF Sync Trigger Modes... all for just $774

A sensitivity of 100 uV/cm is available up to 20 kHz, increasing to 1 mV/cm up to 75 kHz by plugging in the CX-1442 High Gain Differential Amplifier.

High frequency low level signals in the presence of large in-phase signals can be displayed with the CX-1449 Wide Band Differential Amplifier featuring 10 mV/cm sensitivity on the DC-10 MHz bandwidth. Variable sweep delay to 100 ms is provided on the CX-1444 Sweep Delay Time Base. DC external trigger, DC coupled X input and Single Shot are available on the CX-1448 Wide Range Time Base which has 20 ranges from 0.5 us/cm to 1 s/cm extendable to a 25 s sweep.

The modular design of the CD-1400 system protects it against obsolescence and gives greater measurement capability customized to your needs at an unassuming price: the main frame costs only $450, plug-ins start at $91.

Heath/Solartron CD-1400 Series

Main Frame $450* Plug-Ins $91* up

For more information send for the NEW HEATH Scientific Instrumentation Catalog

Circle 58 on Inquiry Card
Delays: 2 to 180 seconds •• Actuated by a heater, they operate on A.C., D.C., or Pulsating Current ... Being hermetically sealed, they are not affected by altitude, moisture, or climate changes ...

- SPST only - normally open or normally closed •• . Compensated for ambient temperature changes from -55° to +80° C. •• . Heaters consume approximately 2 W. and may be operated continuously . . . The units are rugged, explosion-proof, long-lived, and—inexpensive!

TYPES: Standard Radio Octal, and 9-Pin Miniature .

**NEW PRODUCTS**

**STRIPLINE LAUNCHERS**
Gold plated with BeCu contacts.

“Push-on” launchers provide quick connect/disconnect to a Type N interface. They are available for strip line-widths of 0.050 to 0.200 in. with clamping plate spacing of ¼, ½ and ¾ in. Maximum VSWR for end-launchers is 1.08 dc to 11 GHz; right angle launchers is 1.15 dc to 5 GHz. Solitron/Microwave ESCA Div. (305) 287-5000.

Circle 271 on Inquiry Card

**TUNING DIODES**
For UHF control.

High Q, premium diodes, IN5461A, B, C through IN5476A, B, C operate over a 30 V range and are available with a nominal 2% capacitance tol. (“C” suffix units). There are also 5% and 10% (“B” and “A” suffixes, respectively) units available. Nominal capacitance range runs from 6.8 to 100 pF in 16 devices. Motorola Semiconductor Products Inc. (602) 273-8466.

Circle 272 on Inquiry Card

**POLYCARBONATE**
Fiberglass reinforced.

Carbasar uses a combination of long glass fibers with short fibers randomly dispersed in the same molding compound pellet. The combination provides the best benefits of both types of reinforced thermoplastic. The long fibers produce improvements in the resin’s physical properties, while the short fibers provide ease in molding and a high surface finish. Rexall Chemical Co., Fiberfill Div.

Circle 273 on Inquiry Card

**Kepco’s new CC line, six models from 0-200 mA to 0-2 amperes, with load ratings of 0-100V to 0-7V, all made in a 1/6th rack plug-in configuration.**

Special linear IC’s control the regulator (0.01% ) and isolate the dual metering circuit (no loading). The ammeter and the 10-turn current control are switched over a 10:1 range for enhanced set-and-read resolution at the low end.

Recovery is at an amazing 2 µsec per volt (except 4 µsec/V for the 2A-7V model) made possible by a special capacitorless output filter (no unwanted stored energy) that yields a modest 0.02% ripple and noise figure.

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<th>MODEL</th>
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<th>AMPS</th>
<th>PRICE</th>
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<td>CC 7–2M</td>
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<td>CC 15–1.5M</td>
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<td>CC 72–0.3M</td>
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<td>195.00</td>
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The Kepco CC current sources are FAST, ACCURATE and SMALL. Mount 1, 2, 3 or 6 of them in available housings.

For complete specifications, write Dept. T-19

Circle 60 on Inquiry Card
CORE MEMORY SYSTEM
Has a 3 µs full cycle time.

The FI-3 coincident-current ferrite core system has a capacity of 4096 words by 20 bits/word and a 1 µs access time. It is available with address register, sequential counter and memory retention. One timing and control card provides all internal time pulses. Ferroxcube Corp. (914) 246-2811.

Circle 274 on Inquiry Card

LOW NOISE DISCRIMINATOR
Long-term stability is ±0.05%.

