Choosing rf connectors blindly can cost you dearly. Not all jobs need impedance matching. And connectors have less loss and rf leakage than most cables.

But when needed, precision units abound. Solder, clamp or crimp? Bayonet, threaded or self-locking? Choices must be made. Make them without blindfolds. P. 60.
Unique wrap-around wiper offers superior setting stability...

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

Bourns multi-fingered, wrap-around wiper design delivers more consistent, more reliable performance. More stable during setting... more stable in your circuit.

The unique wrap-around design significantly reduces CRV fluctuations and open circuit problems due to thermal and mechanical shock... by maintaining a constant wiper pressure on the element. As you can see in the enlarged photograph of a sectioned single-turn trimmer, the wiper is shaped so that its upper section works somewhat like a lever arm, keeping the contact fingers under constant tension.

Bourns wrap-around wiper design is essentially self-aligning and self-retaining. Therefore, more reliable... because there is very little chance of error during manufacture. Designs that do not "wrap-around" usually require very critical heat-staking procedures to lock the wiper into a plastic slot in the rotor (slider). Our tests indicate that such designs are much less resistant to thermal and mechanical shock, and are often mis-assembled.

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™... a revolution in trimmer reliability

Bourns exclusive Swage-Bond process virtually eliminates pin termination failure... and provides a marked improvement in temperature coefficient consistency. In the Swage-Bond process, the P.C. pins are secured through the trimmer substrate, with a high-pressure compression swage on both the top and bottom sides. The pressure locks the pins solidly into the element, and thoroughly bonds them to the termination material. Compare Swage-Bond™ to less reliable clip-on termination designs.

The seal that seals... without springback

Bourns trimmers stay sealed when others fail. We know. We've tested them all. Bourns uses a chevron-type sealing technique, that seals without 0-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.
We built in the decoder/driver so you don't have to.

Not only the decoder driver but memory too!

HP's family of integrated displays was designed with an on-board IC to save you time and up to 50% of the space required by conventional LED display systems. These bright 0.29 inch high, shaped character displays are completely TTL compatible. All you do is address them directly with four-line BCD input.

HP's 5082-7300 series displays include numeric displays with right- or left-hand decimal points, a hexadecimal display (0-9, A-F), and a "±1" polarity/overflow indicator.

For immediate delivery of any quantities you need, call Hall-Mark, Schweber, Wilshire, or the Wyle Distribution Group (Liberty/Elmar) today.
TO-5 RELAY UPDATE:
Solve your energy crisis with TO-5 relays

Subminiaturization and pc board compatibility — two obvious advantages of Teledyne TO-5 relays. But there’s another outstanding advantage: low coil power consumption. This feature is best illustrated in the above graph which shows our TO-5 relay power savings compared to other miniature relays. The Teledyne 412 Series dissipates about 30% less power than the .150" grid relay, and 50% less than the ½ crystal can. Our sensitive 432 Series is 65% less than the .150" grid. And 75% less than the ½ crystal can.

This means you can save over 6 watts in a typical system using, let’s say, ten TO-5 relays. In the end, you gain significant advantages in terms of thermal and power supply considerations that can help prevent an “energy crisis” in your system.

Our complete line of TO-5 relays includes military and commercial/industrial types, with virtually all military versions qualified to established reliability MIL specs. For complete data, contact Teledyne Relays — the people who pioneered the TO-5 relay.

• Hybrid "T" Series
  SPDT & DPDT types with internal transistor driver and suppression diode

• "D" and "DD" Series
  Military and commercial/industrial versions with internal suppression and steering diodes

• Maglatch Series
  SPDT, DPDT, and 4PST magnetic latching types

• Centgrid® Series
  World’s smallest relay — only .225" (5.72mm) high x .370" (9.40mm) square

• Hi-Rel Series
  Screened versions for space flight applications (NASA qualified)

• High Environment Series
  Hi-temperature, Hi-shock, and Hi-vibration types

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

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Electronic Design 11, May 24, 1976
Tektronix offers an unmatched selection of performance and value leading portable oscilloscopes. Wherever and whatever your portable oscilloscope application, you can choose the best cost/performance/weight combination for your needs from our comprehensive line of 16 models. These include the industry standard 465 (line 6 of the table) and such unique products as the 350 MHz 485, the 466 fast transfer storage oscilloscope with a 1350 cm/µs stored writing rate, the 3.5 pound 213 which combines a full function DMM with an oscilloscope, and 7 other extremely lightweight 200 and 300 series models.

**Maximum Portability**
The wide bandwidth (up to 350 MHz), dual-trace, delayed sweep 400 Series offers seven high performance models for complex measurements on such systems as computers, communications gear, and radar. At 21 to 26 pounds, this series provides excellent performance and weight characteristics.

Tektronix offers the most compact, lightweight line of oscilloscopes anywhere with the 200 Series at 3.5 pounds and the 300 Series at 7 to 10.5 pounds.

**Storage Leadership**
The world’s fastest direct view storage is provided by the 466 which stores even single-shot events at its full 100 MHz bandwidth. Tektronix also offers the lightest weight storage by a wide margin with the 500 kHz 214 Portable Storage Oscilloscope at 3.5 pounds and the 10 MHz model 314 at 10.5 pounds.

**A Choice of Numerical Readout Models**
Only Tektronix gives you a choice of four portable oscilloscopes with direct numerical readout of displayed time intervals (464 DM43, 465 DM43, 466 DM43, 475 DM43). In addition to providing faster, more repeatable, easier timing measurements, these models also measure dc volts, ohms, and temperature.

**Ruggedness for Field Use**
To insure reliable operation under the rough handling and hostile environment encountered in the field or in production areas, TEKTRONIX Portable Oscilloscopes must pass stringent shock and vibration tests as well as subjection to extremes of temperature (-15° to +55° C) and humidity. They are also designed for minimum temperature rise to insure maximum component life.

**Highest Bandwidth of Any Portable**
Portable oscilloscope bandwidth is extended to 350 MHz at 5 mV/div by the 485. The highest gain-bandwidth of any portable is achieved by the 475 with 200 MHz at 2 mV/div. Both are excellent choices for measurements on fast logic signals.

**Performance**
For All Your Portable
Leadership
Oscilloscope Needs

Widest Selection of Portable Oscilloscopes

<table>
<thead>
<tr>
<th>Product</th>
<th>BW</th>
<th>Dual Trace</th>
<th>Delayed Sweep</th>
<th>Fastest Sweep Rate</th>
<th>Other Special Features</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Models</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>466 &amp; 464</td>
<td>100 MHz @ 5 mV/div</td>
<td>yes</td>
<td>yes</td>
<td>5 ns/div</td>
<td>Stored writing speed to 1350 cm µs</td>
<td>$4600/3850</td>
</tr>
<tr>
<td>434</td>
<td>25 MHz @ 10 mV/div</td>
<td>yes</td>
<td></td>
<td>20 ns/div</td>
<td>Split screen storage</td>
<td>$3000</td>
</tr>
<tr>
<td>314 (NEW)</td>
<td>10 MHz @ 1 mV/div</td>
<td>yes</td>
<td></td>
<td>10 ns/div</td>
<td>Only 10.5 lbs.</td>
<td>$2235</td>
</tr>
<tr>
<td>214</td>
<td>500 kHz @ 10 mV/div</td>
<td>yes</td>
<td></td>
<td>1 µs/div</td>
<td>Only 3.5 lbs.</td>
<td>$1350</td>
</tr>
<tr>
<td><strong>Nonstorage Models</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>485</td>
<td>350 MHz @ 5 mV/div</td>
<td>yes</td>
<td>yes</td>
<td>1 ns/div</td>
<td>Widest BW in a portable</td>
<td>$4900</td>
</tr>
<tr>
<td>475</td>
<td>200 MHz @ 2 mV/div</td>
<td>yes</td>
<td>yes</td>
<td>1 ns/div</td>
<td>Highest gain-BW in a portable</td>
<td>$3200</td>
</tr>
<tr>
<td>465</td>
<td>100 MHz @ 5 mV/div</td>
<td>yes</td>
<td>yes</td>
<td>5 ns/div</td>
<td>Cost effective for 100 MHz BW</td>
<td>$2145</td>
</tr>
<tr>
<td>455 (NEW)</td>
<td>50 MHz @ 5 mV/div</td>
<td>yes</td>
<td>yes</td>
<td>5 ns/div</td>
<td>Cost effective for 50 MHz BW</td>
<td>$1745</td>
</tr>
<tr>
<td>335 (NEW)</td>
<td>35 MHz @ 10 mV/div</td>
<td>yes</td>
<td>yes</td>
<td>20 ns/div</td>
<td>Only 10.5 lbs.</td>
<td>$1875</td>
</tr>
<tr>
<td>326</td>
<td>10 MHz @ 10 mV/div</td>
<td>yes</td>
<td></td>
<td>100 ns/div</td>
<td>Only 10 lbs.</td>
<td>$1875</td>
</tr>
<tr>
<td>323</td>
<td>4 MHz @ 10 mV/div</td>
<td></td>
<td></td>
<td>500 ns/div</td>
<td>Only 7 lbs.</td>
<td>$1300</td>
</tr>
<tr>
<td>221</td>
<td>5 MHz @ 5 mV/div</td>
<td></td>
<td></td>
<td>100 ns/div</td>
<td>Only 3.5 lbs.</td>
<td>$900</td>
</tr>
<tr>
<td>213 (NEW)</td>
<td>1 MHz @ 20 mV/div</td>
<td>yes</td>
<td></td>
<td>400 ns/div</td>
<td>DMM/Oscilloscope @ 3.7 lbs.</td>
<td>$1350</td>
</tr>
<tr>
<td>212</td>
<td>500 kHz @ 10 mV/div</td>
<td>yes</td>
<td></td>
<td>1 µs/div</td>
<td>Only 3.5 lbs.</td>
<td>$950</td>
</tr>
<tr>
<td>032 (NEW)</td>
<td>10 MHz @ 10 mV/div</td>
<td>yes</td>
<td></td>
<td>100 ns/div</td>
<td>Low cost for 10 MHz dual-trace &amp; battery</td>
<td>$750</td>
</tr>
</tbody>
</table>

**Time Interval Readout**

DM43 Optional direct numerical readout of time intervals and DMM functions for 464, 465, 466, and 475 models. $395

Let Us Show You

For a demonstration of how one of the above Portable Oscilloscopes can achieve results in your application, contact your Tektronix Field Engineer. Or for our latest Portable Oscilloscope brochure write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077. In Europe write: Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

U.S. Sales Price FOB Beaverton, Oregon

Tektronix® committed to technical excellence

FOR TECHNICAL DATA CIRCLE #261
FOR DEMONSTRATION CIRCLE #262
A Smart Way to Beat Your Power Supply Size Problem

yet this converter produces 1000 volts DC, regulated, from a battery input of 28 VDC! It weights less than 15 ounces.

MIL SPEC ENVIRONMENT — All of the hermetically sealed power modules listed in our new catalog have been designed to meet the severe environmental conditions required by modern aerospace systems, including MIL-STD-810B. They are hermetically sealed and encapsulated in heavy steel containers. New high performance units can meet MIL-STD-461A.

Please see pages 1037-1056 Volume 1 of your 1975-76 EEM (ELECTRONIC ENGINEERS MASTER Catalog) or pages 612-620 Volume 2 of your 1975-76 GOLD BOOK for complete information on Abbott Modules.

Send for our new 60 page FREE catalog.
Historical issue draws raves

Meucci's teletrophone

I want to congratulate you and your editors for the outstanding presentation of the most revolutionary 200 years of technological progress. I have always felt that it is very important for an engineer to know the history and price of progress. It is important to know the social and technical difficulties that our ancestors have encountered along the way.

Knowledge of history should be very strong among managers as well; it will enable them to make more rational and knowledgeable decisions.

I can imagine how hard and frustrating your research has been, I felt the same way during the presentation of my volume on television history. There are cases, however, in which an editor can't report the true facts simply because he consulted material supported by the beneficiary institution.

This is and has been the case with the telephone.

The telephone is 126 years old and it was invented by Antonio Meucci. Meucci was born near Florence, Italy on April 13, 1808. He studied mechanical engineering at the Florence Academy and worked as an engineer until 1835. At that time he went to Havana, Cuba working as a mechanical director and "scenographer" for the Tacon Theater.

In Cuba, in 1849, Meucci filed for the patent on the device that we now call telephone. It was an elaboration of a concept he had developed in 1841. (At that time A. G. Bell was not yet born.) In 1871 Meucci called his device "Teletrophone." At that time he was residing in the U.S. at 420 Tompkin Ave. in Rosebank, Staten Island, where he died in 1899.

Alexander Graham Bell was born in Edinburgh, Scotland in 1847 and he was educated at the University of Edinburgh, London and in Germany. He emigrated to the U.S. in 1871 and worked as professor at Boston University. In 1876 he filed for the patent on the Meucci device.

For more information on the history of the telephone, you can consult: "Antonio Meucci, Inventor of the Telephone" by John Schiavo, published in 1958 by Vigo Press of NY.

Domenico Serafini
U.S. Correspondent
JCE Publications
L.I., NY 11951

Landmark issue

Your "200 Years of Progress" issue is itself a landmark, and all who worked on it deserve much credit. Congratulations!

Frederick T. Van Veen
Teradyne, Inc.
183 Essex St.
Boston, MA 02111

Majority ignored

In reference to your editorial "The Great Men" (ED No. 4, Feb. (continued on page 11)

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

That's just the beginning of the solderless terminal story by AMP.

Featured is Boeing's light rail vehicle being built for Boston and San Francisco.
It’s also many thousands of terminals of all shapes and sizes, each engineered to fill a specific need.

It’s a range of customer application tools—from simple hand models to fully automated termination equipment—to match your production levels.

It’s AMP-engineered dies that produce void-free, contaminant-free crimps that resist shock and critical environments.

It’s nearly 2,000 scientists, engineers, and technical support people around the world ready to help you on production lines, in quality control, in prototype sampling.

It’s all the things we do to assist you on higher performance products and lower installed costs.

Our story never ends—growth and progress never do. Let us show you how your products can benefit from using AMP solderless terminals and the other services that go with them. Call us (717) 564-0100 for a Sales Engineer visit. Or write AMP Incorporated, Harrisburg, PA 17105.
Connections were much simpler 200 years ago. Torch the fuse and the cannon fired.

Supplying the vital spark that makes a modern weapon system do its job is a lot more complicated.

That's where we come in. For many years, primes and OEMs for military and aerospace products have depended on us to provide the vital links in their electronic systems—flat cable, etched circuitry, connectors, and total interconnection systems.

Our high-rel connections have to be the best. They're used in systems like Phoenix, Maverick, Lance, Minuteman, AWACS, F-14, F-15, Space Shuttle, Viking, Sonobuoy, F-4, A-7, Condor, Standard Missle, F-18, AAH, Cruise Missle, F-8, Trident, Hobo, Sprint and many more.

To learn how we can serve your interconnection needs, contact Jack Maranto or Dave Cianciulli: Hughes Connecting Devices, 17150 Von Karman Ave., Irvine, CA 92714.

Or call (714) 549-5701.

Hughes Connecting Devices
ACROSS THE DESK  
(continued from page 7)

16, 1976, your readers undoubtedly join with you in deploring the lack of recognition of "the great men among us."

I am far more deeply saddened that you totally ignore and exclude the achievements and the potential of the majority of the world's inhabitants: women.

Carol E. Lyons  
Chemical Engineer  
Plessey Central Development Laboratories  
3860 Centinela Ave.  
Los Angeles, CA 90066

Ripe nits harvested

I want to compliment you and your staff on the Bicentennial Tribute of your Bicentennial issue, but I also want to pick a few nits from your coverage of the vacuum tube era (1905-1948).

Chronology, p. 98: Edwin Howard (not Albert) Armstrong invented the superheterodyne circuit in 1917-1918, while serving in the Signal Corps, not in 1920.

P. 102: Although Professor Hazeltine's full name was Louis Alan Hazeltine, he usually preferred to drop Louis whenever possible. His invention was the neutrodyne circuit, not tuned-radio frequency.

The first sound film was Lee De Forest's Phonofilm, shown at the Rivoli Theatre, New York, in April, 1923, four years before "The Jazz Singer." Phonofilm was not a commercial success until later, due to equipment and distribution problems.

P. 105: About FM: E. H. Armstrong erected the first FM station in Alpine, NJ during 1938. It was KE2XCC and operated until March 6, 1954. John V. L. Hogan built and operated W2XR, the parent of the present-day WQXR.

Harry E. Fairman  
Consultant

Fairman Associates  
68 Pondview Dr.  
Suffern, NY 10901

A collector's item

Your Bicentennial issue is one of the finest you have put out to date. "200 Years of Progress" was something to see in a trade magazine. It was well laid out, and a lot of thought went into it. Am going to keep it in my library; it will be a collector's item in the future.

Thanks again for the fine job done.  
Donald W. LieVan  
President

LieVan Scientific Research Corp.  
Route 3, Box 4  
Marble Falls, TX 78654

Spectrum analyzers

What a blockbuster your 200 year issue was! And an interesting book, too.

It was fun to read and marvel at the march of progress in the recent years.

The picture of Art Fong and Harley Halverson and their first HP Microwave Spectrum Analyzer was particularly interesting. It did launch HP into spectrum analyzers in a way most of us couldn't comprehend. I did the original market forecast for that product and it was soon outselling the forecast by a factor of 3.5:1. A remarkable blend of old principles and new ideas.

John Minck

Hewlett-Packard Co.  
1501 Page Mill Rd.  
Palo Alto, CA 94304

Misplaced Caption Dept.

What do you mean it's too big?  
It's brighter and cheaper than LEDs.

Sorry. That's Honore Daumier's lithograph, "And that, they have turned down, the ignorant fools!" ridiculing the pretentions of the new "realistic" school.
DO YOU REALIZE ALL THAT CAN HAPPEN INSIDE A CABLE?
THE HORRIBLE THINGS TO YOUR SIGNAL

Cable can distort a signal to the point of uselessness. And because so many variables can affect cable performance, signal distortion is more common than you think.

If, for example, a manufacturer uses poor grade PVC for the dielectric, you’ve got capacitance problems! And no matter how good the materials are, they can’t function properly if the manufacturing tolerances aren’t closely held. And no matter how closely held the tolerances are, you can’t rely on a cable until you’ve tested it. It may be beautiful on the outside, but the inner conductor might look like rigatoni and vary impedance anywhere from 50 to 175 Ohms.

