Miniature-switch specifications sweep details under the carpet. Size, life and load capability are intricately interwoven, not simple to unravel. And installation data are seldom laid bare in catalogs. However, miniatures can be tidily tacked into place, and if handled properly, wear well a long time. Get unpadded basics on p. 66.
Swage-Bond™ ...a revolution in trimmer reliability!

... here today at no extra cost in every Trimpot® Potentiometer

Historically, pin-to-element termination problems have been one of the primary causes of trimmer failure... especially during handling and PC board process operations. Bourns exclusive Swage-Bond™ process virtually eliminates pin termination failure... truly a revolution in trimmer reliability. Furthermore, Swage-Bonding results in a marked improvement in temperature coefficient consistency.

Other trimmer manufacturers utilize a simple clip-on termination. Some solder this connection, some rely on tension pressure alone. In the Swage-Bond process, the P.C. pins are secured through the substrate, with a high-pressure compression swage on both top and bottom sides. The pressure of the swage locks the pin solidly into the element, and thoroughly bonds it to the thick-film termination material.

The seal that seals... without springback
Bourns trimmers stay sealed when others fall. We know. We've tested them all. Bourns uses a chevron-type sealing technique, that seals without O-rings... eliminating the windup and springback that frequently occurs with such seals. The result is faster and more precise adjustability... with a seal that really works.

Wrap-around wiper for better setting stability
Bourns multi-fingered, wrap-around wiper delivers more consistent, more reliable performance. The unique design significantly reduces CRV fluctuations and open circuit problems due to thermal and mechanical shock... by maintaining a constant wiper pressure on the element. Compare the ruggedness of Bourns design with the common "heat-staked" wiper designs. Compare performance. Specify Bourns.

HERE'S PROOF:
Send for a copy of our new engineering report on TRIMMER PERFORMANCE. Tell us about your application, and we'll provide qualification samples that best suit your needs.

Bourns reliability is available at ordinary prices... off-the-shelf from nearly 100 local distributor inventories... plus our largest-ever factory stock. TRIMMER PRODUCTS, TRIMPOT PRODUCTS DIVISION, BOURNS, INC., 1200 Columbia Avenue, Riverside, California 92507. Telephone 714 781-5320 — TWX 910 332-1252.

Swage-Bond™ eliminates pin termination failure, provides more reliable tempco. Microphotograph shows trimmer element magnified 20X.
The sweep signal generator world has a new leader to look up to. Model 2002 sweeps from 1 to 2500 MHz in four bands. Or it can sweep the entire range using the band stacking option. It has more flexibility than any broadband sweeper we've made, along with +13 dBm output, ±0.5 dB flatness, 0.005% marker accuracy, and ±1% display linearity. Look at the Model 2002 from any angle and you'll become a follower. Send us $2700 and you'll become an owner. Circle our reader service number for details.

WAVETEK Indiana Incorporated, P.O. Box 190, Beech Grove, Indiana 46107. Telephone (317) 783-3221, TWX 810-341-3226.

The new 2002 will sweep you off your feet.
Surprise! Wideband Transformers

SURPRISE! Wide bandwidths, 0.015-600MHz
SURPRISE! Low insertion loss, 0.5 dB
SURPRISE! Microminiature, 230\(\times\)270\(\times\)300
SURPRISE! One week delivery

DESIGNERS KIT AVAILABLE:
2 TRANSFORMERS OF EACH TYPE
T1-1, T2-1, T4-1, T9-1, T16-1
KIT # TK-1... $32.00

NO "MAKE OR BUY" DECISION HERE... it costs less to buy Mini-Circuits wideband transformers and there's no delivery delay. Impedance levels from 12.5 to 800 ohms with insertion loss typically less than 0.5 dB

<table>
<thead>
<tr>
<th>MODEL</th>
<th>T1-1</th>
<th>T2-1</th>
<th>T4-1</th>
<th>T9-1</th>
<th>T16-1</th>
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<tr>
<td>Impedance Ratio (50 Ohm prin. imp.)</td>
<td>1</td>
<td>2</td>
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<td>16</td>
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<tr>
<td>Bandwidth (MHz)</td>
<td>1 dB loss</td>
<td>2-50</td>
<td>0.05-200</td>
<td>2-100</td>
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<tr>
<td>3 dB loss</td>
<td>15.400</td>
<td>0.015-600</td>
<td>2-350</td>
<td>15.200</td>
<td>0.3-120</td>
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<td>Price ($10-49)</td>
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<td>$3.45</td>
<td>$2.95</td>
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For complete specs, performance curves and drawings, see pgs 192-193 of the 1976-77 MicroWaves Product Data Directory.

World's largest supplier of double balanced mixers
Mini-Circuits Laboratory
A Division of Scientific Components Corp

International Representatives:
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- GERMANY, AUSTRIA, SWITZERLAND Industrial Electronics GMBH, Klubersstrasse 14, 6000 Frankfurt/Main, Germany
- ISRAEL Electronics, Ltd., 69 Gordon Street, Tel-Aviv, Israel
- JAPAN Denso Kashiwa, Ltd., Eqchi Building, 8-1 1 Chome Hamamatsucho Minato-ku, Tokyo
- EASTERN CANADA B. D. Hummel, 2224 Maynard Avenue, Utica, NY 13502 (315) 736-7821
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- NORWAY Datamatik AS, Ostensjoelen 62, Oslo 6, Norway
- NORTH AMERICA Cain-White & Co., Foothill Office Center, 105 Fremont Avenue, Los Altos, CA 94022 (415) 948-6533
- SOUTHERN CALIFORNIA Crown Electronics, 11440 Collins Street, N. Hollywood, CA 91601 (213) 877-3550

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- SOUTH CAROLINA, ARIZONA Crown Electronics, 11440 Collins Street, N. Hollywood, CA 91601 (213) 877-3550

837-843 Utica Avenue, Brooklyn, NY 11203
(212) 342-2500 Int'l Telex 620156 Dom. Telex 125460

CIRCLE NUMBER 3

Electronics Design 6, March 15, 1977
Distributed microprocessors cut use of electricity in building by more than a third.

Storing energy for peak power use is a job for the new 'super' batteries now under development.

Washington Report

TECHNOLOGY

Focus on miniature switches: Small switches suffer from all the specification problems of their normal-sized brothers, and they present some extra hazards when you handle and install them.

Avoid relay-specification pitfalls. Don't depend solely on published information. The catalogs leave out too much data essential for proper design.

Revisiting the cross-field inductor: Ordinary ferrite pot cores improve this useful device, which offers high Qs in tuned circuits and other advantages.

Design EMI shielding more accurately by taking aperture effects into account. They can be appreciable, even at low rf frequencies.

Predict printed-circuit dc performance with a circuit-analysis program and a measured voltage-drop matrix. You can expect over-all accuracies around 5%.

Ideas for Design:

Circuit provides a Gaussian response with a multifunction converter and op amp. Circuit that latches/unlatches magnetic devices uses almost zero standby current. Diode-feedback comparator circuit regulates a LED's drive current. Time-interval meter reads digitally to 99.9 ms on a DVM IC.

PRODUCTS


Modules & Subassemblies: Low-noise vhf synthesizer is small and inexpensive.

Data Processing: Versatile PROM programmer takes on all memories.

Integrated Circuits

Power Sources

Discrete Semiconductors

DEPARTMENTS

Editorial: My friend

Across the Desk

Application Notes

Vendors Report

New Literature

Cover: Photo by Art Director, Bill Kelly. Switches courtesy of Alco Electronic Products, AMF/IUD Electronics, AMP, Cherry Electrical Products, Chicago Switch, C & K Components, Cutler Hammer, C-W Industries, Dialight, Digitron, EECO, Globe Union/Centralab, Grayhill, Janco, Licon, Micro Switch, RCL, Stackpole, Switchcraft, TEC.
The Microprocessor Buyer's Guide.

(From the people who brought you the Buyer's Market.)
Advanced Micro Devices, the people who made it easy for you to get into microprocessing, make it even easier with this one-page, scrupulously objective buyer's guide.

One.

The best way to make a microprocessor system is the 8080 way. It's the most popular architecture; it has the best support. The flexibility, the upgrade capabilities are better than any other microprocessor.

Two.

The best 8080A is a 9080A. Look:

Three.

Save shoe leather and heartache. We've already done the shopping. Advanced Micro Devices builds all the really important 8080 peripherals that you-know-who invented, a whole bunch that we invented, plus all the memories you'll ever need. And in our traditional heart-warming way, we add a little reliability and performance. (Everything we make is MIL-STD-883 for free.)

Four.

Don't let anyone in this business tell you what to do. You're the customer.

Now, paste this message on the inside of your purchase order book. Or, failing that, write or call Advanced Micro Devices, the Buyer's Market.
Thin-Trim ®
capacitors

Tucked in the corner of this Pulsar Watch is a miniature capacitor which is used to trim the crystal. This Thin-Trim capacitor is one of our 9410 series, has an adjustable range of 7 to 45 pf, and is .200" x .200" x .050" thick.

The Thin-Trim concept provides a variable device to replace fixed tuning techniques and cut-and-try methods of adjustment. Thin-Trim capacitors are available in a variety of lead configurations making them easy to mount.

A smaller version of the 9410 is the 9402 series with a maximum capacitance value of 25 pf. These are perfect for applications in sub-miniature circuits such as ladies' electronic wrist watches and phased array MIC's.

Johanson Manufacturing Corporation
Rockaway Valley Road
Boonton, New Jersey 07005
(201) 334-2676  TWX 710-987-8367
Two left out are now included

The Focus on Keyboards (ED No. 22, Oct. 25, 1976, p. 122) was very interesting, but left out two manufacturers:

Data Interfaces, Inc.
12 Cambridge Ave.
Burlington, MA 01803

Data Interfaces offers adapters that go between other brands of keytops and their double crosspoint switches, as well as standard keyboards.

One subject the Focus didn’t consider is separate switches and encoders for those of us that “roll our own” keyboards. More information in this area would be desirable. For instance, I have not been able to locate an encoder for use with electronic keyswitches.

William B. Rossman
Cascade Research Associates
P.O. Box 534
274 28th Ave.
Longview, WA 98632

Computer hierarchy doesn’t do it all

Your recent article on microcomputer and microprocessor applications (ED No. 22, Oct. 25, 1976, p. 66) gives an excellent overview of their use in new equipment. However, the section on the Airtrans system at the Dallas-Fort Worth Airport is misleading in that it implies that the system is totally controlled by a hierarchy of computers. In fact, the system is structured like the Washington, DC, Metro subway system mentioned earlier in the article. Airtrans also has three interfacing major subsystems:

- Automatic Vehicle Supervision (AVS) supplied by Vought, the prime contractor. This subsystem consists of the central processor and eight satellite computers. This subsystem can reduce vehicle velocities to reduce bunching, modify station dwell times, change the routes of the vehicles, and provide central control with vehicle-tracking and support-system information.


- Automatic Vehicle Protection (AVP), also by General Railway. The AVP subsystem sets and enforces safe speed limits for each vehicle as well as prevents conflicting route movements.

The AVO and AVP subsystems will continue to function and provide complete automatic operation even if the central and satellite computers are disabled.

Samuel J. Macano
Senior Design Engineer
General Railway Signal Co.
801 West Ave.
Rochester, NY 14602

You missed it—we’ve got it

Jim McDermott’s otherwise excellent article, “Focus on Adhesives and Coatings” (ED No. 23, Nov. 8, 1976, p. 40), missed an important type of EMI-combative

(continued on page 10)
Here's how Data General's microNOVA system stacks up against the competition.

**microNOVA Processor:**
- Fully packaged 9-slot microcomputer, 16K words MOS memory, 2.4-microsecond arithmetic operations, hardware stack facility, multiply/divide, DMA capability. Includes RTC, PF/AR and APL. Supports up to 32K words RAM/PROM memory.

**Dual-diskette subsystem:**
- Integral DMA controller, compact 630KB capacity.

**Cabinet:**
- 37 inches high, holds all rack mounted components.

**DASH**
- terminal printer:
  - 30 cps, 132-columns, typewriter keyboard, upper/lower case.

**Systems Software:**

$10,970

The facts speak for themselves. For $10,970, Data General's new microNOVA gives you more system, software and support than any other comparable computer. And we deliver in 60 days.

Any way you look at it, it all stacks up in your favor. For more information and our brochure, call our toll free number, 800-225-9497, or, fill out and return the coupon.

*Quantity and OEM discounts available.*


**CIRCLE NUMBER 7**

ELECTRONIC DESIGN 6, March 15, 1977
Here's how Data General's NOVA 3/D system stacks up against the competition.

Systems Software:
Multitasking real-time disc operating system, FORTRAN IV, Extended BASIC, ALGOL, SORT/MERGE, and Utilities.

NOVA 3/D Processor:
Hardware-protected dual partitions, 700-nanosecond arithmetic operations, 48K-word MOS memory with parity, RTC, and APL.

Video Display:
1920-character screen, upper/lower case characters, detached keyboard, numeric keypad, programmable function keys and character highlighting, display rotates on two axis.

Cabinet:
72-inch high, holds all rack mounted components.

DASHER
Terminal Printer:
60/30 cps; 132-columns; typewriter keyboard, upper/lower case.

Diskette Subsystem:
315KB for program/data interchange, diagnostics and software distribution; convenient, industry-standard offline storage.

Cartridge Disc Subsystem:
10 megabytes (5 fixed, 5 removable); 50ms average access time, shares controller with diskette.

$37,610
List*

The facts speak for themselves. For $37,610, Data General's new NOVA 3/D gives you more system, software and support than any comparable computer. And we deliver in 60 days.

Any way you look at it, it all stacks up in your favor. For more information and our brochure, call or fill out and return the coupon.

*Quantity and OEM discounts available.

Data General
It's smart business.

Data General, Westboro, MA 01581
Sounds like smart business. Send me more information.

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DASHER is a trademark of Data General Corporation.


CIRCLE NUMBER 6

Electronic Design 6, March 15, 1977
Alternate Timebase Display

Gives you the whole picture for $1395.*

Continuous indication of where DELAYED T.B. measurements are taken.

- Eliminate BACK-AND-FORTH SWITCHING
- Forget MIXED-SWEEP limitations

The PM 3214 is the latest addition to the Philips oscilloscope family. At 25 MHz and 2mV sensitivity, the PM 3214 incorporates all the triggering facilities found on the latest, most expensive oscilloscopes available: AC, DC, TV and an auto position that derives its trigger from the peak to peak signal input. Trigger selection from either channel, line and external sources as well as composite triggering for ASYNCHRONOUS signals. Composite triggering in A-B display derives its source from the differential signal, allowing measurement of signals riding on high AC or DC components. The 18.5 lb. portable is double insulated and even has an internal battery option. Supplied with two probes and a protective front cover, the PM 3214 is a money saving solution to many oscilloscope requirements.

If you don't need DELAYED TIMEBASE the economy priced PM 3212 has all the triggering and overall performance of the PM 3214 at only $1,155.00.*

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In Canada: 6 Leswym Road Toronto, Ontario, Canada M6A 1K2 Tel. (416) 789-7188

* U.S. Domestic Price Only

ACROSS THE DESK

(continued from page 7)

coating: one that is both conductive and ferromagnetic. Until recently, useful coatings have not been available, for several reasons. Ferromagnetic metals (iron, cobalt, and nickel) are not usually used as rf shields because they don't conduct as well as copper or silver, especially at the frequencies used. Also, ferromagnetic metals have not been used in conductive composites such as paints and plastics because they oxidize easily and their oxides are nonconductive.

We produce a line of alloy and pure metal particles that are protected against oxidation and other corrosion so that they remain conductive in paints and plastics. The bulk resistivity of these composites is adjustable, and can be optimized for a given set of conditions so that large rf losses occur in the material. These losses arise both from magnetic hysteresis and from Ohm's Law—eddy-current effects.

The applications of these materials are generally different from applications of silver or copper-containing composites. The latter are used where low-loss rf conduction is required, the former when high-loss electromagnetic absorption is the desired effect. There are some exceptions to this. For instance, pure nickel powders are not ferromagnetic above about 200 MHz; and they also can replace silver in applications where low cost is a deciding factor.

William A. Manly
Director
Product Development

The Cobaloy Co.
626 Great Southwest Pkwy.
Arlington, TX 76011

If I don't simplify it, the picture will

The circuit for starting a teletypewriter motor on receipt of the incoming data (ED No. 8, April 12, 1976, p. 122) seems unnecessarily complicated. This is an obvious application for a 555 timer connected as a retrigergable one-shot.

In the circuit shown here, receipt of data causes momentary

(continued on page 15)
Special connectors are an old family custom.

We’ve been designing and manufacturing connectors for special custom applications for a long time. In fact, that’s how we started in the business.

Over the years we’ve built up the special tooling skills and design expertise needed to produce the best connector at competitive prices.

Our in-house manufacturing capability makes for tight quality control. We can produce every part in-house—from the plastic body to the gold dot on the contact.

And we know our gold dots. We’re the people who developed the most reliable system on the market.

We’re not limited to any one design or manufacturing approach, either. We’ve made them all—bifurcated bellows, cantilever, single-beam contacts, thermoplastic or thermoset plastic.

But don’t wait until after you’ve firmed up your design to call us. Our engineers and toolmakers show you ways to save money while getting a more reliable product.

They might even be able to fill your needs with a member of our off-the-shelf connector family.

Contact GTE Sylvania, CPO, Titusville, Pa. 16354. Phone 814-589-7071.

Good connections run in our family.
THE FASTEST, MOST DEPENDABLE, MOST VERSATILE STRIP CHART RECORDER ANYWHERE.

It's the new GOULD/Brush 110 with a thermal pen unmatched in the quality of its easy-to-read blue traces.

It produces clear, crisp, dry traces at all speeds. With no smudges, no smears, no skips, no puddles.

The pen tip warms up in just milliseconds. So it can produce accurate traces even during a series of short movements. And response time is exceptional. Full-scale response time is 250 milliseconds, which enables it to record fast-changing signals more faithfully than most other strip charts.

When it comes to reliability, we back up our promise with a lifetime pen guarantee. One reason we can make such a strong guarantee is that the special ceramic pen tip is virtually wear-free. No frequent, costly pen replacements. And although other pens are sometimes damaged by excessive off-scale input signals, ours is not because we use hard-electronic limiters and soft mechanical stops.

Then take versatility. The 110 has features that let you tailor it to your exact application. For example, you can choose from ten chart speeds. A selection of plug-in signal conditioners accommodate a wide range of input signals. Charts may be pulse-driven by an external device. And an optional solid state electronic chart integrator follows positive and negative signals up to 4 times full scale on the analog channel.

We don't believe there's another strip chart recorder in the market that is as fast, dependable and versatile. But don't take our word for it. We'll be happy to give you a demonstration anytime, anywhere. Once you see it, we think you'll believe it too.

Call your nearest Gould Sales Engineer for a demonstration. Or write Gould, Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Gould Allco S.A., 57 rue St. Sauveur, 91160 Ballainvilliers, France.
Licon® non-lighted PB switches offer you the greatest possible value with good-as-gold quality and reliability at terrific prices!

Know something?
Our Licon lighted PB’s have been glowing so brightly that they’ve cast our non-lighted PB’s into undeserved shadow.
And therein lies an opportunity you may have been missing. Because, quite frankly, Licon non-lighted PB’s are a terrific deal in every way!
You’ll find that there’s one for just about every .25 to 10 Amp switching application you can dream up. Plenty of sizes to choose from, even down to our Series 78, which is possibly the smallest non-lighted PB made. Variety of key tops, lens cap colors and bezel mountings. Momentary and alternate types of action. Choice of terminal configurations in single or double pole. U.L. listed and C.S.A. approved.

Most non-lighted PB models feature Licon’s exclusive, ultra-reliable Butterfly® switching mechanism.
Best of all, though, is the pleasant surprise you get when you check Licon pricing on 1,000-piece and larger orders. Look into it. You’ll be pleased.
Contact your local Licon distributor or call or write for our Switch Catalog: Licon, 6615 West Irving Park Road, Chicago, Illinois 60634. Phone (312) 282-4040. TWX 910-221-0275.

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They're good... no matter how bad

TW MEETS MIL-S-63731. OFFERS SWITCHING VERSATILITY OF LARGER Toggles WITH ADVANTAGE OF SMALL SIZE, PANEL SEALING. IDEAL FOR APPLICATIONS LIKE ON/OFF SWITCH IN THIS MANPACK EQUIPMENT.

SERIES 1 ROUND LIGHTED PUSHBUTTONS OFFER FLUSH MOUNTING, PANEL SEALING AND VERSATILE SWITCH CIRCUITRY INCLUDING SOLID STATE. MIL SPEC QUALITY (MIL-S-22665) AT COMMERCIAL PRICES FOR CONTROL CONSOLES.

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PX KEYBOARDS. TOTALLY SEALED WHEN MOUNTED, WITH ZERO DEPTH BEHIND PANEL. PX IS A NATURAL CHOICE FOR MANPACK EQUIPMENT SWITCH MATRICES.

PANEL SEALED KS KEY SWITCHES. USE OF SPDT SNAP-ACTION SWITCHES (MIL-S-8805) AND FRONT-OF-PANEL REPLACEMENT, MAKE KS IDEAL FOR RUGGEDIZED CONTROL PANEL KEYBOARD APPLICATIONS.
interruptions in the selector-magnet current. At the first interruption, the phototransistor in the optical coupler turns off, and pin 2 of the 555 falls to ground to start the timing cycle. Each interruption also turns on Q1, which discharges the timing capacitor and prevents the circuit from timing out until 110 seconds after the last data character. Diode D1 protects the emitter junction of Q1 from excessive reverse voltage, and D2 prevents the capacitor from being charged through D1.

Supply voltage should be between 5 and 15 V. Up to 200 mA, the circuit will deliver a volt or two less than the supply voltage to the relay coil. The relay can either switch the teleprinter motor directly if its contact ratings are adequate, or control a larger relay.

Craig R. Allen
Naval Electronics Laboratory Center
Code 3400
San Diego, CA 92152

Skip interference may be considerable by '78

In reference to your "Washington Report" concerning the sunspot effect on the Citizen's Band (ED No. 17, Aug. 16, 1976, p. 45): You are in error in indicating that the interference due to skip is not as bad as feared; the report is based on the assumption that we are at the peak of the sunspot cycle.

On the contrary, we are at the bottom of sunspot cycle 20 with the beginning of sunspot cycle 21 expected to take place some time next year. Its peak is expected to occur around 1982.

Therefore, in the next two to three years, considerable skip interference will be noticed, with complete worldwide interference two to three years before and after the peak—at which time communication in the 27-MHz CB band will be next to useless.

Joseph F. Mibelli, WA4JLX
Chief Electronics Engineer
Coulter Electronics, Inc.
590 W. 20th St.
Hialeah, FL 33010
Loss of power on a computer-controlled processing system is real trouble. Get back on line fast—or risk losing an entire batch or run. EMM's reliable MICROMEMORY core memories take care of that. Just push your restart button and you're up and operating. No program reloading. No back-up batteries to worry about. We have designs for 4-bit, 8-bit and 16-bit microprocessors—even larger systems with capacities to 32K x 18. We make semiconductor memories, too. But for process control you need reliable MICROMEMORY core memory.

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(213) 644-9881
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The First Family of 4K Static RAMs

In the semiconductor business, there are more promises than products. Not at EMM SEMI.

Others promised you a family of 4K static RAMs. We delivered. In volume. Military and commercial. We've been delivering for over two years. The first 18-pin 5-volt 4K static memory components (SEMI 4801, 4804). The only 150 ns, 8080-compatible 4K static components (SEMI 4104, 4200). The only 80 ns 4K static component in production (SEMI 4200C). The only 4K static device with enough speed and power dissipation for megabyte applications. (SEMI 4402). Others talked. We delivered the First Family of 4K static RAM components.

One of them will fit your need. See your local EMM SEMI distributor or call us today.

EMM SEMI
a subsidiary of Electronic Memories & Magnetics Corporation
3883 North 26th Avenue, Phoenix, Arizona 85017
(602) 263-0202

CIRCLE NUMBER 15

ARROW ELECTRONICS: Woburn, MA; Hamden, CT; Poughkeepsie, NY; Farmingdale, NY; Saddle Brook, NJ; Moorestown, NJ; Baltimore, MD; Fort Lauderdale, FL; Dayton, OH; Cleveland, OH; New Berlin, WI; Bloomington, MN. CENTURY ELECTRONICS: Denver, CO; Albuquerque, NM; Salt Lake City, UT. SEMICOMP: Newport Beach, CA; Sunnyvale, CA. STERLING ELECTRONICS: Watertown, MA; Amboy, NJ; Metairie, LA; Dallas, TX; Houston, TX; Albuquerque, NM; Phoenix, AZ; San Diego, CA; San Carlos, CA; Seattle, WA.

Electronic Design 6, March 15, 1977
The beginning of any answer to your EMI/RFI problems is right here.