Model 6203 discriminator is for carrier systems transmitting up to eight channels of data over Class A voice links. It has tape speed compensation. Temp. drift is only 0.005%/°C (equal to 50 ppm/°C) and linearity of 0.25%. It requires <0.5 W, or ±20 V, 10 mA/channel to operate. Develco, Inc. (415) 969-1600.

Circle 277 on Inquiry Card

RECORER LOGGER
Automatic, unattended operation.

Model 141 multipoint recorder logger connects directly to multipoint recorders, digitizes and records the data for computer entry. It makes a 4-digit record of each data point on punched paper tape in 8-level ASCII or IBM code. Logging is synchronized to the recorder. Control Equipment Corp., Needham Hts., Mass. (617) 444-7550.

Circle 278 on Inquiry Card

COMMUNICATIONS PROCESSOR
Minimizes software needs.

High-speed Sandac™ 200 programmable processor has 256 I/O terminals that can operate simultaneously with peripheral devices such as display terminals. It has up to 131,072 bytes of directly addressable core memory. It is for computerized reservation systems, message switching and other real time data applications. Sanders Associates, Inc. (603) 885-2814.

Circle 275 on Inquiry Card

TELEMETRY SYSTEM
Comes as a two- or three-freq. system.

Model 4010/4020 tone telemetry operates over any voicegrade circuit, allowing simultaneous transmission of up to 30 tone channels on a single circuit. Data control and alarm channels may be transmitted simultaneously. Vega Electronics Corp., Santa Clara, Calif. (408) 243-9777.

Circle 276 on Inquiry Card

Quality CAPACITORS

- Voltage ratings from 600 to 50,000 volts VDC
- Capacities from .05 mfd to 30 mfd
- Rectangular CP-70 style cans
- These capacitors are offered both inductive and non-inductive, and priced to reflect the difference

WRITE FOR CATALOG AND SPECIFICATIONS

CHICAGO CONDENSER CORPORATION
3255 West Armitage Avenue • Chicago, Illinois 60647 • Phone: (312) 227-7070

Circle 61 on Inquiry Card
Get this valuable data on GRC's wide range of small bobbin sizes, shapes and designs. GRC's methods give you quality and accuracy in small parts die cast zinc alloy, Nylon, Delrin and other engineering thermoplastics. Exclusive limited cavity, automatic techniques allow new designs, now production and assembly shortcuts. Write, wire, phone for samples and bulletins. Send prints for quotations.

Excessive Limited Cavity, Automatic Techniques allow new designs, now production and assembly shortcuts. Write, wire, phone for samples and bulletins. Send prints for quotations.

Get this valuable data on GRC's wide range of small bobbin sizes, shapes and design. GRC's methods give you quality and accuracy in small parts die cast zinc alloy, Nylon, Delrin and other engineering thermoplastics. Exclusive limited cavity, automatic techniques allow new designs, now production and assembly shortcuts. Write, wire, phone for samples and bulletins. Send prints for quotations.

Actual Size

New Microminiature "BITE"* Indicators

* Built-In-Test-Equipment

Now you can design a continuous monitor into electric or electronic circuits to give a visual warning of faulty performance. These indicators provide a sharply-contrasting change in color to signal a malfunction. Even if the failure is transient, the indicator continues to register the fault by means of magnetic latching until a reset signal is applied.

You can use these indicators on a system, sub-system, module, or individual circuit card level to pinpoint malfunctions quickly. They eliminate the need for special test instruments, troubleshooting time, and highly-qualified personnel. Unnecessary downtime can be virtually eliminated.

These indicators respond to a pulse width as low as 15 milliseconds, and use power only during transition from "normal" to "malfunction" state. Several variations are available; all meet the applicable requirements of MIL-E-5400H (ASG) Class 1-A Equipment. Send for information now!

Send for information now!

Modified Model 33 Teletype and acoustic data set has a range of options including paper tape I/O; automatic control of paper tape reader and/or punch; friction or sprocket feed; automatic form feed; 74 or 88 cols./line; mobile stand; separate or built-in acoustic data set providing originate only or originate/answer mode. ComData Corp. (312) 692-6107.

The HSP 3550 chain printer offers up to 192 different characters—numeric, alphanumeric and symbolic—in sets of 48, 64, 96 or 192. Four-character slugs are individually replaceable. It features dual speed, servo-controlled paper feed for maximum throughput and provides IBM compatible vertical format (12 channel). Potter Instrument Co., Inc. (516) 694-9000.

"Elroy moonlights as a songwriter ... He astounded the musical world with his originality!"
MINI-COMPUTER
Sells for $9,700.