But Don’t Panic, there’s no need to become a cable specialist overnight. That’s why we’re here. We make the best cable in the business...and it doesn’t cost a penny more than the stuff that can get you in trouble.

Ask anybody about our reputation for quality. It’s one we’ve earned...in MATV: Security; RF Microwave Transmission; Data Transmission; and Instrumentation.

If you have a question about the selection of the right cable, give us a call or send for our Transmission Line Handbook and Catalog (TL-6). It combines a full product line with a wealth of engineering and applications data. Even if you’ve got a special problem—no sweat. We’ve got an engineering development capability second to none.

So don’t just specify cable by type. Specify by Times Part number...for the sake of your signal.

Specify the performers. The Standard Products Group, Times Wire and Cable, 358 Hall Avenue, Wallingford, CT. 06492, Phone (203) 265-2361, TWX 710-476-0763. Ready when you are.

TIMES Wire&Cable

SUBSIDIARY OF
Insilco Home Products

CIRCLE NUMBER 10
Checkmated by high pushbutton switch cost?

Check These Centralab Distributors For Three New Ways To Cut Switch Costs

The three new Centralab Pushbutton Switch products shown below are now available from Centralab Pushbutton Switch Distributors. They're low-cost money savers, and yet they offer the same high-quality features of all Centralab switches.

You can get these new products, custom assembled to your specifications, from our factory trained Distributor Switch Specialists.

Contact your Centralab Distributor, listed at the right, for complete details. Ask for a copy of Centralab's New Pushbutton Switch Catalog, Series No. 301.

Visual Display in a Non-Lighted Switch
Status indicator button adds visual display to non-lighted Centralab switches. The button, with a unique fluorescent display, uses reflected ambient light to indicate switch status. 6 display colors. Black or chrome plated buttons. 140° peripheral viewing angle.

Low-cost Lighted Pushbutton Switch
T-1¾, wedge base lamp brings cost down. New options increase harmonized panel aesthetics. Flat or recessed lenses. 8 lens colors. 15mm or 20mm spacing. Switch assemblies to 13 stations.

5-amp Pushbutton Line Switch
UL listed for TV-5 rating: 120V, 5A, 78A peak inrush current. Accepts all Centralab button options.

DISTRIBUTOR PRODUCTS

CHECK YOUR CENTRALAB DISTRIBUTOR.

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San Diego
714/276-2112

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Denver
303/371-6500

FLORIDA
Hammond Electronics
Orlando
305/849-0600

INDIANA
Radio Distributing Co., Inc.
South Bend
219/287-2911

MASSACHUSETTS
Starting Electronics
Woburn
617/926-9720

MINNESOTA
Gopher Electronics Co.
St. Paul
612/645-0241

NEBRASKA
Radio Equipment Co., Omaha
402/341-7700

NEW YORK
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Peerless Radio Corp.
Lynbrook, L.I.
516/593-2121
Summit Distributors, Inc.
Buffalo
716/884-3450

OHIO
ESCO Incorporated
Dayton
513/226-1133
Pioneer-Standard Electronics, Inc.
Cleveland
216/587-3600

PENNSYLVANIA
Cam/RPC Industrial Electronics
Pittsburgh
412/288-2800
Herbach & Rademan, Inc.
Philadelphia
215/426-1700
Pytronic Industries, Inc.
Montgomeryville
215/643-2850

TEXAS
Southwest Electronics Inc.
Stafford
713/494-6021
WASHINGTON
Almac/Stroum Electronics
Seattle
206/763-2300

FOR LOW-COST PUSHBUTTON SWITCHES

CIRCLE NUMBER 11

14

Electronic Design 11, May 24, 1976

ISOSTAT LICENSED
Belden has it: a total service capability. Extensive design and application know-how. What it takes to deliver complex cable configurations, special harnesses, cords, lead wires, and even special packages to fit your requirements.

Our specialists and engineers will meet with your people at your plant to discuss problems in processing, assembly, installation, ordering, human engineering, color coordination, physical and electrical parameters, opportunities for cost reduction. And when we can't help you using standard products, we'll innovate a solution to your problem.

Talk to a Belden specialist about your new applications, product ideas, processing problems—all your wire, cable and cord needs. He has thousands of standard items to draw from. And standard or special, he'll come through with the best wire buy around. For answers right now, phone: 317-966-6661 Electronic Div. or mark No. 400 on reader service card 312-986-1600 Electrical Div. or mark No. 401 on reader service card 312-887-1800 Transportation Div. or mark No. 402 on reader service card, or write Belden Corporation, 2000 S. Batavia Ave., Geneva, IL 60134.
great connections...

RACK AND PANEL CONNECTORS
Our high-density rack and panel connectors have an identical contact in both the plug and the receptacle. This mutually embracing contact, Varicon™️, is hermaphroditic, interlocking and spring loaded. Mating surfaces are gas-tight assuring corrosion resistance. And low contact resistance is inherent in Varicon's contact design. Get Elco rack and panel connectors in sizes ranging from 20 to 165 contacts.

FLAT CABLE ASSEMBLIES
We customize flat conductor cable assemblies to meet your needs. So you don't have to buy cable or machinery. Our complete Flattac™️ cable assemblies require no preliminary stripping, welding or soldering. Their multi-contact high-pressure connections assure low contact resistance and mechanical stability.

2-PIECE P.C. CONNECTORS
These connectors use just 1 contact—the unique, spring-action, mutually embracing, hermaphroditic Varicon™️. Used in both the plug and the receptacle, Varicon's mating surfaces provide a gas-tight connection to protect against corrosion. The design's low contact resistance helps produce high current capacity. And Varicon's interlocking design adds resistance to shock and vibration.
whatever the occasion.

P.C. CARD ENCLOSURES
Versatile Varipak® II card enclosures, available in 32 standard models, are ideal for packaging rows of cards and connectors using almost any card spacing. Varipak allows air flow for long component life. And its modular design makes it adaptable to your special packaging techniques at minimal cost.

BACK PANEL SYSTEMS
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News Scope

MAY 24, 1976

F-16 radar system to contain high-level digital processing

The radar for the Air Force F-16 fighter aircraft breaks a number of frontiers, according to its developer, Westinghouse Defense and Electronic Systems Center, Baltimore, MD.

It uses a higher level of digital processing than any existing fighter aircraft radar; it contains more LSI (off-the-shelf, not custom made); it offers more performance for its weight; it provides more operational modes than any air-to-air/air-to-ground radar; it's more reliable; and it costs less to buy and maintain.

And there are other differences:

- The conventional radar-receiver guard channel and associated circuitry have been replaced by software-controlled processing. The guard channel is normally used to subtract unwanted ground returns in the antenna sidelobes from the radar's return signal.
- Eliminating the guard channel results in a major cost reduction, less complexity, lower weight, and an increase in system reliability.
- Computer software takes the place of conventional radar-track loops, which use rate gyros in the antenna. As a result, tracking accuracy and reliability are increased, and system cost is lowered.
- Software keeps clutter off the scope by continually adapting the target-detection threshold to the varying clutter conditions.
- Fully coherent signal-processing uses digital doppler filters for predetection integration; this results in a highly selective signal-detection sensitivity.
- Digital Fast-Fourier-Transform (FFT) filters are used to measure target doppler.
- All of the radar units will be mounted in the nose of the F-16 fighter except the control panels in the cockpit.

The basic performance parameters of the radar are continuously monitored by the radar-control computer. It uses a digital bus to monitor and test each line-replaceable unit. Faults are reported to the avionic system for display upon command, and a built-in test routine, which interrupts normal radar functions, is initiated. The radar computer automatically executes a sequence of radar tests that isolate 95% of all detected failures to a particular line-replaceable unit.

A planar-array antenna, mechanically gimballed in two axes, was selected "for its good gain and low sidelobes over all scan angles." Westinghouse engineers say the balanced electric-drive system for the antenna is "lightweight, highly reliable and easily maintained."

Built-in test circuitry continuously monitors stable local-oscillator signal levels. The first mixer and the first intermediate frequency (i-f) stage of the receiver will be fabricated with micro-strip microwave-integrated-circuit (MIC) techniques. "This will lower cost, improve reliability, reduce weight and size, and reduce the number of interconnections."

The transmitter contains an air-cooled traveling-wave-tube, a solid-state grid pulser, high-voltage power supplies and regulators, and protection and control circuitry. Air cooling instead of liquid cooling, was selected because of its size and weight advantages and improved reliability and maintainability.

Clutter rejection and other radar signal processing is performed by the digital signal processor, which uses standard ICs mounted in dual in-line packages. Off-the-shelf LSI devices are used. Custom LSI devices were avoided for cost and availability reasons.

The F-16 radar computer is a variant of the Westinghouse millicomputer family. During the full-scale development phase, a semiconductor, ultraviolet-erasable, read-only memory (UVROM) will be used to operate program storage.

Final, production radar systems will use programmable read-only memories (PROMs), which can only be programmed once, but offers lower cost for mature production systems. Temporary scratch-pad memory requirements will be met using volatile, semiconductor random-access memories (RAMs).

Mini-Pak: A successor to the conventional DIP?

A new package for microcircuits that is said to be smaller and easier to mount than the conventional dual-in-line package has been developed by General Instrument Corp., Hicksville, N.Y.

Called Mini-Pak, the package is about 1/2 in. on a side and 1/8 in. thick—about one-third the size of a DIP.

The chip is mounted on top of the Mini-Pak substrate and wire-bonded to conductors that carry the signals from the chip to an array of solder bumps formed on the underside of the package. The chip and bonding wires are protected by a special coating.

The Mini-Pak is attached to a PC board by heating the perimeter of the package and allowing the solder bumps to reflow onto the connections of the PC board.

James Teeple, director of Gener-
Floppy-disc recorder has more storage capacity

A floppy-disc recording unit that has achieved four times the storage capacity of an IBM-format disc drive has been introduced by Burroughs Corp.

The unit is part of the company's new B80 "very small general purpose" computer system.

The floppy-disc unit records data at higher density, and on both sides of a flexible disc, to achieve a one-million byte capacity per diskette. The average random-access time for data stored on the disc is 266 ms. As many as six minidisks may be used on a B80 system, providing a total of six million bytes of on-line disc capacity.

New IC tester offers 1000 programs by phone

Software is as close as the nearest telephone with a new computer-controlled IC tester, from Datatron. Its 400 Series features instant retrieval of more than 1000 device programs through a built-in acoustic coupler.

Called Instant Program Access (IPA), the feature eliminates extensive programming and thereby can significantly cut the cost of IC testing. All a user need do is dial a local Tymeshare access number.

At a starting price of $49,000, the Datatron unit falls somewhere between low-end bench-top testers selling for $5000 to $10,000, and top-of-the line units that carry price tags of up to $500,000.

Sun, water combination seen as energy source

Sunlight and water may be valuable sources of electricity and fuel according to recent experiments conducted by the Massachusetts Institute of Technology.

Sunlight conversion efficiencies of up to 2% have been obtained by using electrodes of cadmium sulfide or cadmium selenide in a solution of polysulfide and water. The experiments were conducted by Mark Wrighton, assistant professor of chemistry.

New and more efficient combinations of electrodes and electrode catalysts that will produce hydrogen when electricity is applied are expected by Wrighton and his co-workers—research assistant Steven Kaiser, and Arthur Ellis, a graduate student.

The first system the researchers studied used a water cell containing two electrodes—one of platinum and one of titanium-dioxide crystal—connected by a wire. When ultraviolet light was shone on the crystal electrode and assisted by a small battery, electrons were stripped from hydroxyl ions in the water and reacted with positive hydrogen ions in the water to form hydrogen molecules.

That system worked only with ultraviolet light, but researchers gained substantially higher efficiency using sunlight and replacing the electrodes with cadmium sulfide or cadmium selenide. By adding polysulfide to the water, decomposition of the electrodes—which occurred within minutes—was halted.

At one electrode the polysulfide loses electrons, becoming oxidized. The electrons travel over the wire to the other electrode where they recombine with the polysulfide to regenerate it. No polysulfide is lost, the electrodes don't decompose and the current can be used as a source of power.

The work has been funded in part by the National Aeronautics and Space Administration.
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New computerized X-ray systems provide 3-D view of whole body

Two years ago a revolution began to take place in the way brain disease was diagnosed. Using computerized tomography (CT) scanners unbelievably clear X-ray pictures of the brain were obtained easily and safely. It took only 20 min. to get pictures far better than the poor ones that previously took three to seven days of difficult and dangerous tests to acquire.

Now, CT scanners are available for examining the whole body. Soft organs, such as the pancreas, that have never been seen before in a living human being, show up with unprecedented clarity and resolution from any angle desired. If the organ is the host for a tumor, that growth, too, is clearly displayed, as well as the condition of the tissue that surrounds it.

Pioneered by EMI Medical, Northbrook, IL, CT scanners are now being produced by General Electric, Milwaukee, WI; Syntex Medical Systems, Cupertino, CA; Ohio-Nuclear, Solon, OH; Varian Radiation, Palo Alto, CA; Pfizer Medical System, Columbia, MD; Artronix, St. Louis, MO; and others. Companies known to be developing systems include Siemens in Munich, Germany; Philips in Eindhoven, Holland; CGR in Paris, and Picker in Cleveland, OH.

A variety of scanners offered

The CT equipment now offered or being developed includes scanners for the whole body, for the brain, and for the breast.

The cost for a full system ranges anywhere from $350,000 to $700,000, depending on how much equipment is included in the package.

The market is big: General Electric estimates that each of the 377 hospitals with 500 beds or more in the United States will need a CT scanner, and 90% of the 275 hospitals that have from 400 to 499 beds will buy one.

Computerized tomography differs from conventional X-ray machines in that CT uses X-rays and a computer to reconstruct a three-dimensional picture of a single slice ("tomos" is Greek for "slice") or small cross-section of the human body as seen from a large number of positions.

Conventional X-ray machines, on the other hand, produce two-dimensional pictures of three-dimensional objects, superimposing bones, fluids, air cavities, tissues and tumors on top of one another, making the radiologist's job as much an art as a science.

CT scanners are made up of four major components: an X-ray source, an array of detectors, a high-speed minicomputer and a display console. As in conventional X-ray techniques, the patient is placed between the X-ray source and the detector. In the new method, however, the X-ray source and detectors are mounted on a gantry so they can rotate as a single unit.

With Syntex Corp.'s System 60 tomograph, for example, the patient lies still as low-dose X-rays are passed through the body from 15 different angles within a single plane. The source and detector gantry rotate 12° after each X-ray exposure, eventually completing a half-circle around the patient. The

John F. Mason
Associate Editor
result is a tomogram, or picture of a slice of the patient's body. The slice, 1-cm thick, is viewed from above, as if one were looking along a line from the patient's head down to his feet.

X-ray absorption is the key to CT scanning. As each X-ray passes through the patient's body it is absorbed to a greater or lesser extent by the material through which it passes. Bone tends to absorb more radiation, the liver somewhat less, and air spaces or lightweight tissues, still less.

**Detectors measure absorption**

The detectors measure exactly how much radiation is absorbed by the tissues along many paths during one such X-ray probe or scan. The amount of radiation absorbed is assigned a number, or value, corresponding to gradations between black and white. In EMI's system these ratings run from $+1000$ to $-1000$. Dense bone, for example, might be given a rating of 1000. Then water would be 0 and air is $-1000$; blood is 12, tissue 22 to 46, and fat is $-100$. With such a system, high resolution is possible, as well as digitalization for storing.

In the Syntex System 60, absorption is measured along 750 paths through the body by each of 12 detectors for each traverse. Since there are 15 linear passes for each full scan, each tomogram is a composite of 135,000 data points ($750 \times 12 \times 15$).

First the detectors convert the information from X-ray signals into electrical analog signals. The analog signal is translated into a digital signal that can be manipulated by the computer.

The computer then takes all the information for the amount of absorption for all these paths and puts them together rapidly to create the cross-sectional picture. That picture is displayed on a TV screen for the doctor to examine, giving a two-dimensional "slice" of the patient's anatomy. By studying a series of scans, a picture of the three-dimensional anatomy can be obtained.

The Syntex System 60 uses a constant source of narrow beam X-rays, whose quality does not vary by more than 0.1%. The system also uses sensitive detectors composed of scintillating crystals of sodium iodide. Fine resolution is obtained by displaying the picture on a display matrix, a grid composed of 65,536 tiny squares, 256 units high and 256 units wide.

As each scan is made the data are recorded on magnetic tape. Later, information indicating the X-ray density of each small square of the picture is transferred to a floppy disc. Each disc records 12 slices, or tomograms, the patient's name, and other pertinent information. When the physician wants to review a scan, he places the disc near the viewing screen and uses a keyboard to retrieve the desired scan. A Polaroid camera mounted around the patient, and then quickly rotating it completely around the patient, and then creating the mathematical processing procedures necessary to convert the absorption values to a visual image.

**The choice of detectors**

GE chose xenon detectors instead of sodium iodide, despite the latter's superior efficiency in detecting X-rays, because it is more efficient in an array.

The individual xenon detector cell requires about 1.7 times as many X-rays before reaching the same signal-to-noise ratio as the best NaI detector design, Bueche says. But to keep scan speed down to a breath-holding period of 5 s, a large array of detectors is needed, and large arrays of NaI detectors are not practical.

"The cost would be high," says Bueche, "and a number of technical problems would be insurmountable: photomultiplier-tube gain drift, the
detector's temperature coefficient, the NaI scintillator afterglow, maintaining good optical contact, and minimizing the 'dead space' between cells without adversely affecting the resolution."

The three main attributes required by a detector array—uniformity, rapid response, and high linear dynamic range—were best met by the detector array using high-pressure xenon. The Xe gas is maintained at the same pressure throughout the entire detector array, a pressure so high that there is no appreciable contamination from impurities, and uniformity is better than for a solid-state detector.

Xenon does not have the "afterglow" problem of some scintillator crystals such as NaI, so that it can give a complete response to the X-ray input rapidly. The response is linear over the range of digitization of the information-handling system. The varying amounts of radiation that penetrate through the body are collected by an array of 320 detector elements in a single high-pressure xenon chamber.

Some 90,000 detector readings per scan are collected and fed to a high-speed minicomputer. More than 54-million computing operations are performed within minutes to reconstruct the detector accomplished in less than 10 ms, including transmission.