GASKETS AND GASKET MATERIALS
- Strip Gasketing...with and without environmental seal
- Sheet Gasketing...with pressure seal
- Standard Gaskets...including connector and waveguide gaskets...environmental or pressure seal optional
- Custom Gaskets...designed and factory-fabricated to customer specifications

SHIELDING AND CONDUCTIVE COMPONENTS
- Static Discharge Buttons
- Grounding Components
- Cable Shielding Tapes
- Flexible Cable-Shielding Covers
- Shielded Raceways
- Shielded Conduit Fittings

SHIELDING FRAMES AND ASSEMBLIES
- Shielded Frames...ready-to-mount...pressure or weather seal optional
- Custom-Fabricated Frame Lengths...ready for customer assembly
- Bulk Frame-Strip Gasketing
- Shielded Windows...ready to install...custom-fabricated
- Shielded Ventilating Panels
- Shielded Air Filters

CONDUCTIVE-ELASTOMER
EMI/RFI XECON® GASKETS AND COMPOUNDS*
- Composite EMI/Pressure-Seal Gasketing...7 durometer ratings...sheets, strips, custom die-cut gaskets, molded gaskets
- Armored Xecotm High-Tensile-Strength Gasketing
- Vulcanized Xecotm Pressure-Seal Gaskets
- O-Ring Gaskets for Waveguides
- Standard Connector Gaskets
- Conductive Adhesive
- Conductive Compounds...for EMI/RFI shield coating, caulking, cementing

* Xecotm gasketing compounds are homogenous conductive elastomers consisting of high-grade silicone in which are suspended microscopic silver-coated glass particles that provide the conductive path through the gasket.
We're a whole lot more than fuses.

Everybody knows Littelfuse makes fuses...and a complete line of related devices like fuseholders, fuse clips, fuse blocks, and circuit breakers.

But that's only one side of our story. We're switches, relays, and indicator lights, too.

In fact, our Littellites line includes the widest selection of cartridge lamps and lampholders, subminiature and miniature lampholders, and Snap-mount Plastic Lites you'll find anywhere. And they're available off-the-shelf from a nationwide network of Littelfuse distributors.

Switches and Relays? We make all shapes and sizes, designed to fit a variety of applications—from appliances to computers.

To find out what our products can do for yours, just give us a call or send for our Catalog No. GL-77. We can show you a whole lot more than fuses.
Amphenol® 17-Series rear-release connectors, contacts, and crimpers.

A family that works together to save together.

Cut your assembly costs with a total termination systems approach. Our 17 Series has everything you need for rear-release, input/output connections for data transmission. You get the lowest possible installed cost.

First, the connectors: 50% less costly to assemble. These rear-release connectors permit fingertip contact insertion. Without insertion tools. You can snap several of our crimp Poke-Home® contacts in place in the time normally required for a single contact inserted with a tool. So you can cut labor costs in half—at least. And no special skills or training are needed either.

Some important electrical improvements, too. Our 17 Series connectors have a shrouded rear-release insert to prevent shorting and arc-over. No potting or sleeving is required. These connectors meet EIA Standard RS-232C for data-communication input/output connectors and have an insulation resistance greater than 5000 megohms, per MIL-STD-202A, Method 302.

Second, the contacts: big savings for volume users. With our 15,000-contact capacity reels, you can save a bundle over loose contacts.

Finally, the crimpers: high-speed for lowered costs. Our new hand crimp tool makes accurate, identical crimps—time after time. And our semi-automatic crimping machine can turn out up to 2000 terminations per hour.

Get them all—connectors, reeled contacts, crimpers. And get them now. Five basic contact configurations in 17 Series connectors are now available. So is all termination equipment, backshells, and accessories. For more details, contact: Bob Ashley, Amphenol Connector Systems, Bunker Ramo Corporation, Dept. 0000, 900 Commerce Drive. Oak Brook, Illinois 60521.

The right idea at the right time.
NMOS memories--they're faster and run cooler

Power reductions as large as 80%, density boosts of 2 to 1 and speed improvements by factors of three signalled advances in NMOS memory design at last month's Solid-State Circuits Conference.

The size of a new static memory cell developed by designers at Mostek, Carrollton, TX, has been reduced so much—to just 2.75 mil²—that a 4-k RAM chip, the MK4104, can measure 136 × 184 mil. But what's even better, the power dissipation has dropped drastically to a mere 80 mW in the active state—about 20% of the power normally required by an NMOS 4-k RAM.

In Santa Clara, CA, Intel engineers have pushed NMOS to bipolar speeds in their new 4-k static RAM. Access times have been cut to 45 ns (about one-third that of other NMOS RAMs), typical, and power dissipations held to nominal MOS levels of 500 mW.

Just down the road from Intel, designers at American Microsystems are the first to apply VMOS devices to memory arrays, claims Thurman Rogers, AMI's program director of VMOS and developer of the process. A 1-k static RAM family introduced at the conference will have access times of less than 50 ns and chip sizes as small as 80 × 55 mil.

Read and write speeds in Mostek's RAM haven't been compromised to get the low power. Typical access time is 150 ns, and a full read-write cycle requires 260 ns. The small-area cell uses high-impedance load devices that are made from polysilicon by means of a simple modification of the standard silicon-gate process.

The high-impedance poly regions permit a compact layout—about twice as dense as previous NMOS static-memory cells. Also, the high-value load resistors permit data retention at low values of Vdd—as low as 2 V. And when the chip is not enabled, the RAM has a standby mode that cuts power to a scant 8 mW.

The performance of Intel's RAM is achieved by combining device scaling and substrate bias, and reducing gate-oxide thicknesses. Polysilicon gate lengths are kept under 4 microns and oxide thicknesses to well under 1000 Å. Rather than sacrifice a pin, the substrate bias is generated on the chip. Cell size for the RAM is 3.75 mil².

American Microsystems' VMOS process is used in the company's 1401, a 1-k RAM. Cell sizes have been kept to 3 mil² so that larger static arrays can soon be made available.

The VMOS arrays' performance also approaches that of bipolar arrays—access times of 28 to 45 ns are expected for 1-k chips.

By applying the same VMOS technique to ultra-violet, erasable ROMs or PROMs, arrays of up to 64 k can be easily attained, AMI claims, since cell sizes are less than 0.36 mil².

UV PROMs made with the VMOS technique can be programmed with a 15-V, 100-ms pulse instead of the 26-V pulses normally required for the NMOS versions. Moreover, the VMOS cell requires only 36% of the area needed by currently available NMOS PROM cells.

Computer-scaling the VMOS cell can reduce its area even further for both the ROM and RAM designs. For instance, the 1401 RAM's chip area has been experimentally reduced from 81 × 125 mil to 69 × 100 mil. As a result, the speed improves by 20% to an access time of 34 ns.

A second scaling application on an experimental RAM reduces the size to 80 × 55 mil and improves the speed to 28 ns. Thus, a larger array such as a 4-k RAM can easily be fabricated on a chip whose area is less than 25,000 sq. mils.

Simulated operations help oil tanker officers

In light of the recent spate of oil tanker mishaps around the world, officers of Texaco's 160-vessel tanker fleet are receiving additional, specialized training at La Guardia Airport's Marine Air Terminal in Flushing, NY. Their "trainer" is a computerized ship-handling system owned and operated by Marine Safety International.

Designed and built by Sperry Systems Management, a division of Sperry Rand Corp., the simula-
tor features a full-scale replica of a ship's bridge, including wheelhouse and chart room, and is equipped with all navigational, propulsion-control and communications equipment normally found on board.

The ship's master or conning officer operates the simulator from the wheelhouse and responds to images projected on a 12-by-60-ft curved screen. So the view from the bridge is precisely what it would be if the ship actually were being maneuvered in the geographical area being simulated.

Imagery is provided by a wide-angle optical probe, with three television cameras and a single-lens system, which "tracks" a 15-by-30-ft model board of the simulated geographical area.

As the probe tracks the board in response to helm and engine orders executed on the bridge, it transmits video signals to three closed-circuit TV projectors below the wheelhouse, which project life-size, dynamic video images onto the panoramic screen.

The actual movements of the probe are correlated by a Varian 620-100 minicomputer to correspond precisely to the hydrodynamic characteristics of the ship type being imitated.

A dynamic presentation of a real harbor—also under computer control—includes all the navigational aids, and topographical and physical features of the area, including shore building, lighthouses, piers, jetties, rocks, cliffs and islands.

**Engineers: prepare for a taxing time**

Did you know that you can deduct $2500 on your federal tax return for moving expenses, such as house-hunting trips and temporary-living expenditures?

And did you know that if you are called in for an audit and there are two IRS representatives instead of one, that one or both are Special Agents, which means that the IRS suspects something "criminal" in your return?

Detailed explanations of these and other issues, which are designated to "demystify" the inner workings of the IRS for the engineer, are set forth in "The Engineer & Federal Taxes"—a 44-page booklet sponsored by the United States Activities Board of the Institute of Electrical and Electronics Engineers.

Authored by Paul Opalack, a CPA, and Paul S. Richter, a tax and patent attorney, the booklet is primarily for engineers who wish to prepare their own returns. Priced at $3 for IEEE members and $6 for nonmembers, it can be ordered postpaid from: IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

**Now pilots will know where lightning strikes**

Severe storm turbulence, the bane of aircraft pilots everywhere, can now be avoided with a passive weather-mapping system that displays the location and range of electrical activity in thunderstorms. The new kind of mapping system, called the Ryan WX-7 stormscope, is especially helpful to single-engine aircraft—no weather radar is available for these planes.

Each stroke of lightning is displayed as a bright green dot on the face of a high-intensity CRT. During a thunderstorm, the lightning strokes gather in groups in the central area of the storm. So storm intensity can be gauged on the scope by the size of the dot clusters.

The location of the dot clusters on the scope gives the position of the storm relative to the plane. The display has ranges of 20, 50 and 100 nautical miles.

Named after its inventor, Paul A. Ryan, president of Stormscope in Columbus, OH, the WX-7 picks up energy from the lightning at various frequencies below 200 kHz. Although frequencies are present up into the MHz range, Ryan found that the lower frequencies provide better data for processing into range and bearing data.

The lightning strokes are pinpointed by a special automatic direction-finding system that can scan a full 360° very quickly.

To obtain the storm's distance from the plane—or "pseudo-distance," as Ryan calls it—the system sensitivity is calibrated so that the intensity of received signals is a prime measure of how far away lightning has struck.

The received signals are processed in a hybrid analog-digital computer—first by the analog system with proprietary techniques to enhance range information that is inherent in the signals. Then the signals are fed to the digital portion, which enhances the image and temporarily stores the dot pattern presented on the scope. Where there is a lot of storm activity, the display becomes animated because the dots automatically update themselves as new data come in.

**Zinc-chlorine batteries being readied for cars**

Two experimental zinc-chlorine batteries are being developed for vehicular use by Energy Development Associates (EDA), a joint venture of Gulf & Western Industries and Occidental Petroleum, under a contract with Energy Research and Development Administration. The 50-kWh batteries are capable of cycling either to a complete discharge or in a partial-depth-of-discharge mode.

Eventually, EDA predicts a 40-kWh battery will be able to propel a four-passenger car 150 to 200 miles on a single charge, with an average speed of 50 mph and peak speeds of 70 mph.

**News Briefs**

**Quadrupling the component density used in the 8080, Intel has developed several dual-processor chips, the 8271, 73 and 75, which will be released later this year. These circuits, a serial data link controller, a floppy disc controller and a CRT terminal controller, are only 218 X 244 mil, but contain over 22,000 transistors.**

Combining CMOS and SOS technology, Hewlett-Packard has developed a 16-bit parallel microprocessor capable of operating at a 6-MHz clock rate and consuming less than 400 mW. Although the µP will not be available as a stand-alone product, it will be used as a controller in future HP equipment.
Chances are, we already have the packaging you want. That’s the beauty of our single-chip design and packaging concept: freedom of choice. Because our ultra-low $V_{CE(SAT)}$ modules are pre-rated, pre-tested and inventoried, we can put them in any package to meet any need... help you optimize size, weight and performance without long lead times for custom packaging. Whether you need 5 or 500 pieces, we’ll welcome the opportunity to discuss your special needs. For application notes and further information, call Sales Engineering, PowerTech, Inc., 0-02 Fair Lawn Ave., Fair Lawn, N.J. 07410; (201) 791-5050.

**HIGH CURRENT TRANSISTOR PACKAGING UNLIMITED**

**TYPICAL PACKAGE SELECTIONS**

<table>
<thead>
<tr>
<th>$I_C$</th>
<th>$P_T$</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200A</td>
<td>2100W</td>
<td>PPS 1200</td>
</tr>
<tr>
<td>500A</td>
<td>625W</td>
<td>PPS 500</td>
</tr>
<tr>
<td>250A</td>
<td>325W</td>
<td>PPS 250</td>
</tr>
<tr>
<td>150A</td>
<td>325W</td>
<td>TO-114</td>
</tr>
<tr>
<td>90A</td>
<td>325W</td>
<td>TO-63</td>
</tr>
</tbody>
</table>

Copper grid distributes current most efficiently for lowest $V_{CE(sat)}$. Two choices: 570 mil diam. or 820 mil diam. void-free single chips! Eliminates copper. Hot spots. All packages are solid copper.

PowerTech, Inc.
"BIG IDEAS IN BIG POWER"
Rockwell one-chip computers give you the right fit at the right price.
Right now.
If you're designing a system or subsystem requiring as few as 10 TTL circuits, cost alone is reason enough to consider a Rockwell one-chip computer.

A wide choice of Rockwell one-chip computers is available right now. And the line-up of compatible one-chips is growing fast.

From Rockwell's PPS-4/1 family, you select the most cost-effective computer for your application.

More on-chip I/O eliminates extra interface devices.

All of Rockwell's one-chip computers offer powerful, user-oriented I/O ports that eliminate costly interface circuitry in overall systems.

I/O features, including bidirectional ports, flexibly designed drivers and receivers, and serial input/output ports, provide you with powerful system options.

Many types of displays can be driven directly. Analog-digital conversion is easy. And serial I/O ports offer a new dimension of capability by giving you simple, "no-cost" interfacing for multi-computer systems.

Rockwell flexibility assures cost-effective design.

Rockwell's one-chip computers give you design options you couldn't afford with other logic approaches.

- During the design stage you can add or reduce functions, allocate I/O differently and make dozens of other changes by simple reprogramming or by moving to another software-compatible chip within the family.

Powerful instruction sets increase efficiency.

Rockwell's instruction sets provide ROM efficiencies of typically 2 to 1 over other microcomputers. For example, some one-byte multi-function Rockwell instructions perform operations requiring five instructions in other systems.

More than 80% of Rockwell's instruction types can be executed in one byte and in a single cycle. Special ROM instructions allow many subroutine calls to be handled in one byte. Table look-up instructions for MM77 and MM78 chips provide easy look up of stored data and easy keyboard decoding with minimal programming.

The PPS 4/1 family of one-chip computers.

<table>
<thead>
<tr>
<th>Model</th>
<th>MM76</th>
<th>MM77</th>
<th>MM78</th>
<th>MM75</th>
<th>MM76C</th>
<th>MM75D</th>
<th>MM76E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Basic 76</td>
<td>Basic 77</td>
<td>Jumbo 77</td>
<td>Economy 76</td>
<td>High speed counter 12-bit A/D</td>
<td>Expand ed 76</td>
<td></td>
</tr>
<tr>
<td>ROM (x8)</td>
<td>640</td>
<td>1344</td>
<td>2048</td>
<td>640</td>
<td>640</td>
<td>640</td>
<td>1024</td>
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<tr>
<td>RAM (x4)</td>
<td>48</td>
<td>96</td>
<td>128</td>
<td>48</td>
<td>48</td>
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<td>48</td>
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<tr>
<td>Total I/O lines</td>
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<td>31</td>
<td>31</td>
<td>22</td>
<td>39</td>
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<td>31</td>
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<td>Cond. Interrupt</td>
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<td>Parallel Input</td>
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<td>8</td>
<td>4</td>
<td>8</td>
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<tr>
<td>Bidirectional Parallel</td>
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<td></td>
<td></td>
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<tr>
<td>Discrete</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>10</td>
<td>10</td>
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<tr>
<td>Serial</td>
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<tr>
<td>In-line package</td>
<td>42 pin quad</td>
<td>42 pin quad</td>
<td>42 pin dual</td>
<td>42 pin quad</td>
<td>42 pin dual</td>
<td>42 pin quad</td>
<td>42 pin quad</td>
</tr>
<tr>
<td>Availability</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
<td>2Q77</td>
<td>2Q/77</td>
<td>3Q77</td>
<td>16 wk ARO</td>
</tr>
</tbody>
</table>

Power supply is 15v except low voltage version of Basic 76 available 3Q77. Typical power dissipation is 70mA.

*Two 8-bit or one 16-bit presetable up/down counter with 8 control lines.

Rockwell design aids also help lower your system cost.

To help control development costs, Rockwell makes available a universal Assemulator that lets you assemble, edit, develop and debug programs, as well as load PROMs. Special development circuits enable prototyping.

Your Assemulator can also handle incoming inspection and factory testing. And the same Assemulator can be used to develop systems based on all Rockwell one-chip and multi-chip microprocessors.

For the full story on Rockwell one-chip computers, and how quickly they can be a part of your new product, write on your company letterhead to: Marketing Services, D/727-B, Microelectronic Device Division, Rockwell International, P.O. Box 3669, Anaheim, CA 92803, U.S.A. or phone (714) 632-3729.
To cut a building's energy use, call on 'Judy' the µP system

How do you cut a building's use of electricity by over a third and its kilowatt-hour consumption by nearly a half? Simple. You sprinkle four microprocessors around the facility to control the building's energy use, monitor its security and manage equipment operation.

Called "Judy," a system of four microprocessors distributed around a 50,000-sq-ft underground federal building in Denton, TX, has cut demand for electricity 38% and its actual kilowatt-hour consumption 49%. What's more Judy has managed to save an extra $50,000 a year by filling the void left by the elimination of the security force. The system is expected to pay back its $15,000 cost in less than a year.

Although the four National Semiconductor SC/MP processors form the nucleus that is named Judy each is actually independent of the other, with its own RAM, ROM and duties.

SC/MP 1 is responsible for managing the building's equipment. SC/MP 2 is responsible for controlling the security of the building. SC/MP 3 accepts, formats and stores all the messages that Judy sends out. And SC/MP 4 is the communication control—it dials the phone, sends out messages, answers the telephone and corrects transmission errors.

**War games conserve energy**

Judy's µP No. 1 monitors a variety of alarm points for smoke, intrusion, sump level, pneumatic pressure and fresh air. These points need only open or close switches. The microprocessor also controls the heating and cooling machinery and lighting as well. To do all this efficiently, Judy's designers, Radix II, Inc., Oxon Hill, MD, chose to implement µP 1 as a "war-gaming instrument."

Inside and outside temperature readings are applied as input to firmware "predict-or-correct" algorithms. A particular game strategy is commanded by the operator, who, in programming her, considers such parameters as the season and recent temperature trends.

Every weekday morning, all the equipment under SC/MP 1's control is cycled so as to keep the building's electrical load as low and as constant as possible. Employees begin arriving at 8:00 a.m., but SC/MP 1 starts to "bring the building up" two hours before—and very slowly so as to cause only the smallest demand increment on the power company. Just turning on the lights takes half an hour.

"In an uncontrolled building," explains Dr. G. Lamers, President of Radix II, "demand peaks constitute at least 20% to 30% of the total electric bill. The power utility must provide this level of service at all times, whether it's used or not." Over a three-month period, Judy reduced the peak-energy demand of her building by 38%.

To determine the building's current rate of electrical consumption, Judy monitors the power company's rotating-demand meter wheel. Based on that rate, the SC/MP 1 makes strategic decisions to switch equipment on or off; only the minimum pieces of equipment are activated at any given time. As a result, the building's actual kilowatt-hour consumption has been cut nearly in half.

All told, Judy's energy management has reduced the Denton Federal Building's electric bill to about one third. "After three months of operation, Judy has saved the taxpayers $5500 over the same period last year," says building manager Robert Kuykendall. "She's saving $1800 a month in energy costs alone; at this rate, she will pay for herself within a year."

Judy's SC/MP No. 2 secures the building by controlling access...
What this country needs is a good $39 DPM.

And we’ve got it. The AD2026 from Analog Devices. Priced at $39 in hundreds, it’s the first real alternative to the measurement grade analog panel meter. And the first to give you all the advantages of a DPM at a practical price. Advantages like visual appeal, accuracy, resolution, small size and reliability.

The AD2026 conserves on space, too. Its small front panel size of 3.4” x 2.0” and only 0.64” needed behind the panel makes it smaller than 3½” scale APMs. But its performance outclasses 4½” APMs.

When it comes to reliability, the AD2026 is unsurpassed. Its I²L technology combines most of the active analog and digital circuitry on one chip. The AD2026 has only 14 components and a MTBF of 250,000 hours at 25°C. In a 24-hour-a-day application, you shouldn’t expect a failure for 28 years.

A new commercial tester automatically tests all AD2026’s for defects such as bad components and solder shorts. It also fully tests both the LSI chip and the complete DPM. Following 168 hours of failure free burn-in, the units are again 100% tested.

The AD2026’s low price ($39/100s), small size, superior performance, and remarkable reliability make it the only sensible alternative to APMs. Which is just what this country needed.

Check it out. Return the coupon with your check or money order today to order an evaluation sample at the low 1-9 quantity price of $62. And when you receive your evaluation samples you will also receive a Credit Certificate for $23 redeemable when you place your order for the first hundred or more AD2026’s.

ED 3/15

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*Substantial quantity discounts available.
through as many as 256 doors, including the door to its own room. Each door is equipped with its own μP and a hexadecimal keypad.

To get into the building or any of the secured rooms within it, an individual must enter the correct prefix code, respond to a pattern of unidentified lights, enter a valid identification code and be in the correct time window. A certain number of honest mistakes is permitted, but if the door μP suspects the person outside doesn’t know what he or she is doing, it notifies the SC/MP 2, which activates an alarm.

Distributed μP system can grow to 250 μPs. Each section has its own RAM, PROM and job to do.

If the individual meets all entrance criteria, he or she is admitted, and this information is printed at a security station 50 miles away. They dial each other automatically, “talk” over regular phone lines and leave hard-copy memos to each other.

Microprocessor No. 4 is responsible for sending Judy’s messages out to George or other remote locations. Because the telephone lines used might be low-grade, Radix II combined error-reduction and correction techniques—parity bits, cyclical-redundancy-check characters and Fourier transformation of the transmitted data.

Judy, call George

Once SC/MP 4 has received a message for transmission, it goes about its assigned task relentlessly. Using a Bell 801 Automat Call unit, it repeatedly dials the receiving station until it gets connected.

The data to be transmitted are then provided with odd parity bits. A cyclical-redundancy-check character is generated and appended; finally, the message undergoes a firmware-resident Fourier transformation to desensitize it to transmission errors. This transformation converts the message from the time domain into the frequency domain, so that, for a 1024-bit message, each bit represents only 1/1024 of its actual value. Thus, Judy’s communications link is capable of tolerating a significant error rate.

If the message cannot be reconstructed by the receiving station or it is garbled, Judy requests subsequent transmissions until the message is received correctly.
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THE BASIC SWITCH

The finest engineered switch mechanism available today...automation and precision in the manufacturing processes provide superior switch quality at lower cost. Better switch!

NON ILLUMINATED SWITCHES

ILLUMINATE at low cost by installing a snap-fit lampholder and lamp in C Series and Miniature F Series (not pictured).

DIGITAST MODULAR ELECTRONIC SWITCH INPUT COMPONENT

A remarkable new modular electronic switch input component for use with dual in-line packages (DIP). The inner construction, in connection with standard TTL-IC's, eliminates more costly and troublesome conductor plate sandwiched switches. SPDT. Lends itself to economical PC board designs and assembly techniques of sophisticated electronic equipment.

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New Disc Switch...totally sealed...self-cleaning...high switching power. Provides instant positive contact. By applying pressure on the upper dome, it collapses momentarily, making instant and simultaneous contact with the lower diaphragm in at least three different points in the circular area.

SCHADOW

RIGHT...ON THE BUTTON

Mechanical reflecting indicator buttons that use no electrical energy, generate no heat...They work on the principle of reflecting ambient light through a clear plastic lens, with or without graphics.

POWER SWITCHES

The economical answer for an electronic switch input component to use with standard dual-in-line packages (DIP's), ideally designed for incorporation into a broad variety of electronic devices including advanced microprocessor controlled equipment. Series R is compatible with TTL, CMOS Logic. Redundant contacts insure required reliability. SPST, SPDT. Available modular or mounted on PCB.

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We can supply a complete line of toggles, rockers and miniature momentary push buttons. UL approved, meeting industry standard mounting specifications. PC spikes, right angle PC spikes, solder lugs. Advanced mechanical superiority and exacting precision with very competitive pricing.

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Storing energy for peak power is a job for 'super' batteries

Today, when more power is needed than a utility company's basic system can provide, intermediate-load facilities are switched on. This equipment—usually fossil-fueled, for making steam—is generally older, less efficient, and thus more costly to operate. For real peak-load demands—when both the basic and intermediate systems are close to being swamped—equipment that is older still and even more expensive to operate must be used. As a rule, this equipment is also fossil-fueled.

The solution to the peak-load problem, say members of the Electric Power Research Institute (EPRI) in Palo Alto, CA, is to store energy in large arrays of "super" batteries.

Energy can be generated at night during hours of low demand by the more economical basic power-generating equipment, then stored in the giant batteries to augment peak power demands the next day.

Eventually, super batteries may handle up to 5% of the nation's total electric energy needs and up to 17% of peak-time electricity, according to a study supported by EPRI and the Energy Research and Development Administration (ERDA). (EPRI was formed by the nation's power utilities in 1972 to carry out programs to improve the production of electric power.)