The model H-316 computer is for scientific and control uses. It is available with over 500 software packages, field-proven on other Series 16 computers. Memory cycle time is 1.6 μs and basic memory size is 4,096 16-bit words expandable to 16,384. The H-316 comes in three versions: pedestal, table-top and rack-mountable. Honeywell Computer Control Div. (617) 879-2600.

Circle 216 on Inquiry Card

A/D INTERFACE SYSTEM
High-speed, high-resolution.

Model 380 system consists of a high level (single ended or differential) multiplexer, a sample and hold amplifier and a binary A/D converter. Its 100 kHz throughput rate applies to both random access and sequential modes of operation. Heart of the system is a Model 301 A/D converter that can digitize an analog signal to a resolution of 15 bits binary, at 250 kHz. Data West Corp. (602) 947-4295.

Circle 219 on Inquiry Card

REED RELAY SCANNER
Complete guarding permits high CMR.

The 3383/1221A high-speed computer programmed scanner can select one out of 10,000 input channels and route input data to one of ten output channels. Input storage registers for direct interface to TTL positive or negative logic levels are provided. Instrument Products, 3M Co., 300 S. Lewis Rd., Camarillo, Calif. 93010 (805) 482-1911.

Circle 217 on Inquiry Card

ELECTRONIC “CROWBAR”
Protects microwave output tubes.

Acting within 2 μs after a fault is detected, the crowbar places a low-impedance path—a triggered-spark gap or a hydrogen-thyratron—across the tube output, diverting power which might otherwise damage tube elements. Voltages to 150 kV and currents to several thousand amps can be accommodated. Cober Electronics, Inc. (203) 327-0003.

Circle 220 on Inquiry Card

PAM/PDM COMMUTATORS
Sampling rates from 1 to 100,000 Hz.

Series 300 commutators provide an accurate rate, stable IRIG or special format telemetry pulse train in all airborne, missile or satellite uses. Overall accuracy is > 0.1% and back current is virtually eliminated by using MOSFETs as switches (0.2 μA during non-sampling). Offset (5 mV max.) and scatter (1 mV max.) are low. Stellarmetrics Inc. (805) 963-3566.

Circle 218 on Inquiry Card

DATA SET
For dial-up communications.

The FM-18 data set is a low speed modem for linking peripheral units such as CRT displays to a central processor. It operates at any speed up to 1800 bps, when used as an asynchronous modem. A synchronous option is available. The FM-18 is frequency shift keyed for use in full duplex, half duplex, or simplex operations. Rixon Electronics, Inc. (301) 622-2121, Ext. 358.

Circle 221 on Inquiry Card

Trygon Power Supplies
111 Pleasant Avenue, Roosevelt, L.I., N.Y. 11575
Trygon GmbH 8 München 60, Haideleyweg 20, Germany

Circle 64 on Inquiry Card
**Reed relays**

If you specify reed relays there are several design considerations which you should be aware of. This 16-page brochure discusses these factors, which include dynamic characteristics, dry circuit operation, contact protection, shock and vibration, and relay reliability. It also contains data sheets on several series of reed relays. Self-Organizing Systems, Inc., Box 9918, Dallas, Tex. 75214.

Circle 321 on Inquiry Card

**AC instruments**

A 24-page catalog contains descriptions, specs, and application data for a line of ac instruments and power conditioners. Products include ac line conditioners, filters, line voltage regulators, closed-loop regulated power conditioners, single to three phase converters, and so forth. The 1969 catalog also gives definitions of electrical terms and discusses basic engineering concepts. Wanlass Instruments, 1540 E. Edinger Ave., Santa Ana, Calif. 92707.

Circle 322 on Inquiry Card

**Instrument reference**

A 42-page brochure covers instrument mechanisms—their principle, theory, and application. There is detailed information on electrostatic and permanent-magnet moving coil mechanisms, and notes on special or unique environmental conditions and their impact on instrument design. A reference source to help you choose between digital and analog presentation, and a series of informal sketches of instrument mechanisms, make this a handy reference. Weston Instruments Div., Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, N. J. 07114.

Circle 323 on Inquiry Card

**Electrically conductive products**

New techniques for achieving immunity from electromagnetic interference are discussed in a 14-page application guide. Conductive products described include elastomeric gaskets, adhesives, and caulking, potting, and coating compounds. These provide effective shielding and sealing in electronic enclosures, subassemblies, connectors, waveguides, and switches. Chomerics, Inc., 85 Mystic St., Arlington, Mass. 02174.

Circle 324 on Inquiry Card

**Electron-beam evaporation**

A 12-page booklet discusses the concept of electron beam evaporation for producing optical and electronic thin film devices. The basics of the technique, and the scope and benefits of its use, are outlined. Airco Temper, Div. of Air Reduction Co., Inc., 2850 Seventh St., Berkeley, Calif. 94710.