EMI's CT5005 whole body system uses an array of 30 sodium iodide crystal detectors and photomultipliers to study sections of the head or body that are 13-mm thick. If even smaller portions need to be examined, additional collimators narrow the slice down to 8 mm.

When the patient has been positioned, the scanning frame traverses linearly across the patient, taking just over 1 s; during this time the detectors record more than 18,000 readings on the X-rays emerging from the tissue.

At the end of the linear traverse, the scanning frame with the X-ray tube and detectors moves around the patient 10° and another linear traverse is made. This process of traversing and 10° indexing continues until 18 linear traverses, spanning 180°, have been completed.

During this 20-s scanning procedure, the readings taken by the detectors are digitized and fed to the minicomputer. Over 300,000 absorption readings are taken during a single scan.

Storing the data

The large volume of data accumulated during each scan is processed and stored on the magnetic disc.

EMI's CT 1010 unit for examining the head and neck allows two ranges of total scanning angle to be selected: the standard scan angle of 180°, or the increased scan angle of 240°. Two scanning speeds are also available: 1 min or 4 min. The longer scan increases the sensitivity of the system by 2-1/2 times, thus allowing a very substantial increase in the diagnostic information amassed during the scan. The basic EMI-scanner CT 1010 costs approximately $370,000.

A number of scanners offer color presentations by incorporating a color monitor and alternative circuit boards in the diagnostic display console, which retains all its standard controls and functions.

Varian's CT scanner makes a full 360° scan in only 6 s, using a fan-shaped X-ray beam transmitted through the patient's body to 300 xenon gas detectors. Reconstruction time is 120 s.

An advantage Varian claims is the scanner's ability to take high-resolution 6-s scans with a section width of less than 8 mm, thus permitting better definition of anatomical detail.

Special components needed

In general, today's CT scanners rely on the best available components, including MOS, CMOS and µPs. The heart of the system is a standard, general-purpose minicomputer, but the future will have less dependence on the minicomputer and more on µPs and other special components as they are developed.
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ELECTRONIC DESIGN 11, MAY 24, 1976
Analog servo system puts live actors in mini sets

A very accurate servo system that allows live actors to seemingly perform "inside" of complex miniature sets has been developed by the Magicam Div. of Paramount Pictures in Los Angeles.

The two-camera technique for either film or videotape employs one camera trained on the actors performing on a blue-matte stage, and a second servo-controlled camera that views a miniature set. When a proportional mixer puts the two images together, the actors appear to be on the mini set.

"The technique allows for better than an order of magnitude saving in the cost of set building," says Joseph Matza, executive director of Magicam. "We're the first group to accomplish real-time coordination of camera movements to within 3° of arc. Previous systems handled about 2 to 5 minutes of arc at best," says Matza.

A sensor array involving 12 different transducers is used to collect velocity and position information from the foreground dolly (on which the camera viewing the actors is mounted). The signals from these transducers are processed to derive X and Y-axis positions, pan position and tilt position.

The processed signals are then fed to the positioning system for the background camera (for viewing the miniature set). Position information from the background camera is fed back to an error amplifier and the resulting signal repositions the background camera.

Matting not new

News shows have used matting for years, with the commentator typically sitting at his desk in front of a blue screen. The foreground camera would view this scene, while the background camera would view slides or news film.

The two images would be combined into one composite picture in which the video from the background camera replaces the fore-
NEW 192 page Manual written by General Electric Application Engineers contains 7 basic sections of practical user oriented information relating to Emitters, Detectors & Couplers—

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ground areas in which blue exceeds a pre-set level.

Chroma-key is a video switch that acts on the input of a comparator. Color cameras typically have three sensing tubes that are sensitive to red, green and blue. The chroma-key system subtracts half of the red-plus-green signal from the blue and uses the result to drive the comparator.

Matza points out that the foreground image always looks pasted into the background image because of the edge that is generated by the switch. Also, areas of indecision—like shadows on the blue, translucent objects, out-of-focus edges and blue reflections—tend or are noisy as the comparator switches in and out of its threshold area.

Magicam solves this problem with a proportional process that uses differential amplifiers to perform blue-subtraction and fast dissolves (mixing of foreground and background signals). Thus, a shadow area on the blue floor, where there is reduced luminance but the same blue chroma value, will be reproduced in the composite scene as an area of reduced luminance in the background scene.

A transparent object in the foreground, such as a glass of beer, will be reproduced as a transparent object with the amber cast of the beer (minus the blue) subtracted from the background scene.

The electronics in the Magicam system allow the foreground and the background scenes to be scaled to virtually any size relative to each other.

---

**Thermal printhead plus uP equals greatly simplified circuitry**

How do you drastically reduce the amount of drive circuitry and cabling in a thermal printhead structure? You let a microprocessor take over some of the functions.

A new thermal printhead designed to interface with a μP is in volume production at Texas Instruments, Houston, TX. The printhead is used for generating hard-copy readout in a portable data terminal, the Model 743/745 also being manufactured by TI.

The printhead uses the same physical structure and semiconductor-implantation process as in TI's earlier thermal printhead, Model EPN 2200. However, the number of conductors in the flexible connecting cable that links the printhead to the electronic-drive circuitry has been reduced.

In the new data terminal, the dot pattern for each alphanumeric character generated by the printhead is stored in the μP's read-only memory (ROM). The ROM also contains the μP program that controls such other data-terminal functions as keyboard encoding and motor control. The μP, TI's 8080, uses part of its memory for storing character-generating information, and thus allows a reduction in the amount of required buffer circuitry that leads to the printhead.

A unique feature of the μP-compatible printhead is that latching (switching on, and holding) is accomplished in the head itself, through an npn and pnp-integrated structure (see Fig. 1) that operates in a manner similar to the latching action of a silicon-controlled rectifier.

Thermal printheads are not new. Earlier models, however, required that individual print elements (usually a single mesa—a raised surface formed on an inte-
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For example, if you're designing with integrated circuits and other semiconductor components, you've got to guard against overvoltage as well as overcurrent. Transient overvoltage protection requires nanosecond response; overcurrent for semiconductors may require microseconds. Sometimes conventional circuit breakers simply aren't fast enough.

And if you're designing equipment to be used on a typical ac line—motors that can burn up, instruments that can become inaccurate, and computers that can garble—you've got to watch out for brownout. But undervoltage protection is something else you can't get with conventional breakers.

These are tough problems. But Heinemann can solve them all—often with a single device combining several protection functions. We have three kinds of breakers—electromechanical, hybrid electromechanical/solid-state, and all solid-state—so we're not committed to selling you any one technology that may have limitations.

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OMQ and OSQ series also offer units for optional access to bulkhead connectors via flexible or semi-rigid cable. This includes quick connect/disconnect units that can be used with or without positive locking.

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1. An npn and pnp-integrated structure achieves latching directly at the thermal printhead.

2. The 8080 microprocessor controls TI's thermal printhead while also handling other data-terminal functions.
Problem
Interacting low-frequency filter adjustments.

Solution
HP's 3580A Spectrum Analyzer.

Benefit
Time saved, tuning simplified.

It's a typical problem. Your finished prototype usually contains multiple adjustments—which means you use a lot of time tuning your filter for top performance.

If you're designing filters to operate in the 5Hz to 50kHz range, you now can stop using so much time, stop being bothered by interactive adjustments. Our 3580A combines a built-in tracking oscillator, wide dynamic range, and digital storage to help speed and simplify every step of your next filter design. Follow this typical example and learn how the 3580A can help.

Step 1 With the 3580A, observe your spectrum and determine which frequency components to pass, which to attenuate. Decide the best type of filter to get the performance you need. Design your filter.

Step 2 Once you've selected your components and breadboarded a prototype, you can analyze your filter's performance with the 3580A. Its 80 db dynamic range gives you a clear view of everything taking place so you know exactly how your prototype is performing. Now with the tracking oscillator driving your filter, you can trim component values to optimize filter performance. Note how the tracking oscillator lets you observe the influence of each adjustment on filter performance—how it reduces the frustration you experienced before with interactive adjustments.

Step 3 Package and build your first production filter. Use the 3580A's digital storage to superimpose both waveforms for simultaneous viewing—a big advantage of the 3580A. Now set up and store the response of a good production filter and simply compare other production units against the good one, making adjustments as needed.

All of the capabilities in one instrument gives you extra value in your filter design and production. It's priced at $4485*. Your local HP field engineer can give you all the details. Or write for our 8-page technical data sheet.

*Domestic U.S.A. price only.

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CIRCLE NUMBER 23
NEW 3½ Digit Multimeter from B&K-PRECISION

...you’ll want it for its features
...but it’s the price that will sell you!

- High intensity LED display is easily read from at least 6 feet in the brightest room
- 0.5% DC accuracy
- 100% overrange (1000 scale reads to 1999)
- Automatic polarity
- Automatic decimal point
- Flashing overrange indication on display
- Four ranges each for voltage and current
- Six resistance ranges to 10 meg.
- Reliable In-circuit resistance measurements
- Overload protection on all ranges

Complete new circuitry makes the Model 283 the most dependable and versatile 3½ digit multimeter you can buy. The extra-bright display allows you to use it where other units would cause reading problems. The selectable "low ohms" function permits accurate measurement of semiconductor shunted resistors.

An optional, internal battery pack (BP-83, $50.00) provides 8 hours of continuous use on one overnight charging and charges when the Model 283 is in use on 115/230VAC. Thoughtful, convenience features like a side carrying handle, tilt stand and detachable line cord add to its usefulness.

Your B&K-PRECISION distributor has them in stock and will be glad to demonstrate its features to you. Call him, or write for additional information.

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Who provides the industry's broadest line of electronic packaging hardware ... including Edgeboard Connectors?

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You can choose between .100", .125", .150" or .166" contact spacings. Single or dual readouts. Pierced eyelet, dip solder or wire-wound terminations in one, two or three levels. Even right-angle terminals if that's what you need.
You can pick either 10, 30 or 50 mils gold over nickel plating; thru-hole or tapped insert mounting styles; in-contact or between contact polarizing keys; and phenolic or thermoplastic housings.
And if we haven't described one you like, we'd be pleased to quote a custom connector to your specification!
Our new 128 page packaging handbook gives complete details, and also describes our entire line of electronic packaging and interconnection hardware.

Stanford Applied Engineering, Inc.
340 Martin Ave., Santa Clara, CA 95050
(408) 243-9200 TWX 910-338-0132
CIRCLE NUMBER 25
five important reasons to specify
the KEPCO JQE power supply

- JQE deliver their rated output right up to +71°C without any derating whatever. Moreover, they run cool! Internal blowers actually help circulate the air in your system to keep hot spots from developing.

YOUR MECHANICAL PEOPLE WILL APPRECIATE THIS.

- JQE produce clean d-c, less than 0.2 mV rms ripple and noise (1.0 mV p-p including spikes up to 10 mHz). The output varies less than 0.0005% for the worst sort of line variation, and long-term drift is less than 0.01%.

YOUR LOAD WILL APPRECIATE THIS.

- JQE are wide-range instruments. Every JQE can be set from zero to its rated output. What's more, they all have one additional volt capacity so that wire drops do not subtract from the voltage available to your load. Buy a 0—15V model to cover the 5V, 6V, 8V, 10V, 12V and 15V loads. A 0—36V model to take care of 18, 24, 28, 32 and 36V jobs.

YOUR BUDGET WILL APPRECIATE THIS.

- JQE are fully programmable—by resistance (100Ω/volt) or by voltage (any gain ratio you choose) or by parallel binary or BCD logic. That means you can easily interface your JQE with a computer control bus. (Use the Kepco SN Programmer)

YOUR SYSTEM WILL APPRECIATE THIS.

- JQE are linear voltage stabilizers—which means that JQE are a lot simpler and more reliable than switching machines. (You get a 5-year warranty.) A linear JQE will respond in microseconds to a load shift; will maintain its low output impedance into high frequency pulsed loads; produces no RFI/EMI and doesn't hack up the power line like SCR types.

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JQE is a premium quality voltage stabilizer for the no-compromise job

KEPCO

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CIRCLE NUMBER 26
GAO to eliminate some disaster warning systems

In case of national disaster, man-made or natural, present plans call for the American people to be warned into a state of paralysis by five general-purpose systems and seven specialized systems. The General Accounting Office thinks that two systems would be enough, and that elimination of the other 10 would save a lot of money—$310 million to be exact.

The two favored systems are the National Oceanic and Atmospheric Administration's Weather Radio System and the Defense Civil Preparedness Agency's national warning system. NOAA already has 77 of the planned 331 transmitters in operation for its system and expects to have them all going by 1978. Each one covers a 40-mile radius, the entire system would reach 90% of the population.

The DCPA system operates through telephone linkups of national warning centers with state and local civil defense units. The GAO estimates that these two programs will cost $42 million through 1980.

Among the 10 systems that GAO doesn’t feel are needed are NOAA’s Satellite Disaster Warning System, slated to cost $81 million through 1980, and the Defense Dept.’s Decision Information Distribution System, which has a price tag of $73 million.

An overland Loran is in the works

The Loran C radio navigation system, which covers most of the world’s oceans, may be extended to cover the continental United States.

The go-ahead depends on the findings of a special-project office set up by the Dept. of Transportation to investigate the benefits and costs of such a service.

The department says its preliminary investigations show that many government agencies and private companies could use to advantage the positioning data provided by an overland Loran system. Contributing to the attractiveness of the proposal: developments in receiver technology are continuing to bring down size and power requirements, thus making the system cheaper to use.

ILS units to get ‘lightning rods’

The Air Force is installing special devices to protect instrument landing systems from the disruptive effects of lightning strikes at 58 of its bases and 72 Federal Aviation Administration units.

Developed by the Air Force's Electronic Systems Division and Rome Air Development Center, the modification kit consists of a series of diodes and
tubes that ESD says act as a self-restoring circuit breaker. The device grounds the power surges that now account for many outages and equipment failures on the solid-state AN/GRN-27 ILS units now in use.

Grissom AFB, IN, was the first to receive the lightning fix. The rest of the Air Force and FAA installations will be modified this spring, with those that have the most severe thunderstorms having priority.

FCC opens a consumer office

The Federal Communications Commission has opened a Consumer Assistance Office to handle queries from the public. The move is part of the Ford administration's campaign to convince Congress that a consumer protection agency is not needed.

According to the FCC, any person or group seeking information about rules, applications, hearings or matters pending, or FCC policies or regulations, may now contact this office, which is on the second floor of the agency's headquarters building in Washington. The telephone number is (202) 632-7001.

The office will also provide assistance to anyone who wants to participate in the Commission's processes, such as hearings, or wants to know how to file a license application.

Capital Capsules: The White House's Office of Telecommunications Policy expects to have a study by mid-1977 on the impact of optical-fiber technology on future communications systems, particularly in urban areas. The study will be conducted through the Dept. of Commerce's Office of Telecommunications Policy Research in Boulder, CO.

Betty Ford may well become the patron saint of citizens-band-radio retailers. The granting of a temporary license to the First Lady prompted the FCC to allow distributors to issue temporary tickets, good for two months, to new buyers. It's likely, however, to remain a permanent procedure because the FCC now gets about 500,000 applications per month and its Gettysburg, PA, office is saturated when it gets 300,000.

The Air Force has awarded Raytheon a contract to build the first operational phased-array missile warning system (PAVE PAWS) at Otis AFB, MA. Under the $46.5-million contract, Raytheon will build and test the unit to watch things from the East Coast. Later, a companion unit will be built at Beale AFB, CA to detect sea-launched ballistic missiles.

You have until June 30 to send in nominations for membership on the United States Metric Board, which is to lead the nation toward voluntary adoption of the metric system. One member is to be selected from lists of qualified individuals recommended by engineers and organizations representing engineering interests.

The Naval Air Development Center is seeking firms to design, develop, fabricate, and test bi-level solid-state switches for airborne multiplex applications, and solid-state load controllers.

Wireless communications for trackless haulage vehicles in coal mines is getting high priority from the U.S. Bureau of Mines. Under a new study program, the agency plans to determine the necessary vehicular and wayside repeaters needed in a coal mine to interface a radio system, developed by the Bureau of Mines, to an existing cable or telephone line in a mine.
116 reasons why only Buchanan® PC Board Connectors provide Lowest Total Applied Cost!

And here are 110 more—the 110 connections you eliminate!

Here's how to achieve significant Lower Total Applied Cost when building control panels or other equipment using printed circuit boards. Simply specify the new Buchanan Connector that eliminates hybrid interfaces between electronic circuitry and electrical connections. It replaces multiple terminal strips and costly interwiring; actually saves up to 5 separate connection points—potential trouble spots—per circuit!

Models are available for just about every standard requirement. For complete engineering and ordering information, use the Reader Service Card. Or, call one of our Factory Regional Offices shown below. They'll also be happy to talk to you about special configurations.

Just one Buchanan Printed Circuit Board Connector (A) replaces the two terminal strips (B), the edge card connector (C), the double wiring (D), and the 110 costly terminations (E) shown at left. Result: LTAC (Lower Total Applied Cost)!

Models available for surface or through-the-panel mounting, with or without card guides and keys.
Hand us your interconnection design problem.

We’ll hand you back the solution.

At Fabri-Tek’s National Connector Division, we do more than just sell connectors out of the book. We’ll custom-tailor a complete interconnection system from our wide line of plate, molded, backpanel, and special connector products. And we’ll handle your job from start to finish:

- Design engineering and artwork
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- Field service, applications engineering

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Call Peter Van Wyngeeren at (612) 533-3533.

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- Metal backplanes and plate connectors
- Special molded connectors
- Standard card edge connectors
- Card cages
- I/O connectors
- Telephone and military connectors

Single and Multilayer P.C. Backpanels = 201
Aluminum Backpanels = 202
Edge Card Connectors = 203
Special Molded Connectors = 204
Commercial = 205
Military = 206

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We were going to second source Intel, but we couldn’t wait.


- **Fully Static**—no refresh required. No dynamic nodes.
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- **High speed:** Access times to 200 nanoseconds.
- **Two organizations:** Am9140-4Kx1, Am9130-1Kx4.
- **All input and output logic levels identical to TTL**—full 400 mV noise immunity.
- **Low power dissipation:** 250 mW typ.
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- **Full military range available:** −55°C to +125°C ambient.
- **DC standby mode.** Reduces power dissipation by 80%.
- **Memory status signal.** Indicates when data are valid, allows improved overall performance, and simplifies timing. (And if you don’t want to use it, just ignore it. It won’t affect conventional memory operation.)
- **MIL-STD-883, of course.**
New 10 Amp device makes one-stop shopping easy for fast-switching power transistors.