Get them together

To supply a large amount of power, super-battery modules might be clustered like cars in a parking lot. With an individual storage capacity of, say 3 kWh/ft³, it would take 3000 ft³ of these batteries to produce 100,000 kWh of power.

A unit about the size of a file drawer, which is now being developed by General Electric, will have about 10 kWh. A standard lead-acid battery of the same dimensions would be hard pressed to provide a storage capacity of 5 kWh. Several of GE's units will be put into a desk-sized module capable of storing more than 100 kWh of electricity.

"We can't say how much these batteries will save the utilities in every case," says EPRI's Dr. Fritz Kalhammer. "That depends on the cost of fuel and the efficiency of the peak-load equipment. We do know, though, that the savings would be considerable."

By the year 2000, according to utilities spokesmen throughout the country, storing energy won't be just a shrewd money saver. It will be required. The use of electricity in the United States will probably shoot up to 3.8 times the quantity used now, while the use of oil for generating this power will drop by a third. As a result, an estimated 1000-billion kWh of peak power will have to be fueled annually by alternative means such as wind and sun, both of which will have to be stored. And whatever the source, some of the energy will have to be stored to handle peak loads.

According to the Institute, facilities will be needed for storing up to 100,000 MW of energy that can be discharged, on the average, for 2000 hours a year.

The arguments for batteries

Batteries are uniquely versatile and rapid in their response to elec-

When the zinc-chlorine battery is charged, zinc is released and deposited on graphite electrodes. Released chlorine is moved to a chamber where it is cooled and stored in hydrate form. While the battery is discharging, chlorine released from a mix of chlorine hydrate and water is pumped back into the graphite-electrode compartment. The zinc is then dissolved by the chlorine to form zinc chloride in an ion exchange that releases electrical energy. A 300-kilowatt-hour battery will be tested this year with a 100-MWh battery to be built in 1980.
Engineers whose job descriptions include designing far-out hybrid circuits are invited to shop at PMI's Chip City.

We've got lots of chips for you, and will gladly sell you any quantity, large or small. Op amps. DACs. Comparators. References, including our new REF-01 (+10V) and REF-02 (+5V) chips. All triple passivated, all 100% visually inspected, all 100% electrically tested to guaranteed limits. Obviously, we can't test for temperature drift (since the chips aren't packaged), but we can assure you they will all operate over the full MIL temp range.

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Santa Clara, CA 95050
(408) 246-9222. TWX 910-338-0528.

CIRCLE NUMBER 23
nic systems' needs, says James R. Birk, EPRI's project manager for advanced-battery development. They can respond to demands within minutes and match the incremental changes in load with no penalty in efficiency. By contrast, a standby generator's efficiency is best only at one output.

The use of batteries to store power is attractive to environmentalists. Regardless of their size, batteries make little, if any, noise. They create almost no emission, and don't need extensive excavation. Moreover, neither fuel nor waste would have to be carried to and from battery sites. Even the land requirement would be relatively modest: about a half-acre for a 20 MWh battery storage installation.

The principal candidates for playing a role in tomorrow's utilities are four battery types now being developed, and one—the lead-acid battery—that's nearly a hundred years old, says EPRI's Birk. The four advanced batteries are sodium-sulfur, sodium-antimony trichloride, lithium-metal sulfide, and zinc-chlorine. While development proceeds on these, the old lead-acid battery is being redesigned to see how well it fits into a load-leveling role.

Work on all five batteries is funded in varying amounts by both EPRI and ERDA.

No battery is perfect

The lead-acid super battery is too expensive for widespread appeal to the electric utility industry, EPRI says. And by utility standards its life is limited—about 10 years. Nevertheless, the battery is rugged and reliable. By 1979, a lead-acid system will be ready for testing in the Battery Energy Storage Test (BEST) facility, which will be built by EPRI and ERDA in Hillsboro, NJ, to test all the advanced batteries now being developed for electric utilities. The lead-acid battery will be ready for commercial introduction between 1981 and 1983. At least five companies are working independently—and competitively—toward these goals.

The advanced batteries differ from the lead-acid battery in several ways:

- They operate at higher temperatures—lead-acid operates at 20 to 30 °C while the advanced batteries operate at from 50 to 450 °C.
- Their energy and depth of discharge are both greater.
- Their cell size is much smaller.
- Their active materials are cheaper.

High operating temperatures are good and bad. They're beneficial because they permit the liquid-electrolyte materials to be used instead of solid materials, which are subject to morphology changes (sometimes called sluffing of materials). In time, the active material in solid electrodes deteriorates.

Liquids, on the other hand, have no hysteresis effect; a liquid doesn't remember from one cycle to the next what happened, thus making it possible, theoretically at least, for the electrolyte material to have a very long life.

High temperatures are bad because they accelerate corrosion. The materials used become more reactive.

The four other candidates

The sodium-sulfur banner is being carried by three groups: General Electric, sponsored by EPRI, and Dow Chemical and Ford Motor, both sponsored by ERDA.

A sodium-sulfur battery, whose materials, according to EPRI, may very well cost the least of the four advanced types, operates between 300 °C and 350 °C. It uses a solid (ceramic) electrolyte of beta alumina (made of sodium, aluminum and oxygen), which separates the molten sodium and sulfur electrodes.

"Coming up with this high-quality electrolyte material has been a major step forward for the sodium-sulfur battery," Birk says. A year ago it wasn't possible to make use of more than 50% of the sodium-sulfur cell's storage capacity—"what people sometimes call 'depth of discharge'," says Birk. "Now the figure is consistently 85%.

Also, the cell life has been boosted to more than 8000 hours of continuous charge and discharge. Currently, GE's lab cells—each about 1 in. x 8 in.—can store 32 Wh. But considerable engineering design will be needed to scale the battery up to 100-kWh modules, Birk notes—each expected to employ 350 individual cells. "By 1981," he continues, "we hope to have GE install and test 50 modules in a 5-MWh system at the BEST facility."
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Meanwhile, two problems remain to be solved: Deterioration of the glass seals, which react with sodium, and the corrosiveness of sulfur, which reacts with the metal container housing the electrode. If the problems can be cleared up, a full-scale battery module will be fabricated and tested in 1978.

Instead of beta alumina, Dow Chemical uses a very thin glass capillary as a solid electrolyte, 70 microns in diameter, with a wall thickness of 10 to 15 microns. “Both beta-alumina electrolyte and the glass capillary look very promising,” Birk says.

Sodium-antimony trichloride, which is being developed by ESB, Inc., is a kind of offshoot of the sodium-sulfur battery. It’s got the same sodium electrodes and the same beta-alumina electrolyte. But instead of sulfur in the positive electrodes, it uses a mixture of sodium chloraluminate and antimonic trichloride. The idea behind choosing the materials, Birk says, is to use something that melts at a lower temperature than sulfur and thereby avoid some of the problems, like heightened corrosiveness, that accompany high temperature. The sodium-antimony trichloride battery operates at 200°C, not 300 to 350°C.

The seal is also different. Instead of glass, silicone rubber is used, which, according to Birk, is easier to work with. Furthermore, the battery type’s cell-operating potential, 2.6 V, is the highest of the four advanced types.

But there are negative tradeoffs as well. Lower temperature means the electrolytes have lower conductivity, therefore must operate at lower current densities—less milliamperes per square centimeter. So to get more current, the electrolyte area must be enlarged, which, in turn, jacks up the cost. As a result, according to Birk, the sodium-antimony trichloride battery costs more than the sodium-sulfur. The availability of antimony itself is even in doubt.

The lithium-metal (iron) sulfide battery has a long life (1000 cycles, to sodium-sulfur’s 400), but operates at a high temperature (400 to 450°C). Another minus—lithium is not only expensive but scarce.

**Lithium systems on the way**

Nevertheless, four giant organizations are developing lithium-metal systems and hope to have them tested at the BEST facility by 1981: Atomics International, Rockwell International, Argonne National Laboratory and General Motors.

Since 1972, these manufacturers have been shifting gradually from liquid-lithium and sulfur electrodes to solid lithium-silicon and iron-sulfide electrodes. This change is necessary to eliminate capacity degradation caused by electrode materials migrating or dissolving into the electrolyte.

Atomic International reached a milestone last year by operating a 150-Wh cell for nearly 1000 cycles and 10,000 hours. At has now tested a 1-kWh cell, and is building a 2.5-kWh full-scale, load-leveling cell.

Zinc-chlorine, which operates at near ambient temperature (50°C) and uses a water-based electrolyte, will probably be the first of the big four to make it to the BEST test facility, EPRI’s Birk believes.

The battery is complex, he adds, because of its flowing, water-based electrolyte, and its external storage of chlorine—aspects which may lead to a cost penalty. The system is, however, farther along in development than the others and has performed well in sizes larger than any of the advanced batteries.

Under development since the late 1960s, the zinc-chlorine battery got a shot in the arm last month when EPRI awarded a contract for more work to Energy Development Associates (EDA), a joint venture of Gulf & Western Industries Inc., and Occidental Petroleum Corp. The two companies already had spent $10-million of their own funds on the project. Under the terms of the new contract, they will invest $3.8-million more, which EPRI will match.

The goal is to design, develop and fabricate a 10-MWh zinc-chlorine system. An efficient 1-kWh battery has been tested successfully by EDA and cycled 100 times. “On a four-hour charge/four-hour discharge regime, the zinc-chlorine prototype battery demonstrated a 78% energy efficiency with no degradation in performance over the first 100 cycles,” says A. A. Guffey, executive vice president of Hooker Chemical, a subsidiary of Occidental Petroleum.

"During 1976, we scaled up in battery size and are now testing a 20-volt, 20-kilowatt-hour system. This year, we plan to build a 100-volt per 100 kilowatt-hour battery module for evaluation as the basic building block of megawatt-hour-level systems. We also will assemble three of these 100-kilowatt-hour modules in 1977 into a 300-kilowatt-hour battery to demonstrate the interfacing of the modules for test next year," Guffey notes.

“Our 1978-79 commitments call for assembling a 10-megawatt-hour system for testing during 1979 and 1980 at the BEST facility. The evaluation will be conducted at the Public Service Electric and Gas substation in Hillsboro, N.J. With success at BEST during 1979, the first 100-MWh battery array will be built in 1980,” the Gulf & Western executive predicts. ■■

**Rows of battery modules** will store electric energy generated at night during hours of low demand, and discharge it during periods of peak load.

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Electronic Design 6, March 15, 1977
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NEWS

μP-based computer system sells for under $1000

Taking advantage of a microprocessor's flexibility, speed, and low cost, ECD Corp. of Cambridge, MA, has built a general-purpose computer with a base price of $987.54. Built around MOS Technology's 6512A microprocessor, the MicroMind is designed not only for personal computing, but also for such OEM applications as environmental-chamber controls, text editing and animated sign controls.

The MicroMind package includes a keyboard, CPU, display processor and video interface, along with the necessary power supplies, system documentation, and software package. An interconnect bus system is designed for expandability and multiprocessing; up to 16 microprocessors can be connected to the bus for parallel processing.

The CPU board contains 8 kbytes of dynamic RAM and sockets for an additional 8 kbytes. Its memory capacity can be expanded by adding 32-kbyte memory-expansion boards. And even though a 16-bit-address microprocessor like the 6512A can only address 64 kbytes of memory directly, a memory-mapping option allows the MicroMind to have a total addressable memory area of 64 Mbytes.

It's in the keyboard and display processors that the MicroMind really benefits from its added flexibility. The display processor provides two point-plotting graphics formats on an external CRT, such as a video monitor or television set. The map format displays a bitmap pattern with a 128 by 160-point format. Each picture element corresponds to a bit in memory. The character-display format displays each character in a dot matrix. In this mode, a text memory holds the data to be displayed, and a font memory contains the definition of each character.

By using a RAM font memory instead of a ROM character generator, the MicroMind system can display any alphabet, character set or type face. Each character is defined by the appropriate set of dots within a 8-wide and 12-high dot matrix.

The MicroMind keyboard has 80 keys, each of which has a function defined by software. To match the flexibility of displayed characters, the key caps can be relabeled.

Additions to an improved MicroMind now being developed at ECD include an extension of BASIC high-level programming language — called notso Basic. A line printer to provide hard-copy printout from the system is also in the works.

The MicroMind package is a general-purpose computer system that includes a 6512A microprocessor, a character and graphics display processor, an input-output interface board, power supply and keyboard.
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For complete information write Malco, 12 Progress Drive, Montgomeryville, Pennsylvania 18936 or call (215) 628-9800.
Weapons costs approach $200-billion

Major increases in weapons procurement in the 1980s—such as two more Trident submarines and a doubling of F-16 fighters to 1368—have been revealed in the latest Selected Acquisition Reports (SAR) submitted to the Congress by the Pentagon. The additions, which also include more FFG-7 frigates, F-14A fighters, P-3C patrol aircraft and E-2C airborne early-warning aircraft, drive up the projected cost of the 45 largest military systems to nearly $200-billion. That's the biggest cost growth revealed in the quarterly SARs since 1970.

Scheduled to be procured in fiscal year 1984, the two additional subs will raise the number in the Trident program to 13. Each will be equipped with 24 MIRVed missiles. Four Tridents are currently under contract with General Dynamics Electric Boat Div. The missile, produced by Lockheed Missiles & Space Co., made its first two flight tests in January and February.

The Trident subs are expected to assume increasing importance as a U.S. strategic deterrent if President Carter carries out his plan to delay the B-1 bomber and M-X missile programs by a year or more.

NASA eyes electronic advances

A synthetic aperture radar (SAR) image processor, a multispectral-scanner data processor, and a family of microprocessors for future spacecraft are three of NASA's new electronic-development programs planned for fiscal 1978, the space agency has told Congress.

The SAR image processor would use digital charge-coupled devices to convert 120-Mbit/s satellite data into images in real time and, according to NASA, would reduce the cost per image from $12,000 to $280. (An analog CCD processor is being considered for the Landsat earth resources satellite.)

Space station to cost up to $3-billion

A minimum-capability space station based on present technology could go into operation by 1985 for $1-billion to $3-billion, reports NASA's two study contractors on the project, Grumman Aerospace Corp., and McDonnell Douglas Astronautics Co. Each company has a $700,000 concept-formulation contract.

A basic station capable of accommodating a crew of four or six will cost $1-billion, according to preliminary findings. Another $2-billion will be required for conducting specific missions in low earth orbit, such as
processing materials, erecting large structures in space, generating power, conducting life-sciences experiments, and advanced communications. The station will be put into orbit in modules by the reusable Space Shuttle.

**NBS finds VSWR variations in connectors**

Subminiature, Type A (SMA) coaxial connectors—the most commonly used types in military and communications microwave equipment—have excellent repeatability up to 18 GHz, but the voltage-to-standing-wave ratio (VSWR) varies drastically among connector types, according to tests conducted by the National Bureau of Standards.

Test values of VSWR, which measures impedance mismatch between cable and connector, ranged from 1.1 to 1.08 at 4 GHz and from 1.2 to 1.5 at 18 GHz. Typical insertion loss varies with frequency, and is equivalent to 1 and 2 cm of Type 141 coaxial line length at frequencies up to 12 GHz, and increases to the equivalent of 10 cm of line length at 18 GHz.

**Flying command post due in 1979**

The Air Force's first full-capability Advanced Airborne Command Post, a Boeing 747 outfitted with uhf and shf communications-satellite terminals as well as its standard communications equipment, is now expected by the summer of 1979. The first of these aircraft, dubbed the E-4B, has undergone flight tests by prime contractor Boeing and is being outfitted with the satellite terminals by E-Systems of Greenville, TX.

The tested E-4B will join the current fleet of three E-4A flying command posts, which lack the E-4B's satellite communications capability. The aircraft are intended to be used by the President and Secretary of Defense to direct military operations from the air in case of nuclear attack. Two more E-4Bs will be delivered before the companies upgrade the current E-4As to the full-capability configuration. The whole program is due to be completed in 1983 at a cost of nearly $150-million per aircraft, which makes the flying command post the most expensive aircraft in history.

President Carter last month became the first President to fly in an E-4A. President Nixon had once flown in the earlier model EC-135 flying command post.

**Capital Capsules:** Even though it isn't operational yet, the Air Force's **Cobra Dane phased-array radar** was used to track the recent Soviet missile tests in the Pacific. The system is currently being installed by Raytheon on Shemya Island in Alaska, at the western tip of the Aleutian islands and just 450 miles away from the Soviet Union. The system reportedly can also detect and track 200 objects in space simultaneously. . . . One of the Carter administration's first opportunities to spell out its future procurement plans for industry will be at the **Electronic Industries Association's annual “Doing Business with the Government” seminar in Washington March 15 to 17.** Also on the agenda is how the new A-109 procurement circular standardizing federal procedure will impact industry. . . . Despite opposition from local environmentalists, Michigan's Upper Peninsula remains the Navy's first choice for its **Seafarer ELF communications system.** The draft environmental impact statement has been completed and public hearings are planned in late March and April.
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Coils, ranging in size so small that 150 can be placed in a teaspoon to some weighing over 10 lbs. were moving off high speed production lines.

No wonder. Wabash is the country's largest maker of molded coils including epoxy, nylon, and engineered thermoplastic and thermoset material with over 20 standard epoxy formulations and hundreds more that can be adapted for specific application such as heat, cold, rain, salt and sun.

Things change quickly nowadays. But two things you can count on. Whether it's next week or next year, Edna and Gladys' chicken soup will still be the best around—and Wabash will still be the nation's leader in coil manufacturing.
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Should you use static or dynamic RAMs?
Only the system can say for sure

When designing a microprocessor memory system, the choice of a RAM is more than a simple question of dynamic versus static. "It's no use comparing dynamic and static data sheets," says Daryl Koker, memory applications manager at Mostek. "It isn't a device comparison at all—it's a system consideration."

While dynamic RAMs offer greater bit density than static RAMs—1 sq. mil per bit versus 4 to 5 sq. mils—and are cheaper, there are other more important parameters to consider before committing to one family or the other.

The cost of power now runs about $1.25/W, and dynamic memory systems use only one-third the power of static memory systems. But, as always, to avoid that cost, some complex peripheral circuitry must be added to the dynamic system.

Peripheral circuitry cost is essentially a step function—design and build it into a system just once, and it will accommodate a wide range of memory system sizes. But the cost of power increases linearly with memory size.

In a small system, designing and providing peripheral logic to support dynamic chips may be very expensive. Interfacing dynamic memories to the rest of the system can also be complex: Three separate power supplies are usually needed (+12 V_{cc}, +5 V_{cc}, -5 V_{cc}) and designing the address-scanning and clocking logic can be time-consuming.

Static memories, however, are ideal for small systems. Directly TTL-compatible, they often require just a single +5-V power supply and need only to be addressed by the central processing unit (CPU). And the design effort is quick and easy.

On the other hand, says Koker, large memory systems simply can't justify the power required by an array of static devices. Hardware is expensive, dissipated heat is adverse to reliability,

(continued on page 52)

Computer-in-a-book easily expands to complete system

Originally designed to serve as an instructional course for engineers and/or hobbyists, the Iasis ia7301 computer-in-a-book will soon be expanded into a complete microcomputer family. Additional memory and interface cards, capable of increasing capacity from 1 to 65 kwords of memory and from 2 to 256 I/O ports, are now available. Soon to be announced are cards for CRT-display driving, full keyboard interfacing and floppy-disc interfaces.

The ia7301 consists of a 250-page programming course, an 8080-based microcomputer and a hex keyboard—all in a standard three-ring looseleaf. The μC board holds a cassette-tape interface, 1 kbyte of RAM, 1 kbyte of PROM, 8 seven-segment LED displays, 3 indicators and a 25-key keypad.

Available completely assembled and tested, the ia7301 also includes a hex-conversion card and a machine-language coding pad. The computer requires +5 and +12 V, and all interfaces are made via a 28-pin edge connector. The computer-in-a-book costs $450, and delivery is 4 weeks.

Iasis, 815 W. Maude Ave., Sunnyvale, CA 94086. Charles Hornisher (408) 732-5700.

CIRCLE NO. 417
and end users are increasingly conscious of the cost of power.

Dynamic memories run cooler than statics and, since they can be packed more tightly together, save on costly board area. The large-systems manufacturer strives to get the highest possible memory size-to-package ratio and, once the peripheral circuits have been designed and built into a memory, can add address multiplexing logic to accommodate packages of ever-increasing density.

Because of lower over-all hardware cost, dynamic memories gravitate toward bulk-storage applications. And since static memory systems cost less to design, they are more efficiently used in applications requiring a minimal hardware outlay.

Traditionally, RAM manufacturers have addressed their biggest markets first—the large-system houses that buy high volumes of dynamic RAMs. Low-volume static-RAM users must wait for the higher-density memory products.

Today, 16-kbit dynamic memories, like Mostek's MK 4116, are available in production quantities. But for someone working with static parts, the maximum density currently available is only 4 kbits. However, since dynamic RAMs usually precede static-RAM development, many static and dynamic 4-kbit RAMs are currently available.

In addition to the present repertoire of clocked static RAMs and self-refreshing dynamic devices, a number of schemes will be introduced to combine the ease of static RAM system design with the power-saving aspects of dynamic RAMs, predicts a spokesman for Texas Instruments.

For example, Texas Instruments will bring out 4-k static RAMs, the TMS 4046 and 4047. These products have split internal power requirements—the actual memory array is powered independently of the decode, read, write and chip-enable circuitry. Most of the overhead power is eliminated, and the device's memory array can be kept “alive” with only a few milliwatts per package, versus hundreds of milliwatts for currently available static RAMs.

Program 6502 systems with resident assembler/editor

A resident-software-assembler program, the DATA1K, provides 6502-based systems with full assembly-language capability. The DATA1K assembler/text editor requires about 4500 words of RAM and comes on either paper tape or magnetic cassette. Available at a cost of $250, which includes a one-year update service, the DATA1K is shipped from stock. Johnson Computer, P.O. Box 523, Medina, OH 44256. Kevin Johnson (216) 725-4560.

CIRCLE NO. 418

16-channel multiplexer handles synchronous/async data

Handling up to 16 asynchronous or synchronous digital data channels—or any mixture of both types—the µP-based M1318 Multitran multiplexer lets remote job entry terminals, synchronous video-terminal controllers and interactive asynchronous terminals communicate over a single voice-grade telephone line. The M1318 may connect terminals via dial-up or dedicated modems, short-haul data sets, or direct EIA cabling.

Aided by an 8080 microprocessor, the M1318 also provides optimum multiplexing capabiliti—(continued on page 54)
Status symbols

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CIRCLE NUMBER 38
Minimize programming with \(\mu P\)-controlled laser-trim system

For the engineer who wants to maintain a dialogue with a laser trimmer without resorting to time-consuming computer programming, a \(\mu P\)-controlled system permits working programs to be stored and retrieved easily with a dual floppy-disc memory. The Model 1080 from Quantrad, El Segundo, CA, comes with software that is compatible with interactive and adaptive programming languages and is fully operational with IEEE/ASCII instrumentation interface.

Considered a low-cost approach to the high production of thick and thin-film resistor trimming, the system combines a krypton-pumped Q-switch YAG laser with closed-loop galvanometer beam-positioning at a basic price of $85,000.

The \(\mu P\) in control is the 8080—chosen, Quantrad's chief scientist says, because it was the only multiple-source \(\mu P\) around when the system was being designed, and because of the \(\mu P\)'s wealth of available software.

For active or functional trimming, the Model 1080 is capable of full computer control and instrumentation interface. Critical operational parameters of the laser are displayed on the monitor in real time, such as laser-pump current, laser power and, as safety measures, the flow rate of the cooling water and the temperature of the water.
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For complete technical data, write for Engineering Bulletin 3534 to:

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CIRCLE NUMBER 39
ELECTRONIC DESIGN 6, March 15, 1977

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sockets on the processor board, permits UV PROMs to be used instead of fusible-link
PROMs.

Both three-slot and six-slot motherboards are available for system development. However,
the six-slot board, the QMS 00-1501, contains data and address displays as well as
many control switches. The three-slot board, the QMS 00-1510, is a bare-bones system with
no display and just three control switches. All boards except the EPROM board use
100-pin edge connectors.

Due to international currency fluctuations, prices cannot be printed. But inquiries will
be answered. The company is also inviting U.S. distributors to inquire into handling the
equipment line.

Quarndon Electronics, Slack Lane, Derby DE3 3ED, England. Telephone 32651. Telex 37163.

CIRCLE NO. 421

Support circuits added to 8080 repertoire simplify system design

An expanded line of interface and support circuits for the 8080A microprocessor plus two additional versions
of the 8080A µP have been introduced by National Semiconductor. The INS8080A-1 and INS8080-2 offer 1.3
and 1.5-µs cycle times.

The interface devices include an 8-bit I/O port (DP8212), a clock generator and driver (DP8224), and
a single-chip system controller (DP8228) and bus driver (DP8238), all built with Schottky bipolar technology.
Two other interface circuits, an interface latch element (DP8301) manufactured by silicon-gate CMOS process
and an 8-bit bidirectional bus transceiver (DP8304) fabricated by low-power Schottky process, are also
available from the company.

Three I/O buffer drivers will soon be ready for both 8080A and general µP applications.
The DP8216 and DP8226 are 4-bit parallel transceivers and the DP8304 is an 8-bit
bidirectional bus transceiver. The DP8304 will provide high, active outputs to both
ports, as well as sink 50 mA on the bus port and 5 mA into low-power Schottky loads.
Prices for the circuits start at $2.90 (in 100-unit lots) for the 8212, and delivery is from
stock to 60 days.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. Chuck
Troiani (408) 737-5873.