Circle 325 on Inquiry Card

**Wide-band amplifiers**

A 4-page application note on wide-band amplifiers discusses definitions of frequency for full output, gain bandwidth product, and slew rate. It lists precautions to take when you use wideband amplifiers, and gives other helpful data. Data Device Corp., 100 Tec St., Hicksville, N. Y. 11801.

Circle 326 on Inquiry Card

**Thermocouples**

This 12-page guide tells you how to install and use Chromel® — Alumel® thermocouples. It gives nine rules of good thermocouple practice and lists five check steps to take to isolate the source of trouble when you suspect you're getting erroneous readings. It also covers metallurgical factors which affect thermocouple performance. Hoskins Manufacturing Co., 4445 Lawton Ave., Detroit, Mich. 48208.

Circle 327 on Inquiry Card

**Drafting templates**

Catalog No. 75 (17 pages) contains photographs and descriptions of over a hundred drafting templates. Of special interest to EEs are the 13 electrical/electronic templates. There are also templates of instrument symbols, mathematical symbols, flow chart symbols for computer diagramming, fluidic symbols, and various mil-spec symbols. Rapidesign, Inc., Box 6039, Burbank, Calif. 91505.

Circle 328 on Inquiry Card

**Electronic devices**

A short-form catalog covers the company's product lines, which include high energy switching devices, xenon flash tubes, trigger transformers, and triggered spark gaps. The 6-pager also contains data on light instruments, photodiodes, thermoelectric products, and flash and strobe equipment. EG&G, Inc., Electronic Products Div., 160 Brookline Ave., Boston, Mass. 02215.

Circle 329 on Inquiry Card

**Electrical tapes**

You will find the latest data on a line of pressure-sensitive adhesive tapes in this new catalog. To simplify selection, the Mystik tapes are classified in five functional categories—masking, packaging, electrical, protective, and special purpose. Within each category are tapes which range from light to heavy duty, or for environmental conditions which run the gamut from standard to special to critical. Especially helpful in the 36-pager are a tape reference index and a list of government specification data. Borden Chemical Co., Mystik Tape Div., 1700 Winnetka Ave., Northfield, Ill. 60093.

Circle 330 on Inquiry Card
IC logic cards
You will find 208 pages of data on a line of integrated circuit logic cards in this handbook. Criteria for selecting logic cards and card features are discussed. Then descriptions, circuit operations, parts lists, specs, outline drawings, and prices are given for each module in the line. The handbook covers three card series—DTL, TTL, and HTL—as well as power supplies, hardware, and accessories. Datascan, Inc., 1111 Paulison Ave., Clifton, N.J. 07013.
Circle 331 on Inquiry Card

TTL logic ICs
Engineering Bulletin No. 25640 contains data on five high-speed TTL logic ICs recently added to the company’s 5400/7400 family. Operating and electrical characteristics are included in the 8-page booklet, as are schematics. Sprague Electric Co., Marshall St., North Adams, Mass. 02147.
Circle 332 on Inquiry Card

Fluidic circuits
Data Sheet FAD-IC describes fluidic integrated circuits. Basic advantages of these devices—miniaturization, quick removal and replacement, and lower cost per circuit or gate—are discussed. Corning Glass Works, Corning, N.Y. 14830.
Circle 333 on Inquiry Card

Electromagnetic counters
A 23-page brochure discusses the history of counting and the company’s facilities, and describes in detail a line of counters and accessories. Application and technical data and a coil selection chart are included. Hecon Corp., 31 Park Rd., New Shrewsbury, N.J. 07724.
Circle 334 on Inquiry Card

Circle 65 on Inquiry Card

Circle 66 on Inquiry Card
IC wire wrapping

Users and specifiers of wire-wrap devices will be interested in this 8-page folder, which describes the company’s integrated circuit wire-wrap packaging and special services. Included in the source are descriptions, illustrations, and charts on products ranging from individual IC sockets to card files, complete with power planes and card connectors. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138.

Circle 335 on Inquiry Card

Resistors and trimmers

This 1969 catalog contains data on miniature discrete resistors and trimming potentiometers for use in microcircuitry. You will find devices available with thin film, thick film, and wirewound resistive elements to cover a wide range of applications. IRC Div. of TRW Inc., 401 N. Broad St., Philadelphia, Pa. 19108.

Circle 336 on Inquiry Card

Reed relay series

An informative 24-page catalog covers over 160 reed relays. Topics include: reed relays as analog and digital devices, life and reliability characteristics, dynamic and static characteristics, and mechanical construction. Several series are detailed, including ultra-miniature, micro-miniature, miniature, standard, and mercury-wetted reed relays. Wheelock Signals, Inc., 273 Branchport Ave., Long Branch, N.Y. 07740.