Now, IR is your source for a wide variety of 3, 5 and 10 Amp JEDEC fast-switching power transistors, to simplify your buying. These hard-glass passivated devices are the ones to use for better reliability and lower costs in line operated power supplies, whether you're chopping line voltages at 20 KHz or inverting and stepping down at high frequency.

Fast Switching Speed—Cooler Operation...the oscillographs show typical fall times in the one-microsecond and lower range. Gives extremely low switching losses for cooler operation and higher reliability.

Lower Leakage—High Temperature Stability...with ICBO in the micro-amp range, IR devices are about one-tenth the accepted leakage rates of others. Provides the higher stability important for high performance at elevated temperatures.

High Second Breakdown — High Reliability...high second breakdown helps provide a broad safe-operating area for an extra margin of safety.

Glass Passivation—Long Term Reliability...high reliability and long term stability is achieved by hard glass passivation. Also, if you're using chips to make your own circuits, IR's glass passivation gives you the most stable, easy to assemble chips.

## New International Rectifier Fast Switching Power Transistors

<table>
<thead>
<tr>
<th>Part No</th>
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<th>IC Peak</th>
<th>HFE</th>
<th>BV (Max V)</th>
<th>IC (Sat)</th>
<th>Pd (W)</th>
<th>tC (µs)</th>
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<td>1.5</td>
<td>10.0</td>
<td>175</td>
<td>2/1</td>
</tr>
</tbody>
</table>

If you are paralleling devices, the tight gain, switching time and saturation voltage control of these transistors make the job easier. And through 100% testing of key parameters we can provide even closer matching if necessary.

JEDEC types listed are immediately available, so contact your local IR salesman, rep or distributor today. International Rectifier, 233 Kansas Street, El Segundo, California 90245. (213) 678-8261.

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The right DMM decision means 1 μV sensitivity, 0.03% accuracy, and a $425 price.

Introducing HP's 3465A DMM.

Now you have a five-function DMM with the needed accuracy, sensitivity, and low cost to solve your bench or field service requirements. See how HP's 3465A Digital Multimeter combines capability, convenience, and confidence with low cost to bring you to the right decision.

**Capability:** Take a look at the front panel. It has all the functions and ranges you'd expect, and more. You get ohms, ac/dc volts, and ac/dc current. Extra resolution is obtained with a full-scale readout of 19999. Accuracy is ±0.02% of reading ±0.01% of range on dc, meeting the needs for most field or bench applications. The 10 mV dc range and 100 mV ac range provide performance typically found only in more expensive 5½-digit multimeters.

**Convenience:** The 3465A's functional design means easy rack and stack with other instruments in the lab, while its compactness and low power consumption result in a handy field-service instrument. It will operate from four different sources of power: 1) Four standard D-cell** batteries. 2) The ac line using an HP hand-held calculator charger. 3) The ac line using its own internal power supply. 4) Rechargeable Nickel Cadmium batteries.

**Confidence:** Fewer components and higher reliability are achieved through the use of a newly developed Tantalum-Nitride on Sapphire thin-film resistor. Easy calibration and improved performance are obtained with a new dual-slope integrator that uses a single reference supply. All these design features, plus input protection, give you the performance you'd expect from HP.

**Cost:** The standard 3465A costs $500* and is equipped with an internal power supply, a battery recharging circuit, and Nickel-Cadmium batteries. If you don't need the rechargeable batteries, order Option 001 for $480* and save $20. Order Option 002 for $425* and save $75* by powering the HP 3465A from dry-cell batteries. Also, Option 002 can operate from the ac line when using one of HP's Model 82002A chargers (supplied with most HP pocket calculators).

When you consider its capability, convenience, and cost, you can be confident that the 3465A is the right decision. Contact your local HP field sales engineer, or write for more information.

*Domestic U.S.A. Price Only. **U-2 Batteries in Europe

HP DVM's... the right decision
Words cannot describe how good our SRL supplies are.

So let's look at some numbers.

- 14 models for laboratory/systems
- 0-10 to 0-60 volts
- 4 to 100 amps
- 250 to 2000 watts
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And one important word – Programmable.

All SRLs are remotely programmable in both constant current and voltage modes. And if your programming source happens to be digital, our DAP Series high-speed digital-to-analog programmer is what you need. It accepts inputs from all forms of digital sources and converts them into analog signals to program SRLs (or any other Sorensen power supply). DAPs are fully addressable, accept parallel inputs, are fully buffered. Perfect for automatic test systems and process control.

We have lots more helpful numbers. Just circle the inquiry number to receive our new catalog of over 200 power supply products, including SRLs and DAPs. Sorensen, a Raytheon Company, 676 Island Pond Road, Manchester, N.H. 03103. (603) 668-4500.

SORENSEN POWER SUPPLIES
Development system simplifies designs based on COSMAC

The COSMAC Development System (CDS) comes fully assembled and can do system prototyping and software development. The CDP18S004 system is based on RCA's CDP1802 single-chip microprocessor.

The development system is supplied in a 19-in. rack-mountable chassis that has a power supply, a front panel with basic controls, a printed-circuit backplane, a basic set of small PC boards that make up an expandable COSMAC microcomputer and 22 empty card slots.

The basic set of cards provides buffering and address latching to support memory systems up to 65,536 bytes. Additional RAM, ROM and PROM cards can be bought from RCA (Route 202, Somerville, NJ 08876. 201-722-3200).

A monitor card contains an interactive utility program that performs such functions as program loading, memory dump, memory examination and modification, examination and modification of all CPU registers, specification of program "breakpoints," single or multiple-step instruction execution and start of program execution at a given location, with automatic speed adjustment for 110 to 1200 baud terminals.

The CDP18S004 system supports many different terminals, depending on the interface option selected. The system comes with 4-k bytes of RAM, which is sufficient to run the COSMAC resident assembler or the resident editor, both of which are included in the purchase price.

A total of nine spare PC-card positions for memory are presbussed for expansion, and a total of 13 spare I/O positions (one prewired) are made available for the control electronics of user devices. Small, 44-pin PC cards (4.5 x 3-in.) are used in the basic card set and larger cards (4.5 x 6.5 in.) are used for the RAM and monitor boards. The basic COSMAC development system costs $2250 and is available from stock.

Wire-wrapped board accommodates 6800 emulation kit

A socket board for Motorola's M-6800 chip set can save many man hours devoted to chip interconnection and evaluation. Offered by Cambion (445 Concord Ave., Cambridge, MA 02138. 617-491-5400) and designated the 787-2000-03-03, the board comes completely wire-wrapped for the 6800 evaluation kit, which can be obtained from Cambion. Pre-wired sockets on the board are available for the inclusion of additional memory. Cambion sells the board for $197.50.

Memory expander for 2650 µP adds 4-k bytes of RAM

A static MOS memory board, designed for use in the development of 2650 µP-based systems, has been introduced by Signetics (811 E. Arques Ave., Sunnyvale, CA 94086. 408-739-7700). The board (called the 2650PC2000) contains 32, 21L02 MOS RAMs, organized as 4096 words x 8 bits.
MICROPROCESSOR DESIGN

(continued from page 47)

The PC2000 can be used to extend the memory capacity of the company's PC1001 µP-prototyping card. The PC1001 card contains 1-k byte of ROM, 1-k byte of RAM and comes completely assembled. The ROM contains a loader and debugger program (Pipbug) plus the necessary software to interface the processor with a serial data input, such as an RS-232 device.

As a stand-alone prototyping card, the PC1001 can store over 900 bytes of user program. In conjunction with the PC2000, the user program can be extended to approximately 5-k bytes.

The 2650PC2000 costs $550 and the PC1001 costs $495. Both cards, purchased as a set, cost $900. Either card is available within four weeks.

CIRCLE NO. 572

F8-based evaluation board sells for $185

The key elements of an F8-based system come fully assembled and wired on a circuit board from Fairchild (Microsystems Div., 1725 Technology Dr., San Jose, CA 95110. 415-962-8816). The new F8 kit includes a connecting cable for power supply and teletypewriter hookup, and it costs just $185.

The board contains a 3853 CPU, 3851 program-storage unit, 3853 static memory-interface circuit and eight 2102 static RAMs (1-kilobyte memories). Other features include 32 I/O bits, two levels of interrupts and all necessary control circuits. The kit comes with programming manual and data book.

A Fairbug program is stored in the 1-kilobyte ROM of the program-storage unit. The program contains a bootstrap loader for easily entering a program into RAM memory from the terminal, at speeds from 110 to 2400 baud. It also can dump memory from RAM for future loading or to create a PROM program tape, and can read from a high-speed paper-tape reader.

Delivery is from stock.

CIRCLE NO. 573

µP-controlled printer combines high throughput and diagnostics

A series of microprocessor-controlled, intelligent matrix printers are designed for use on the Sycor 440 clustered-terminal processing system. The Model 4600 series printers made by Sycor (100 Phoenix Dr., Ann Arbor, MI 48104. 313-971-0900) operate at 60, 120 and 180 characters per second. They use a microprocessor and 5-k bytes of memory for real time control of all system dynamics.

The throughput of the printers is greater than that of conventional printers, claims the company, because of several developments. 1. The unit can print in both directions, thereby eliminating the "dead time" of the carriage return. 2. The µP can move the head to the beginning or end of the next print line, whichever is closer, and print that line from either left to right or right to left, thereby minimizing the time between the completion of one print line and the beginning of the next. 3. There is automatic vertical slewing whenever two or more line feeds are encountered.

In most print applications, the company claims, its 60 cps printer can equal the throughput of conventional 165 cps printers. The Sycor printers have a 12-key function pad that permits the user to set margin widths, form length and vertical and horizontal tab positions. The printers execute commands such as "top of form," and have dynamic form alignment for pre-printed forms.

The µP-driven system also generates two diagnostic test patterns that can be initiated (continued on page 50)
Select from this family of aluminum electrolytic capacitors designed for output filtering in switching power supplies

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>TYPE 672D</td>
<td>Suitable for parallel stacking</td>
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<tr>
<td></td>
<td>Plug-in PWB mounting</td>
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<tr>
<td></td>
<td>Low to medium ripple current capability</td>
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<tr>
<td>TYPE 604D</td>
<td>True 4-terminal isolation</td>
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<tr>
<td></td>
<td>Low profile PWB mounting</td>
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<tr>
<td></td>
<td>Medium ripple current capability</td>
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<tr>
<td>TYPE 622D</td>
<td>Symmetrical ESR and capacitance tolerance</td>
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<tr>
<td></td>
<td>Conventional stud mounting</td>
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<tr>
<td></td>
<td>High ripple current capability</td>
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<tr>
<td>TYPE 432D</td>
<td>Lowest available ESR and impedance</td>
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<tr>
<td></td>
<td>Bus-bar mounting</td>
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<td></td>
<td>Maximum ripple current capability</td>
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### Technical Specifications

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<th>TYPE 622D</th>
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<td>Rolled-Section</td>
<td>Stacked-foil</td>
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<td>4 terminals, wire leads</td>
<td>2 terminals, low or high female threaded</td>
<td>2 terminals, strip-line, female threaded</td>
</tr>
<tr>
<td>Case Size Range (D x L.)</td>
<td>.326&quot; x .505&quot; to 1.000&quot; x 1.625&quot;</td>
<td>.750&quot; x 1.825&quot; to 1.000&quot; x 3.625&quot;</td>
<td>1.375&quot; x 2.125&quot; to 1.375&quot; x 5.625&quot;</td>
<td>1.375&quot; x 2.125&quot; to 3.000&quot; x 5.625&quot;</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>-55°C to +105°C</td>
<td>-55°C to +105°C</td>
<td>-55°C to +85°C</td>
<td>-49°C to +85°C</td>
</tr>
<tr>
<td>WVDC Range</td>
<td>6.3 to 100</td>
<td>5 to 200</td>
<td>5 to 55</td>
<td>6 to 50</td>
</tr>
<tr>
<td>Capacitance (Range ±F)</td>
<td>4.7 to 6800</td>
<td>50 to 16,000</td>
<td>2,800 to 67,000</td>
<td>470 to 100,000</td>
</tr>
<tr>
<td>Capacitance Tolerance</td>
<td>-10, +100%</td>
<td>thru 50 V: -10, +75%</td>
<td>±20%</td>
<td>±0, +100%</td>
</tr>
<tr>
<td>Max. Inductance (@1 MHz &amp; within .125&quot; of capacitor)</td>
<td>20 nH</td>
<td>2 nH</td>
<td>20 nH</td>
<td>2 nH</td>
</tr>
<tr>
<td>Max. ESR (@25°C and 120 Hz)</td>
<td>.11 ohm</td>
<td>.022 ohm</td>
<td>.004 ohm</td>
<td>.0015 ohm</td>
</tr>
<tr>
<td>RMS Ripple Current (@85°C)</td>
<td>2.61 A @ 100 kHz</td>
<td>7.00 A @ 10 kHz</td>
<td>19.5 A @ 20 kHz</td>
<td>54.6 A @ 1 kHz</td>
</tr>
<tr>
<td>Max. Impedance (@25°C)</td>
<td>.06Ω @ 100 kHz</td>
<td>.017Ω @ 10 kHz</td>
<td>.01Ω @ 10-40 kHz</td>
<td>.001 Ω @ 10 kHz</td>
</tr>
<tr>
<td>Engineering Bulletin</td>
<td>3452</td>
<td>3458A</td>
<td>3459</td>
<td>3443A</td>
</tr>
<tr>
<td>Check on Reader Service Card</td>
<td>Check 161</td>
<td>Check 162</td>
<td>Check 163</td>
<td>Check 164</td>
</tr>
</tbody>
</table>

For complete technical data, write for Engineering Bulletin(s) (see table for bulletin numbers) on the capacitor(s) in which you are interested to: Technical Literature Service, Sprague Electric Company, 347 Marshall St., North Adams, Mass. 01247.

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS
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(continued from page 48)

from the function keys. Page format is set at 10 characters to the inch and six lines to the inch, or is optionally condensed to 16-1/2 characters to the inch and/or eight lines to the inch. The increased density, in effect, doubles the storage of a page and can cut paper costs in half.

The 60 cps Model 4606 printer costs $155/month on a one-year lease and $133/month on a three-year lease. The 120 cps Model 4612 costs $218/month on a one-year lease and $190/month on a three-year lease. The 180 cps Model 4618 costs $276/month on a one-year lease and $242/month on a three-year lease. Purchase prices for the printers are $5600, $6600 and $8620, respectively. All lease prices include maintenance. Delivery is within 8 weeks or from stock.

CIRCLE NO. 574

Enhanced macro cross-assembler arrives for 6500

An advanced macro cross-assembler for the MOS Technology 6500 microprocessor operates on both IBM S360/370 and DEC PDP-10 computers. Offered by Zeno Systems (2210 Third St., Suite 110, Santa Monica, CA 90405. 213-396-6020), the software package is written in assembly language in both cases, and is said to be more cost effective than competing packages written in Fortran.

Functionally equivalent to the software provided by the µP manufacturer, the new ZSI assembler has normal arithmetic expressions and a macro and conditional assembly capability. Other enhancements include the following: extensive error diagnostics within the assembly listing and summarized in a separate file or at the user's terminal; optional variable cross-reference listing; and improved assembly-listing format.

CIRCLE NO. 575

Compact µP-based data terminal weighs only 13 lb

A lightweight portable data terminal uses a µP to reduce component count and improve performance. The Model 745 terminal, introduced by Texas Instruments (P.O. Box 1444, M/S 784, Houston, TX 77001. 713-494-5115), weighs 13 lb and costs only $1995 in single quantities.

The unit includes an ANSI-standard keyboard with calculator-style numeric keypad and has half-duplex and full-duplex operating modes, standard parity options, automatic paper loading and 30 cps thermal printing. Also included in the 745 is a built-in acoustic coupler and optional auxiliary EIA interface capability.

In addition to the 745 TI has introduced the Model 743 KSR terminal. It is intended for time-sharing and I/O console applications and costs $1395 in singles. The 743 offers all the features of the 745 except that it does not contain the acoustic coupler. Both units are available from stock for purchase or lease.

CIRCLE NO. 576

Macro-assembler and simulator available in Fortran IV

A set of macro-assemblers and simulators for microprocessors is available in standard Fortran IV. The programs are intended for support of the 6800, F8 and 2650 µP systems and will run on any computer that has a word length of 16-bits or more and at least 16-k words of main memory.

The assemblers provide all the standard features, including symbolic addressing, relative addressing and constant generation. In addition to the standard features, Microtec (P.O. Box 337, Sunnyvale, CA 94088. 408-733-2919) has added features, including a macrofacility,
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conditional-assembly statements, a set of listing and punch-control pseudo-ops and many diagnostic error messages.

The simulators have a set of commands that permit you to set breakpoints, trace program flow, display and patch memory locations, display and modify simulated processor registers, simulate I/O routines and interrupts, and keep track of timing information. The programs cost $800 and can be supplied on several different media. A detailed manual, source listing and test program are included.

CIRCLE NO. 577

Single chip holds complete microcomputer

A complete microcomputer with 31 I/O channels and interrupt capability is available on a single chip. Developed by Rockwell International (3310 Miraloma Ave., P.O. Box 3669, Anaheim, CA 92803. 714-632-2321), the chip costs less than $10 in 10,000-unit orders.

The microcomputer chip contains a $1344 \times 8$-bit program ROM, a $96 \times 4$-bit RAM, and a processor. The chip is designated the PPS-4/1 and has an instruction set of 50 commands. I/O options include two 4-bit input channels that can be simultaneously used for testing or comparing data; two 4-bit I/O channels, and 10 discrete I/O lines. Two interrupt-request input lines, one of which can be used to automatically trigger an echo signal, provide priority input and status capabilities.

The \( \mu C \) also permits clocked, simultaneous serial I/O. This feature allows “infinitely” expandable I/O options. Pulsed or complex digital waveforms may be easily generated as a variety of serial or parallel outputs. The I/O options also permit the cascading of PPS-4/1 chips to create multiprocessor systems.