CIRCLE NO. 422

Micro Capsules

Cutting corners for high-volume users of its 1802, RCA in Somerville, NJ, has trimmed
down the 40-pin µP so it can fit into a 28-pin DIP. Tentatively called the 1803, the new
unit will lose some flag lines, an N line, the DMA interface and some other features, but
otherwise be compatible with the 1802. . . . A complete microcomputer on a chip is being
readied for introduction in late April by Signetics, Sunnyvale, CA. The chip will contain
2 kbytes of mask-programmable memory, have 31 I/O lines and be program-compatible with
the company's 2650 µP. . . . An 8085-based microcomputer kit, under development by Intel,
Santa Clara, CA, will be patterned after the company's successful SDK-80 and should be
available by mid-year. . . . Look for a complete Basic interpreter to come from Motorola,
Phoenix, AZ, in the next month. The interpreter is expected to require 8 kwords and cost
under $300.
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Check your authorized TRW/UTC local distributor for immediate off-the-shelf delivery or contact TRW/UTC Transformers, an Operation of TRW Electronic Components, 150 Varick Street, New York, N.Y. 10013. Area Code: 212 255-3500.

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Always smiling, always ready with a kind word or enthusiastic praise, Jack is the kind of guy anybody would treasure as a friend.

Charlie is different. Sometimes I can't stand him. If I make a mistake, especially one that might be important, Charlie's always ready to tell me where I went wrong—and why. Yes, I know he does it gently and with understanding, but he frequently makes me feel I'm not as smart as I really am. Sometimes, in fact, he blows away the clever reasons I use to justify some of my actions that he thinks are stupid. When, for example, I explained away a nutty action on the grounds that nobody had informed me of company policy on the matter, he gently informed me that ignorance of company policy is not a particularly fine excuse for stupidity. As if I didn't know.

You can well imagine what Charlie said when I explained one of my actions on the grounds of tradition (it was what was usually done in such cases). And he just laughed in my face when I told him I did something because that's what our competitors did. After all, we're living in a hard business world, and we're forced to be a bit clever because our competitors are a bit dishonest—or they would be if we gave them half a chance.

While Jack always lets me know how brilliantly I do things, Charlie frequently lets me know how I could do things better. And that's often painful. I admit that, in some ways, I am a better human being, and I'm certainly better in my profession, as a result of Charlie's chiding. But heck, friends are supposed to make you feel good. Aren't they?

GEORGE ROSTKY
Editor-in-Chief
SPECIAL REPORT: MICROPROCESSOR PERIPHERAL CHIPS

With all the recent editorial attention given to microprocessor chips, memories and central processing units, readers have asked that “equal time” be devoted to devices that make a system work . . . to interfacing. Our May 10 report will cover the new breed of complex LSI circuits that are designed to support microprocessors (some of which are becoming more complex than the microprocessor itself). Among the circuits covered will be floppy disc controllers, UARTs, specialized interface circuits, programmable timers and mixed ROM and RAM input-output circuits.

ALSO IN THE MAY 10 ISSUE — ANOTHER INSTALLMENT IN OUR MICROPROCESSOR BASICS SERIES:
SOFTWARE FOR MICROPROCESSORS

One of the most important subjects to appear in Electronic Design — and one of the most popular — will continue in the May 10 issue. “Software for Microprocessors” is gutsy, important, how-to information. The series assumes no prior knowledge, works systematically with building blocks to give hardware designers fluency in low level machine or assembly language. Software is a vital part of any computer. For a specific application, instructions and hardware/software tradeoffs may determine the microprocessor selection. Don’t miss this installment. (The series began in Electronic Design’s January 4 issue.)

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SEE OUR COMPLETE CATALOG IN EEM: PAGES 317 TO 335, AND GOLD BOOK PAGES 103 TO 121; OR contact us directly.
Small switches can give you big headaches. Along with the problems encountered when specifying and applying standard-sized switches, miniatures present extra difficulties, particularly during installation. Moreover, the smaller they become, the more they cost. Clearly then, you should specify the largest "miniature" switch the available space can accommodate.

But what's a miniature switch? The definition changes continuously. As the average size of electronic components shrinks, the definition of the word "miniature" changes. Today, double-pole toggle switches with about 1/2-in.-cube bodies, usually with 1/4-in.-diameter bushings, are popularly called miniatures, say experts at Alco. These same switches were called subminiatures, or even ultraminatures, five or ten years ago. For example, toggle switches like Alco's TT Series with approximately 3/8-in.-cube bodies, although called subminiatures today, may well be the miniatures of tomorrow.

Speaking for European manufacturers, Carl Evington, Product Manager of A. B. Electronic Components Ltd. (Wales, U. K.) defines today's miniature as any switch that occupies a panel area of about 30-mm (1-3/16-in.) diameter. In Evington's view, a subminiature switch occupies about 20-mm diameter; a microminiature (ultrамиnature?) 10 mm or less. All of these dimensions include projecting solder clips. There are no hard and fast rules, however, for these categories, and the labels are applied loosely.

Biggest problem is installation

But whether the units are miniature, subminiature or microminiature, the biggest problem stems from improper installation. Seldom are miniature switches hermetically sealed; consequently, immersing or spraying degreasing solvents often carries contaminants into the switch and onto the contact surfaces. Excessive heat applied to the switch terminals often causes the terminals to expand and crack the seals, so more paths are created for the entry of contaminants. In particular, soldering flux enters the switch via wicking action. Neither molded-in terminals nor epoxy seals can provide protection when terminals are overheated.

Flux and other contaminants that end up on the contacts can cause a permanently open circuit, or worse, an intermittent condition. Once contaminants enter the switch, the damage is generally irreversible. But catalogs seldom warn of these dangers or how to cope with them. Miniature switches designed to mount on panels or other places where they are hand-soldered into the circuit should be handled according to the following rules:

- Don't immerse or spray to preclean. Switches should be ready for soldering as received from the manufacturer.
- Use a small iron—25 to 40 W.
- Use small-diameter solder and a minimum of flux.
- Apply the iron for no more than 2 s.
- Don't solder with the terminals upright.

Observe those rules, and no after-cleaning should be needed.

Ideally, when a miniature switch must mount onto a PC board, the designer should be able to handle the switch as he would any other component. But he can't with far too many switches—even when the switches are adapted with PC-mounting terminals and tabs. Usually, the adaptation doesn't go far enough.

Morris Grossman
Associate Editor

ELECTRONIC DESIGN 6, March 15, 1977
Many switches originally designed for hand soldering to the terminals, one at a time, can't take the heat when all the terminals are wave-soldered simultaneously. The switch can't take the heat even when the temperature at each terminal is correct. Not only can internal heat build-up break terminal seals, but it also can distort, relax spring tension, misalign contacts and cause many other problems.

Switches adapted but not specifically designed for PC mounting tend to retain contaminants that enter the switch's housing during normal PC cleaning processes. They can't be cleaned with all the other components. Although such switches can be temporarily sealed for wave-soldering and board cleaning, this extra preparation is costly. And hand-soldering the switch on a completed PC board is also expensive and time-consuming.

Such problems are neatly solved with a two-piece design in Chicago Switch's Mr. Clean miniatures, intended for wave-soldering applications. Only the lower-base half of the switch is wave-soldered to the PC board; the unit's over-center, snap-action mechanism is not attached. After a thorough cleaning process, with the contacts completely accessible, the upper half of the switch is snapped by hand to the base.

Other manufacturers, such as Cutler-Hammer's Control Switch Division, make it easy to clean contacts by designing their PC-mountable switches with an "open" construction that allows the cleaning fluid to flow easily into and out of the switch structure and to remove contaminants.

Keep your options open

After you have considered the special difficulties in installing miniature switches and examined the available switch designs that may help with these problems, you still have three selection criteria to fulfill—size, electrical rating and life. Leave those to the last and you may find that you have locked yourself in.

If you need a 24-position switch that can carry

Miniature versions of toggle switches abound. Some come with PC-type terminals—both straight and angled—and others come with conventional terminals for hand soldering. Bat handles, short and long handles, and many unconventional custom-handle styles can be obtained. Among the manufacturers who supply miniature toggles are (from top left, counterclockwise) Alco, American Switch, Micro-Switch and Chicago Switch.
Small rotary switches adapted for PC mounting (Standard Grigsby—top left) and enclosed and ganged rotaries (McGraw-Edison, S Series—top center), subminiature rotaries (Chicago Switch, TO-5—left center), tiny thumb or screwdriver-actuated rotaries with BCD coding (AMP 642-1 Series—top right) and miniaturized thumbwheel types (C&K Components—bottom right) are only a fraction of the large variety of miniature rotary switches available. The sizes, shapes and styles of miniature rotaries are many and continually being added to. But the problems of specifying, selecting and installing them are generally the same no matter what the type is.

3 A reliably for 100,000 cycles and must fit into a small space (say, 1/2 x 1/2 x 1/4 in.) you have a tough problem to solve. At this late point you can’t go to a manufacturer’s catalog and pick a switch with optimum specifications. Trade-offs among size, electrical rating and life must be made—the earlier the switch is selected, the wiser the options.

To make effective trade-offs, however, you need more information than you can find in most catalogs. Right off, you should realize that space limitation and the inability to anticipate all possible combinations of uses force the manufacturer to list only the most obvious conditions, and then often in a nominal or “coded” form. This lack of details often can lead to misapplications.

For simplicity, a manufacturer may give a certain miniature switch a 2-A rating. It’s true that the switch can carry 2 A safely, but switch only 100 mA at 12 V ac—and then only if the temperature is no higher than 40 C. These important details may not be listed or may be buried in footnotes and tables. The life of the switch may be listed as 100,000 cycles, but this value may be the mechanical life without an electrical load—another fact sometimes left out or mentioned only in a footnote.

However, a more conscientious manufacturer may list this switch’s life as 25,000 cycles when switching 100 mA, because thereafter the contact resistance exceeds, say, 0.15 mΩ. But what if your circuit can tolerate 1 Ω? A telephone call to the manufacturer might inform you that a 1-Ω end-of-life will raise the effective switch life to 50,000 cycles—just what you need. But you don’t know any of this without that telephone call.

On the other hand, the same switch can carry 250 mA at 12 V ac if the end-of-life criterion is 1 Ω and the life is derated to 10,000. Maybe you’re willing to trade life for higher switching current. But to do so, you need information.

Catalog ratings can be misleading

The load and life ratings shown in many catalogs usually don’t apply to most applications. The interplay of environment, duty cycle, failure criteria, actual load and contact material is com-
Pushbutton, rocker and paddle switches—some lighted—and low-cost versions for home appliances, also have followed the path to "miniaturization." However, the size of the human finger provides a lower limit to size. Small pushbuttons are represented by (top down) Licon's Type-05 and Compu-Lite's "shorty" switches; both can be LED-illuminated. And Cutler Hammer's and Carling Switch's small paddles and rockers are adapted particularly to electrical appliances.

The old numbers game

The search for ways to make spec numbers appear bigger and better is an ongoing pastime. At one point, for example, dielectric strength for switches was commonly defined as the voltage at which 1-mA leakage occurred—still a standard in most MIL specs. To improve the numbers, some manufacturers have established their own higher-current leakage. Others have come up with a parameter called "voltage breakdown"—the voltage required to strike an arc and maintain it between two conducting members. This spec is unnecessary if the more difficult 1-mA criterion is observed.

Another example of creative spec writing revolves around the life of rotary switches. A complete cycle of operation for a rotary switch calls for rotating from position one through all active positions and returning to the starting point. However the search for "improved" numbers has created the term, "circuit operations," so a 12-position, 25,000-cycle switch ends up with an impressive life of $12 \times 25,000 \times 2$ circuit operations. Fortunately, a knowledgeable designer isn't likely to be fooled by such a blatant ploy.

If a vendor makes a claim that seems far out of line compared with what other vendors offer, greet it with skepticism. Ask him to substantiate the claim. If his design improvement, new material or process truly and dramatically improves the switching function, he will be most happy to demonstrate his claim.

Contact-system design, switch materials, actuator mechanisms and other switch parts have been so thoroughly investigated by most reliable manufacturers over the years that real breakthroughs can be expected to be rare. So be from Missouri!
Generally, there is little room for overcautious design in small switches. You can’t expect to use a safety factor of 100 to 1000% and still keep the switch small.

**Miniature switches require compromise**

Often, when occasional surges exist for only a few milliseconds, a small, 1-A rated switch can handle as much as 10 A.

Even with inductive loads, miniature switches must work with small safety factors. Study the load and its Q carefully to determine the true needs. Use suppressors to keep the current surges down.

And, of course, if you must squeeze a lot of capability into a small space, you may have to compromise on life expectancy—which may be a smaller sacrifice than you think. The actuations per hour in your application may be low, so even with a derated life, the hours of operation can outstrip the useful life of the equipment. The switch need not outlast its circuit.

Moreover, a switch rated at, say, 10,000 actuations with a 50% duty cycle, may be able to operate for 50,000 actuations at a 20% duty cycle. Designing the 10,000-actuation switch for a 50,000 actuation life, however, may not only increase its size substantially, but also raise the price 200 to 500%.

What’s most important, miniature switches are often used in relatively high-impedance applications such as logic circuits, while end-of-life criteria (when provided) are generally measured in milliohms of contact resistance. Between 0.1 and 1 Ω is realistic for an end-of-life value in such circuits; in some cases even 10 Ω can be tolerated. Such impedance values vastly increase the switch’s life expectancy so that is nearly as long as the mechanical life.

A large proportion of miniature-switch applications control currents in the range of only tens of milliamperes with voltages under 28 V. Yet low-cost silver and silver-alloy contacts are most often supplied as standards, despite the tendency of silver to form oxide and sulfide films that require substantial pressure or voltages to punch through the surface contaminants.

**Silver—a primrose path?**

A clean silver surface is an excellent conductor, has good mechanical qualities and is relatively cheap. However, silver performs best when the electrical energy in the switched current can produce some small amount of arcing (about 0.4 VA) and the available contact forces are 30 g or higher. But since such a combination isn’t always available in miniature switches, the switches often perform erratically. Therefore, unless specifically stated, assume the miniature switch is unreliable for voltages below 28 V and 100 mA.

When some arcing is present but without 30 g of contact force, choose palladium and its alloys. Palladium alloyed with up to 40% silver to reduce cost performs reliably in the low-level circuits encountered in the telephone industry.

But where neither arcing nor 30 g of force is present (voltages under 12 V at milliamperes currents), gold becomes the contact material of choice, especially for dry circuits.

**Gold is not a panacea**

However, gold is by no means a solution to all the problems that can occur at low-level switching. Even the best gold contacts may be useless if lubricant in the switch assembly or a contaminant such as flux gets on the contact surfaces. The low-level energy may not be able to punch through the surface contaminants.

**Snap-action switches were one of the first types to be miniaturized.** Micro Switch, a pioneer in miniaturized snap-action switches (right), shows off some of its tiny versions next to standard sizes, as does McGill Manufacturing (left).
through the oil film and the contact pressure may be too weak to push it aside, especially in miniature switches. And above a level of about 0.4 VA and 20 V, gold tends to erode very rapidly.

Some manufacturers bend the specs of their so-called “gold contacts.” The high cost of gold is an inducement to cut corners, so a few switch makers try to whistle by with words such as “gold-plated contacts,” or even “heavy gold-plated contacts.” Actually, the gold contacts may be

merely flashes—between 10 and 15-millionths of an inch thick—virtually useless for long-term reliable operation. Such a thin flashing may be useful, however, to extend the shelf life of silver contacts by keeping oxide and sulfide formation down. But the layer will burn or wear off rapidly in use.

Even “average thickness” is suspect. Variations in thickness can be over 50%. Only a guaranteed minimum thickness fully documented and tested—preferably in-house—can assure that the plating is adequate.

Gold plating should usually be applied over a barrier layer of hard dense material, like nickel, to prevent the gold from migrating into the contact base—silver, copper or brass. However, plating directly onto silver, some experts claim, may sometimes be advantageous, while other experts report that silver/gold compounds with poor conductivity can form.

At low-level switching, gold thickness of about 50-millionths of an inch is adequate for switch lives of about 10,000 actuations. Longer-lived units call for greater thickness or inlaid solid-gold inserts. But only the mating parts of a contact set need be gold. Careful contact design puts the gold only where needed and can save a lot of money. But even though the contacts may be most important, the other parts of a miniature switch also must receive careful consideration.

Although all forms of miniature switches—toggle, rotary, pushbutton, slide, snap, and others

A miniature matrix slide switch made by AMP contains several manually operated, 10-position slide switches in a matrix configuration for PC mounting. Gold-plated crosspoints for logic-level switching (12 V dc 100 mA) offer a dry-circuit contact resistance of less than 1 Ω.

Miniature dual in-line switch assemblies, variously called (from top left counterclockwise) DIL (Spectra series by Erg Industrial), DIP (Series 206 by CTS-Keene) and BIT switches (Standard Applied Engineering) are all designed for PC mounting and need very small fingers, or better, a stylus to actuate them.
Tiny inertia switches, Models 1575 and 1576 (bottom), used for lighting wristwatch LEDs at the flick of the wrist; a rotary switch, type 1508, used in helicopters; and a delicate 0.007-in.-diameter beryllium-copper unit (upper right) for consumer electronics are all part of the J. M. Ney Company's extensive line of specialized miniature switches.

Thumbwheel switches, such as these EECO 2500 series low-profile switches in a strip, feature PC-board mounting by wave, flow or hand soldering. No mounting hardware is needed. Single modules can be snapped together to form a multistation switch assembly of any desired length. Tabs of the end switches snap off easily.

— are being used more and more, the slide and pushbutton types seem to be advancing in popularity at a faster rate. Slide switches are particularly desirable for low-level or dry circuits because of their inherent wiping action.

Butting-type contacts often allow deposits to build up rapidly and shorten life prematurely in low-level circuits. Generally, butting contacts should be applied to power circuits (above 0.4 VA) and slide units used for logic levels. One of the most reliable butting-contact arrangements for the pushbutton is the gold-alloy crossbar, which concentrates the available contact pressure into a small area.

Actuating mechanisms and mechanical contact systems used in many switches are often chosen by manufacturers more to avoid infringing existing patents than to provide a unique function, so don't be taken in by exaggerated claims.

Up to a few years ago, few switches were made specifically for PC mounting. At first, standard-sized switches were adopted for PC use, but they were too large and their terminals were spaced on odd-ball centers. Now, switches specifically de-
signed for PC use, such as the many versions of the so-called DIP switch, have terminals on 0.1-
in. centers. Some manufacturers have introduced designs that prevent or alleviate solder and flux
wicking. And many slide and pushbutton switches have shrunk so small that they are below human-
finger size and must be actuated with a stylus.

Imported switches—blessing or curse?

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Avoid relay-specification pitfalls.
Don’t depend solely on published information. The catalogs leave out too much data essential for proper design.

You can’t depend entirely on specification sheets when selecting relays. If you do, you just might give a relay credit for capabilities it doesn’t have. So in addition to the manufacturer’s published information, keep these considerations in mind:

- Over-all electrical limitations.
- Over and undervoltage characteristics.
- Protection against transients.
- Mechanical and electrical lifetimes.
- Temperature limitations.

Detailed data on these topics are often missing, sketchy or at best buried in footnotes and incomplete charts and tables.

Watch those over-all ratings

Relay specification sheets almost always list the maximum permissible amperage per contact. But they don’t always make clear that a multipole relay may be limited further by a maximum total current-carrying capacity. For example, consider a four-pole relay that incorporates contacts rated at 10 A each. Apparently, the total relay capacity is 40 A. But as a matter of fact, the maximum total load on all contacts of the relay might be only 30 A. Such information must either be dug out of footnotes or obtained via a phone call to the manufacturer.

Or say a relay is rated at 10 A at 120 V ac or 24 V dc. What is the current rating at 48 V dc? The catalog probably doesn’t say, and you shouldn’t guess. Ratings above 24 V dc are a function of contact gap, which can vary widely from one 10-A relay to another. The only safe solution is to explain your needs to the relay manufacturer and get his opinion.

Similarly it’s easy to inadvertently exceed the load ratings for reed relays. Usually, the maximum amperage, voltage and wattage (or volt-amperes) are specified separately. However, the wattage is the limiting factor. Even if amperage and voltage are within limits, you should multiply them together to determine if the wattage also is within allowable limits. For example, if a reed relay is rated at a maximum of 250 V and 1 A, then

\[
15 \text{ V} \times 1 \text{ A} = 15 \text{ W} \quad (\text{maximum rating at } 1 \text{ A})
\]

or

\[
250 \text{ V} \times 0.06 \text{ A} = 15 \text{ W} \quad (\text{maximum rating at } 250 \text{ V})
\]

or

\[
24 \text{ V} \times 0.625 \text{ A} = 15 \text{ W} \quad (\text{maximum rating at } 24 \text{ V})
\]

All the maximums can’t be used together.

Don’t operate relays near voltage limits

Although specification sheets usually provide an allowable under-to-overvoltage tolerance range around a relay coil’s nominal-rating range, the effect of continuous use outside the nominal range is rarely mentioned. Such a tolerance range is meant to allow for the occasional fluctuations that occur in nearly all power sources. It doesn’t mean you may operate at a continuous over or undervoltage without paying some price. This is seldom explained.

Usually, the specification clearly indicates the allowable range of continuous operating voltage. For example, many relays are rated to operate continuously between 110 and 125 V dc. However,
the relays also have an extra tolerance—typically 80 to 110% of nominal at 25 C—for transient fluctuations. This means that the voltage normally available must be between 110 and 125 V dc, but the relay can still operate properly when the voltage temporarily drops to 88 V dc or surges to 137 V dc.

But if the operating voltage remains continuously at, say, 100 V, you can expect problems. The low voltage provides reduced contact pressures, which can cause premature contact failure. On the other hand, a continuous supply of, say, 130 V can overheat and also cut the relay's life. Nevertheless, both the 100 and 130 V are well within the 88-to-137-V spec.

Especially with ac relays, when operating at low voltages (less than 85% of rated nominal), the armature may not close firmly, resulting in a noisy, chattering relay that will fail prematurely. The coil may overheat or the contacts weld.

Select a relay nominally rated as closely as possible to the actual long-term supply voltage. If the normal supply voltage is 100 V, 60 Hz, don't try to use a relay rated at 120 V, 60 Hz—even when the relay's under and overvoltage specs allow such operation. Get a special 100-V coil. The small added cost of the special coil can save you quite a bit of money in the long run, as well as provide more reliable performance.

Dependable relay manufacturers usually have a wealth of information—far more than they can publish in their catalogs. Perhaps you need a relay coil that can pull in at a very low voltage but also can withstand high voltages. It generally won't be in the catalog. Neither will the information you must have about transients.

**Transients troublesome to SSRs**

Electromechanical relays normally handle most transients in both the coil and contact circuits so well that manufacturers rarely specify or provide transient protection for them. But solid-state (SSR) or hybrid relays can be readily damaged by transients.

For example, a specification sheet may read: "Relay is unaffected by transients of 5-ms duration with an exponential slope from 0 V to a 20-µs peak of ±2000 V." But what if the period of peaking is longer? Does the same relay withstand, for instance, a 100-µs peak, even if the voltage is well below 2000 V?

If you anticipate such long-duration transients, you must ask the relay manufacturer for complete transient-protection statistics; the longer, the more important the information.

And don't overlook the two kinds of transients. Besides the familiar transients that occur every time a circuit closes, there are random, unexpected ones that are difficult to predict and protect against. There's no excuse for not selecting a relay that can handle the former. But the latter may require some measurements and statistics pertaining to your particular application.

An elementary—but often overlooked—point: Most relays carry two "lifetime" ratings. One is the anticipated electrical lifetime based on operation at the rated load; the other is the mechanical lifetime with no electrical load.

A given relay may have a life of 500,000 cycles at 10 A, but 10-million cycles with no electrical load. Data for loads between zero, which is the mechanical life, and rated load are rarely published and usually not linearly proportioned between these points. So again you must ask the manufacturer, and hope he has the data. Some manufacturers may even have life data for load currents above the rated and other variations—such as with transients. For a given relay, you may be willing to trade life for a high load.

A relay's life is also affected by temperature. Relays are usually rated for a "safe" ambient temperature range. But since temperature also affects operating parameters, relays don't necessarily operate equally well at all points within the safe temperature range.

A relay may have an operating range of -10 to 55 C. But the relay's pull-in and drop-out voltages and timing repeatability are almost certain to fall off as either temperature extreme is approached. Especially with time-delay relays, a timing repeatability rating of ±3% in the range of 20 to 25 C can easily deteriorate to ±10% at the extremes of the operating range. Such data are rarely published in the catalog.

And finally, even with all the engineering data in the world, some decisions must still be based upon value judgments. If a relay fails, will the failure cause only a minor inconvenience? Or, can the result be serious? And, of course, what's the manufacturer's reputation? • •
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Revisiting the cross-field inductor: Ordinary ferrite pot cores improve this useful device, which offers high Qs in tuned circuits and other advantages.

The cross-field inductor not only can do many jobs better than conventional parallel-field reactors, it's also versatile. It can provide remote control, detect picoamps, transform dc, multiply frequencies, trim antennas, couple amplifiers and tune oscillators. But the cross-field inductor is largely ignored because of the mistaken belief that special and costly magnetic cores are required. In fact, you can adapt ordinary ferrite pot cores for cross-field inductors to do otherwise difficult jobs.