Circle 337 on Inquiry Card

Drafting equipment

A 100-page catalog covers a whole line of drafting equipment for engineers and draftsmen, including drafting furniture, fixtures, accessories and supplies. Equipment for drafting, materials for engineering graphics, sensitized drafting material, tools for drafting and illustration, and training material are the five product sections of the catalog. Frederick Post, A Teledyne Co., Box 803, Chicago, Ill. 60690.

Circle 338 on Inquiry Card

Laminated plastic tubes?

We’ve got 1600 of ‘em in 3/64” to 24” I.D. round sizes alone (not to mention square, rectangular, oval…)

Synthane rolled or molded tubes are available in the widest variety of shapes, sizes and grades. Synthane is a lightweight thermoset plastic offering heat, wear, shock, chemical and moisture resistance for your application. Order from our large inventory of materials… save time and money by using our complete fabrication facilities. Write for our new tubing catalog, or contact your local Synthane representative today. Synthane Corporation 18 River Road, Oaks, Pa. 19466.

Circle 68 on Inquiry Card
Microwave components

A 28-page capabilities brochure provides data on a line of metal glaze and microwave components. Among the products described are metal glaze power film resistors and networks, hybrid thick film devices, general microwave components, coaxial components, and stripline devices. EMC Technology, Inc., 1300 Arch St., Philadelphia, Pa. 19107.

Circle 339 on Inquiry Card

Relay rundown

Catalog No. 270 lists various stock relays for custom applications. The 16-pager describes several new products. It also covers a full line of general purpose, coaxial and hermetically sealed, telephone type, dry reed, mercury-wetted, industrial power, and plug-in relays. Latching, high voltage, and pc relays are included too. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, Ill. 60630.

Circle 340 on Inquiry Card

Digital data systems

This 12-page brochure discusses a new concept in automated digital data systems. It describes a complete automated data processing system and has a spec chart of computer-controlled telemetry equipment. Also covered are high-speed central processing units, system software, and support. EMR Telemetry, Box 3040 Sarasota, Fla. 33578.

Circle 341 on Inquiry Card

PC boards

Off-the-shelf ic breadboards, custom designed pc boards, and accessories are the subject of a 24-page catalog. Products include ejectors, connectors, bus bars, card racks, and card rack cases. The catalog also has a checklist to help you prepare specs for custom boards. Douglas Electronics, Inc., 718 Marina Blvd., San Leandro, Calif. 94577.

Circle 342 on Inquiry Card

Delay measurements

How to measure group delay on a swept frequency basis is the subject of Application Note 77-4. The 8-page booklet discusses modulation frequency needed, accuracy considerations, and explains how the measurement is made. Illustrations and schematics are included. Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304.

Circle 343 on Inquiry Card

Electrical contact tape

Econ-o-Tape®, a weldable electrical contact strip, is the subject of a 32-page brochure. Complete with charts, tables, and engineering data, the publication covers contact material selection, application, and design. Technical Service Dept., Englehard Minerals & Chemicals Corp., 113 Astor St., Newark, N.J. 07114.

Circle 344 on Inquiry Card

Air trimmer capacitors

An 8-page foldout guide provides data on concentric ring air trimmer capacitors. How they are constructed, how they work, and what are their main design features are discussed. Titled "The Inside Story," the reference also compares non-rotating trimmers with conventional air trimmers on a part-by-part basis. Voltronics Corp., West St., Hanover, N.J. 07936.

Circle 345 on Inquiry Card

Industrial amplifiers

A product catalog includes data sheets on a variety of transistorized amplifiers for use in electromechanical analog computers and data conversion equipment. Some of the products are an ac op amp, dual channel booster amps, an acc amp, servo amps, a summing amp with quadrature rejection, crt deflection amps, and so forth. Melcor Electronics Corp., 1750 New Highway, Farmingdale, N.Y. 11735.

Circle 346 on Inquiry Card

The Electronic Engineer • May 1969

(UNLIKE PEOPLE, THEY DON'T KNOW WHEN TO RETIRE)

Think about that. If you buy a Blue M Oven with the POWER-O-MATIC 60 Proportioning Control now, it might still be operating the day you retire — and long after.

The POWER-O-MATIC 60 is an amazingly simple control with no moving parts, no auxiliary components to wear out or replace. There are thousands of them in service. To the best of our knowledge, every one of them is still operating . . . is still maintaining the close tolerances for which it was designed.