Other features of the device include: TTL and CMOS compatibility, an arithmetic logic unit with five working registers, an on-chip resistor-controlled clock generator that can be externally synchronized, and a single-power-supply (15-V) requirement. Power dissipation is 70 mW.

To facilitate production testing of the programmed \( \mu C \), an on-chip scheme enables complete testing of every function, including the customer's unique ROM patterns.

The instruction set of the PPS-4/1 \( \mu C \) is very similar to that used for the company's PPS-4/2 and PPS-4 \( \mu P \) systems. Full software support, including assembly and simulation programs is available on the G.E. time-share network.

An evaluation model (P/N A6799) has address and memory lines bonded to external pins. A program can be stored in an external PROM or RAM for real-time development and testing, or even as a low-cost, low-quantity system.

CIRCLE NO. 578

Memory and interface support cards fit both 8080 and 6800

Common support cards for microprocessor-based systems are available for either 8080 or 6800-based systems. The cards include a ROM/RAM and a ROM or RAM, and were developed by Pro-Log Corp. (2411 Garden Rd., Monterey, CA 93940. 408-372-4593). Any combination of 64-k 8-bit words for either \( \mu P \).

Also available are common input/output cards, TTL-input gate cards, a TTL-output latch card, driver cards, isolation cards and serial I/O cards. Prices for the cards start at $55 and go up to $280 and delivery is four weeks.

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- Payment amount/period
- Present value
- Future value
- Net present value
- Internal rate of return for up to 10 different uneven cash flows

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- Variance
- Normal distribution
- Linear estimate
- Mean
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Shooting at the wrong target

Ken was a fine manager. He read (and quoted from) almost any management text you could name. And he followed all the time-honored principles of management—except when they conflicted with his feelings of the moment.

He would frequently assemble his engineers and give them lectures on the importance of disciplining themselves to direct their efforts most effectively towards achieving set objectives.

Ken's lectures were largely successful. They made sense, so his engineers automatically followed most of the basic management tenets. When a competitor offered a better counter at a better price, they quickly saw that they had to do something because counters were one of their principal products. Without neglecting their other lines, they concentrated on developing a better counter.

Unfortunately, it was at this time that Ken had the bright idea that what the country really needed was a new DVM. "Sure," his engineers agreed, "a DVM would be nice and we'll spend some time on that, too. But right now, we're tops in DVMs. Nobody comes close to us. Our real problem is counters. If we don't develop a better counter pretty damn quick, our competitors will slaughter us. They'll hit us where we hurt."

Ken knew that it would be easier to improve a voltmeter or to tell the world that his voltmeters were best. But he didn't want to face the fact that counters were his problem. This was easy for Ken because he was the boss and management principles didn't affect him. They are simply tools used to instruct underlings. Ken won the argument, of course. His engineers spent their time improving an already fine DVM line.

As one might have predicted, Ken's company took a beating. It's no longer the vibrant, prosperous company it once was. It's now struggling to stay alive. But Ken feels vindicated, nevertheless. It wasn't his bad policy that sent the company into a tailspin but, rather, poor execution on the part of his engineers.

Ken's blindness is obvious to everybody except Ken. But he may not be alone. He may not be the only engineer to solve a problem he had an easy solution for, instead of attacking a problem that needed a solution.
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*In volume
1Patented
Mention rf connectors, and many engineers immediately think of problems with leakage, loss and impedance matching. The result: widespread overspecification and use of connectors with properties that far exceed the average system's needs. And manufacturers don't go out of their way to discourage this practice.

“Highly matched, precision connectors will work well from dc into the GHz range,” says Tore N. Anderson, staff consultant for Solitron/Microwave, “so many engineers simply specify matched types for all applications—an expensive approach.”

Impedance matching isn't always needed

Not all rf-connector applications need impedance matching. Where the signal frequencies are low and electrical lengths spanned by a connector are, say, 1 to 5 percent of the signal's wavelength, you can do the job quite well with so-called uhf connectors, like the “RCA phono plug” or the Type-F CATV connector. Uhf connectors are the oldest and least-expensive class of coaxial-connector designs.

But take care: Uhf connectors are uhf in name only. Use them only up through the vhf band (see chart). Their usefulness ends where the uhf range begins.

Uhf connectors, because they are not designed for impedance matching, usually have nonuniform impedances within their structures. With different impedances in their cable-junction, internal-support and mating-contact regions, the resulting poor voltage-standing-wave ratio (VSWR) can seriously distort signals above the vhf band.

Morris Grossman
Associate Editor

The popular BNC rf connector finds rivals in Omni Spectra's smaller OMQ and OSQ series.

TNC connectors—threaded versions of the BNC—and SMA types are Solitron/Microwave specialties. Both types, widely used for microwave work, come in numerous versions and from many vendors.
Somewhere between 100 and 1000 MHz impedance-matched connectors become important. At 100 MHz, 1 percent of a wavelength is 1.18 in., which is about the same order of magnitude as the length of rf connectors; at 300 MHz, the electrical length of a typical uhf connector is about 5 percent of a wavelength.

The practice since uhf types were developed has been to consider 300 MHz as about the upper limit for uhf connectors. Below 300 MHz, a uhf connector acts merely as a lumped small shunting capacitor across the circuit with perhaps a very small amount of inductance in series with the signal. Any impedance mismatch that occurs can be neglected. Fortunately, many video and pulse-circuit applications lie below 300 MHz.

**Leakage is usually negligible**

To insist on impedance matching is not the only way you can overspecify rf connectors. Unless you are familiar with coaxial-cable performance capabilities, you may not realize that rf leakage in rf connectors is usually negligible in comparison with cables. A coaxial cable such as RG-59/U can easily have leakage that's only 30-dB down from the signal level. Ordinary BNC and TNC connectors, which can fit the RG-59/U, are specified to have −55 to −66-dB leakage at 3 GHz. The N series, which is somewhat superior, has as little as −90 dB—six orders of magnitude less leakage than a typical cable.

Obviously, the rf leakage you specify for connectors should be related to the quality of the cable. If you have a critical application that demands a double-shielded triaxial or a solid-sheathed cable with, say, only −90-dB leakage, you should use a precision connector specified with about −120-dB leakage. Units in Amphenol’s APC-7 Series, for example, are so specified to 18 GHz, but you’ll pay a good price for them.

For general purposes, BNC connectors are much cheaper. They fit small-diameter cables with ODs to about 3/8 in. The BNCs can be used to 4 GHz with low reflection losses at a nominal impedance of 50Ω; they’re still useful to 11 GHz in some applications.

However, the BNC’s two-eared bayonet locking device allows the connector to “rock” when coupled, thus producing noise in the system. This problem can be avoided by use of a TNC connector. This type has a threaded coupling that holds more securely, and allows somewhat better VSWR characteristics and a slightly lower insertion loss.

As in the case of leakage, a cable’s signal losses also can outweigh the effects of even the cheapest connector. For example, losses in the popular, 0.4-in.-OD, RG-8/U cable can run as high as 1 dB/ft at 10 GHz. However, a compatible connec-
Subminiature SMA connectors come in many configurations for bulkheads, striplines, semi-rigid and flexible cables. OSM is Omni Spectra’s designation for these military SMA connectors.

MHV series—a high-voltage version of the BNC—can withstand 5 kV peak, versus only 500 V peak for the BNC. But, the MHV units lack the BNC’s broadband performance. In fact, the MHV’s VSWR rating usually isn’t given in manufacturer’s data. The connectors are recommended for use only to 50 MHz, compared with 4 GHz for the BNC.

Look carefully at connector voltage ratings. Spec-sheet data are generally inadequate. Worse still, they can be confusing and misleading. One large manufacturer lists a widely used connector at a 500-V-peak working voltage and another lists exactly the same type as 500 V rms. Is this significant, or merely sloppy editing of the spec sheet? And different rf connectors made by the same manufacturer can be specified differently. For example, one reputable manufacturer lists its BNC’s working voltage as 500 V rms, but specifies its high-voltage SHV units at 5000 V dc or 3500 V ac.

Another pitfall: Don’t confuse a connector’s dielectric withstanding voltage with its working voltage. Spec sheets never explain the difference. The working voltage is what you’re most often interested in: It’s much lower in value than the dielectric withstanding voltage. Working voltage is the voltage the connector can handle internally; dielectric withstanding is the flashover voltage to ground a connector can tolerate. The flashover spec is intended to apply to cases where the connector body is above ground—not a good safety practice under most circumstances.

Furthermore, you usually aren’t told the frequency of the specified voltage. What you’d really like to know is the performance of rf connectors at the microwave frequencies at which the con-
Some popular rf-connector types

<table>
<thead>
<tr>
<th>Connector types</th>
<th>Coupling method</th>
<th>*Size classification</th>
<th>Cable OD dimensions</th>
<th>*Maximum frequency</th>
<th>*Working voltage</th>
<th>Relative cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>QL, QM, LC, LT</td>
<td>thread</td>
<td>large</td>
<td>0.87-1.195 in.</td>
<td>3 GHz</td>
<td>5000 V rms (at sea level)</td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>thread</td>
<td></td>
<td>0.545-0.870</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>thread</td>
<td></td>
<td>0.600-0.870</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>thread</td>
<td></td>
<td>0.730</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N, C, SC</td>
<td>thread</td>
<td>medium</td>
<td>3/8-7/8</td>
<td>11</td>
<td>1000 medium</td>
<td>medium-low</td>
</tr>
<tr>
<td></td>
<td>bayonet thread</td>
<td></td>
<td></td>
<td></td>
<td>1500 medium</td>
<td></td>
</tr>
<tr>
<td>BNC, TNC</td>
<td>bayonet thread</td>
<td>miniature</td>
<td>1/8-3/8</td>
<td>4</td>
<td>500 low</td>
<td>low medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>SMB, SMC, SMA</td>
<td>snap-on thread</td>
<td>subminiature</td>
<td>1/16-1/8</td>
<td>3</td>
<td>500 low</td>
<td>low medium</td>
</tr>
<tr>
<td></td>
<td>thread</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td></td>
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<tr>
<td></td>
<td>thread</td>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>SSMA</td>
<td>thread</td>
<td>ultraminiature</td>
<td>&lt; 1/16</td>
<td>40</td>
<td>250 medium</td>
<td>medium</td>
</tr>
</tbody>
</table>

*Some manufacturers may have different values for these specs or may express them differently.

Rf connectors, not specifically designed for low intermodulation, easily generate signals of $-80 \text{ dBm}$ when carrying transmitter power levels of only 50 to 100 W. Such “noise” could swamp the many sensitive receivers that operate at $-120\text{ dBm}$ signal levels.

Of course, rf connectors aren’t the only culprits. Other trouble sources include cables with copperweld-steel cores, braided rf cables, silicon-carbide resistors, carbon-based resistors, gold plating on a nickel undercoat, ferrite devices and rusty bolts.

Fortunately, most rf-connector applications aren’t sensitive to intermodulation; hence, to require that all MIL-spec connectors be intermod-free is an undue expense and restriction. Stainless-steel connectors generally wear very well, and nickel-plated units maintain their bright fin-
ish far better than silver-plated ones.

But if the problem is likely to occur, connectors such as offered by Solitron/Microwave and other manufacturers, having gold-plated beryllium-copper structures free of ferrous and other potentially troublesome materials, can keep intermodulation down to $-190 \, \text{dB}$.

**When impedances must be matched**

Don't forget: Above 300 MHz, a uniform characteristic impedance within a connector becomes increasingly necessary; above 1 GHz it's essential. The impedances of all the cross sections within a precision rf connector should be substantially equal to each other. You judge the connector's degree of impedance uniformity by the voltage standing-wave ratio (VSWR), which is determined by the ratios of the impedances of abutting cross sections (see illustration). The ideal VSWR of one is never reached, only approached in a few high-precision laboratory-standard connectors.

In addition, of course, the connector must match the cable. If you join a 50-Ω connector to a 75-Ω cable, at microwave frequencies the resulting VSWR of 1.5 and the 20-percent reflection factor can cause considerable signal distortion.

But what is the best impedance to use? Calculations and measurements show that an impedance of approximately 30-Ω maximizes a cable's power-handling capability; about 77-Ω impedance provides minimum attenuation. Most manufacturers have selected a 50-Ω value as a compromise; thus many standard rf test instruments come equipped with 50-Ω circuits and couplings.

However, at the relatively low frequencies of video (CATV) and data-communication circuits, you can profitably use 75 Ω. Since communication circuits generally carry low-power signals, you lose nothing but have much to gain by minimizing attenuation. This consideration is especially important in long-line communications. And where low circuit capacitance, as in pulse circuits, is your aim, you might use 93-Ω cables. But few connectors are designed for 93 Ω, and even 75-Ω units aren't always available.

You can sometimes find impedance adapters for coupling 75 or 93-Ω systems to 50-Ω test instruments; however, for uhf application, you can usually get away with a 50-Ω connector for a 75-Ω cable. Or if your system can work with only a low-cost uhf connector, don't worry about impedance matching; most uhf connectors don't have impedance ratings.

But many test and measurement set ups can tolerate nothing but the highest precision connectors. Although precision connectors don't command a large portion of the total rf-connector market, they are a must in rf laboratories and other applications to ensure accurate, reproducible measurements. Their most important electrical characteristic—a low VSWR—should be less than 1.04; only about 1.25 is available with the standard type N. The precision APC-7, however, operates to 18 GHz with a VSWR of less than 1.039.

Precision-connector specifications are governed by IEEE Standard 287. Most precision types have been standardized in 14 and 7-mm sizes. These dimensions refer to the inside diameter of the connector's outside conductor. The cutoff frequency in a coax assembly is inversely proportional to this diameter.

For example, the theoretical limit for the 14-mm size is about 9 GHz, but this limit increases to over 18 GHz for the 7-mm size. Smaller 3.5-mm units designed by the Alford Mfg. Co. are said to operate to 30 GHz with a VSWR of less than $1.005 + 0.03 f_{\text{GHz}}$. And 1.75-mm connectors can operate past 40 GHz with a VSWR in the neighborhood of 1.2.

**The problem with sex**

For extreme uniformity in a connector pair's impedance, mating connectors should be as alike as possible. Thus, for high-precision laboratory applications, "sexless" connectors are the logical approach. With the standard "sexy" type N, though...
Rf-connector military standards set the pace

World War II spurred the development of rf connectors. Radar systems were a principal application of the first Type N, which was followed in quick succession by the BNC, HN, and LT; others dropped by the wayside. After the hot war ended, the cold-war era that followed spawned several more series. Type C and its threaded version, SC; and type TNC, a threaded BNC, soon followed. With miniaturization, the SMC and SMB types came into existence, followed by the SMA.

However, a firm basis for standardization was not established until 1965, when Committee C83.2 of the American National Standards Institute (ANSI) produced MIL-C-39012—the bible of rf-connector standards.

Of course, many revisions and corrections have been made since then. The latest version can be obtained from the Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120. All engineers who specify or use rf connectors should become familiar with this spec—even if the work they do is strictly nonmilitary.

The spec has strong influences on commercial versions of rf connectors. Spec terminology and test methods are used throughout the rf-connector field. The spec carefully defines these terms and methods, and manufacturers assume you are familiar with them. In fact, manufacturers use this as an excuse for failure to define the ratings of the connectors in their catalogs.

The 39012 format includes two classes of rf connectors: Class I, a high-performance laboratory connector; and Class II, the basic connector in general field use. Class II is divided into several subclasses: (A) field-serviceable units, (B) nonfield-replaceable units, (C) field-replaceable crimp units, etc.

Slash sheets are issued for specific connectors—BNC, TNC, N, C, etc. Over 100 types are available. And also a qualified parts list (QPL) can be provided. Be sure to specify which slash sheets you want when ordering the spec, or the clerk won’t be able to fill your order. Also specifically ask for the QPL.

But a word of caution: Connectors made to a MIL spec, such as the UG/U series, are not necessarily approved by the military nor are they of superior design. The UG/U numbers simply provide mechanical interface standardization and help simplify procurement and stocking. They are merely a convenient way to list particular units that may have been used only once in a military application.

International standards move slowly

The International Electrotechnical Commission (IEC) started work on rf-connector and cable standards in 1959. Today, ANSI C83.2 provides the basis for U.S. representation. The BNC and type C were adopted immediately, because no screw threads were involved: An international screw-thread scheme did not exist before 1963. Some of the U.S. inch-threaded types are being adopted, but slowly.

The agreement to standardize the type N was made in 1968, yet in 1976 the type-N standard is still only in secretariat-draft form. A revised type C to agree with MIL-C-39012 has been published, and a new BNC standard is in progress.

Meanwhile, several metric-threaded connectors based on German World War II designs have been standardized, such as the 13-mm (inner-conductor), 30-mm (outer-conductor), 50-Ω and the 8/28, 75-Ω designs.

The IEEE Precision RF Connector Standards, which have made possible great improvement in coaxial instrumentation, have been adopted as IEC Publication 457, covering 7-mm, 14-mm and 21-mm sizes.

Tore Anderson, chief U.S. delegate to the September, 1974 IEC Standards meeting in Bucharest reports an interesting highlight: The N, SMA and U.S. uhf connectors are the principle rf connectors used in Poland, despite the German claim that metric connectors are widely used behind the iron curtain. Also, understandably, most NATO countries follow U.S. practice.

Electronic Design 11, May 24, 1976
Beware of screw-machine shops

Obviously, manufacturers must make the mechanical parts of precision rf connectors dimensionally precise and keep close control of material uniformity. But that is not enough, according to Bruno O. Weinschel, president and chief engineer of Weinschel Engineering, a company engaged in rf Connector designing.

"Many connector manufacturers are basically screw-machine shops with insufficient microwave-engineering support," he says. "Too few connector manufacturers are set up to employ rf-performance tests as part of their quality control. They rely mainly upon mechanical tolerances.

The technical capability of most connector manufacturers in the U.S. is very low."

Other rf-connector experts, who highly respect Weinschel's opinions, say he probably had mostly high-precision, high-frequency applications in mind when he spoke. Fortunately, most production low-cost rf connectors for use to about 1 GHz don't require such demanding standards.

And the so-called screw-machine shop shouldn't be crossed off your list completely. A knowledgeable engineer-user, with his own company's test facilities to back him, could buy from such a vendor, and perhaps do so at a considerable cost saving.

Whenever a given spec is really critical the designer needs to know how the manufacturer's stated values were derived, advises Allen Kasiewicz, product manager of the Bunker Ramo RF Div.