Basically, the cross-field inductor is a saturable magnetic device that has two or more windings with orthogonal fields. Mutual inductance coupling—the familiar transformer action—is absent, but a current in one winding affects the inductance of the others. With currents in several windings, energy can be transferred by parametric pumping.

Figure 1 shows a cross-field device and a conventional parallel-field reactor. Both devices exhibit zero mutual inductance, yet in either device, current in one winding affects the inductance of the other winding. The major difference between the two devices is that you don't have to match cores in the cross-field inductor.

In the figure, the two sections of winding 2 are in series opposition to the flux produced by the current in winding 1. Transformer coupling is cancelled if the cores are balanced. The mutual inductance between windings 3 and 4 is zero because of the orthogonal configuration. No balancing of core components is necessary.

Windings 1 and 2 have similar properties, so usually it makes little difference which is used for the control and which for the modulated circuits. The magnetic paths for windings 3 and 4 are quite different, so how the winding roles are assigned is important.

Winding 3 is a conventional bobbin coil whose flux path has a substantially uniform cross-section area over its entire length. If 3 is used as a


1. Contrasting two kinds of saturable reactor: the parallel-field type (a), widely used in magnetic amplifiers (for clarity, less than the optimum number of turns is shown) and the cross-field counterpart made with a standard ferrite pot core (b). The annular winding (No. 4) consists of 16 turns through the mounting hole and usually acts as the control or modulator. A bobbin coil works best in circuits requiring the highest Q or highest impedance. Winding details are shown in (c).
control winding, all portions of the core will saturate at the same current level.

The effects of core geometry

On the other hand, modulating current in winding 4 first saturates the inner region of the center post. As the current increases, the saturated region spreads to the entire center post. With very large currents, the entire pot core becomes saturated. Thus, the effect of \( I_1 \) on \( L_1 \) is strongly influenced by the core geometry, whereas the effect of \( I_1 \) on \( L_2 \) depends largely on the B-H curve of the material.

Standard international pot cores aren't ideal for cross-field use because the center holes are too small, and the slots on the outer diameter increase the MMF needed for saturation. Of the international cores, the 1408, 2213 and 2216 are most suitable for cross-field use. The adverse effect of the core slots can be reduced by rotating the two halves a quarter turn (see Fig. 1b).

The sharp edges of the center hole should be relieved by grinding to avoid damage to the annular-coil insulation. Some devices can be constructed with very large pot cores (the Allen-Bradley C2400, for example) that have been rebored by grinding.

Design considerations of conventional inductors apply to cross-field devices as well. The ferrite should have appropriate properties for the highest expected frequency. For high-frequency coils, use Litz wire; for high-frequency, high-impedance coils, use multiaxial bobbin.

Because of low permeability, high-frequency ferrites are not easily saturated. So, since wide swings in inductance cannot be achieved with modest control-signal power, consider ferrites of higher permeability than you normally would choose to get the maximum Q at the operating frequency.

The cross-field as a chopper

Data for a working cross-field device are shown in Fig. 2. The open-air inductance of the bobbin

2. The inductance of a cross-field bobbin coil vs its toroidal dc ampere-turns. The bobbin has 68 turns, and its core is Magnetics, Inc., type 43622-UG, a type-D, moderately permeable ferrite that saturates at about 3 oersteds. The steep part of the curve, between 6 and 15 ampere-turns, corresponds to the saturation of the center post. An appreciably greater inductance swing can be obtained with a similar core made from Magnetics type G or Ferroxcube type 3B7 ferrite.

3. Almost three decades of linearity are obtained from a cross-field modulator made with a 1408-A100 miniature pot core. Winding \( W_a \) is annular, with 30 turns, \( W_b \) is a 750-turn bobbin coil made with 39-gauge wire.
4. Output of the cross-field inductor of Fig. 1b when driven from a 50-Ω signal generator. The bobbin winding has 130 turns of Litz made with 16 strands of AWG 38. The core is a Ferroxcube 3622-A1000-387. The Q of the resonant circuit is approximately 600. The slightly greater attenuation on the high-frequency side of resonance is an anomaly caused by stray capacitance.

5. The results of tuning winding 3 of the device in Fig. 1b. The inductor is tuned to 13 kHz with a 0.013-µF capacitor. The vertical sensitivity is 0.1 V/div for both traces, and the horizontal sweep speed is 50 µs/div. A dc bias of 120 mA in the 16-turn toroidal winding (No. 4) is used to peak the harmonic response. Note the absence of 6.5-kHz drive signal in the top trace.

The cross-field as a modulator

Figure 3 illustrates the performance of a cross-field modulator made with an ordinary miniature pot core. The device operates open-loop and is linear over nearly three decades. Output falls off at the upper end because the signal current causes the core to be partially saturated. The inductance of the bobbin coil thus decreases, and so does the energy stored per 1°. At the lower end, a finite signal develops despite a zero-input signal. The reason, in this case, is residual magnetization, which cannot be distinguished from the input signal. This magnetic effect can be eliminated by an appropriate dc bias on either winding. But then other effects begin to be important.

A second harmonic of the modulating frequency is coupled by the small but finite mutual inductance between \( W_a \) and \( W_b \). The isolation between \( W_a \) and \( W_b \) is on the order of 50 dB, and allows some of the modulating signal to feed through. Much of the fundamental component is rejected by the tuned circuit, \( C \), which is resonant to 10 kHz. A second harmonic of the modulator is also coupled but, of course, is not attenuated by the 10-kHz tuned circuit.

Square-wave modulating current is chosen for
two reasons: It is easy to generate, and there's no second harmonic—theoretically, at least.

Galvanic isolation prevails if you provide an additional bobbin winding for the output. To preserve sensitivity, most of the available bobbin space should be allocated to the dc signal circuit. Since this coil will thereby have the higher Q, the capacitor should remain.

Even with a low-source impedance, inductance L and resistance R allow a high-tank Q. If desired, a much smaller L can be used. Temperature changes in the resistance of W, will introduce errors that can be compensated for by a negative-tempco series resistance.

Preventing saturation

With feedback from an absolute-value amplifier, you needn't use a gapped core to prevent saturation by the signal current. The sensitivity of the device is proportional to the inductance of the bobbin coil which is increased about thirty-fold by replacing the A-100 core with an ungapped 1408-3C8. Whereas the sensitivity of the device in Fig. 3 is approximately 1/4 µW, the ungapped core should work down to 10⁻⁶ W.

Most of this energy is dissipated in the resistance of the isolating inductor, L, which contributes 340 Ω to the input circuit's resistance vs 60 Ω for the bobbin winding. Further improvement in sensitivity can be obtained by lowering signal-circuit resistance or by raising the inductance with a larger pot core.

As the sensitivity is pushed above 10⁻¹⁰ W, modulator feedthrough and ferrite anisotropy pose formidable problems. The theoretical limit imposed by ferrite noise is about 10⁻¹⁵ W, a performance ceiling that shouldn't be too confining in process-control, among other applications.

The cross-field inductor in tuned circuits offers many advantages. In conventionally coupled circuits, the Q is limited by the terminating impedances. But cross-field inductors can be driven by low-impedance sources without Q impairment. Figure 4 shows the response of the device of Fig. 1b when resonated with a 0.005-µF capacitor. The achieved Q of 600 is hard to obtain in conventional circuits; the resonant circuit is current-tunable and not affected by either the driver or the tuning-current source.

Cross-field devices are also very efficient at frequency doubling and tripling as shown in Figure 5, top and bottom. Harmonic selection is accomplished simply by tuning the circuit of Figure 4 to the desired harmonic. Best results are obtained when some dc bias, such as provided by a Class-A driving stage, is allowed to flow in either winding. The inherent isolation between the two windings ensures an output that is free of any fundamental frequency component. **

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Design EMI shielding more accurately by taking aperture effects into account. They can be appreciable, even at low rf frequencies.

What do microwave ovens, fast computers, wireless intercoms, and the recent flood of CB gear have in common? They all pose a threat to air waves that already are overcrowded. So shielding against unwanted electromagnetic radiation has become extremely important, and you must be able to predict it with higher accuracy than was common in the past.

Traditionally, the shielding effectiveness of metallic barriers has been determined by breaking it down into two components—one accounting for reflections at both surfaces of the shield, and the other describing the attenuation of the wave, as it proceeds through the interior of the metal. Based on transmission line theory, these two effects are well understood, and can be predicted with high accuracy.1

This method is very useful for the selection of materials and their required thickness for the construction of a particular shield. Material selection is most critical for shielding high power, low frequency sources from predominantly magnetic fields. Otherwise, the structural metal enclosures of electrical equipment usually provide adequate shielding.

There's the hole problem

In practice, over-all shielding efficiency is nearly always determined by openings in the enclosure, often resulting from the construction methods used. What you need is a simple means for estimating their effects.

Since high-frequency leakage involves only the concepts of radiated and received power, you can apply antenna theory directly to solving the problem. Leakage is most serious at microwave frequencies, but extends down to the 100-MHz range. Fig. 1 maps out the strategy for attacking leakage. Antenna 1 with gain $G_1$ is radiating power $P_1$, directly at a slot in an infinite shield. Assume that the polarization of the incident electric field $E$ is perpendicular to the long dimension of the slot, which induces maximum currents perpendicular to the slot and gives minimum shielding effectiveness.

The slot reradiates part of the power to antenna 2, which has a gain $G_2$. The difference in dB between the powers received by antenna 2 with and without the shield in place gives an insertion loss called shielding effectiveness $SE$.

A slot absorbs no power

You can consider the slot as an antenna that, by the principle of duality, has the general characteristics of a similarly shaped metallic antenna in free space. In fact, the field distributions are the same for both antennas, except that the magnetic and electric components are reversed. Since the energy contained in a radiated wave is equally distributed between the electric and magnetic components, the power received by similarly shaped slot and metallic antennas oriented for maximum pick-up is the same.

Equations generally used to calculate antenna power assume that the antenna is terminated in a conjugate-impedance load. The antenna then absorbs the maximum power from a passing

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William Jarva, Consultant to ARK Electronics, 624 Davisville Road, Willow Grove, PA 19090.

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1. To attack the slot-leakage problem, put a radiating and a receiving antenna on opposite sides of an infinitely large metal plate. The slot itself becomes an antenna, receiving power from antenna 1, and reradiating it to the receiving antenna 2.
electromagnetic plane wave of given power density. In the case of the slot, however, the antenna is not terminated, and all of the intercepted power is immediately reradiated into the surrounding space on both sides of the shield. This reradiated power is four times the power received by a matched termination.

Assuming a slot gain \( G_s \), the power received and reradiated by the slot is given by the following equation, in rationalized MKS units:

\[
P_2 = \frac{4 P_1 G_s G \lambda^2}{(4 \pi d)^2}
\]

where \( \lambda \) is the wavelength. Power received by the receiving antenna is then:

\[
P_3 = \frac{P_2 G_s G \lambda^2}{(4 \pi d)^2} = \frac{4 P_1 G_s G \lambda^2}{(4 \pi d)^2 (4 \pi D)^2}
\]

If the shield is removed, the received power becomes:

\[
P_4 = \frac{P_1 G_s G \lambda^2}{(4 \pi (d + D))^2}
\]

The shielding effectiveness is the ratio of \( P_4 \) to \( P_3 \), in decibels:

\[
SE = 10 \log \frac{P_3}{P_4} = 10 \log \left[ \frac{2 \pi d}{(d + D) G \lambda} \right]^2
\]

But Eq. 1 is only accurate at the slot’s resonant frequency, which represents the worst case. You thus obtain a simple estimate of the minimum shielding efficiency due to a particular opening in a shield. Eq. 1 also shows:

- Shielding effectiveness is independent of the gain of the test antennas, for the completely aligned condition. If the test antennas are aligned with each other but not with the slot, the measured SE then becomes a function of the directivity of the test antennas, which results in higher SE. Lacking slot orientation is the primary cause for large variations in shielding measurements.
- SE depends on the distance of the receiver from the flaw in a shield. This fact becomes extremely important when safety hazards are involved. For instance, when looking into a microwave oven, you may put your eyes close to a flaw in the oven door. Distance is also important in the protection of equipments from an electromagnetic pulse caused by a nuclear burst (EMP).
- If distances \( d \) and \( D \) are equal (the usual condition for shielding-test specifications), shielding effectiveness is 6 dB lower than when \( D \) is very large compared to \( d \).
- Eq. 1 is symmetrical with respect to \( d \) and \( D \); the principle of reciprocity holds and the transmitting and receiving antennas may be reversed without changing shielding effectiveness.

Don’t forget harmonics

Eq. 1 also indicates that SE becomes greater with frequency (decreasing \( \lambda \)). However, you must remember that a linear antenna resonates at multiples of a half-wave, and the radiation pattern breaks up into a number of high-gain lobes. The test antennas in Fig. 1 are therefore always positioned and directed so as to intercept the main lobes of the slot in the shield. Tests indicate that the shielding effectiveness at successive resonance points (higher frequencies) becomes progressively greater at half-wave resonance.

It has often been assumed that the shielding efficiency of an opening is inversely proportional to the cross sectional area of the opening. Antenna theory, however, shows that a terminated half-wave dipole in space has an effective area equal to \( 1.64 \lambda^2/4\pi \). This area yields the maximum power that a given plane-wave can deliver to the load. For the half-wave slot the intercepted power is four times as great, but because the power also passes on to the remote side of the barrier, the area (called the “acceptance area”) is twice as great, namely \( 3.28 \lambda^2/4\pi \). In effect, the slot’s acceptance area is approximately equal to the slot length squared, and not the slot’s cross section.

Table 1 gives SE values for several half-wave slots if the two test antennas of Fig. 1 are each 1 meter away from the shield, and if \( G_s \) equals 1.64. The results of Table I are accurate only if the test antennas are far enough from the shield to locate the slot within the far-field, or “Fraunhofer,” region of the transmitting antenna. If \( L \) is the antenna’s largest dimension, this region begins at \( 2 L^2/\lambda \). When the test antenna’s dimensions are similar to slot dimensions, and \( d = D = 1 \) m, the calculations shouldn’t be used for slots much larger than 0.5 m.

Short slots act differently

Slots shorter than half a wavelength have reactive components. Instead of using the effective area, you must consider the electric and magnetic fields, and the effective length of the antenna.

The voltage induced in an electric dipole in free space due to an incident electric field, \( E_i \), is
found as follows:

\[ V = E_1 \times L_e \]

where \( L_e \) is the effective length of the dipole.

For the magnetic dual antenna, an equivalent equation gives the current induced by a magnetic field:

\[ I = 2 H_1 \times L_e \]

The current (and magnetic field) at the surface of the metal sheet is twice the incident field. The factor of 2 indicates that the dipole in free space is not the exact analog for the slot in a metal sheet. The equivalent would be an electric dipole imbedded in an infinite sheet of very high intrinsic impedance. The electric field would double and the factor 2 appear in the equation for the electric field as well.

The power reradiated by the slot is \( P_s = \frac{R_s}{2} \), where \( R_s \) is the slot’s radiation resistance:

\[ P_s = 4(H_1 L_a) \cdot R_s \]

If you use the standard equations for \( H_1 \) at the slot due to antenna 1, and follow the same procedure as for the derivation of Eq. 1, you obtain the shielding effectiveness off resonance:

\[ SE = 10 \log \left[ \left( \frac{d}{(d + D)} L_e \right)^2 \frac{480 \pi^2}{R_s G_s} \right] \]

The series impedance of the slot is related to the metallic dipole impedance \( Z_e \) by:

\[ Z_e = \left( \frac{120}{R_s} \right)^2 \]

You can then express the radiation resistance of the slot in the more familiar terms of dipole resistance \( R_e \) and reactance \( X_e \):

\[ R_e = \frac{(120 \pi)^2}{R_s^2 + X_e^2} \]

You obtain the shielding effectiveness for the slot:

\[ SE = 10 \log \left[ \left( \frac{d}{(d + D)} L_e \right)^2 \frac{R_e^2 + X_e^2}{30 R_s G_s} \right] \]  \( \text{(2)} \)

where \( G_s \) and \( L_e \) are the same for both antennas and where \( R_e \) and \( X_e \) are the characteristics of the equivalent metal dipole.

When the physical length of the antennas increases from very short to a half-wavelength, the length factor varies only from 0.5 to 0.637, and the gain of the antennas varies from 1.5 to 1.64. So, neither factor has much effect on the final result. Indeed, if you assume the extremes in any given calculation, the result changes by a maximum of 5 dB. Thus, if you know only \( R_s \) and \( X_e \), you can obtain reasonable estimates of the shielding effectiveness below half-wave resonance.

Table 2 contains representative results assuming a slot length of 10 cm and a width of 0.61 cm. The calculations are based on values for \( R_s \) and \( X_e \) taken from the literature. At 1500 MHz, where the slot is half-wave resonant, the values for \( SE \) are the same as in Table 1, as you would expect.

**Magnetic fields can pose problems**

In the vicinity of low-impedance antennas or other low-impedance radiators, magnetic fields prevail over electric field components, often by a large factor. Because testing for magnetic fields is usually done with loops, assume that the antennas of Fig. 1 are now small, coplanar loops with distances \( d \) and \( D \) measured from the loop centers. The equations for magnetic field emission of small loops then yield:

\[ SE = 20 \log \left[ \frac{2 \pi \omega \mu d^3 D^3}{(d + D)^2 L_e^2 Z_e} \right] \]  \( \text{(3)} \)

where \( \omega = 2 \pi f \) and \( \mu \) is the permeability of free space \( (4 \pi \times 10^{-7}) \).

Measurements in induction fields require that all distances and antenna sizes be small compared to a wavelength, and are therefore restricted in practice to frequencies of 10 MHz or less. The metal-dipole equivalent of the slot then has an almost purely capacitive impedance:

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2. Shielding effectiveness in the presence of a 10-cm slot is summarized over a frequency range from the kHz to the GHz region. Different effects prevail in the different frequency regimes.
After substitution of $Z_s$ in Eq. 3, the magnetic shielding effectiveness reads as follows:

$$SE = 20 \log \left[ \frac{d^2 D^2}{18 (d + D)^2 L_e^2 C_d} \times 10^9 \right] (4)$$

where $C_d$ is the capacity of the dipole, approximately given by:

$$C_d \approx \frac{\pi \varepsilon L}{\ln \left( L/a \right)}$$

where $\varepsilon$ is the permittivity of free space ($8.85 \times 10^{-12}$) and $L$ and $a$ are the length and diameter, respectively, of the dipole. Assuming a length of 1 m and a diameter of 0.6 cm, $C_d$ becomes 5.5 pF. The capacitance of a one-meter whip antenna above a ground plane is twice that, or 11 pF. The known value for the 41-in. whip used in military electric field tests is 10 pF, in very good agreement with the calculation.

To apply the capacity of the equivalent dipole to the slotted shield, set the diameter, $a$, to one-half the width, $w$, of the slot. Then, the shielding effectiveness of the slot due to a magnetic field, expressed in terms of slot parameters alone, is:

$$SE = 20 \log \left[ \frac{2 d^2 D^2 \ln (2L/w)}{(d + D)^2 L_e^2 L} \right]$$

Because the effective length, $L_e$, for short antennas equals one-half the physical length, $L$, the equation can be simplified to:

$$SE = 20 \log \left[ \frac{8 d^2 D^2 \ln (2L/w)}{(d + D)^3 L_e^3} \right] (5)$$

$$= 60 \log \left[ \frac{2 d D}{(d + D) L} \right] + 20 \log \left[ \ln (2L/w) \right]$$

Under the conditions specified in MIL-STD-285 ($d = D = 0.47$ m, loop dia = 12 in.) the shielding calculation for a 10-cm slot of 1 mm width results in a shielding effectiveness of 55 dB.

Eq. 5 indicates that SE for magnetic fields is independent of frequency, which is confirmed by many tests with small loops, over a wide frequency range. Nor is SE affected much by the slot width, which is also borne out by measurements.

**Shielding for electric fields**

Fields generated by high-impedance antennas such as short whips or dipoles are predominantly electric, with a very small magnetic component. Assuming that the test dipoles are short, the shielding effectiveness for electric fields is given by:

$$SE = 20 \log \left[ \frac{d^2 D^2}{(d + D)^2 L_e^2 Z_e f} \right]$$

where $\varepsilon$ is the permittivity of free space ($10^{-9}/36 \pi$) and $f$ is the frequency in Hz. In terms of the capacity of the equivalent short dipole, the equation becomes:

$$SE = 20 \log \left[ \frac{d^2 D^2 1.266 \times 10^9}{(d + D)^2 L_e^2 Z_e f} \right]$$

Using only the slot dimensions, the shielding effectiveness is:

$$SE = 20 \log \left[ \frac{d^2 D^2 \ln (2L/w)}{(d + D)^3 L_e^2 f^2 L} \times 4.65 \times 10^{15} \right] (6)$$

Under MIL-STD-285 test conditions ($d + D = 25$ in.), the electric-field SE for the 10-cm slot with a 1-mm width becomes 132 dB at 1 MHz, and 92 dB at 10 MHz. Both the large values and rapid change with frequency are again confirmed by experience.

**Getting it all together**

The various calculations for the 10-cm slot under the methods of MIL-STD-285 are plotted in Fig. 2, which provides an over-all view of how shielding varies throughout the usual frequency range.

The region between 10 MHz and a few hundred MHz, indicated by dotted lines, is the range where simple equations for low-frequency conditions are no longer accurate. The wave impedances approach that of free space, and with further increase in frequency the results become equal to those for plane waves.

For magnetic fields, at frequencies lower than about 100 kHz (depending on shield thickness), the metal is penetrated and the shielding effectiveness is no longer a function of the slot characteristic.

In the plane-wave or radiated-power region, antenna sizes become large in comparison with reasonable antenna spacing if the frequency falls below a few hundred MHz. The shield is then well within the Fresnel (or near-field) zone, and the simple equations assumed for radiated and received power no longer apply.

**References**

3. *Antenna Theory and Practice*, p. 555

**Table 2. SE for a 10 cm meter slot at and below resonance**

<table>
<thead>
<tr>
<th>Freq (MHz)</th>
<th>Impedance</th>
<th>Length</th>
<th>Gain</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>6</td>
<td>650</td>
<td>0.051</td>
<td>1.5</td>
</tr>
<tr>
<td>1000</td>
<td>20</td>
<td>250</td>
<td>0.055</td>
<td>1.6</td>
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<tr>
<td>1500</td>
<td>73</td>
<td>0</td>
<td>0.0637</td>
<td>1.64</td>
</tr>
</tbody>
</table>
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with a circuit-analysis program and a measured voltage drop matrix. You can expect over-all accuracies on the order of 5%.

Multilayer printed-circuit (PC) cards often contain a power distribution plane that is tapped at several points, for instance by DIP power connections. Generally, the power planes contain cutouts to provide clearance for other circuit elements. Consequently, you can't readily calculate the resistance from the edge connector to the tap points. But you can perform a number of measurements and derive the equivalent network for the power-distribution plane.

If you have access to a computer, these equivalent networks can be used to determine such data as dc drops, voltage differentials and required power supply tolerances for any particular PC card design. Powerful computer circuit analysis programs are available that provide remarkable speed and accuracy, even for networks consisting of many hundreds of elements.\(^1\)\(^,\)\(^2\) The computer should be capable of inverting moderate-size matrices.

Consider the circuit card with eight large components (load locations 1 through 8) and power feed points along the socket edge (9 through 11 and Ref) in Fig. 1. (Numbers 1 through 11 and Ref are assigned arbitrarily.) The following vector matrix equation completely describes the nodal dc behavior of the power plane:

\[
\mathbf{v} = \mathbf{M}\mathbf{i},
\]

where

\[
\mathbf{i} = [i_1, i_2, ..., i_{11}] \text{ is a vector made up of elements } i_k \text{ defined as the current entering the } k^{th} \text{ node}
\]

\[
\mathbf{v} = [v_1, v_2, ..., v_{11}] \text{ is a vector with elements } v_k \text{ defined as the potential measured from node } k \text{ to node Ref}
\]

\[
\mathbf{M} = 11 \times 11 \text{ matrix that describes the resistive nature of the plane.}
\]

If \( \mathbf{M} \) is known, your computer can calculate the solution to any dc problem by conventional methods for solving simultaneous linear equations. The matrix, \( \mathbf{M} \), can also be represented by an equivalent circuit such as the one shown in Fig. 2. You can find the values of the resistors in Fig. 2 with the following measurement method.

Inject a known current in node 1, return it through node Ref and measure \( v_1, v_2, ..., v_{11} \). The measured values divided by the known current represent the first column of \( \mathbf{M} \). Now remove the current from node 1 and inject it at node 2, and again return it through node Ref, and measure \( v_1, v_2, ..., v_{11} \). Those measured values divided by the known current represent the second column of \( \mathbf{M} \). Continue through node 11 for a total of 121 measurements to fill in \( \mathbf{M} \) completely.

---

Dr. J. R. Pivnichny, Development Engineer, and J. Pavlik, Senior Lab Specialist, IBM Corp., System Products Div., Endicott, NY 13760.
The Reciprocity Theorem provides a check on the measurements because it requires that \( m_{ij} = m_{ji} \), that is, \( M \) is a symmetric matrix. Use a computer to subtract \( M \) from its transpose, element by element. Any large elements in the difference matrix are suspect, and the corresponding measurements should be repeated.