In performance and economy, too, the POWER-O-MATIC 60 has no equal. It offers actual repeatability of ±1% of 1% of scale — the same as costly (and complicated) potentiometer systems. Yet, POWER-O-MATIC 60 units are competitively priced with equipment with inefficient, failure-prone on-off controls.

If you're looking for an oven that will be working after the others quit, look at a Blue M POWER-O-MATIC 60. Write: Blue M Engineering Company, A Division of Blue M Electric Company, Corporate Headquarters, Blue Island, Illinois 60406.
Power transducers

A 12-page application note (No. 3) covers coaxial rf-to-dc power transducers. Operating and application data for three models are given. Their applications include remote monitoring of antenna power and commercial broadcast transmission power, protecting power-surge sensitive devices, and so forth. Narda Microwave Corp., Commercial St., Plainview, N.Y. 11803.

Circle 347 on Inquiry Card

SS motor protectors

A solid-state device which prevents motor damage caused by excessive temperature in the stator windings is the subject of an 8-page brochure. Complete operating and performance characteristics for the Statorstat motor protector are given, as are schematics and illustrations. Robertshaw Controls Co., 155 Hill St., Milford, Conn. 06460.

Circle 348 on Inquiry Card

Transistors

This 1969 Condensed Catalog covers a line of silicon and germanium small signal and power transistors.

Data for each family of transistors is grouped in separate sections, which contain typical curves, spec charts, outline drawings, and photos. The 52-pager also provides suggested applications. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404.

Circle 349 on Inquiry Card

Ceramic thermoelectrics for your critical temperature control problems

Specify CAMBION® ceramic thermoelectric components where highest performance, maximum packing density, maximum uniformity and maximum durability are prime requisites for demanding temperature control applications.

Military, space and avionics systems, baths, ovens, liquid-to-liquid and air-to-air heat exchange systems ... for all sensitive component temperature control ... CAMBION thermoelectric devices or systems can provide you extremely precise control, reliability and on-time delivery.

Designed to be used separately or incorporated in larger systems as series parallel arrays, a wide range of sizes and heat-pumping capacities may be obtained. CAMBION ceramic modules are available for immediate delivery from stock.

Get more information on these high-performance ceramic thermoelectrics for your temperature control problems. Talk to Gordon Bird at (617) 492-7082, or write to him direct in Cambridge - Cambridge Thermionic Corporation, 509 Concord Avenue, Cambridge, Massachusetts 02138.

Standardize on CAMBION®
The guaranteed electronic component assemblies

Do You Need A SLEEVING that doesn't exist?

Most flexible insulating tubing or slewing applications can be taken care of by the existing Varflex-manufactured lines. Occasionally something special comes along. Miniaturization in particular has produced a number of special needs.

However non-existent this sleeving may be today, it could be part of wired circuitry tomorrow. Varflex has cooperated with many engineers to develop specialized sleevings. We welcome the opportunity to work with you; our diversified experience will be helpful.

Send for Free Folder of Actual Test Samples.
Zeners and SCRs
An 8-page newsletter contains two separate articles, one of which describes silicon temperature compensated reference diodes (TC Zeners) and their applications. The second article examines the controversy over fast switching SCR circuits involving high inrush current. International Rectifier, 233 Kansas St., El Segundo, Calif. 90245.
Circle 350 on Inquiry Card

Inductors catalog
A 15-page booklet covers a variety of inductors, as well as coils, rf chokes, and coil forms. Descriptions of each series are given along with spec tables and outline drawings. James Millen Mfg. Co., Inc., 150 Exchange St., Malden, Mass. 02148.
Circle 355 on Inquiry Card

Ferrite devices
Catalog SF-1005 describes, in 12 pages, a line of coaxial and waveguide ferrite devices for airborne, shipboard, and ground-based radar and communication systems. Included in the 1969 Catalog are electrical and mechanical specs and outline drawings for circulators, isolators, and modulators. Microwave Associates, Burlington, Mass. 01803.
Circle 356 on Inquiry Card

Logic breadboard
The Model 401 logic laboratory, a device for breadboarding logic circuits and systems, is the subject of a 10-page catalog. The unit’s concept of movable modules permits the construction of circuits identical in form to their block diagrams. Adtech, Inc., Box 10415, Honolulu, Hawaii 96816.
Circle 353 on Inquiry Card

Miniature coaxial cable
An 8-page catalog lists features and specs of a miniature coaxial cable line. It gives illustrated tips on how to cut and trim this cable, and also describes miniature coaxial connectors (including microwave types), cable assemblies, and delay lines. Phelps Dodge Electronic Products Corp., 60 Dodge Ave., North Haven, Conn. 06473.
Circle 357 on Inquiry Card

Fasteners
Shown in an accordion-folded packet is a montage of spring steel and plastic fasteners. The pocket-size portfolio includes application ideas for various types of fasteners—both popular standards and new types. Tinnerman Products, Inc., Dept. 14, Box 6688, Cleveland, Ohio 44101.
Circle 354 on Inquiry Card

Looking for a "power house" random access switch?
You've got it with our McKee switch for harness and cable checking equipment, aircraft test systems, and engine test stands. It has: 1. High power capability. Handles up to 2 amps at 4000 volts. 2. Programmability. By every control device from tape to direct computer input. 3. Complete random access. Unique design permits signal to go in and come out at any point in the matrix.