"Differences in measuring equipment or test methods significantly affect the test results, especially in the GHz range. To properly interpret VSWR values—especially if a low VSWR is essential—the designer must know what test equipment was used, whether the connector was assembled to a cable and whether the connector was tested as a mated pair or as a single unit with a compensating adapter.

"It's the manufacturer's responsibility to make this information readily available."

Rf-connector MIL specs are successful

Military specifications for rf connectors achieve a degree of success that far exceeds the many overlapping attempts at the standardization of other types of connectors, such as in the multipin, circular-connector field. MIL-C-39012—the first tri-service coordinated coax-connector spec—replaces most of its predecessors (see box).

Many experts attribute its success to the stress placed upon performance, testing and qualification procedures rather than upon detailed dimensional drawings, material callouts and protective-coating requirements. Prior to the advent of MIL-C-39012, military rf-connector specifications carried fully detailed dimensions with little in the way of performance requirements.

The dimensions called out in MIL-C-39012 are mating-surface dimensions to ensure interconnectability. The manufacturer is free to use its ingenuity in all other areas. Ed Forney, project manager at AMP's Coaxicon RF Div., believes "this is the reason connectors are now better than ever.

"But," he warns, "a change has been proposed that also would require the standardization of the dimensions of the cable end of the connector." The proposal is that a new category-D connector be included in MIL-C-39012—a connector that would "require only standard military crimp tools... and have standard stripping dimensions." Forney believes this trend is ominous, and if encouraged would eventually leave little room for the manufacturer to improve connector performance.

"For example," he points out, "several nonstandard impedance-matching crimps for the center conductors of coaxial cables and for braided-shield connections can provide better performance than the MIL spec'd types.

"The user should be allowed to determine how much of a toll he is willing to pay, and when to stifle design improvements in favor of standardization," Forney insists.

On the other hand, Weinschel thinks, "the time has come to talk about complete cable-connector assemblies, not just about the separate mating front-and-rear ends of the connector.

"The cable interface has never been standardized or optimized. Tremendous variations exist among manufacturers, and that makes it difficult to switch suppliers."

And Weinschel doesn't think MIL-C-39012 goes far enough. In addition to cable-interface standards, he would like to see eccentricity tolerances spelled out.

"While MIL-C-39012 has come to grips with critical mating and interface dimensions and tolerances of a linear nature, no portion of the spec addresses itself to eccentricities, which have a great influence upon the life and repeatability of a connector."

In fact, he believes one of the biggest mistakes designers make in specifying rf connectors is
that they disregard their repeatability characteristics and life. This applies especially to small connectors (such as the SMA family) that are rather fragile.

**Holding the cable to the connector**

In some crimped cable-retention methods, the cable's center contact is not held captive in the connector. Many experts prefer fully captive center-contact types for both commercial and military applications.

"The connector industry has resisted this trend for a long time and used all kinds of excuses," Weinschel observes, "but the technical problems of captive center contacts have been satisfactorily solved by several connector manufacturers. They furnish both the inner contact and bead, and use injection-molding techniques."

"A captive center contact ensures correct mechanical alignment, so the connector can meet the VSWR performance standards in MIL-C-23329A and MIL-C-39012 for crimped coax connectors."

Different crimp-retention methods applied to the outer coax conductor won't materially change a connector's performance, but the center conductor is much more critical. Thus Fred Pak, spokesman for King Electronics, questions the desirability of mandating a particular technique to crimp the center contacts.

"The requirements vary with each cable-connector combination," he explains. "And there is no simple way to reduce this to a common method for the whole spectrum of rf connectors. Not enough work has been done to specify each one for its optimum performance."

**Consummating the connection**

After you have considered cable size and impedance matching, you must examine connector-pair coupling methods when making an rf-connector selection. The bayonet type allows a rapid push-on and twist-to-lock action. The screw-on type takes more time to attach and disconnect, but it produces less leakage and provides a more noise-free connection. Also, you are assured of greater mechanical security, especially in applications subjected to vibrations and extensive cable movement.

A third type, the push-on self-locking coupling, is ideal for test equipment and other applications that require frequent and rapid coupling and uncoupling. You simply push to mate. To disengage, you pull on the shell of the connector. Perhaps equally important as the ease and speed of coupling is that the push-on coupling also can save valuable space when many receptacles must be clustered on a panel.

Robert Wersen, national manager of Lemo U.S.A., points out that many engineers erroneously think of small-sized connectors only as a means of saving panel space. This is only one factor.

More important is the clearance you need for your fingers—approximately 0.6 in. all around the connector—to lock and remove a plug from its receptacle. A screw or bayonet mechanism with, say, a 0.5-in. OD then must allow a finger clearance completely around the connector shell of at least 1.7 in. Small size doesn't help; a 0.25-in. connector still requires almost the same clearance—1.5 in. But push-on types need only 0.6 in. on two sides of the connectors so they can be very close to each other in a single line. "As much as 40-percent less space is needed than with bayonet or screw-on types," Wersen concludes.

Of course, where frequencies are high (to about 18 GHz) and cable diameters are small (to about 0.14 in.), the use of subminiature rf connectors can save space and weight. The subminiature types SMA, SMB and SMC are included in MIL-C-39012 and have become very popular in recent years. Many manufacturers, including Bunker Ramo, AMP, Sealectro and Omni Spectra, make these or proprietary substitutes.

Omni Spectra says that it pioneered subminiatures with its OSM series, which is the equivalent of the military designation SMA. And Sealectro's Conhex and smaller Nanohex connectors are said to meet SMB and SMC requirements, while its SMR series also is said to be an SMA equivalent.

In addition to its subminiature OSM line,
Sexless connector mating used in the design of GenRad's precision 874 (top) and 900 (bottom) lines helps ensure a low VSWR.

Omni Spectra also manufactures a comparable ultraminiature OSSM line, and quick-connect disconnect OMQ and OSQ lines.

Also available in quick-connect/disconnect types is Sealectro's Nanohex series with snap-on, screw-on and slide-on versions for both braided and semi-rigid cables.

William M. Schumacher, manager of development engineering at AMP's Coaxicon RF Div., reports a very positive uptrend in the use of small rf connectors "with the present growth rate for the 3-mm (SMA, etc.) types about double that of BNCs and about 10 times that of the old type-N standby."

He attributes the trend to increased operating speeds for digital equipment and the attendant increased use of small coaxial cables. "The rapid acceptance of the ribbon coax-cable for multicable assemblies AMP introduced last year is a result of and aids in the trend to use of small connectors," he concludes.

Assembly must be carefully done

Even small variations in mechanical dimensions or material properties of coaxial connectors can be critically significant. Despite efforts by manufacturers to simplify procedures, poor field assembly is still a major problem. Poor assembly techniques can easily destroy the advantages of even the best connector.

A major problem area is in the attachment of the braid of a coaxial cable to a connector. For a long time, clamping the braid between the conducting body and a retainer was the most popular method. But this technique requires extra connector parts, skill and more labor than such newer alternatives as crimping, according to Lee A. Eichenseer, a vice president of the Bunker Ramo RF Div.

With crimping, the braid is positioned between the connector body on the inside and a crimp-sleeve cylinder on the outside. A crimping tool then secures the connector to the cable braid—a quick, simple, strong and low-cost process. But you can't repair the assembly; the connector must be replaced; and you need special tools.

The problems with soldering braid are well known; you'll find few redeeming features. Nevertheless, some military applications still call for field-serviceable solder connectors. But the military has recognized crimping, and MIL-C-39012 includes a few standard crimp-type connectors and tools for field use.

One problem that often occurs because of poor assembly techniques is loose butt joints and air pockets where the cable's dielectric presses against the connector's dielectric. You should make every effort to ensure a tight fit.

Another problem is rounded dielectric corners. Both rounded corners and loose butt joints result in a nonuniform impedance (mismatch) and poor VSWR performance. Also, in high-voltage cables, air pockets reduce the assembly's peak-voltage capability.

Often problems result from stresses inadvertently set up during assembly that later cause physical misalignments. For example, if you assemble connectors to a long cable while the cable is coiled, the ends of the center conductor can assume a different position relative to the outer braid when uncoiled. An electrical mismatch is the result. For similar reasons, you should never assemble a cable and connectors when they are
excessively hot or cold.

Also, keep in mind that off-centered or pinched cables can cause poor performance.

Would you believe that connector center pins attached with too much or too little solder change the connector’s impedance characteristics? Too little solder tends to lengthen the current path in the center conductor, which increases the path’s inductance; too much can enlarge the diameter of the center pin and increase the value of the shunt capacitance.

Small-sized connectors are most sensitive to this solder problem; solder films can produce proportionately larger dimensional changes on the smaller dimensions.

Poor assembly techniques can spoil the performance of even the best and most expensive connector. But properly assembled, even a low-cost connector when suited to the system’s needs, can outlast the life of the equipment it serves.

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Need more information?

The manufacturers and connector types mentioned in this report are only a small sample of many more available. For further information, readers may wish to consult manufacturers listed here by circling the appropriate number on the reader service card. More vendors and information may be found in ELECTRONIC DESIGN’S GOLD BOOK.
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Insulating materials have been serving the electronics industry since its infancy, in applications ranging from heat sinking to structural support and encapsulation. Improvements in materials and processing have led to a wide choice of available insulations including numerous plastics, elastomers, ceramics and glasses.

If you know the key characteristics of each type of insulator and their significance for your specific application, you'll find it a simple task to identify the materials best suited for your needs. But a good understanding of insulator characteristics and their measurement is essential.

**Insulation factors and their significance**

The primary insulating characteristics are dielectric strength, dielectric constant, dissipation factor, resistivity, loss factor and arc resistance.

*Dielectric strength* is the voltage gradient at which electric failure results. The failure is characterized by an excessive flow of current and by partial destruction of the material. Dielectric strength is measured through the thickness of the material, as shown in Fig. 1, and is expressed in volts per unit of thickness.

There are two principal methods for measuring this: (1) short-time and (2) step-by-step. The short-time test is performed by increasing the voltage at a predetermined rate (100 to 3000 volts/sec) from zero to breakdown. The rate is specified by the investigator. In the step-by-step test an initial voltage of 50 percent of the short-time voltage is applied to the material, then increased in equal increments and held for lengths of time determined by the investigator.

Dielectric strength is influenced by temperature, humidity, electrode configuration, frequency, specimen geometry and voids or foreign materials in the specimen. It is often difficult to compare breakdown data from different sources unless all test conditions are known.

The higher the value of dielectric strength, the better the insulating material. Material suppliers can provide curves that show the variation of dielectric strength with thickness.

*Dielectric constant* is the ratio of the capacitance formed by the two plates with a material between them, and then with only a vacuum between them (Fig. 2). This value is of particular interest to designers of microwave equipment. In radar, for example, the thickness of the part is dictated by the frequency, physical loads and the dielectric constant. For most plastics, this value is between 2 and 10. For many plastics, dielectric constant decreases

---

3. **Dissipation factor** is the ratio of parallel reactance to parallel resistance. Thus it is the tangent of the loss angle, $\delta$, or the cotangent of the phase angle, $\theta$.

with frequency and increases with temperature.

To minimize electrical power losses for high-frequency or power applications, low values are best. Higher values are best for capacitor applications.

**Dissipation factor** is the ratio between the parallel reactance, and the parallel resistance. The parallel resistance is the tangent of the loss angle or the cotangent of the phase angle (Fig. 3). It should be noted that dissipation factor ($\tan \delta$) is not identical to power factor ($\cos \theta$). However, at low values of $\tan \delta$ (less than 0.10) the values are nearly identical to those for power factor. The dissipation factor is related to the energy dissipated and hence to the efficiency of the insulation material.

**Loss factor** is another term used by some designers. This is the product of the dielectric constant and the dissipation factor. It is related to the total loss of power (in watts) occurring in the insulation material.

Dissipation factors for most plastics tend to decrease as the frequency goes up and to increase as the temperature goes up. Since this property may vary widely through any temperature or frequency range, care should be taken when reported values do not include the test conditions.

**Power factor** is the ratio between the power dissipated (watts) in an insulating material and the product of the effective voltage and current (volt-amps).

**Some measures of resistance**

**Insulation resistance** is the ratio between voltage applied to a sample and the current flowing in the sample. It has two components: surface resistance and volume resistance. Measurement of surface and volume resistivities (the specific resistances) involves separating these two components from the insulation resistance. Separation is accomplished by using three electrodes (Fig. 4), with the outermost (guard) electrode at the same voltage as the top electrode.

**Surface resistivity** is the resistance between two opposite edges of a surface film 1-cm square. Since the length and width are identical, their units cancel and the true unit for surface resistivity becomes ohms; however, to avoid confusion with usual resistance values, surface resistivity is normally given in "ohms per square." Surface resistivity is very sensitive to humidity, surface cleanliness, and surface contour.

**Volume resistivity** is the electrical resistance between opposite faces of a unit cube for a given material at a given temperature. The units of measurement are ohm-cm. Volume resistivity is related to the temperature, the moisture in the
material and the nature of the insulator.

Since dry-out and resistance increase occur rapidly, tests on a section of material that has been subjected to moist or humid conditions must be made at controlled time intervals during or after application of the test condition. Comparison or interpretation of data is difficult unless the test period is controlled and defined.

Tests for arc resistance

Arc resistance is a measure of the insulator surface breakdown caused by an arc that tends to form a conducting path. Many testing methods have been developed and are useful for specific problems.

However, only four have been agreed upon by the American Society for Testing and Materials.

The earliest of these is ASTM D49561 which is a high-voltage low-current test under clean conditions (Fig. 5).

Other tests are specified to relate more closely to contamination and surface conditions found in practice, and all rely on introducing some contaminant into the arcing area.

The dust-fog test specified by ASTM D2132-66T is performed at 1.5 kV on a sample in a fog chamber, and with a standardized dust applied to the sample surfaces. Failure is characterized by erosion of the sample or by tracking. ASTM D2302-65T describes the differential wet-track test. This test makes use of a 3-kV arc at several power levels. The sample is inclined and partially immersed in a water solution of ammonium chloride and a wetting agent. Failure is by tracking.