Note that this procedure does not check the diagonal elements. The accuracy of off-diagonal elements can be improved by calculating a new \( M \) equal to half the matrix sum of the measured \( M \) and its matrix transpose, thereby effectively using the average of two measurements.

Once you know the \( M \) matrix, you can calculate the individual elements in the equivalent circuit of Fig. 2 from conductance matrix \( G = M^{-1} \) as follows:

The value of the resistor elements, \( R_{ij} \) connecting the reference node to node \( i \) is

\[
R_{ii} = \frac{1}{g_{ii}} \quad (i = 1, 2, 3 \ldots n)
\]

The value of resistors \( R_{ij} \) connecting nodes \( i \) and \( j \) is

\[
R_{ij} = \frac{1}{-g_{ij}} \quad (i, j = 1, 2, 3, \ldots n \text{ but } i \neq j)
\]

How well does it work?

An application example will clarify the measurement technique. Fig. 1 shows a typical PC card. Power enters the card at four tab locations and is connected to an internal power plane by means of a short surface line and plated-through holes. The power plane itself is made from 1 oz/ft² copper with 0.075-in.-diameter clearance holes located on a 0.100-in. grid. The clearance holes provide a path for the signal to pass through the card without contacting the power plane. There are no clearance holes where a component picks up power, as at locations 1 through 8 in Fig. 1.

Resistance measurements on such highly conductive materials as these copper planes require proper 4-terminal connection procedures to eliminate errors due to contact resistance. Fig. 3 shows the typical connecting points used in this example. The contact posts, one of which is shown in Table 1 were measured, and the resistive, which had no clearance holes at these points.

With the numbering scheme of Fig. 1, the data shown in Table 1 were measured, and the resistance values calculated as described. They range from 4.26 mΩ between nodes 2 and 4 to 506 mΩ between nodes Ref and 11.

To establish the over-all accuracy of the calculated equivalent circuit, a particular load pattern like that shown in Fig. 4 was applied to the actual card. The voltage differentials between all nodes and point Ref were measured. The same voltage differentials were also calculated with the circuit-analysis program ASTAP using the equivalent circuit of Fig. 2. The resistors of Fig. 4 were represented as current loads. The calculated and measured voltage differentials were then compared for three different load patterns to establish overall accuracy of the equivalent circuit.

The three separate load patterns were:

Case 1: Identical 1 mΩ ±1% loads at all 8 component locations simulated a uniformly loaded card; four nearly identical power feeds were used at the four indicated tab locations, and one ampere was applied to the card through the four wires attached to the power input tabs. The free ends of the eight resistors are connected together as shown in Fig. 4.

Table 1. Measured-resistance matrix \( M \) (milliohms)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tr>
<td>1</td>
<td>3.86</td>
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<td>3.57</td>
<td>3.85</td>
<td>4.09</td>
<td>4.31</td>
<td>4.44</td>
<td>5.35</td>
</tr>
</tbody>
</table>

Except for the diagonal elements (deep color), this symmetrical matrix contains all resistance values twice - e.g. \( R_{13} = R_{31} \) (white).
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Comparison between measured (white) and calculated (color) voltage differential (mV) from REF to nodes 1 through 8.

Table 2. Result of verification tests

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<td>1.197</td>
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<tr>
<td>2</td>
<td>1.159</td>
<td>1.351</td>
<td>1.303</td>
<td>1.239</td>
<td>1.504</td>
<td>1.355</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. For the verification test, eight 1-Ω resistors and four power feed points are used.

The results are summarized in Table 2. It compares the calculated with the measured voltage differentials between the reference point (REF) and the load points. Similar tables can be compiled for the power entry points 9, 10 and 11.

The conclusion from the three test cases is that this method of generating resistive equivalent networks for PC card power distribution planes yields a 5% over-all accuracy, with a few 10% worst-case values. Thus, equivalent networks and a circuit-analysis program for the circuit models permit you to predict the over-all dc operation of any PC card.

References

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CIRCLE NUMBER 60
Jim Wolfe of Centralab Speaks On Decentralizing Engineering
Most companies with many plant facilities do their manufacturing in the various plants, but do their engineering back home. The theory is that this makes for highest efficiency. The manufacturing is done where it's close to raw material, transportation facilities, labor supply or markets. The engineering is done where engineers can talk to each other and learn from each other. And there's economy in the engineering-support services.

Well, we don't think that works well for an electronics business with a diverse product offering in a broad spectrum of markets. And we speak from experience because that's just the way we used to do things up to about seven years ago. We had the typical functional organization, with the main functions here at headquarters in Milwaukee. Here's where our VP Engineering, our VP Marketing and our VP Manufacturing ran things. We used to have almost all manufacturing located here, but now we're spread around the world.

When we first started moving manufacturing facilities to different parts of the country and then, the world, we did it mainly for reasons like labor supply. But what started as an effort to find better labor supply emerged, 10 years later, as a situation where we are now in the markets we want to be in. The labor-base question is still important, but less significant.

The point is that, when we now move out geographically, whatever the impetus for the move, we move our engineers, too—as many as we can justify.

As soon as we can, we try to get our engineers right next to manufacturing. We'd like to get them out there from Day 1. We want to get as much locally designed tooling as possible and as much local engineering. We want our engineering there because that's how we get the most effective manufacturing and the most effective problem solving. We want our engineering close to the market that's influenced by it.

That's a significant departure from the practice followed by most companies. For example, if they have an operation in Seoul, the only senior person there might be a manufacturing manager. Engineers would commute from the home office whenever there's a problem and, in most cases, the problems would be frequent. Or they would try to fix things by telephone, cable or letter. That doesn't work too smoothly either.

My observation is that, in most places, when somebody at a remote manufacturing organization has a problem and asks for help, he gets a pedantic letter from the home office telling him things he already knew. That wastes time and accomplishes nothing.

We don't think it's practical to manage an operation on a day-to-day basis from a distance. The way to avoid glitches, communications blocks and plain lost time is to have the engineering where the manufacturing action is.

Now the obvious question: Is this efficient? You need separate engineering staffs, separate labs, duplicate equipment, and redundant support services. Every time you have an engineer, you need a secretary, a technician and a draftsman—perhaps not on a one-to-one basis, but in some ratio.

Well, we've found that it's not a problem if you have the courage to make an offsetting change at the home office. Using local engineering, we solve at least 90 percent of the operational problems. For the remainder—and only for the remainder—we can send in talent from the home office.

What led to our reorganization was the understanding that the problems in manufacturing and marketing that were faced by our men in the Far East were completely different from the problems faced by the people in South America or, for that matter, Europe or North America. We found that we needed intimate communications among the people abroad who were involved in marketing and manufacturing and the people back home who were involved in engineering.

When you have a centralized engineering force, the communications link with far-flung markets becomes too strained. It's just too easy to get things wrong. And it becomes impossible to respond quickly to a change in the marketplace.
So we now support these organizations locally with the highest level of engineering that those businesses will sustain. Of course, if they have a special problem they may have to reach back here for help. Our engineering staffs in Milwaukee and Los Angeles are available for major trouble-shooting jobs anywhere in the world. But the day-to-day manufacturing-support engineering is done at the local plants. As these businesses grow, we push more and more engineering talent into them.

Now there's a risk in making that kind of transition. When you begin to transfer functions, unless you're alert, you can find that you're doing the same job in two locations. And that you don't need.

If you're going to move work to someplace else, you must remove it from the first location. That's traumatic and it takes a certain amount of discipline to make the transition.

But there's a factor that makes the transition easier and less traumatic, and it doesn't show up on any organization chart. Managers and engineers at all our locations are in close contact with each other. A problem faced by one engineering group could easily involve a solution developed by another.

For example, the people working on monolithic chip capacitors in Los Angeles might well be able to use circuit knowledge from our people in Lafayette, Indiana. And the people in Lafayette, who make thick-film hybrid circuits, are one of the largest customers for the chip capacitors from Los Angeles.

Further, ceramic capacitors for the U.S. market are assembled in Juarez, Mexico. But Juarez gets much of its raw ceramic material from Mexico City. And Mexico City also manufactures complete capacitors and sells them in South America as well as Mexico.

Of course, in a large organization, it may not be possible or wise to decentralize the entire engineering staff.

Who is Jim Wolfe?

After he got his Masters in Business Administration from Harvard in 1948, 25-year-old James W. Wolfe went to work as a financial man in a nut-and-bolt works. "Well," he says, "they weren't nuts and bolts for long. When we went from $13 million a year to $25 million, we realized that they were industrial fasteners."

After seven years, Wolfe moved to the consulting firm of Booz-Allen-Hamilton, where he remained for another seven years, then on to A.O. Smith for a seven-year hitch. In 1969, eight years ago, Wolfe joined Centralab as general manager and vice president of the parent company, Globe-Union Inc., which enjoys annual sales of about $290 million.

He finds the components part of the business particularly fascinating because there is a high degree of price elasticity and extreme sensitivity to capacity and demand. "You can have wild price fluctuations over a very short period of time," he points out, "and that's a problem."

Wolfe and the former Marion Hayner were married in 1945—as soon as he got off the boat, he says. Well, he admits, maybe it was a few weeks later. They have three sons, David, Paul and Stewart, and a daughter, Anne. When he wants to relax, Wolfe often races his 23-foot, full-keel sailboat—sometimes with his wife.
If you decentralized all your engineering, you might find the local engineers devoting their efforts to local and immediate problems. Design of future products and new types of products might be left to chance. The engineers working on trimmers, fixed capacitors or switching arrays would probably spend most of their time designing enhancements of trimmers, fixed capacitors or switch arrays. They wouldn’t be working towards a completely new electrode system for capacitors.

That kind of development normally emanates from central product development and research groups whose work is normally aimed at a more distant future. Those central engineers and scientists should not normally be involved in the day-to-day engineering required by on-going businesses. They must be experienced, versatile and have the technical breadth and depth to solve any problem.

We have our central scientists in a group we call Corporate Applied Research. The head of this group is responsive to corporate management, that is, Globe-Union Inc., Centralab’s parent company. The activities of this group can stem from requests for help on difficult problems or from projects generated by the division marketing and research staff.

Let’s say, for example, that we were planning a product development and we identified a basic materials problem. Perhaps it was something in the chemistry or physics of a substrate—something needing a breakthrough that we’re not equipped to work on at the normal engineering level. Here’s where the Corporate Applied Research people come in. They don’t develop products, but they can define the material composition that we need, say, for a ceramic capacitor or a resistor.

An example of their effort lies in the Cerbon™ system for our resistors. Our new system gives us trimmer resistors with almost the qualities of cermets at a price that’s almost as low as conventional carbon compositions.

As another example, the original technology for our Base-Metal-Electrode chip capacitors came from this group. One of the researchers came out of engineering and studied for his doctorate in a rather esoteric branch of ceramics engineering at Marquette University. When he came back, he had some ideas and went into the Corporate Applied Research Group. When BME™ became much more than a laboratory concept and moved into production in Los Angeles, we asked him to transfer so he could contribute broadly in our entire line of monolithics.

And that’s the key to our concept. We want our engineers where the manufacturing action is. •

---

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CIRCLE NUMBER 61
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"So this year we placed 297 pages — an entire separate volume — the largest single paid advertisement ever carried by an electronics industry directory.

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"And because of free layouts, production at cost, and massive savings in printing, postage and distribution, we saved $200,000 in the bargain.

CIRCLE NUMBER 62

ELECTRONIC DESIGN 6, March 15, 1977
We're offering you a chance to evaluate Gould switching power supplies without obligation for two good reasons: (1) you know good design, and (2) only you know what your system needs. You'll find that our switchers achieve maximum efficiency in the least space at a minimum cost. As a result, our line offers you a lot of benefits for your system:

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GOULD
CIRCLE NUMBER 63
A simple circuit that provides a Gaussian response accurate to within 2.2% of full scale can be built with a multifunction converter, an op amp and a few discrete components (see figure).

The Gaussian, or normal-distribution, function is very important in electronic computations and statistical analysis. A circuit having a Gaussian transfer response is therefore often needed for analog computation systems and in special applications requiring statistical weighting in accordance with the function

\[ f(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}. \]  

(1)

Such a nonlinear function can be approximated with straight-line segments produced by diodes. Or, a power series with multipliers to generate the power terms could be used. However, using a multifunction converter with op-amp feedback is much simpler. A multifunction converter is a multiplier/divider that has the capability of generating powers and roots.

Analysis of the circuit reveals that its transfer function is

\[ e_o = -\frac{0.7 R_1}{1 + 0.7 \left(\frac{E_{in}}{E_{R1}}\right)^{2.62}}. \]  

(2)

This expression approximates the positive half of the Gaussian distribution as follows:

\[ e_o = -1.75 \frac{E_{in}}{R_1} \cdot \frac{1}{\sqrt{2\pi}} e^{-\left(\frac{e_i}{E_{in}}\right)^2}, \ e_i \geq 0. \]  

(3)

The choice of \( R_1, R_2 \) and \( E_{R1} \) determines the circuit's scaling; voltage \( E_{in} \) sets the input range. With the components and voltage levels shown, a 0-to-10-V input swing produces the same output signal range. An \( e_i/E_{in} \) span of 0 to 1.64 represents the coverage of two standard deviations.

The mathematical approximation between Eqs. 2 and 3 is the primary source of error. For a range of two standard deviations, the approximation error is 2.1% of full scale, which is only 0.8% of the content of the total distribution. When designed for a span of three standard deviations, the approximation deviates by 3.9% of full scale. The multifunction converter contributes an error of only 0.1% of full scale, and the op-amp dc errors are negligible.

To limit circuit errors, the exponent, \( m \), of the multifunction converter and the \( R_s/R_1 \) ratio must be set within 1%. At high frequencies, feedback current of the phase-compensation capacitor, \( C \), and bandwidth limitations of the multifunction converter and the op amp introduce more errors. Phase-compensation capacitor \( C \) and resistor \( R_s \) are needed to ensure circuit stability.

References


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

CIRCLE NO. 311
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The S11 and S11L are industry standard box frame, AC-DC solenoids which meet or exceed the performance of competitive units. We offer pull-on-operate or push-on-operate models with .187" quick connect terminations. Coil voltages are 6 to 24V DC and 24 and 120 AC are available. Terminations are standard .187" quick connects. Acetate yarn finished coils meet Class A (105°C) insulation requirements.

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Some jobs call for muscle, and that's when our heavy duty solenoids really perform. Holding forces range up to 170 oz. continuous, or up to 200 oz. intermittent duty. That's power! All you need is for a wide range of tough applications. And, it's available in our S4 and S4H series heavy duty solenoids. They pack more power in less space.

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When low cost plus performance is important, our new C-frame S34 series is the only choice. The decision is especially easy when you have a volume application like appliances, vending machines, or valve actuators.

If a little more pull is needed, take a look at our S9 series. It, too, features low cost C-frame construction, but provides a higher range of force characteristics for tougher jobs.

Coil powers are from 5 watts (S9: 6 watts) continuous duty to 10 watts intermittent duty. Standard voltages of 6, 12, 24 DC, and 24 and 120 AC are available. Terminations are standard .187" quick connects. Acetate yarn finished coils meet Class A (105°C) insulation requirements.

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Solenoid actuated switch assemblies provide low cost control for garage doors, home appliances, heating and air-conditioning, or automated conveyor systems. Assemblies with one or two "M" style switches are available, with ratings to 10, 15 and 20 amps @ 125/250V AC, 1/2 HP. Solenoid coil voltages are 12 to 240V AC and 6 to 120V DC.

Where corrosive or dirty environments can be anticipated, our encapsulated solenoids really shine. Our Model S99 is designed to operate two-way diaphragm or piston type valves. Corrosion resistant materials handle water and dry or lubricated gases as well as air with ease. Hexagonal plunger design assures proper operation, even when handling water with particulate contaminates up to .02" diameter. Coil voltages are 6 to 120V AC and 6 to 24V DC. Standard mounting is by 3/4" x 20 UNEF 2A nut.

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Magnetic-latching devices, such as reed relays and miniature electromechanical indicators, are advantageous in low power applications. They don't need any continuous electrical holding power. But only if their drive circuit requires little power, can this benefit be realized fully.

The circuit of Fig. 1 consumes virtually zero standby power (only nanowatts of leakage). It is used in a small portable micropower electrometer (radiometer) where a latching-reed relay switches the unit's high-impedance \((5 \times 10^{12}\Omega)\) ranges within a sealed module (Fig. 2). The circuit can also be used for many other purposes, such as for driving a Minelco-type Brite scale-range or alarm indicator.

Switch S (Fig. 1) is part of the instrument's multiposition range switch \((S_{1n} \text{ in Fig. 2})\). When S is switched, toggle action from position 2 to position 1 produces a positive trigger pulse with peak value \(V_s\) in the gate terminal of FET Q3. This pulse causes Q1 to turn on rapidly and Q3 to saturate. Point P of the device's coil connects to \(-V_s\) momentarily but long enough to ensure latching.

The ON period of Q1 can be calculated from the following relationships:

\[
t_{on} = R_1 C_2 \ln \left[ \frac{2V_s}{V_{BE(ON)} + V_{GS(th)} + V_{(Q)}} \right]
\]  

and

\[
V_{(Q1)} = \left[ \frac{2(V_s - V_{FE(sat)})}{h_{FE} \beta R_L} \right]^{1/2}
\]

where

- \(V_s\) = Supply voltage.
- \(V_{BE(ON)}\) = Voltage drop of forward-biased base-emitter junction of transistor Q1 or Q2.
- \(V_{GS(th)}\) = Voltage drop (collector-emitter) of saturated transistor Q1 or Q2.
- \(h_{FE}\) = Forward-current transfer ratio (static-current gain) of transistor Q1 or Q2.
- \(V_{DS(th)}\) = Gate-source threshold voltage of (enhancement type) MOSFET Q1 or Q2.
- \(\beta\) = Gain factor (mhos/V) of MOSFET Q1 or Q2.
- \(R_L\) = Resistance of magnetic device.

Energy demand during switching is approximately \((V_s^2/R_L) t_{on}\) in joules per pulse.

The magnetic device becomes unlatched when switch S is thrown from position 1 to position 2. The resulting positive current pulse through the coil of the magnetic device restores the device to its original state.

The trigger signal for the circuit also can be a square-wave derived from a control system.  

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ELECTRO 77: BOOTH 1531
IDEAS FOR DESIGN

Diode-feedback comparator circuit regulates a LED's drive current

Here's a comparator circuit that can drive a LED display with constant current independent­ly of wide power-supply voltage changes. Add a diode to a standard LM3900 current-differencing amplifier and the circuit can operate with a power-supply range of at least 4 to 30 V (see figure).

An external 1N914 diode, along with the forward-biased diode that is part of the LM3900's internal circuit at the inverting input, blocks current flow from output to input for low output-voltage states. However, when the output voltage swings up and the voltage across R, rises to approximately 1 V, a small current (typically less than 30 nA) flows into the inverting input and maintains a constant 1 V across R.

With 10-MΩ resistances for R, in, and the inverting input of the comparator grounded, the circuit becomes a LED driver with very high input impedance. Of course, the circuit can figure in many other applications where a controllable constant-current source is needed.

Tom Frederiksen and Martin Giles, Application Engineers, National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051.

CIRCLE NO. 313

Without the added feedback diode, the comparator would drive the LED with a widely changing current as the power-supply voltage changed. However, the diode acts to keep the LED current nearly constant at about 10 mA.

Time-interval meter reads digitally to 99.9 ms on a DVM IC

Measuring time intervals is a frequent requirement. To meet this need conveniently, the circuits in Figs. 1 and 2 read time in decimal numbers to three places—from 00.0 to 99.9 ms.

The circuit uses a 555 timer in combination with a current source to form a sawtooth generator (Fig. 1). The sawtooth voltage across capacitor C, is buffered with a FET input to an L144 op amp. A second op-amp circuit in the L144 scales the ramp and permits the offset to be adjusted. This op-amp's output is a negative-going ramp that periodically resets to zero.

A sample-and-hold circuit stores a voltage sampled from the ramp in capacitor C, Feeding this voltage into the input of a three-digit DVM IC (LD130) produces a digital readout of the time between ramp initiation and sampling (Fig. 2). Direct interface between the hold capacitor and the DVM IC is possible, because the LD130's input impedance is 1000 MΩ.

A current source charges the 0.1-µF capacitor, C, to generate a linear ramp. The ramp slope, controlled by the charging current (3.33 µA), is obtained with two 2N4403s connected as a current source and adjusted by varying the 10-MΩ potentiometer, R,. Resistor R, controls the discharge time of C, and an output pulse at pin 3 of the 555 of about 1 ms in width is produced.

The ramp amplitude, scaled by 1/3, results in an approximately 1-V ramp height. The ratio R, / R, controls the ramp scaling without varying the over-all frequency.

All of the system's offsets can be "tweaked" (continued on page 110)
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CIRCLE NUMBER 67
1. A linear ramp voltage generated by a timer IC and constant-current source is sampled and then measured by a DVM to determine time intervals. All circuit offsets can be zeroed out with $R_{os}$.

out and the ramp dc level translated by adjusting the $R_{os}$ potentiometer. The ramp across $C_i$ starts at $1/3 \ V_{cc}$ and ends at $2/3 \ V_{cc}$, but after scaling its magnitude becomes $(1/9) \ V_{cc}$ and its polarity inverted.

The DVM IC measures 000 to 999 mV and consumes little power. Very few additional components are needed to create a complete three-digit DVM.

As an elapsed-time meter for sonar (water or air) and phase and rise or fall-time measurements, the system can be synchronized to external events by controlling pin 4, the 555's reset input.

Thomas J. Mroz, Applications Engineer, Siliconix, Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054.

CIRCLE NO. 314

IFD Winner of November 8, 1976
Peter A. Ernst, Institut fur Regelungstechnik, Universitat Erlangen-Nurnberg, Cauerstrasse 7, 8520 Erlangen, Germany. His idea “Remotely Control a Pocket Calculator with a Simple CMOS Interface Circuit” has been voted the Most Valuable of Issue Award.

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SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of $1050 (cash)! Here’s how. Submit your IFD describing a new or important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive $20 for each published idea, $30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of $1000.

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Arrow-M Member of Matsushita Group
Industry's first 18-bit modular DAC fits in palm-sized case

Analog Devices, Rte. 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. Barry Friedrman (617) 329-4700. P & A: See text.

Claiming a major first in converter products, Analog Devices has squeezed an 18-bit accurate digital-to-analog converter into a 2 x 4 x 0.4-in. module. Moreover, in addition to now offering the most accurate modular DACs anywhere—the DAC-1138 series—Analog has also introduced what are reported to be the lowest-cost DACs with 16-bit accuracy—the DAC-1136 series.

The DAC-1138 comes in two versions, one that delivers 18-bit accuracy and resolution (the DAC-1138K), and one that delivers 17-bit accuracy but 18-bit resolution (the DAC-1138J). Neither unit will put much of a strain on your budget: the 1138K costs only $950 and the 1138J a mere $750—just slightly more than the cost of previously available top-quality 16-bit converters.

And if you don't need 17 or 18 bits, there are the DAC1136K and DAC1136J, also 2 x 4 x 0.4 in. modular DACs, that offer 16-bit accuracy and resolution or 15-bit accuracy and 16-bit resolution, respectively. Prices for the 1136s are $220 for the J and $260 for the K model.

Both the DAC1136 and 1138-series units come in 2 x 4 x 0.4-in. modules and are pin-compatible with the company's older QM series of 14 and 16-bit converters. Offset-temperature coefficients for the converters are 0.5 ppm/°C; differential linearity tempcos are 0.4 ppm/°C. Except for the 1138K, each d/a converter operates at a specified resolution over a range of 5 to 50 C. The 1138K maintains its accuracy over a ±10-C window around any precalibrated point within the 5-to-50-C range. Converter linearity for the 1138K and 1136K is specified at ±0.5 LSB and ±1 LSB for the J models.

All converters can be set for either current or voltage outputs, which can be either unipolar or bipolar. Available current outputs are 0 to -2 mA or ±1 mA, and possible voltage ranges include 0 to +5, 0 to +10, ±5 and ±10 V.

Settling times to within 0.5 LSB for the current output mode are 10 µs for the 1138 series and 8 µs for the 1136 units, both for a full-scale step. In the voltage-output mode, full-scale settling times for the 1138 increase to 250 µs (unipolar), 3 ms (bipolar), and for the 1136 to 30 µs (unipolar) and 40 µs (bipolar), and in all cases the internal amplifiers are used. For a faster voltage settling, an external-output amplifier can be used.

Requirements for the converter's power supply aren't hard to satisfy: only +5 V at 9 mA and ±15 V at 30 mA for any unit—all regulated to within 5%. Power supply rejection in the voltage-output mode is 80 dB for gain error and 75 dB for offset error.

Since both converter series are also available in card-mounted assemblies, you can select options from a "library" of input codes and output amplifiers. Input options include binary, complementary binary, 2's complement, complementary 2's complement, sign-plus-magnitude binary and complementary sign-plus-magnitude binary. The 4.5 x 6-in. circuit card also permits you to use three output options: the DAC1138 internal output amplifier, the Model 44 K high-speed modular op amp or the 234L low-noise, low-drift op amp. A four-terminal output connector on the card permits contact-resistance compensation.

No other companies offer an 18-bit d/a converter in modular form, but a few others besides Analog Devices sell 16-bit units: Analogic, Wakefield, MA, offers the MP-1916A; Burr-Brown, Tucson, AZ, the DAC-70; Datel, Canton, MA, the DAC-HR; and Intech, Santa Clara, CA, the 416 BIN and A-867-16.