The McKee Switch
Switching systems problems? Let our know-how in systems engineering work for you with: McKee random access matrices; crossbar switches for general purpose/high performance requirements; reed matrix switches for high frequencies; Telefunken OHS (ordinate holding) switches for low cost applications.
Free Design Data. Request new Data Sheet No. 602. Write or call Cunningham, Carriage St., Honeoye Falls, N.Y. 14472. Phone: (716) 624-2000.

Cunningham
Subsidiary of Gleason Works
Proven capability in engineered switch products and systems.
Circle 73 on Inquiry Card
New Miniature Series
Variable Air Capacitors

High capacity in a small package — exclusive round nut permits installation in tight places or miniaturized packaging. Ultra-rugged construction.

Specifications
- Small Size: .220" dia. 1 5/32" length
- Q @ 100 mc: > 5000
- Capacity Range: .4 pF — 6 pF (> 8 Turns)
- Working Voltage: 250 VDC (Test Voltage 500 VDC)
- Insulation Resistance: > 10^6 Megohms
- Temperature Coefficient: 50 ±50 ppm/° C
- Temperature Range: -65°C to +125°C

Power systems
A 40-page catalog covers chargers, inverters and converters, dc supplies, ringing and tone supplies, and power systems for the communications industry. Features, applications, and specs are given. North Electric Co., Electro-netics Div., Galion, Ohio 44833.

High-voltage rectifiers
Two 4-page brochures cover two series of Solidpak® high-voltage rectifiers. Technical data, charts, and graphs help describe these devices, which are designed for space, missile, airborne, surface, and under-sea applications. Solitron Devices, Inc., 256 Oak Tree Rd., Tappan, N.Y. 10983.

Switches and indicators
Illuminated push-button switches and matching indicator lights are the subject of Catalog L-169D. Operating data, drawings, and ordering information are provided in the 12-page brochure. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237.

Lab humidity chambers
Bulletin 686 covers Vapor-Temp® temperature/humidity chambers, portable cooling units, batch and laboratory ovens, high temperature ovens, and baths. Design, construction, and pricing information are included in the 4-page booklet. Blue M Electric Co., 138th & Chatham St., Blue Island, Ill. 60406.

DC test instrument
The 300 PVB, a dc test instrument that combines seven measurement functions in a single portable case, is the subject of a 7-page brochure. Priced at $975, this unit can serve as a potentiometric voltmeter, voltage source, ammeter, guarded Kelvin bridge, resistance comparison bridge, ratiometer, and electronic null detector. Electro Scientific Industries, Inc., 13900 N.W. Science Park Dr., Portland, Ore. 97229.

Terminal blocks
Catalog No. 369 (24 pages) covers a line of terminal blocks. Among the new products listed are electrotinned tubular connectors and continuous jumpers. Illustrations, dimensions, de-
A COMPREHENSIVE SUMMATION
Microwave Semiconductor Devices and Their Circuit Applications

visions, the text opens with Part 1 serving as a short, to-the-point summary of the key parameters of microwave devices. It divides them into two classes (with some overlap, of course) by device behavior (non-linear resistance or reactance, controllable impedance, and so forth) and by structure (pn junction, Schottky-barrier, IMPATT, Gunn, and so forth).

The five chapters of Part 2, “Semiconductor Physics,” take you step-by-step from the Schrödinger wave equation and atomic structure, through crystals, electrical conduction, and junction theory to semiconductor surfaces and ohmic contacts. Such material is often a stumbling-block for many readers. But this text reads more easily than most others.

The meat of the book—as suggested by its title—is in Part 3, “Microwave Diodes and Circuits.” Here are 388 pages of detailed discussion on varactors, pin diodes, Schottky-barrier devices, switches, limiters, and phase shifters; detector and mixer diodes and circuits; tunnel diodes; IMPATT diodes; and bulk GaAs devices. Besides explaining how all of these semiconductor devices operate, Part 3 also shows the why and wherefores of their important uses.