Table 1. Approximate ratings of some insulating materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Dielectric Strength (V/mil)</th>
<th>Volume Resistivity (G-ohm)</th>
<th>Dielectric Constant</th>
<th>Dissipation Factor</th>
<th>Arc Resistance (seconds)</th>
<th>Max. Continuous Use Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS (20-40% glass filler)</td>
<td>350-500</td>
<td>7.16x10^-14</td>
<td>-</td>
<td>0.007-0.015</td>
<td>25-40</td>
<td>200-230</td>
</tr>
<tr>
<td>ABS (heat resistant)</td>
<td>350-500</td>
<td>1.5x10^-16</td>
<td>2.40-3.80</td>
<td>0.007-0.015</td>
<td>50-85</td>
<td>190-230</td>
</tr>
<tr>
<td>ABS (high impact)</td>
<td>350-500</td>
<td>1.5x10^-16</td>
<td>2.40-3.80</td>
<td>0.007-0.015</td>
<td>50-85</td>
<td>140-210</td>
</tr>
<tr>
<td>ABS polycarbonate alloy</td>
<td>350-500</td>
<td>1.5x10^-16</td>
<td>2.40-3.80</td>
<td>0.006-0.013</td>
<td>70-120</td>
<td>220-250</td>
</tr>
<tr>
<td>ABS (self-extinguishing)</td>
<td>350-500</td>
<td>3x10^-16</td>
<td>2.40-3.80</td>
<td>0.007-0.015</td>
<td>25-70</td>
<td>130-180</td>
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<tr>
<td>Acetal homopolymer</td>
<td>380</td>
<td>10.15</td>
<td>3.70</td>
<td>0.0048</td>
<td>125-150</td>
<td>195</td>
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<tr>
<td>Acetal (20% glass filler)</td>
<td>580</td>
<td>1.2x10^-14</td>
<td>3.90</td>
<td>0.0062</td>
<td>125-150</td>
<td>185-220</td>
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<tr>
<td>Acrylics (impact)</td>
<td>400-500</td>
<td>2x10^-16</td>
<td>2.20-3.20</td>
<td>0.004-0.02</td>
<td>(no tracking)</td>
<td>140-200</td>
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<tr>
<td>Acrylics multipolymer</td>
<td>493</td>
<td>2x10^-16</td>
<td>2.80-2.90</td>
<td>0.02</td>
<td>(no tracking)</td>
<td>165-175</td>
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<tr>
<td>Cellulose acetate</td>
<td>250-600</td>
<td>10.10,10.14</td>
<td>3.20-7.00</td>
<td>0.01-0.1</td>
<td>50-300</td>
<td>140-220</td>
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<tr>
<td>Cellulose nitrate</td>
<td>300-600</td>
<td>10.15 x 18.1</td>
<td>6.40</td>
<td>0.06-0.09</td>
<td>25-75</td>
<td>140</td>
</tr>
<tr>
<td>Epoxy (glass filler)</td>
<td>300-400</td>
<td>10.14</td>
<td>3.50-5.00</td>
<td>0.01</td>
<td>120-180</td>
<td>300-500</td>
</tr>
<tr>
<td>Epoxy (low density)</td>
<td>380-420</td>
<td>10.12,10.14</td>
<td>2.00-3.00</td>
<td>0.005-0.012</td>
<td>120-150</td>
<td>300-450</td>
</tr>
<tr>
<td>Epoxy (mineral filler)</td>
<td>300-400</td>
<td>&gt; 10.1</td>
<td>3.50-5.00</td>
<td>0.01</td>
<td>150-190</td>
<td>300-500</td>
</tr>
<tr>
<td>Epoxy encapsulation (glass filler)</td>
<td>250-400</td>
<td>&gt; 10.14</td>
<td>3.50-5.00</td>
<td>0.01</td>
<td>120-180</td>
<td>300-450</td>
</tr>
<tr>
<td>Fluorocarbon (FEP)</td>
<td>500-600</td>
<td>&gt; 2 x 10.18</td>
<td>2.10</td>
<td>0.0002</td>
<td>&gt; 165</td>
<td>400</td>
</tr>
<tr>
<td>Ionomers</td>
<td>900-1000</td>
<td>&gt; 10.16</td>
<td>-</td>
<td>0.0019</td>
<td>&gt; 90</td>
<td>160-200</td>
</tr>
<tr>
<td>Melamine (alpha cellulose filler)</td>
<td>270-300</td>
<td>1.2x10^-12</td>
<td>7.20-8.40</td>
<td>0.027-0.045</td>
<td>110-140</td>
<td>210</td>
</tr>
<tr>
<td>Melamine (asbestos filler)</td>
<td>410-430</td>
<td>1.2x10^-15</td>
<td>6.10-6.70</td>
<td>0.041-0.05</td>
<td>120-180</td>
<td>250</td>
</tr>
<tr>
<td>Melamine (fabric filler)</td>
<td>250-350</td>
<td>10.5 to 10.10</td>
<td>6.50-6.90</td>
<td>0.036-0.041</td>
<td>100-200</td>
<td>250</td>
</tr>
<tr>
<td>Nylon (polyamide) type 6</td>
<td>400-580</td>
<td>10.12,10.15</td>
<td>3.50-4.70</td>
<td>0.019-0.021</td>
<td>125-150</td>
<td>175-250</td>
</tr>
<tr>
<td>Nylon (polyamide) type 6/6</td>
<td>365-480</td>
<td>10.14,10.15</td>
<td>3.40-3.60</td>
<td>0.017-0.018</td>
<td>130-140</td>
<td>180-300</td>
</tr>
<tr>
<td>Nylon (polyamide) type 6/10</td>
<td>500</td>
<td>10.12,10.15</td>
<td>3.50</td>
<td>0.016-0.022</td>
<td>90-150</td>
<td>180-250</td>
</tr>
<tr>
<td>Nylon (polyamide) type 11</td>
<td>425</td>
<td>2x10.11</td>
<td>3.20</td>
<td>0.015-0.02</td>
<td>125-150</td>
<td>180-300</td>
</tr>
<tr>
<td>Phenolic (mica filler)</td>
<td>350-400</td>
<td>10.12 to 10.14</td>
<td>4.20-5.20</td>
<td>0.005-0.013</td>
<td>100-200</td>
<td>250-300</td>
</tr>
<tr>
<td>Phenolic (glass filler)</td>
<td>140-400</td>
<td>10.12 to 10.13</td>
<td>4.50-7.00</td>
<td>0.01-0.026</td>
<td>25-200</td>
<td>350-550</td>
</tr>
<tr>
<td>Polycarbonate (10% glass filler)</td>
<td>450</td>
<td>3x10^-16</td>
<td>3.05</td>
<td>0.0075</td>
<td>5-120</td>
<td>280-295</td>
</tr>
<tr>
<td>Polycarbonate (10 to 40% glass filler)</td>
<td>450</td>
<td>4.5x10^-16</td>
<td>3.00-3.48</td>
<td>0.0067-0.0075</td>
<td>5-120</td>
<td>280-295</td>
</tr>
<tr>
<td>Polystyrene (general purpose)</td>
<td>500-700</td>
<td>&gt; 10.16</td>
<td>2.40-2.65</td>
<td>0.0001-0.00004</td>
<td>60-85</td>
<td>150-170</td>
</tr>
<tr>
<td>Polystyrene (high impact)</td>
<td>300-600</td>
<td>&gt; 10.16</td>
<td>2.40-3.80</td>
<td>0.0004-0.002</td>
<td>20-140</td>
<td>140-175</td>
</tr>
<tr>
<td>Polystyrene (heat and chemical resistant)</td>
<td>400-600</td>
<td>&gt; 10.16</td>
<td>2.40-3.10</td>
<td>0.0005-0.005</td>
<td>20-140</td>
<td>150-170</td>
</tr>
<tr>
<td>Polystyrene (glass filler)</td>
<td>350-425</td>
<td>3x10^-16</td>
<td>2.38</td>
<td>0.001-0.003</td>
<td>25-40</td>
<td>180-200</td>
</tr>
<tr>
<td>PVC (flexible, filled)</td>
<td>250-800</td>
<td>10.11 to 10.14</td>
<td>3.50-4.50</td>
<td>0.08-0.1</td>
<td>—</td>
<td>130-150</td>
</tr>
<tr>
<td>Silicones (glass filler)</td>
<td>200-400</td>
<td>—</td>
<td>3.20-4.70</td>
<td>0.002-0.02</td>
<td>150-250</td>
<td>700-750</td>
</tr>
<tr>
<td>Silicones (mineral filler)</td>
<td>200-400</td>
<td>10.14</td>
<td>3.40-6.30</td>
<td>0.002-0.005</td>
<td>250-420</td>
<td>500-750</td>
</tr>
</tbody>
</table>
The inclined-plane test is defined by ASTM D2303-64T. In this test a specimen is inclined at 45 degrees and electrodes are placed on the underside. An electrolyte is fed onto the surface at a controlled rate, and the applied voltage is increased simultaneously. Failure is by erosion and tracking.

Ratings of insulating materials

Approximate ratings of a variety of insulation materials are listed in Table 1. The figures for short-term dielectric strength are based on tests per ASTM D149 for a thickness of 1/8 in. Volume resistivities were measured at a relative humidity of 50% and temperature of 73 F. Dielectric constant and dissipation factor were both tested per ASTM D150 at a frequency of 1 MHz. Arc resistance was measured per ASTM D495.

The table provides a convenient general guide for comparing insulating materials. But it should be used only as a guide; refer to specific ratings from suppliers for detailed design specs. Also be aware that properties shown in the table vary as a function of such key parameters as frequency, temperature and thickness.

Consider the thermal properties

Thermal classifications of electrical insulating materials are particularly important in modern electronic systems, which often have to operate at elevated temperatures. Most electrical proper-

Table 2. Definitions of insulating-material classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 C (class 0)</td>
<td>Materials or combinations of materials such as cotton, silk, and paper without impregnation. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 90 C.</td>
</tr>
<tr>
<td>105 C (class A)</td>
<td>Materials or combinations of materials such as cotton, silk, and paper when suitably impregnated or coated or when immersed in a dielectric liquid such as oil. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 105 C.</td>
</tr>
<tr>
<td>130 C (class B)</td>
<td>Materials or combinations of materials such as mica, glass fiber, and asbestos with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 130 C.</td>
</tr>
<tr>
<td>155 C (class F)</td>
<td>Materials or combinations of materials such as mica, glass fiber, and asbestos with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 155 C.</td>
</tr>
<tr>
<td>180 C (class H)</td>
<td>Materials or combinations of materials such as silicone elastomer, mica, glass fiber, and asbestos with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 180 C.</td>
</tr>
<tr>
<td>220 C</td>
<td>Materials or combinations of materials which, by experience or by accepted tests, can be shown to be capable of operation at 220 C.</td>
</tr>
<tr>
<td>Over 220 C (class C)</td>
<td>Insulation which consists entirely of mica, porcelain, glass, quartz, and similar inorganic materials. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at temperatures over 220 C.</td>
</tr>
</tbody>
</table>
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CIRCLE NUMBER 42


factor in analyzing the performance of insulating materials. Physical stability and electrical stability often are indicated by the continuous-use temperature. Although this rated value implies no specific property at the stated temperature, it is generally accepted that a material will perform without major physical or electrical instability at the specified continuous-use temperature.

One widely accepted temperature classification system is the IEEE thermal classification of electrical insulating materials (Table 2). A material properly rated into one of these classifications can be expected to operate continuously and reliably up to the maximum operating temperature of its classification for a predetermined period (usually 20,000 hours but sometimes up to 100,000 hours).

It should be noted that this system implies performance only as electrical insulation and does not necessarily cover satisfactory mechanical performance. The IEEE classification system has especially wide use in rating wire insulation as a function of temperature as shown by the typical curves of Fig. 6. • •

References


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Here's an accurate and quick way to determine the geometry of parallel-coupled microstrip lines (Fig. 1). Microstrip lines are used as components in high-frequency couplers, filters and other microwave-frequency circuits.

The data available in the literature\textsuperscript{1-6} are not designed for easy use, and curves are difficult to generate for specific requirements. Simultaneous solutions for the strips' dimensional ratios, W/H and S/H, are not easily obtained. And though some of the equations appear simple,\textsuperscript{6} direct use would require either a digital computer or tedious calculations by hand.

Nevertheless, without substantially affecting accuracy, the equations were approximated to a form required for the construction of the nomograms (Fig. 1). The nomograms provide simultaneous solution for W/H and S/H, and relate to both the even-mode, $Z_{eo}$, and odd-mode, $Z_{oo}$, impedances of the microstrip (Figs. 3 and 4).

But first, the (W/H)$_{ee}$ ratios for both odd and even modes must be obtained from a set of curves (Fig. 2) drawn for a range of dielectric constants, $\varepsilon_r$, between 1 and 10. The curves are plotted from Wheeler's synthesis formula.\textsuperscript{4}

A separate pair of nomograms (Figs. 5 and 6) provide solutions for the most commonly used substrate—alumina with a dielectric constant of 9.6. With these alumina nomograms, the designer bypasses use of the curves in Fig. 2 and directly determines W/H and S/H for both the even and odd-mode impedances.

Using the nomograms

To learn how to use the nomograms, consider the example where

\[ Z_{eo} = 60 \, \Omega \]
\[ Z_{oo} = 40 \, \Omega \]
\[ \varepsilon_r = 10 \]

1. On Fig. 2, (W/H)$_{ee} = 2.3$ for $Z_{eo} = 60 \, \Omega$.

2. A straightedge on Fig. 3 between (W/H)$_{ee} = 2.3$ and (W/H)$_{oo} = 4.2$ shows that (S/H)$_{0} = 0.5$.

3. A straightedge on Fig. 4 between (S/H)$_{0} = 0.5$ and (W/H)$_{oo} = 4.2$ shows that (W/H) + (1/2) (S/H) = 1.18.

4. Solving (W/H) + (1/2) (S/H) = 1.18 by substituting S/H = 0.5 yields W/H = 0.93.

Use of the nomograms in Figs. 5 and 6 for $\varepsilon_r = 9.6$ is simpler; step 1 is not needed. The value for S/H is obtained from $Z_{oo}$ and $Z_{eo}$ directly on the nomogram, Fig. 5.

References


2. For a given impedance of either mode, $Z_{mo}$ or $Z_{pe}$, and dielectric constant, $\varepsilon_r$, the corresponding ratio, can be readily obtained from this set of curves.


Acknowledgement
The authors are grateful to Prof. U. R. Rao, Director, ISSP, for his encouragement. Thanks are also due to the Antenna & Microwave Group for its help and suggestions.
NOMOGRAM FOR OBTAINING S/H FROM (W/H)_{se} AND (W/H)_{so}

NOMOGRAM FOR OBTAINING (\frac{W}{H} + \frac{1}{2} \frac{S}{H}) FROM (W/H)_{so} AND S/H
NOMOGRAM FOR OBTAINING $S/H$ FROM $Z_{oe}$ AND $Z_{oo}$, $\varepsilon_r = 9.6$

NOMOGRAM FOR OBTAINING $\frac{W + \frac{1}{2} \frac{S}{H}}{H}$ FROM $Z_{oo}$ AND $S/H$, $\varepsilon_r = 9.6$
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Wiring for high-speed circuits
needs special treatment. Otherwise signal reflections
and delays can distort signals and impair performance.

Connections between high-speed switching cir-
cuits that operate in the nanosecond range need
special treatment. Ordinary wiring can adverser-
ly stretch out and delay pulse rise and fall times,
and uncontrolled reflections from improperly im-
pedance-matched components at wiring-run
terminations can badly distort pulse shapes. Such
circuit wiring should be treated with the same
considerations given any transmission lines:
Connection runs must be impedance-matched at
either the input or load ends, and the delay time
between input and load must be taken into ac-
count in the circuit's behavior.

Wiring with transmission lines

Wiring for nanosecond circuits behaves like a
lossless transmission line—a line with negligible
series-resistance and shunt-resistance losses.
The characteristic impedance of a lossless
transmission line is
\[ Z_0 = \sqrt{\frac{L_0}{C_0}} \]
and the delay per unit length of line is
\[ d_0 = \sqrt{\frac{L_0}{C_0}} \]
where \( L_0 \) and \( C_0 \) are the inductance and cap-
citance of the line per unit of its length.

When impedances are not matched, the reflec-
tions that occur at the interface terminals can
cause transition signals to overshoot or under-
shoot. The degree of mismatch can be expressed
by a reflection coefficient,
\[ \rho = \frac{R_1 - Z_0}{R_1 + Z_0}, \]
where \( R_1 \) is the resistance of a device attached to
a line with characteristic impedance \( Z_0 \).

Repeated reflections bouncing between un-
matched terminations on a line can continue for
periods that are many times longer than the de-
lay of a single pass of the signal “down” a line.
An extreme example, where a driver circuit of
low, or zero, internal resistance drives a line with

Joseph L. DeClue, Vice President of Engineering, Uni-
versal Automation, Inc., 1310 E. Edinger Ave., Santa
Ana, CA 92705.
An improperly matched, high-resistance load can result in a very long signal rise time—several times greater than the delay of the transmission line.

In Fig. 2, the source has an internal impedance, \( R_s = 8 \, Z_n \), and the receive end is open-circuited—that is \( R_i = \infty \). Thus \( P_r = 7/9 \) and \( P_t = +1 \), and all reflected signals are additive.

Although the waveforms in Figs. 1 and 2 are theoretical and may appear exaggerated, such conditions of mismatch are not unusual in practical cases. The example in Fig. 1 closely approximates a totem pole circuit that drives a lightly loaded line. The second example, Fig. 2, approximates an open-collector driver with a 1000-Ω pull-up resistor driving a single high-impedance load. In the first example, undershoots during 3\( t \) to 5\( t \) can drop below the logic-ONE threshold level of the circuit and cause errors. In the second example, a delay several times greater than the delay of the line occurs before the signal reaches the circuit's switching threshold.

In practice, the idealized waveforms of Figs. 1 and 2 are distorted. Noise in the power and ground-distribution system helps to mask the clean, sharp lines of the waveforms. And infinite-step waveforms are not possible. The appearance of rise and fall times are modified.

However, when speed is not important, a signal's slow rise and fall times can be used to mask reflection effects. When the rise time or fall time is equal to or greater than two delay times of the transmission line, the overshoot-undershoot conditions of Fig. 1 won't occur. And in Fig. 2, the waveforms would closely resemble the classic exponential equation

\[
V(t) = V(1 - e^{-t/T})
\]

which represents the waveform of a simple RC network. Then the connection wiring can be represented as a lumped capacitor,

\[
C = C_0 \cdot \text{length of line}
\]

Each method of connection—open-wire, twisted pair or PC board—has different transmission characteristics. For example, glass-epoxy boards have a dielectric constant about three times greater than that of air. The resulting higher capacity per unit length produces a lower \( Z_0 \) and greater delay per unit length. The approximate characteristics of the three most common wiring techniques are as follows:

<table>
<thead>
<tr>
<th>Method</th>
<th>( Z_0 )</th>
<th>( d_0 )</th>
<th>( C_0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open wire</td>
<td>150 Ω</td>
<td>1.2 ns/ft</td>
<td>1.0 pF/ft</td>
</tr>
<tr>
<td>Twisted pair</td>
<td>115</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Etched wiring</td>
<td>100</td>
<td>1.7</td>
<td>1.46</td>
</tr>
<tr>
<td>(micro-strip)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Some loads are distributed

Not all loads are attached at the end of a wiring run. It is necessary also to consider the effects of loading at various points along a line. All load inputs include some capacity, and the best way to handle this capacitance is to consider it distributed along the line length.

This capacitance, \( C_s \), of course, modifies the transmission-line characteristics. The characteristic impedance \( Z \) is lowered to
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\[ Z_0 = \sqrt{L_0/(C_o + C_i)} \]

and the delay per unit length is increased to

\[ d_o = \sqrt{L_0/(C_o + C_i)} \]

In addition the cutoff frequency, \( f_c \), of the line is reduced. This has the effect of smoothing the waveforms.

Of course, when low-speed circuit components are used, long connecting paths, reflections and mismatches cause few problems. Nevertheless lines should be as short as possible. Some additional steps you can take to overcome wiring problems in high-speed circuits include the following:

- Divide a single line that drives two loads; make the source drive two lines instead. This approach increases the loading on the driver and thereby its rise and fall times, which eases the problems of driving long lines.

- Terminate lines with a 220/330-Ω resistor network. With 220 Ω connected to +5 V and 330 Ω to ground, the termination is 132 Ω to +3 V. This arrangement covers many practical cases. Only an approximate match to the \( Z_o \) of a line is usually necessary, because the reflected component is about one-half of the mismatch—a 20% mismatch results in only a 10% reflection. And this terminator need not be at the end of the line. In some cases termination near the source improves rise time while increasing fall time, and in this way, it increases the line length that can be driven without harmful reflections.

- Use Schottky diodes to clamp the overshoot. This, in turn, eliminates undershoot. When the diode conducts, it appears as a short-circuit giving a \( \rho \) of -1 that cancels a \( \rho \) of +1 caused by an open line.

- Use twisted pairs. Twisted-pair lines help eliminate noise caused by poor power distribution and filtering, and they also tend to reduce radiation and coupling. However, the penalty is a low impedance line that will likely need special terminators. Twisted-pair wiring may involve also the penalties of high cost and high power consumption.

And, finally, don't overlook the need for a well-filtered, low-impedance power distribution wiring system for your high-speed circuits. Switching currents, especially with TTL circuitry, generally present far greater loads than expected. High-current load pulses can generate noise signals on the \( V_o \) and ground lines, which when added to reflection effects, greatly increase the potential for errors.

Reference

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CIRCLE NUMBER 46
To get the best performance from your engineers—or from anybody else—you must provide them with the best management. To provide the best management you need the best managers. And the best engineering managers, in my opinion, are most likely the engineers themselves.

The function of the people who are assigned engineering-management responsibilities should be to draw out and develop the ideas and opinions of their engineers.

In a sense, good management is like ideal government, which is run by the people. The people are basically groups of individuals. So the ultimate benefit should go to the individual. We must not regard the people as a mass, but rather, as a group of individuals. Similarly, we must not regard our engineers as a mass, but rather, as individuals.

Our whole philosophy at Matsushita, since the company was founded 58 years ago by Konosuke Matsushita, has always stemmed from the concept of management from below, from the ranks,
from the individual. We don’t want to impose management; we want management to rise from the ranks.

We try to structure things so that all individuals will contribute. So the role of our manager is to draw ideas out of the ranks—not only in engineering—but throughout the company.