All of Analog's DAC1136 and 1138 converters are available from stock to 30 days. And the DAC-1138s come with a certificate of performance, including a 1000-hour zener-stability record and a test record of linearity.

For Analog Devices CIRCLE NO. 302
For Analogic CIRCLE NO. 303
For Burr-Brown CIRCLE NO. 304
For Datel CIRCLE NO. 305
For Intech CIRCLE NO. 306
Low-noise vhf synthesizer is small and inexpensive

If you're looking for a source of low-noise signals in the 60-to-120-MHz range, check the Model PT-2 from Rohde & Schwarz Sales Co. This compact synthesizer doesn't have all the features of some of its competitors—for example, each PT-2 can only generate frequencies within a narrow part of the band. But, priced at only $2000 in unit quantities, and $1400 for 30 or more, the 1-3/8 x 3 x 5-1/4-in. PT-2 costs less than half of what you might otherwise have to pay.

Applications like frequency calibration and satellite communications usually require only a few discrete frequencies. But until now, engineers who needed a programmable low-noise source in the vhf range had to rely on general-purpose synthesizers such as Hewlett-Packard's 8660A or Fluke's 6160B. These instruments can synthesize a wide range of frequencies and have all the controls and features expected in a rack-mount instrument—along with prices upwards of $6000.

The PT-2's price is much lower because it doesn't have all the frills. It doesn't even include a power supply—you'll have to provide 10 to 13 V at 300 mA. And while the PT-2's design is capable of generating any frequency from 60 to 120 MHz, individual units are tailored to a much narrower spectrum.

To specify a PT-2, start with a single frequency between 60 and 120 MHz. The module then provides up to 20 predetermined synthesized frequencies, starting at the specified frequency and stopping at a frequency 1.4% higher. For example, a single PT-2 might have 20 frequencies between 100 and 101.4 MHz. When it receives a BCD command, the PT-2 delivers the right frequency at a level of zero dBm ±3 dB into 50 Ω.

The output signal is very quiet. In the PT-2, discrete spurious signals within 20 MHz of the output signal are suppressed by 100 dB or more, and all other discrete spurious signals are down 60 dB.

Rohde & Schwarz Sales Co., 14 Gloria Lane, Fairfield, NJ 07006. Allen Freeland (201) 575-0750. P&A: see text.
Unit measures gas flow from outside the pipe

Teledyne Hastings-Raydist, Hampton, VA 23661. (804) 723-6531. $490; 3 wks.

All circuitry for the AFSC series of gas-mass flow meters is contained inside the unit's base. There are no sensing elements or projections into the flow stream. The unit operates on a thermal principle that measures true-mass flow. Available in eight ranges from 10 to 50,000 standard cubic cm/min, the devices operate from 24 V dc and produce linear outputs of from 0 to 5 V dc. Normal calibration is for air with conversion factors provided for most gases. Accessories include meters with direct-reading scales, single-and-two-point alarm meters, digital panel meters, totalizers, controllers, and 115-V-ac to 24-V-dc converters.

Take your pick... DPST, SPDT or SPST programmable DIP switches

CTS offers them all... with the addition of NEW 2, 3, 4 and 5 section SPDT and DPST switch styles. A total of 15 Series 206 DIP switch packages are now available from CTS...7 with SPST actuation, 4 with SPDT actuation and 4 with DPST actuation. All have .100" by .300" centers for PCB or standard DIP socket insertion. Gold plated contacts with nickel barrier assure lowest contact resistance throughout life. All provide crisp slide actuation and reliable, positive contact wiping action. Program up to 10 different logic functions with one compact SPST package or up to 5 SPDT or DPST functions with the identical size package.

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MODULES & SUBASSEMBLIES

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with the HVD-100 resistive divid­

er. Boasting a 1-GΩ input imped­

ance, the divider is intended for

high-voltage low-current sources.

Additional specifications for the
device include: 100-kV input volt­

age; 100, 10 and 1-V output taps;

100-ppm/°C tempco and 0.01 % 8-h

stability. The recommended cali­

bration interval is 90 days.

Digit displays contain

multiplexing diodes

Refac Electronics, P.O. Box 809, Winsted, CT 06098. W. Gillis (203) 379-2731. From $21.95; stock.

Series MDD-450, 440 and 450

are seven-segment directly viewed

incandescent digital displays that

contain seven isolation diodes for

multiplexing. The package meas­

ures 0.665 X 0.275 X 1.025 in.

The displays can be mounted di­

rectly to a PC board or plugged

into sockets. The units feature

light output of 9000 fL with the

0.25-in. character life-rated at

100,000-h per segment. The 4-V

and 5-V displays provide a 7:1

contrast ratio in bright sunlight

with proper filtering and can be

dimmed for night viewing.
Converter zips polar digits to analog X-Y

Interface Engineering, 386 Linde­lof Ave., Stoughton, MA 02072. (617) 344-7383. From $240; stock to 45 days.

The DR320 accepts a 10, 12, or 14-bit natural-binary angle (θ) and a reference (R) and delivers R Sin θ and R Cos θ outputs at up to 500-k conversions/s. The trig functions are digitally controlled and the outputs conform individually to the theoretical sine and cosine functions as well as maintaining arctan θ ratio accuracy. The resultant vector, therefore, exhibits an accurate length as well as an accurate pointing angle. You can use the device as a fast multiplier with a trig-function translation and get a conversion lag of less than 1 μs. The unit accepts a reference (R) input in analog form, from dc to complex waveforms. The module provides d/r and d/s as well as polar-to-rectangular conversions. The converter's speed lets you dynamically control electron-beam deflection in CRT displays. The A model provides ±0.3% vector-amplitude vs angle conformance and ±0.2° arctan conformance. The B models provide ±0.1% vector-amplitude conformance and ±0.05° arctan conformance.

Multiplexer links 15 ports to a CPU

Digital Systems, Walkersville, MD 21793. J. R. Laughlin (301) 845-4411. From $5250; 90 days.

The Model 6116 connects to a high-speed bisynchronous communications adapter on a host processor and then fans out that high-speed port to 15 slower speed asynchronous ports. The unit functions either locally or remotely with respect to the host computer. The speed of each terminal device connected to the multiplexer can be preselected at from 110 to 9600 baud, and the speed for each device is independent of the others. The unit is built around a μP system with 15 separate input buffers. Data are transmitted a character at a time to the device, which then buffers the data until the end of a record is reached.

Solid-state delay switches 4 A

Polytron Corp., P.O. Box 984, Elk­hart, IN 46514. Alex Saharian (219) 294-3924. $6.50 (100 qty); stock to 2 wks.

The ND-2 line of solid-state time-delay relays is intended for heavy-industrial application. These normally-ON or normally-OFF devices are fully encapsulated and switch loads of up to 4 A at various line voltages. The unit measures 2.5 x 2 x 1 in.

24 GHz

-30 dBm sensitivity, FM tolerance standard

Just those three features alone put Systron-Donner's new Model 6054B Microwave Counter in a class by itself! But there's lots more...

- Coverage: 0.02 to 24 GHz in one band with one connector input.
- Sensitivity: -30 dBm to 10 GHz; -25 dBm to 18 GHz; -20 dBm to 24 GHz.
- Dynamic range: No dead zone! Operative over the complete range up to +30 dBm (1 watt).
- Protection: Flashing LED's provide early warning of pending overload.
- FM tolerance: Full channel loading and heavily modulated signals with rates up to 10 MHz are measured easily.
- Models: If you don't need 24 GHz coverage, S-D also offers 1.25, 4.5, 6.5 and 18 GHz automatic counters.
- Information: Call Scientific Devices or contact S-D at 10 Systron Drive, Concord, CA 94518. Phone (415) 676-5000. Overseas, contact Systron-Donner in Munich; Leamington Spa, U.K.; Paris (Le Port Marly); Melbourne.
X-Y recorders catalog

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14-bit a/d offers four input ranges

CPS Inc., 722 E. Evelyn Ave., Sunnyvale, CA 94086, (408) 738-0530. $195 (1-9); 8 wks.

A 14-bit successive-approximation a/d converter, Model CYAD-14 QM, offers pin-selectable analog input ranges of 0 to +5-V, 0 to +10-V unipolar, ±5-V and +10-V bipolar. The unit has a conversion time of 100 µs, and guaranteed monotonicity over 0 to +50 C. The module includes input buffers. Power requirements are +15 V ±5% at 60 mA, −15 V ±5% at 40 mA or +5 V ±5% at 180 mA. The device measures 2 × 4 × 0.4 in.

CIRCLE NO. 323

D/f converter latches onto BCD inputs

Syntest, 169 Millham St., Marlboro, MA 01752. C. Hoffman (617) 481-7827. $242 (unit qty); stock.

Featuring direct-BCD programming of both frequency and amplitude range, the SM-106 also gives you on-board logic latches that simplify computer control. Output frequencies between 1 Hz and 160 kHz are available in five ranges. Three digits of BCD frequency-control plus one BCD-digit of range control is provided. The output is a sine wave capable of driving 10 V pk-pk into 600 Ω. Total harmonic distortion of less than 1% is provided over the entire frequency range. Power requirements are +15 V dc at 100 mA and −15 V dc at 50 mA and on-board monolithic voltage regulation is provided.

CIRCLE NO. 324

Enjoy the good life in Florida...with a rewarding future at the ITT LSI Systems Support Center

This recently established, corporate-funded organization is located in West Palm Beach, where the year-round living is all you could ask for. The career opportunity is the ideal complement, because this Center is charged with providing the means for optimum use of LSI in wide-ranging ITT telecommunications, space, defense, automotive and industrial product areas. This scope and challenge dictate the building of a highly qualified, technology oriented, system sensitive professional staff. True ground-floor positions with unusual reach into the future, offering excellent prospects for career advancement, are available to those who qualify.

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If interested and qualified, please send your resume in confidence to Mr. Robert VerNooy, Personnel Manager, ITT LSI Systems Support Center, 3301 Electronics Way, West Palm Beach, Florida 33407.

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CIRCLE NUMBER 122
A New Standard of Keyboard Quality

Grayhill 3x4 Keyboard Pads for data input and telecommunications

2 out of 7 coded output—tested for millions of operations!

- ½" or ¾" button centers
- Excellent tactile and audio feedback
- Patented snap-action dome contact provides rugged, durable performance

These new Grayhill low-profile, 12-button keyboard pads feature a 2 out of 7 coded output, standard mounting dimensions, and are ready for top-side or sub-panel mounting. The contact system is life-rated for 3,000,000 operations per button, and is readily interfaced with logic circuitry. The new Grayhill Series 87 modules offer excellent audio and tactile feedback characteristics with total button travel of only .015". These durable keyboards are molded of tough ABS plastic, feature buttons with black on white molded-in legends as standard, and a variety of other legend options including clear snap-on caps for user legending. Complete specifications and truth table are provided in Bulletin #262, available free on request from Grayhill, Inc.

CIRCLE NUMBER 82

DATA PROCESSING

Versatile PROM programmer takes on all memories

Data I/O, P.O. Box 308, 1297 N.W. Mall, Issaquah, WA 98027. (206) 455-3990. P&A: See text.

Able to program any available PROM, the Model 7 from Data I/O offers the user more than just another universal PROM programmer. To begin with, the Model 7 is a "portable" but line-operated unit, only 6 x 11 x 15 in., and has a wide selection of options and communication capabilities.

In its basic configuration, the Model 7 can program over 200 PROM types. Program-personality modules, which dedicate the programmer to a specific PROM family, plug into an access opening below the front panel. Socket adapters, which match the programmer circuitry to the PROM pinouts, plug directly into the front panel. Thus, generic PROM families from one manufacturer can be programmed with a single personality module and different socket adapters.

This generic programming capability can produce significant savings. For example, the 12 PROMs in the Monolithic Memories generic family can be programmed on the Model 7 at a cost of $400 for one personality module and $600 for 12 $50 socket adapters. Without the Model 7's generic-programming ability, programming the Monolithic Memories family might cost well over $4800. A separate personality module may be required for each PROM in the family.

A modular design enables the Model 7 to communicate with serial or parallel peripheral devices. Serial I/O is ASR33 and RS232-compatible, at 110 to 2400 baud. Parallel I/O operates on a busy/ready basis. I/O interfaces, available to make the programmer compatible with any data terminal, can automatically check for faults in data transmission. And a remote control option lets the programmer work as a computer peripheral.

An expansion option upgrades the unit to a Model 9 by adding direct entry of keyboard data, address and data display of RAM contents, display of error codes, random-addressing capability, and insertion/deletion RAM editing. Also, a 1-k x 8-bit RAM included in the basic Model 7 to hold programs can be optionally expanded to 4 k x 8 in 1-k increments.

Power required for the programmer can be 100 to 240 V ac, 48 to 66 Hz, at 120 VA. Designed to operate over a 0-to-45-C range, the programmer has an optional, 18.5 x 14 x 8-in. carrying case.

Prices for the Model 7 start at $1095 and I/O options up the price by $225. Additional memory costs $50 to $200 more, while conversion to the Model 9 costs $995. Delivery is from stock.

CIRCLE NO. 301

ELECTRONIC DESIGN 6, March 15, 1977
Super floppy claims only 3-ms access time

Wangco Inc., 5404 Jandy Pl., Los Angeles, CA 90066. (213) 390-8081. $500 (small qty); 4 wks.

Said to be twice as fast as any other standard drive, the Model 78 floppy-disc drive boasts a 3-ms track-to-track access time. Other features include optional autoload, double-density capability to 6.4 M bits, GCR encoding, separation of sector and index pulses, low-power drive and daisy chain capability up to eight drives. Two units fit side-by-side into a 19-in. rack.

CIRCLE NO. 325

Portable terminals have fine resolution


The Exexecpor 3000 series are not only the first portable terminals with a 136-column width, but they also have plotting capabilities with a resolution of 240 points per square in. (24 vertical by 10 horizontal). The 1/4-line stepping also permits subscripts, superscripts, and underscoring. The weight (22.5 lb) is the same as for previous models, but the visibility of the print area has been improved. The 3000 series offers built-in couplers, a choice of keyboards, and an RS-232 connection for interfacing with other peripherals.

CIRCLE NO. 326

Emulator board mimics Gould printer/plotter


You can replace a Gould series 5000 printer/plotter with the Varian Statos 4000 series, without having to change software handler, application programs, interface or cables. All you need is the Model 40-340 emulator option to support the full speed capability and high resolution of the Statos printer/plotter in which it is installed. The emulator consists of a single PC board, which mounts in the card cage of the Varian printer/plotter. The cable is I/O plug compatible with the Gould interface. The emulator should be ordered at the same time as the Statos printer/plotter.

CIRCLE NO. 327

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CIRCLE NUMBER 83
Fast static memory expands to 512 kbytes

Cromemco, Inc., 2432 Charleston Rd., Mountain View, CA 94043. (415) 964-7400. See text; 1 wk.

The Model 4KZ is a 4-kbyte static RAM card, expandable to eight banks of 64-kbytes each. The memory operates at 4 MHz to match the Cromemco Z-80 CPU card. The 4-MHz speed of the Model 4KZ is achieved by using an address anticipation strategy, in which on-board address counters are incremented at the end of each machine cycle in preparation for the subsequent cycle. The 4KZ can be organized into as many as eight banks of 64 k each. An eight-position switch on the board is used to select the bank, or banks, in which the board resides. The board is available from computer stores or directly from the factory at $195 for the kit, or $295 assembled.

Fast-access diskette edits, searches strings

Western Telematic Inc., 3001 Red Hill, Bldg. 5-107, Costa Mesa, CA 92626. (714) 979-0363; $2750 (1 to 4); 8-10 wks.

DataMaster II is a flexible disc I/O recorder and editing system that plugs between an ASCII terminal and its RS232 modem. Effectively, it adds 311-k characters to your “working storage.” Random access to any of 2431 lines of 128 characters each averages 0.3 s, and a complete search for strings up to 128 characters takes 12 s per disc. Edit and file-jump commands are accepted either from the unit’s own keyboard, the terminal, or remote processor.

Number always busy?
This phone dials itself

Communications Electronics Specialties, Inc., 2311 E. South St., Orlando, FL 32803. (305) 896-0215. $100; 6-8 wks.

If you suffer from having to redial that same busy number over and over, here is an inexpensive prescription: A telephone that not only gives you pushbutton dialing, but also remembers the last number you called. Just lift the receiver, and there is your party—busy again, most likely. Except for the memory-enable switch, the unit looks like any pushbutton phone, and needs no external power. An optional memory module stores as many as 10 numbers.
INTEGRATED CIRCUITS

Redesigned op amp replaces LM108 units

Precision Monolithics, 1500 Space Park Dr., Santa Clara, CA 95050. Donn Soderquist (408) 246-9222. From $4.50 (100-up); stock.

A totally redesigned 108A low-input-current operational amplifier series directly replaces the popular LM108A/308A series. Key maximum specifications include offset current of 200 pA, bias current of 2 nA, offset voltage of 0.5 mV and power consumption of 18 mW (with ±15-V power supplies). The offset-voltage drift is 5 µV/°C, and offset current drift is 2.5 pA/°C. The PM108A is specified over -55 to +125 C and the PM-308A over 0 to +70 C.

CIRCLE NO. 331

Dual op amp has little crossover distortion

Fairchild Camera and Instrument, Analog Products Div., 461 Ellis St., Mountain View, CA 94042. (415) 962-3816. From $1.15 (100-up); stock.

Able to operate from a single power supply, the µA798 dual op amp virtually eliminates the crossover distortion usually prevalent in single-supply op amps. The µA798 maintains the standard pin-out for dual op amps. It is a high-gain, internally compensated device with an input common-mode range, which includes ground during single-supply operation and V - during dual-supply operation. The device can sink a minimum of 0.35 mA at a 0.2-V output and a 1-V input signal. This is a significant improvement over similar devices that can typically sink approximately 0.01 mA under similar conditions. The µA798 comes in three versions: the µA798HC (commercial grade in a metal can), the µA798HM (military grade, metal can) and the µA798TC (commercial grade, molded DIP).
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INTEGRATED CIRCUITS

Precision dual op amp tops 747 performance

*Precision Monolithics, 1500 Space Park Dr., Santa Clara, CA 95050. Donn Soderquist (408) 246-9222. From $3.70 (100-up); stock.*

The OP-04, a dual matched high performance operations amplifier, provides improved specifications over the industry standard 747. Input offset voltage and common-mode rejection ratio of the two op amps in the 04 are matched to within 1 mV (max) and 94 dB (min), respectively. Key maximum specifications for the individual amplifiers include input offset voltage of 0.75 mV, input offset current of 2 nA and input bias current of 50 nA for the OP-04A and OP-04E. All models are pin-for-pin improved replacements for 747 types in both the hermetic 14-pin DIPs (Y suffix) and 10-lead TO-100 packages (K suffix).

CIRCLE NO. 333

Watch circuits display time in four languages

**Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 996-5000. From $8 (100-up); stock.**

Foreign-language display versions of the ICM7214, five and six-function alphanumeric timekeeping circuits, are now available. The ICM7214, a five-function circuit with alphanumeric capability, provides readout of hours, minutes, day, date and seconds. Its perpetual calendar must be reset only once every four years. The ICM7214A is a six-function version, which also provides a readout of the month. Both circuits interface directly with existing nine-segment LED displays. The foreign versions display the day of the week in German, French, or Italian.

CIRCLE NO. 334

Multiplying converters settle in only 85 ns

*Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Peter Guest (408) 739-7700. From $3.45 (100-up); stock.*

Designated NE5007/8 and SE5088, the multiplying d/a converters handle 8-bit inputs and settle in 85 ns. The 5007/8 units are pin and functionally compatible with monoDAC-08 converters originally introduced by Precision Monolithics Inc. Monotonic multiplying performance in the 5007/8 units is attained over a 40-to-1 reference-current range. Full-scale current is prematched to ±1 LSB. Linearities are as close as 0.19% over the entire operating temperature range, which is -55 to +125 C for the SE5008. Operation from ±4.5 to ±18-V supplies is possible and the units are housed in 16-pin plastic DIPs.

CIRCLE NO. 335

Video i-f circuits give discrete performance

N. V. Philips Gloeilampenfabrieken, Elcoma Div., P. O. Box 523, Eindhoven, the Netherlands, J. Geel.

The TDA2540 and 2541 ICs, designed for color and high-quality monochrome television receivers, contain full video i-f circuitry. They offer performance equal to any discrete solution. The only difference between the two circuits lies in the tuner age outputs: the TDA2540 has an output compatible with npn tuners and the TDA2541 with pnp tuners. Contained in the circuits is a noise protected age detector that generates an age voltage for the i-f amplifier and an age current for the tuner. A built-in afc circuit generates a voltage from the reference signal. It has a range of 10 V and is accurate to within 100 kHz.

CIRCLE NO. 336

ELECTRONIC DESIGN 6, March 15, 1977
Dual line driver made for differential lines

Texas Instruments, P.O. Box 5012, Dallas, TX 75222. Dale Pippenger (214) 238-2011. From $2.12 (100-up); stock.

A dual differential line driver, the SN75158, meets the Electronic Industries Association's RS422 specification. It operates from a 5-V supply, has short-circuit protection and input clamp diodes. Inputs are standard TTL and the outputs provide differential signals with high current capability for driving balanced lines. The output stages are TTL totem-pole types that provide a high impedance state in the power off condition. The SN75158 is characterized for a 0-to-70-C operating range and is offered in either plastic or ceramic 8-pin DIPs.

CIRCLE NO. 337

Multidecade counter delivers parallel BCD

LSI Computer Systems, 1235 Walt Whitman Rd., Melville, NY 11746. (516) 271-0400. $7.50 (100-up); stock to 6 wks.

Able to be used as either a dual three-decade or a six-decade up/down counter, the LS7040 delivers BCD data in parallel. This data format enables off-chip comparisons to be made with a minimum of hardware. The synchronous counter operates from dc to 350 kHz, is equipped with output latches and provides a carry/borrow output for synchronous or asynchronous cascading with another LS7040. The count input may have infinite rise and fall times. All inputs are CMOS, TTL and DTL compatible when the LS7040 operates from 5 V. The circuit operates from a 5-to-15-V-dc supply and comes in a 40-pin DIP.

CIRCLE NO. 339

Image sensors come with 128 to 1728 elements


Two families of line scanners, designated the H series and the G series, are available with 15 µm and 25 µm element-to-element spacings. The G series is offered in 128, 256, 512, 768 and 1024-element configurations and contains on-chip monolithic drivers and video amplifier circuits. And, instead of critical multiphase clocks, the G series units accept signal phase TTL drive. Device architecture is such that cascaded devices readily drive one another for very high resolution applications. The "H" series units come in 1024 and 1728 element formats for high resolution single-chip facsimile and OCR use. Both units also offer on-chip noise cancellation circuittry, which significantly improves the dynamic range otherwise limited by clock glitches.

CIRCLE NO. 338

Standard Grigsby's rotary switches have printed circuit and solderless terminals that will not bend or twist

"YES" - Save the valuable time wasted on straightening the P.C. terminals of rotary switches!

Our exclusive printed circuit "T" terminals are ruggedly designed to allow EASY insertion of our rotary switches into any P.C. board pattern.

If you wire your rotary switches with wire-wrap or other solderless techniques, try a terminal that won't bend or twist... Standard Grigsby's NEW solderless "T" terminal.

Send for Free "Yes" button and literature.

standard grigsby, inc.
920 Rathbone Avenue • Aurora, Illinois 60507
(312) 844-4300

CIRCLE NUMBER 89

ELECTRONIC DESIGN 6, March 15, 1977
POWER SOURCES

Power-supply series offers 1, 2 or 3 outputs

SGR Corp., Neponset Valley Industrial Park, P.O. Box 391, Canton, MA 02021. (617) 828-7773. $49 to $159; stock to 15 days.

Members of the 140 series of power supplies deliver single outputs for logic circuits, dual tracking outputs for power op amps and other function modules, and triple outputs for a/d and d/a conversion. The series contains two economy models that offer line regulation of 0.01% and load regulation of 0.05%. Premium models provide 0.005%-line and 0.02%-load regulation. The plug-in modules operate from 105 to 125 V ac, 50 to 400 Hz and include overvoltage protection. Other features are a transient response of 1 µs and a dynamic output impedance of 1 Ω at 100 kHz.

CIRCLE NO. 340

The hottest news in digital pyrometers is now a cold fact.

from only $250.

Measure temperature accurately at lowest cost with Newport's model 267A digital pyrometer.

Available in 30 measurement ranges with direct inputs from thermocouples or RTD sensors on bright ½" LED's.

Ranges are bipolar with resolution to 0.01° and conformity to ±0.005°C for RTD's and 0.1°C for thermocouples. Changing ranges in the field is made easy with Newport's plug-in polylog linearizer module.

Opto-Isolated BCD outputs are standard while buffered, gated and latched outputs are optional.

Other 267A options include a bench mount all metal case with 1 or 12 switched inputs, rechargeable battery operation, linearized analog output, digital setpoint controller, orange LED display ... and more. The 267A is now available from World Wide distributors, representatives, or factory direct. For immediate response, call (714) 540-4914.

LH Research, 1821 Langley Ave., Irvine, CA 92714. (213) 843-8465. $685 (10-24); 9 wks.