And lest we forget the faithful transistor, Part 4 is a two-chapter disquisition on microwave transistors that includes a detailed study of the design and construction of a 4-GHz amplifier.

Part 5, “Present Trends,” compares a number of devices with regard to noise performance, power output capabilities, and reliability. This part concludes with some estimates about future possibilities.

To sum up, you will find that this volume emphasizes basic principles. It includes a sufficient number of real-device descriptions and applications to orient both device and circuit designers, and shows the physical and technological limitations on performance. The text has a wealth of references.
Advertisers — May 1969

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The Electronic Engineer • May 1969
Op amps, like girls, are pretty much alike.

Now meet Miss Universe.

Now, we're not ones to thump the tub much. But this month we're unveiling our RM4131 fully compensated op amp, a pin-for-pin replacement for the good old 709, 101A, 107 and 741, and we felt you ought to know. It's not that the RM 4131 has anything the others don't have. It just has a potful more of everything.

Figures don't lie.
Here are all the significant figures. Read 'em and weep, you other guys. And they don't even mention things like the RM4131 only needs a 10k ohm trim pot for balancing, not a 5 meg pot like some we could name.

<table>
<thead>
<tr>
<th>Specification</th>
<th>741</th>
<th>107</th>
<th>4131</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slew rate (v/µs)</td>
<td>2k load</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Min. voltage gain (dB) @ ±3 volts</td>
<td>80</td>
<td>80</td>
<td>94</td>
</tr>
<tr>
<td>Typ. bandwidth (MHz)</td>
<td>0.8</td>
<td>0.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Max. power consumption (mW) @ ±20V, 25°C</td>
<td>120</td>
<td>120</td>
<td>64</td>
</tr>
<tr>
<td>Max. bias current (nA) @ 25°C</td>
<td>500</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>Max. offset current (nA) @ −55 to 125°C</td>
<td>500</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Max. offset voltage (mV) @ −55 to 125°C</td>
<td>6.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Take slew rate.
Compare our 2.0 v/µs typical slew rate to 0.5 v/µs for the others. And our slew rate is guaranteed 1.5 v/µs minimum across the whole ±3 to ±20-volt supply range, while the others peak sharply at ±15 volts.

And voltage gain.
Time now for a graph. Notice that the 107 shows specified gain only down to ±5 volts. At ±3 volts our RM4131 has 94 dB gain, compared to about 80 dB for the others.

Or bandwidth.
Naturally, frequency response jumps, too. At 25°C, the RM4131 is down 3 dB at 50 kHz, and hits unity gain at 4 MHz. Compare this to 8 kHz and 800 kHz respectively for 107s and 741s. Need we say more? Well, we will anyway.

How come?
Briefly stated, the RM4131 does all these neat things because of (1) that patent-pending current regulator in the gray patch above. It preserves gain at low voltages. And (2) our handy knack with small geometries, which gives frequency response a kick in the back porch. Plus (3) a winning way with latest process technologies, such as our new silicon nitride passivating layer for superb surface stabilities and high-beta transistors.

And how much.
Price for 100-999, full military version (−55°C to +125°C) is $20. Commercial versions are also available. So for evaluation quantities of our optimum op amp, see your Raytheon distributor. Or send for data from the company that's delivering the ideas in linear ICs. Raytheon Semiconductor, Mountain View, California. (415) 968-9211.
Now! High Power, High Efficiency at 225-400 MHz with New Family of RCA "overlay" Transistors

New power performance for VHF/UHF comes in RCA’s new radial lead package—in a family of “overlay” transistors. For your driver, pre-driver, and output circuit requirements, RCA offers the following developmental types:

- TA7344-16 W (min.) output at 400 MHz; 6 dB gain
- TA7367-10 W (min.) output at 400 MHz; 8 dB gain
- TA7411-2 W (min.) output at 400 MHz; 10 dB gain

These units, silicon “overlay” n-p-n transistors, are housed in a package designed for low input and output parasitic lead inductances. And low capacitances, too. The wide leads, all isolated from the stud, are uniquely “sandwiched” between ceramic layers to provide an over-all hermetic case with exceptional mechanical strength.

TA7344, TA7367, and TA7411 can be used effectively as direct replacements for plastic stripline types. All are intended for large signal, broadband linear RF power amplifiers for military and industrial equipment operating in VHF/UHF frequencies.

For more information on this expanded family of “overlay” types and other RCA “overlay” transistors, see your local RCA Representative or your RCA Distributor. For technical data on specific types, write: RCA Electronic Components, Commercial Engineering, Section No. PJ-5, Harrison, New Jersey 07029.

Circle 3 on Inquiry Card