The Model MMX-420 is a two-output switching-regulated power supply that delivers a total of up to 750 W from a package that measures 5.1 x 7 x 12.75 in. Primary output of the unit is 5 V at 150 A. The second output can be any one of the following: 2 V at 24 A, 5 V at 24 A, 12 V at 20 A, 15 V at 20 A, 18 V at 16 A or 24 V at 10 A. The combined power of both outputs is 750 W max. The up-to-80%-efficient device features 1% or 50-mV pk-pk ripple and noise on the output, 0.4% line regulation over the entire input range, and 0.4% load regulation from no-load to full-load. Response is 200 µs to 1% after a 25% load change. The supply operates at full rating from 0 to 40 C and derated to 50% at 70 C. The switcher contains an integral fan.

CIRCLE NO. 341

Line regulators are efficient at all loads

Topaz Electronics, 3855 Ruffin Rd., San Diego, CA 92123. J. Pedlow (714) 279-0111. From $265; stock.

Three series of ac line regulators boast efficiencies greater than 98% from no-load to full-load. The 73000, 75000 and 77000 series offer regulations of ±3.3%, ±5% and ±7%, respectively. These desktop models are primarily intended to protect minicomputers and related equipment from brownouts and other severe voltage fluctuations. Regulators in these series handle power in the 600-to-1600-VA range. Other models are available with ratings through 100 kVA.

CIRCLE NO. 342
3-φ line sentinel has UL recognition

UL recognition has been granted the Model 263 three-phase power monitor. The unit monitors each phase of a three-phase line. Low voltage, loss of phase, or phase reversal causes the device to trip. The trip point is adjustable from the front panel. A trip light is provided. The instrument is stocked in four ranges: 85 to 125 V ac, 160 to 240 V ac, 340 to 480 V ac and 420 to 575 V ac. It is usable on either wye or delta systems.

CIRCLE NO. 343

Unit supplies 14 W and stays cool

Semiconductor Circuits, 306 River St., Haverhill, MA 01830. (617) 373-9104. $86.95 (singles); stock.

The chassis mountable power supply, Model ES12SI200, features a typical case-temperature rise of 15°C above ambient when delivering its full-rated output of 12 V dc at 1.2 A. No derating is required over the -25 to +71°C range. The input can range from 105 to 125 V at 50 to 440 Hz. Regulation is 0.3% for line and load, and output ripple and noise is 7 mV rms. The output responds smoothly to input-power switching and abrupt changes of load. The output terminals float, and the unit has more than 60 dB of line-transient immunity. The output is short-circuit protected by a power-foldback circuit, and the MTBF exceeds 150,000 hours at 25°C under high-line and full-load conditions. The module is 2.5 x 3.5 x 2 in.

CIRCLE NO. 344

LOW COST...UL approved, 6 amp, SPDT, Printed Circuit Relay

Model BC69 relay was designed for use in vending machines, air-conditioning controls and other lighting and switching applications. It is available in a wide range of coil voltage from 1.5 V dc to 48 V dc.

Call Virgil Simpson, Mike Altman or write for a data sheet and free samples.

Available from stock at Hamilton-Avnet.

The way to say Quality Relay...BABCOCK Military/Aerospace/Commercial

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CIRCLE NUMBER 92

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with Eternacell® Lithium Batteries

There's a new technology in primary batteries. It's called the Eternacell Lithium Battery. Or Eternacell for short.

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- -65°F to 160°F performance
- Up to 10 years shelf life
- Highest energy and volume density of any battery system
- 1/2 to 30 amper-hour cell sizes in production quantities
- Stable voltage output

CIRCLE NUMBER 93

Janco
PUSH BUTTON ROTARY SWITCHES

Unique by virtue of their simplicity, Janco Push Button Rotary Switches function accurately and quickly in the most adverse environmental conditions and are "right on the button" for high density packaging.

Available in Bi-directional and Uni-directional models in 8, 10, 12 and 16 positions in all standard coded outputs with a wide variety of custom features. Qualified to MIL-S-22710.

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CIRCLE NUMBER 94

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PM and SHUNT-WOUND
adjustable speed drive systems

Catalog CDC-PM describes
PM systems, 1/12-1/4 Hp. 20
pages, 57 drawings, photos
and tables.

CDC-SH describes
shunt-wound systems,
1/50-1/4 Hp. 16 pages, 51
photos, drawings and tables.

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ability and performance you might ex-
pect only from far more costly and
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CIRCLE NUMBER 95

Have it your way.

Toggle, pushbutton, rocker handle... snap-in or standard panel mounting... quick-on or screw terminals—you can have our famous Type J breaker any way you please.

It's still the standard hydraulic-magnetic breaker that revolutionized circuit protection for electronic and electrical gear drawing up to 30A ac or dc. And the optional special circuits (relay, shunt, Du-ConTM, high-inrush, no-voltage-trip, etc.) extend the Type J's usefulness well beyond its prime function of precision overcurrent protection—protection that adds value to your product.


HEINEMANN
We keep you out of trouble.

CIRCLE NUMBER 96

ELECTRONIC DESIGN 6, March 15, 1977
Zener diodes absorb very fast transients

$3.35: 1N5555 (250 up); stock; 4 wks.

A transient-absorption zener-diode, the TAZ, has an extremely fast response time of 10^-12 s and a very high surge-handling capability of 1.5 kW for less than 10^-12 s. The zener series is available in the hermetically sealed DO-13 case—JEDEC series 1N5555 to 1N5558, 1N5629 to 1N5665A and 1N5907—and covers a range of 6.2 to 200 V. Because of the fast response time, protection characteristics and high discharge capability, the TAZ units have a wide application range.

CIRCLE NO. 345

Power Darlington driven directly from ICs

NEC America, Inc., 3070 Lawrence Expressway, Santa Clara, CA 95051. (408) 738-2180.

NEC’s line of 2SD4XX/4YY low-frequency amplifier and low-speed switching transistors are npn silicon power Darlington devices that can operate directly from IC outputs without predrivers. The Darlington devices feature high-breakdown voltage and low collector saturation voltage. Common applications include hammer, pulse-motor and relay drivers. The 2SD405/410 series is particularly useful in printers, and the 2SD411/412 series is for automotive ignition and similar high-voltage applications.

CIRCLE NO. 346

Power transistors handle 175 W

International Rectifier, 233 Kansas St., El Segundo, CA 90245. (213) 322-3331. $7.45: 2N6546, $10.70: 2N6547 (100-999); stock.

A new series of npn power transistors, 2N6546 and 2N6547, rated for 175-W operation features exceptionally fast inductive switching even at elevated temperatures. The transistors have maximum fall times of 0.71 µs at 10-A peak collector current and 100-C junction temperature. The units can operate at 850 V (collector to base) with a peak-collector current to 30 A. The transistors are packaged in JEDEC TO-3 metal cases. DC current gain for the 2N6546 is 12 to 60 at 2 V (collector-emitter) and 5-A collector current. Gain for 2N6547 is 6 to 30 at 2 V and 10 A. Inductive switching times for both types is just 5 µs at 10-A collector current and 100-C case temperature.

CIRCLE NO. 347

TRY OUR CERAMIC CAPACITORS FOR size... ...AND cost savings

Need a subminiature or standard ceramic capacitor? Try us for size. With over 40 formulations, we offer the widest range of ceramic capacitors within the industry and off-the-shelf and custom capacitors are available with a capacity range of 1 pF to 10 mFd. Multi-layer, single-layer chip capacitors, conformal-coated leaded devices, glass sealed ceramic capacitors and discoidal ceramic capacitors are available as small as .050” x .040” or as large as .500” x .500”...try us for size.

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CIRCLE NUMBER 97

ELECTRONIC DESIGN 6, March 15, 1977
Think of the expense and time involved in designing and building your own power supply, and how those resources can be applied to designing and building other components. Now think about the exclusive Arnold Magnetics “Design-As-You-Order” system. You simply order your custom power supply from proven “off-the-shelf” sub-modules ... no engineering charges, no lost design time. Just fill in our “easy-to-use” specification form, we’ll do the rest. Your miniaturized, high-efficiency power supply arrives encapsulated and pre-tested.

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Culver City, Ca. 90230 • (213) 870-7014

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**PACKAGING & MATERIALS**

### Flat-cable connector comes fully assembled

**AP Products**, 24500 Chagrin Blvd., Cleveland, OH 44122. (216) 464-3636. $24 (1000); stock.

Cable-connector assemblies with the flat cable of your choice plug directly into 26-pin shielded receptacles made by 3M, Berg, AMP and others. The glass-filled nylon connectors have probe holes, and balanced-force floating contacts. They are compatible with high-speed (1.5 ns/ft) ribbon cables. A two-ended cable assembly runs $24 plus the cost of the cable, in 1000-quantities.

**CIRCLE NO. 348**

### Cables meet EIA RS232C specifications

**International Data Sciences**, 100 Nashua St., Providence, RI 02904. (401) 274-5100. See text; stock-30 days.

The 8520 series of 25-conductor cables meets the Electronic Industries Association’s RS232C specification. The cable length and connector sexes on each end can be specified. One cable having a 25-ft long conductor with a male connector on one end and female on the other, costs $27.50 in single qty (Model No. 3520-25-MF).

**CIRCLE NO. 349**

### These plastic trays give you no static

**Wescorp**, 1501 Stierlin Rd., Mountain View, CA 94040. (415) 969-7717. From $10 (1-25); 3 wks.

Wescorp has added seven new configurations to the award-winning “Scat” line of trays, designed to prevent static failure of microcircuits during manufacture or storage. Anti-static trays range in size from 1-5/8 to 9-in. dimensions, with 3 to 9 compartments per tray. Wall thickness is 40 mils. The transparent polystyrene contains a permanent agent that interacts with atmospheric moisture to produce a conductive surface coating. Therefore no conductive particles can flake off the trays.

**CIRCLE NO. 350**

### Heat-shrunk jackets encapsulate splices

**Niemand Co.**, 45-10 94th St., Elmhurst NY 11373. Bob Harris (212) 592-2300. 3-4 wks.

A versatile, convenient cap for moisture-sensitive wire splices consists of a heat-shrinking Mylar jacket with a heat-expanding liner. After a few seconds at 200 to 250 F, the End-Capsulator is completely filled with a thermoplastic polymer. The forces created by the shrinking cap and expanding liner cause the liner to flow in and around the splices, forming a waterproof seal.

**CIRCLE NO. 351**

### Reliable DIP socket keeps low profile

**Textool Products Inc.**, 1410 W. Pioneer Dr., Irving, TX 75061. (214) 259-2676. See text; stock.

The compact “Low Side” DIP socket requires up to 15% less board area than similar sockets, and features low-insertion force contacts for damage-free loading and unloading. Since the contacts do not extend above the top of the socket, they are protected from possible bending or breaking. The low sidewalls leave the device body exposed for better heat dissipation and more uniform airflow, but are high enough to act as a guide for devices with bent or distorted leads. A center slot accepts all current loading and unloading tools. The polysulfone body tolerates up to 300 C. In quantities of 10,000, the sockets costs 74¢ and 81¢ each for 14 and 16-pin versions, respectively.

**CIRCLE NO. 352**
Screen printer speeds thick-film deposition


The Model 505 thick-film screen printer provides stable operation with tolerances in all three axes within ±0.001 in. Conductors, glasses, resists, or epoxies can be applied at a rate of 400 pieces per hour, in semi-automatic operation. When fully automated, production rates can reach 3000 pieces per hour. The Model 505 accommodates a square print area up to 2-7/8 in. It consists of the printer (15 X 30 x 19 in.) and a controller (12 x 18 x 20 in.) that provides pre-programming of power flooding, double printing and squeeze up/down adjustment.

CIRCLE NO. 353

Card cage holds 23 PC boards in 19-in. rack

Garry Manufacturing Co., 1010 Jersey Ave., New Brunswick, NJ 08902. (201) 545-2424. $1 to $2 per card position; 2-4 wk.

A rack assembly, called the ECM 72 series, holds up to 23 PC boards measuring 4.375 x 4.862 in. The board center-to-center spacing is 1.2 in. The over-all rack length is 19 in. The rack assembly also holds a 23-connector back panel. Each card connector has 35 contacts with two wire-wrapable posts per contact.

CIRCLE NO. 354

Cases offer custom look at bargain cost

Instant Instruments, 306 River St., Haverhill, MA 01830. E. Eastman (617) 373-9280. From $12.90 (1-9); stock.

A new series of custom-look instrument cases at bargain prices is available in two configurations. The PV-series has a handle that doubles as a stand, while the NV-series does not. Each case consists of black-textured 0.090-in. aluminum covers with 0.063-in. brush-anodized aluminum front and back panels that are easy to remove and punch. Six sizes are currently available.

CIRCLE NO. 355

C. Itoh means excellence in Digital Printermatics.
NEW
ULTRA WIDEBAND AMPLIFIER

Model 1W1000
1 to 1000 MHz
1 Watt Linear

Here's a unique, all-solid-state amplifier that delivers 1 watt of swept power output from 1 to 1000 MHz instantaneously. It's the Model 1W1000 from Amplifier Research. A reliable, unconditionally stable unit, the new Model 1W1000 provides 1 watt of linear power over three decades of bandwidth.

Its performance is matched only by its versatility. For example, Model 1W1000 can be used with high-level sweepers, VSWR measuring systems and network analyzers. It's also used to increase the sensitivity of spectrum analyzers, oscilloscopes and wideband detector systems. It has all the bandwidth you'll ever need. For complete information, write or call:

Amplifier Research
160 School House Road
Souderton, PA 18964
215-723-8181

CIRCLE NUMBER 102

FUNCTION GENERATOR COMES WITH OUTPUT METER

Philips Test & Measuring Instruments, 400 Crossways Park Dr., Woodbury, NY 11797. (516) 921-8880. $675; 6-8 wks.

A new multifunction generator (sine, triangle and squarewave waveforms), the PM 5108L, offers a frequency range of 1 Hz to 1 MHz, and two outputs of 50 and 600-Ω impedance. A calibrated output meter and fixed attenuators of 20 and 40 dB are also standard. The PM 5108L includes ±5-V-dc offset and an external sweep input with which the output signal can be modulated in many ways. The function generator is short-circuit proof. The output meter is calibrated in both volts and decibels. The PM 5108L has six ranges of frequency selection plus a vernier dial.

CIRCLE NO. 356

BIT-ERROR SET DETECTS ERRORS AT 325 MHz

Tau-Tron, 11 Esquire Rd., North Billerica, MA 01862. (617) 667-3874. MB-301, $600; MN-301, $3900; 8-10 wks.

The MN-301 transmitter and MB-301 receiver form a state-of-the-art pseudorandom generator and error-rate detector pair for use from 1 to 325 MHz. The MN-301 provides for two different PN sequence lengths, a fixed test pattern and local or remote error injection. The MB-301 receiver features automatic synchronization, variable threshold adjust and a four-digit counter and display, which allows for totalize, autorange bit-error rate or manual range BER. In addition, the counter features BCD printer output and can be used as an independent frequency or time-rate counter.

CIRCLE NO. 357

INSTRUMENTATION

CIRCUIT NO. 359

Four-digit DVM is computer compatible

McKee-Pedersen Instruments, P.O. Box 322, Danville, CA 95032. (415) 937-3630. $350.

The MP-1045 four-digit DVM features a 14-bit BCD output and can be remotely controlled with logic levels. All necessary data and control lines are available for interfacing the DVM with a computer or peripherals such as a printer. Data can be transferred in byte-parallel or in serial form. Three calibrated and three variable input ranges go from ±0.3000 to ±30.00 V full scale. The variable ranges allow you to adjust meter readings to correspond to pH units, absorbence, etc.

CIRCLE NO. 358

BROADBAND AMPLIFIERS DELIVER UP TO 50 W

Ailtech, 19535 E. Walnut Dr., City of Industry, CA 91748. (213) 965-4911. 2020, $4475; 5020, $4175; 6 wks.

Two new solid-state wideband amplifiers cover the 1-to-200-MHz frequency range. Model 2020 features a linear output of 20 W with up to 35 W available. Model 5020 features linear output of 50 W with up to 75 W available. The units are usable from 500 kHz to above 225 MHz. Designed to be driven by signal sources such as milliwatt sweepers and frequency synthesizers, Models 2020 and 5020 feature a true directional wattmeter to measure forward and reflected power delivered to the load.

CIRCLE NO. 359

Electronic Design 6, March 15, 1977
INGENUITY
in creating Stepper Motors.

Like our Model LMS: 7½° step angle. Torque ranges to 10 oz. in. at 75 P.P.S. Start-stop rates of 450 steps/second. Slew capability to 1100 steps/second.

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ONLY VISHAY GIVES YOU
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VISHAY

CIRCLE NUMBER 103
CIRCLE NUMBER 105
CIRCLE NUMBER 104
CIRCLE NUMBER 106
AUTHOR'S GUIDE

If you've solved a tricky design problem, if you have developed special expertise in a specific area, if you have information that will aid the design process... share it with your fellow engineer-readers of Electronic Design.

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Circle No. 250

CIRCUIT勢 NUMBER 360

COMPONENTS

Solid-state relay features low cost

International Sensor Systems, P.O. Box 345, Industrial Park, Aurora, NE 68818. (402) 694-6111. $8.50 (50 up), $3.50 (10,000 up).

A low-cost optically isolated solid-state relay, Model 750A, features TTL compatible inputs, no contact bounce, DIP packaging, no moving parts and solid-state speed and reliability. Input/output isolation is 1500 V ac over an operating range of -55 to 100 C. The relay will typically handle a 0.5-A-dc load current with a control current of 15 mA at 2.7 V dc. The off-state breakdown voltage across the output is greater than 60 V dc. Hybrid thick-film technology ensures an input-output isolation resistance of greater than $10^{10}$ Ω.

CIRCLE NO. 360

Miniature attenuator pad is multiturn unit

TRW, 2801 72nd St. N., St. Petersburg, FL 33733. (813) 347-2181. $2.40 (1000 up).

A low-cost miniature multiturn bridge-T pad with 75 Ω ±20% impedance (input and output) featuring five adjustment turns (1800°), provides better resolution than single-turn attenuators. The resistive pattern on the ceramic substrate of the device is a metal glaze that provides four to five times the temperature stability of carbon composition, according to TRW. Type 9950 mounts horizontally; Type 9955 mounts vertically; and each is 11/16-in. rectangular. They provide attenuation from 0.25 to 20 dB over a frequency range from dc to 300 MHz; power rating is 0.125 W at 20 C; and operating temperature range is -55 to 125 C.

CIRCLE NO. 361
12-button keyboard supplies 2-of-7 code

Grayhill, Inc., 561 Hillgrove Ave., La Grange, IL 60525. (312) 354-1040. $7.07: 0.5 in., $7.70: 0.75 in. (100 up); 4 to 6 wks.

- Low profile, 12-button Series 87 keyboard pads feature a 2-out-of-7 (row/column) coded output. Suited for telecommunication applications, the compact keyboard is arranged in a 3 x 4 button array and is available with either 0.5 or 0.75-in. button centers. The keyboard's contact system is rated for 3-million operations per button. The contacts have excellent audio and tactile feedback characteristics with a total button travel of only 0.015 in. Molded-in legends are standard for numbers 1 through 9 on the first three rows and *, 0 and # on the bottom row. Switches may be ordered with clear snap-on caps for user legending.

CIRCLE NO. 362

Ultra-stable capacitors meet MIL-C-55514

Reliable Capacitors, 7409 Bellaire Ave. N., Hollywood, CA 91605. (213) 983-1970. $0.79: 316 pF at 1% (1000 up); 4 to 6 wks.

- Ultra-stable polystyrene wrap-and-fill capacitors exhibit only a 1% capacitance change at -55 C and 0.5% at 85 C. The dissipation factor varies from 0.05% to 0.06% between -55 and 85 C. Voltage derating is 50% from -65 to 85 C. Insulation resistance is 10^6 Ω at 25 C and 10^4 Ω at 85 C. The capacitors meet MIL-C-55514. Models are available from 100 pF through 2 µF.

CIRCLE NO. 363

Parallel Entry Printer

Prints 3 lines per second, 11 character locations per column with a capacity up to 16 columns. Print mechanism is small (5¼" x 10" x 8").

Options available: Serial or parallel BDC interface
Power supply Attractive case

With the addition of calculator logic, it becomes our "Intelligent Printer".

Write for catalog of Addmaster computer peripherals.

CIRCLE NO. 363

SpaceSaver: New RCA Flameproof Film Resistor Kit

Introducing RCA’s convenient, preloaded and prelabeled Flameproof Resistor Kit containing a wide range of the most-needed, standard value resistors in ½, 1 and 2 watt ratings. Two of each rating for a total of 330 resistors; all ±2% tolerance. Packed in a sturdy metal-frame cabinet for easy availability.

Service Technicians prefer RCA Flameproof Film Resistors because of their inherent safety characteristics. Design Engineers prefer them because they won’t flame or short even under severe conditions. Look to RCA — your best single source for a complete line of flameproof film resistors.

Contact your authorized RCA Parts Distributor for all the details, or write to RCA Distributor and Special Products Division, 2000 Clements Bridge Road, Deptford, NJ 08096.

CIRCLE NUMBER 109

CIRCLE NUMBER 110
Atlantic's patented planar investment casting process provides high production rates and true precision control. The process combines the best features of Plaster Mold and traditional Investment Casting. Almost any shape or contour is possible. No order is too big or too small. Delivery in 3 to 5 weeks from Atlantic...the only producer of both investment castings and plaster mold casting serving the industry today.—Literature available.

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Application Notes

Vector voltmeters
Various methods in which a vector voltmeter may be used, such as scattering-parameter, phase, amp-gain, harmonic, group-delay and component measurements, are covered in a 12-page paper. PRD Electronics, Syosset, NY

V/f and f/v converters
Applications bulletin AN-20 discusses solving your measurement problems with v/f and f/v converters. Teledyne Philbrick, Dedham, MA

Impatt diodes
Details of the design procedure for waveguide and coaxial amplifiers using HP Impatt diodes are given in an application note. Circuit drawings and design-aid graphs are included. Hewlett-Packard, Palo Alto, CA

Passive filters
Applications information as well as a tutorial look at the design of passive filters and their functions are found in "Using Passive Filters." Comatron Seg, Freeport, NY

Q standards
The theory and technique for design and construction of 1-MHz capacitive Q standards are described in a 10-page application note. Boonton Electronics, Parsippany, NJ

Spectrum analyzers
"Notes on Spectrum Analysis," a 22-pager, discusses the important design and operational features concerning spectrum analyzers. A simple-to-follow question-and-answer format is used. Ailtech, Farmingdale, NY

Vendors Report

Annual and interim reports can provide much more than financial position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

Solid State Scientific. CMOS, memories, CBs, mobile communication and photo-mask fabrication.

Sykes. Data storage systems.

Wyl Corp. Data communication services.

WUI. International and domestic communications.

Unitrode. Power semiconductors.


Anderson Jacobson. Data-communications equipment, keyboard-printer computer terminals and small business computer systems.

Comten. Communications computer systems and computer performance evaluation products.

Data 100. Data processing terminal systems.
Microcomputers
An eight-page brochure describes the Mini-Micro Designer, MMD-1 education and development µC and its optional accessories. E&L Instruments, Derby, CT

Instrumentation recorder
Features and specifications of the Ana-log 714 instrumentation recorder can be found in a 24-page catalog. Philips, Eindhoven, the Netherlands.

Power supplies
Electrical and mechanical parameters on more than 180 power supplies are detailed in a 40-page handbook. Datel Systems, Canton, MA

Arc lamp power supplies
Xenon-and-mercury-arc lamp power supplies are described in a four-page brochure. Specifications are given as well as applications in the following areas: optical instrumentation, image projection, graphic arts and medical. Electronic Measurements, Neptune, NJ

Video equipment
Closed-circuit TV cameras and video products are highlighted in an eight-page brochure. RCA Solid State Div., Somerville, NJ

Rack, panel connectors
Input/output rack and panel connectors are covered in a 32-page catalog. Elco, Huntingdon, PA

Int'll switch approvals
The complexities of national standards covering snap-action switches are dealt with in a 16-page handbook. Procedures for application, specifications, markings, creepage and clearance distances and electrical-life requirements are covered. Copies may be obtained by sending $2 in cash, check or money order to Cherry Electrical Products, P.O. Box 718, Waukegan, IL 60085

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ELECTRONIC DESIGN 6, March 15, 1977

137
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Components
- Electronic components, transformers, electronic tools, test equipment, hardware and other related items are featured in a 64-page catalog. Mouser Electronics, Lakeside, CA

Test equipment

The rental and lease of mobile communications test equipment are covered in a six-page brochure. Metric Resources, Burlingame, CA

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Technical descriptions, drawings, specifications and major advantages for off-the-shelf MIC products are covered in a 40-page catalog. Tek-wave, New Hyde Park, NY

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Technical and operational specifications on over 40 photodiodes are given in a 12-page catalog. Physical specifications and electrical characteristics along with applications data are covered. Quantrad Corp., El Segundo, CA

Industrial controllers

Specifications, physical characteristics and options of industrial controllers are detailed in a catalog. Theta Instrument, Fairfield, NJ

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Sizes and properties of sheet stock and foil for magnetic shielding are given in a four-page catalog. The catalog gives the physical parameters of Eagle’s alloys, the dc and ac magnetic properties of each, machining and drilling speeds and suggestions for welding, soldering and annealing. Eagle Magnetic, Indianapolis, IN
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