We do, in fact, have great participation. We have suggestion boxes around the plant and we get some 800,000 suggestions a month from our 80,000 employees. It’s not important how many of these suggestions we use. What’s important is that we create the environment in which employees know that management welcomes their participation.

Let me show you how the concept of management from below pays off. Koichi Yoshida, here, is responsible for setting up new factories in our Electronic Components Group. Well, he uses a system based on our philosophy and called 3-3-3. What we mean here is that three managers can work with 300 people in an area of 3000 tsubo—that’s about 10,000 square meters. Right here you can see one advantage of our 3-3-3 system; we need only a very small number of managers. One manager to 300 people is a very small ratio.

We don’t need so many “higher level” people because all our people act with a higher level philosophy and eagerness.

The objective of any system I install is to develop good managers. So everything comes down to developing people. We don’t worry much about immediate financial success. We’re more concerned with having people grow. If the people are developed, the financial achievement will follow.

Our attempt to get away from the traditional management pyramid structure is not new. We’ve been working at this since the earliest days of our company. But it’s a continuing process; it is not something that is ever completed. So we are always restructuring the company to approach this ideal more closely.

As our company grows we keep reexamining the traditional system that includes section managers, general managers, division managers, and so on. And as we grow we become more concerned with some of the bad aspects of such structures. We have noticed a similar development, by the way, in the General Electric Company in the United States. From what we can see, General Electric’s structure is the traditional pyramid in theory, but, in practice, the company seems to be moving away from that. GE seems to be attempting management at lower levels.

Our whole orientation is toward people rather than things. We feel people will take care of things if we take care of people.

Let me show you how this works in the engineering world. In a typical Japanese company, the research and development engineers are off by themselves. They are in their own little world. Typically, the research laboratory develops a product, then brings it to the marketing department with all the basics completed for further development of the product in any particular direction. But the product is not yet tied down, not yet tailored to the needs of a particular market.

How do we respond to this problem? First, we take the short-term projects out of the research laboratory and give them to separate development groups. We get these development groups involved in all aspects of getting a product to the customer. They are given a total responsibility for the success of their products, so they can no longer develop a product in a vacuum and ignore what happens to it when they’re finished. They have great interplay directly with the marketplace. As a result, they, themselves develop more in very practical directions.

Of course some people don’t succeed. But we believe a great deal in the inner strength of an individual. So if a person is not doing too well in one particular function, he might do far better in another.

For example, we quantify the success of our various divisions. If one division is not doing well for a long time, we assume that the manager of that division is not well placed. So we’ll rotate him into another division. Or we’ll rotate him into another function where he is likely to have greater success.

Sometimes, too, the success or failure of an individual may not be his fault but may be the result of outside economic or technological circumstances. For example, if semiconductor memories are replacing cores, we cannot expect core memories to show continued growth. But we would expect the core man to alert us to what’s going on in the market. We would not have to tell him that his technology is receding. He’s more likely to tell us. In fact, he would probably be the first to alert us to the importance of semiconductor memories and it’s likely that he would be placed in charge of semiconductor memory development.

This is one way some of our people grow. Look at another example. We have frequent meetings with a great deal of participation by rank-and-
Who is Taro Kuninobu?

Like Konosuke Matsushita, founder of Japan’s most profitable company, Taro Kuninobu did not get a great deal of formal education. Still, he became Managing Director of the Electronic Components Group of the Matsushita Electric Industrial Co., Ltd.

And recently, when the group was segregated from the rest of the firm to form the independent Matsushita Electronic Components Co., Ltd., he was named its first president. Nor is Kuninobu sorry he did not spend more years in school. He feels that formal education can be more of a hindrance than a help.

Without it, one can get a great education by listening to other people. Formal education, he says, can actually limit you because it makes you think you know, so you don’t have to listen. It makes you feel you can stop listening when you leave school. There are too many people today who think a man isn’t educated if he didn’t go to Tokyo University.

But graduating from a fine university is no guarantee of success, Kuninobu says. The university education is often too limiting. It breeds business men, or government men, or education men—but not necessarily educated men. The greatest vehicle for education, Kuninobu feels, is the wide open ear.

That’s been his principal source of education since he joined Matsushita Electric Industrial Co., Ltd. in 1933 after graduating from a commercial high school in Yamaguchi at the age of 16. (Konosuke Matsushita didn’t get that far; economics forced him to abandon formal education during his fourth year in primary school.)

Kuninobu concentrated on the financial and administrative field, was appointed a Director in 1970, then Managing Director in 1972. His group, Japan’s largest components manufacturer, had sales of about 96-billion yen ($320 million), a significant part of Matsushita’s sales (in 1974) of 1.45-trillion yen ($4.8 billion).

In his spare time he enjoys construction of electronic equipment and cameras, photography and building high-fidelity sound equipment, almost as much as he enjoys golf, a game in which he tends to go two rounds.

He’s also an admirer of fine chinaware. Every year he has a fine plate inscribed with some expression of his personal philosophy. A recent plate bears the bitter commentary: “One general’s great success can mean that 10,000 soldiers will die.”
so we get a great deal of cooperation because we're all growing together. Our problem is in coordinating the growth so that we have all people working toward a common goal.

This spirit, this feeling that everybody is important, permeates our entire company, and it helps the entire company. I can give you an example right from the production line. On each production line we have a small group of volunteers, maybe four to seven individuals, called the Quality Control Circle. These people talk among themselves about production-quality problems. They discuss what they have done, what worked out well, and what's not so good. They are constantly evaluating their own efforts and the efforts of their colleagues on the production line.

These people are not quality-control functionaries; they are line operators. So, in evaluating their own performance they stimulate themselves and their colleagues continually to improve performance and thus improve the product they're producing.

Does the system work? It certainly does. I have a letter from Dr. J. M. Juran of New York City. He's an outstanding authority on quality control and he's been teaching Japanese companies how to set up effective quality-control systems. He has been using our system as a model of good quality-control management. Where does this management come from? From the operators on the production line. That's just like engineering management. That comes mostly from our engineers. 

---

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CIRCLE NUMBER 47
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Ideas for Design

Phase-locked-loop circuit multiplies frequencies by 2 to 256

A phase-locked-loop (PLL) circuit (Fig. 1) can multiply an input frequency, \( f_i \), by any number between 2 and 256 and provide an output up to 130 kHz.

An XR-2208 serves as the phase detector. The flip-flops in a 4013 CMOS IC are used to divide by two to ensure that the input to the phase-detector from the frequency divider has a 50-percent duty-cycle.

The voltage-controlled oscillator in an XR-2240 programmable timer serves as the local oscillator. The open-collector outputs of the 2240's binary counter are wired-OR connected to allow division by any number from 2 to 256. The multiplication index, \( N \), is determined by the equation

\[
N = 1 + \sum_{n=1}^{\infty} \left( \frac{2}{2} + 1 \right)^{n-1}
\]

where \( n \) is the pin number on the XR-2240 from 1 to 8. The figure shows the lock-range ratio, \( \frac{\Delta F}{f_i} \), as a function of \( R_r \), where \( \Delta F \) is the frequency deviation and \( f_i \) is the circuit's free-running frequency. Frequency \( f_i \) is determined by the time constant \( R_C \), with \( R_r \) open circuited.

For most applications, the time constant \( R_C \) should be set to provide a cutoff frequency of from 0.1 to 2 percent of the input frequency, \( f_i \). The impedance at pin 12 of the XR-2240 is about 7080 \( \Omega \). This impedance is in parallel with \( R_r \). Thus the time constant generated with \( C_r \) is

\[
t = \frac{R_r}{1000 \mu F}
\]

If only powers of 2 are required for \( N \), the 4013 flip-flops can be eliminated along with the RC network to pins 10 and 11 of the XR-2240. Then pin 10 should be grounded and pin 11 connected to +V. The 33-k\( \Omega \) resistor connected to pin 5 of the XR-2208 should now be connected to any one of pins 1 through 8 of the XR-2240. Also, a 6.8-k\( \Omega \) pull-up resistor should go from the pin to +V. Output can be taken from the 2N3904 collector.

For \( N \leq 128 \), the output can be taken from pin 1 with the help of a pull-up resistor. Then the 2N3904 and its two resistors also can be eliminated.


CIRCLE NO. 311

1. The free-running frequency, \( f_i \), of this PLL is determined by the time constant of \( R_C \), with \( R_r \) open circuited. The time constant of the \( R_C \) combination must include the 7080-\( \Omega \) resistance presented by pin 12 of the XR-2240. The lock range of the PLL is determined by resistor \( R_r \).
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CIRCLE NUMBER 50
Current-controlled bandpass filter can be built with only one IC

Electronic tuning of an active bandpass filter with independent control over both center frequency and bandwidth can be done with only one IC, five resistors and no capacitors (Fig. 1).

The circuit uses a dual programmable op-amp IC in which there is a direct relationship between current inputs at programming pins 1 and 13 and the amplifiers' open-loop responses. These current inputs control current sources within the IC to make the amplifiers behave as programmable integrators that need no external capacitors.

Frequency can be programmed over a four-decade range to cover audio as well as video-frequency applications. The cut-off frequencies can be set simply, by the selection of two resistors to determine $I_o$ and $I_1$ (Fig. 2). To help calculate the current magnitudes, consider the terminal voltage at pins 1 and 13 to be one diode voltage drop below the positive supply rail.

A dynamic bandpass can be realized by modulating these control currents with active sources such as transistors or FETs.

Here's how the circuit works: op-amps $A_o$ and $A_1$ are, respectively, low and high-frequency integrators that independently control the lower and upper cut-off frequencies of the filter's bandpass. To understand this action, consider the transfer functions of the circuit. For $A_o$ we have

$$ e_2 = \frac{(R_1 + R_2)}{R_2} e_1 $$

Similarly if $A_o$'s output impedance is small the output voltage, $e_o$, is given by

$$ e_o = \frac{(e_i - e_2) (R_1 + R_2)}{1 + sT_o} \frac{R_2}{R_3} $$

For convenience let

$$ A_0 = \frac{(R_1 + R_2)}{R_2}, $$

$$ A_1 = \frac{(R_1 + R_2)}{R_2} \frac{R_2}{R_3}, $$

$$ H_o = \frac{R_1}{R_2} \frac{R_2}{R_3 + R_2}. $$

Assume $A_o$'s output impedance is small. Then $e_2$ is given by

$$ e_2 = \frac{(R_1 + R_2)}{(R_2 + R_2 + R_2)} e_1. $$

Control of programming currents, $I_o$ and $I_1$, enables selection of the cut-off frequencies.
As you can see, this chip is housed in ceramic and mounted in a forty pin, dual in-line package. As you can't see, it's a NOVA® computer. Inside that packaging sits a full 16-bit, silicon gate, NMOS microNOVA CPU. The mN601.

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CIRCLE NUMBER 142

Electronic Design 11, May 24, 1976
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IDEAS FOR DESIGN CONT.

Combine the above equations and the result is the circuit transfer function
\[
e_n \frac{A_1 (sT_1 + 1 - H_A)}{e_i} (1 + sT_1) (1 + sT_2).
\]

Now, if the circuit components are chosen such that
\[H_A = 1,
\]
then Eq. 7 becomes
\[
e_n = \frac{A_1 (sT_1)}{(1 + sT_1) (1 + sT_2)}.
\]

This equation represents a classic bandpass filter. The time constants, \(T_1\) and \(T_2\), in conventional circuits are dependent upon external resistor-capacitor combinations, but here they are directly controlled by the currents out of pins 1 and 13, respectively. In addition, the over-all circuit gain is controlled by \(A_1\), and can be adjusted independently. The bandpass response of the circuit at several current settings is shown in Fig. 2 for \(A_1 = 10\).

The circuit’s low and high-frequency skirts closely approximate a single-pole response having maximum slopes of \(-20\) dB/decade and \(-25\) dB/decade, respectively. The response is accurate to within \(\pm 1\) percent within the passband. The maximum out-of-band attenuation at the lower frequencies is a function of the residue of Eq. 7. The residue, given by \((1 - A_1 H_A)\), was measured to be \(-58\) dB down from the passband reference. If more low-frequency attenuation is desired the residue can be minimized by the selection of resistors that more closely satisfy Eq. 8.

Ernie Thibodeaux, Senior Applications Engineer, Harris Semiconductor, P.O. Box 883, Melbourne, FL 32901.

CIRCLE No. 312

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Photoresistor provides automatic dimming of electronic display systems

To automatically adjust the illumination intensity of electronic readout displays a photoresistor can be used. The photoresistor controls the RC time constant of a monostable multivibrator triggered at a fixed frequency. The output of the mono can then drive the blanking input of such typical lamp drivers as SN7446 ICs.

In Fig. 1, transistor \(Q_1\) controls the charging current to capacitor \(C_1\), and thus the transistor varies the duty cycle of the mono—one-half of an MC 14528.

As the ambient light changes from near total darkness to bright sunlight, photoresistor \(R_1\) changes its resistance from a very high impedance to a very low resistance compared with \(R_2\).

In darkness the 100-k\(\Omega\) resistor, \(R_2\), controls the current into the base of \(Q_1\), producing a low duty cycle in the mono and blanking the controlled display most of the time. In bright light \(R_1\) is much lower than 100 \(\kappa\Omega\), the duty cycle is high and the controlled display is at its brightest.

Diode \(C_{R_1}\) helps offset the effects of temperature changes on the transistor's \(V_{be}\); capacitor \(C_1\) slows the response time of the circuit and prevents sudden changes in illumination intensity; the mono is triggered continuously from a 500-Hz source.

Michael A. Molack, Senior Engineer, Dynell Electronics Corp., Melville, NY 11746.

CIRCLE No. 313
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A little-known feature of synchronous counters such as the 9310, 9316, 74160, 74161 and 74162/74163 allows them to be used as four-bit data traps.

In many digital systems, especially in computer peripherals, a storage device must accept and trap new input data, while the device maintains its previous outputs. The trapped data are then transferred to the outputs at a later time. Thus, a long output word can be assembled in the storage without any limit to the time needed. When fully assembled, the bits in the device's outputs can all be changed simultaneously.

The data-trap capability is possible only in counters where the mode-control inputs (CET, CEP, and PE) are not edge triggered; Schottky and LS versions are fully edge triggered and can't be used. When the CET and CEP inputs are permanently disabled with a LOW connection, the four master latches of data-trap counters can receive information from their P inputs as long as the clock and PE inputs are LOW (Fig. 1).

When PE goes HIGH, the four data bits are trapped in the counter's four master latches. But the counter's four outputs remain in their previous state until the clock input also goes HIGH. Between the rising edge of PE and the rising edge of the clock input, each of the four master-slave flip-flop circuits can store two bits of data statically for any length of time.

The set-up time of the data inputs, after the PE input goes HIGH, is less than 30 ns. The output delay from the time the clock input goes HIGH to the appearance of the output is less than 23 ns; the clock HIGH time must be 17 ns or longer.

Peter H. Alfke, Manager, Digital Systems Application, Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94042.

Data can be accumulated in some synchronous counters, while the counters' outputs remain constant.

IFD Winner for January 19, 1976
M. V. Subba Rao, Scientist, Central Electronics Engineering Research Institute, P.O. Pilani-Rajasthan 333031, India. His idea "Programmable Divide-by-n Counter Provides Symmetrical Outputs for all Divisors" has been voted the most valuable of Issue Award.

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   A President
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   C Vice President of Engineering
   D Technical Director
   E Chief Engineer
   F Principal Engineer
   G Research Director
   H Section Head

2 □ Your principal job function: (Insert code)
   1 General and Corporate Management
   2 Design and Development Engineering (circuits, components, equipment systems)
   3 Engineering Services (evaluation, quality control, reliability, standards, test)
   4 Basic Research
   5 Manufacturing and Production
   6 Engineering Assistants (draftsmen, lab assistant, technician)
   7 Purchasing and Procurement
   8 Marketing: excluding Sales
   9 Other Personnel (explain)

3 □ Your own work
   The primary end product (or service performed) at your plant, and the product (or service) that is your own work. (Insert code in each box even if the same)

   A A Large Computers
   B B Mini-Computers
   C C Computer Peripheral Equipment
   D D Data Processing Systems (Systems Integration)
   E E Office and Business Machines
   F F Test, Measurement and Instrumentation Equipment
   G G Communications Systems and Equipment
   H H Navigation and Guidance Systems and Equipment
   J J Consumer Entertainment Electronic Equipment
   K K Consumer Electronic Appliances
   L L Other Consumer Electronics
   M M Airline Engineering
   N N Industrial Controls
   O O Components and Sub Assemblies
   P P Materials and Hardware
   Q Q Aircraft, Missiles, Space and Ground Support Equipment
   R R Oceanography and Support Equipment
   S S Medical Electronics
   T T Industrial Companies using and/or incorporating any Electronic products in their manufacturing, research or development activities
   U U Independent Research, Test and Design Laboratories
   V V Government Agency and Military
   W W Other

4 □ Your design function: (Insert letter that applies)
   A I do electronic design or development engineering work
   B I supervise electronic design or development engineering work
   C I set standards for, or evaluate electronic design components, systems and materials

5 □ Your principal responsibility: (Insert code)
   1 Management other than Engineering
   2 Engineering Management

6 □ Please estimate: (Insert letter)
   The number of electronic engineers at this address:
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7 □ Title

8 Products you specify or authorize purchase of:
   □ 1 Resistors and Capacitors
   □ 2 Connectors
   □ 3 Switches and Relays
   □ 4 Function Modules: Op Amps, Converters, etc.
   □ 5 Potentiometers
   □ 6 Test and Measurement Equipment
   □ 7 Computers, Medium and Large
   □ 8 Electronic Power Supplies
   □ 9 ICs and Semiconductors
   □ 10 Microwave Devices
   □ 11 Minicomputers
   □ 12 Computer Peripherals
   □ 13 Computer Components
   □ 14 Cabinets and Enclosures
   □ 15 Panel Meters, Analog or Digital
   □ 16 Readout and Display Devices
   □ 17 Rotating Components
   □ 18 Cooling Products
   □ 19 Printed Circuits
   □ 20 Calculators
   □ 21 Indicators including LEDs
   □ 22 Materials, Pasting and Stamping
   □ 23 Communications Equipment

9 □ Do you specify or buy through distributors?

10 Minicomputers at this address:

   □ Yes □ No

   3 Cincinnati Milacron
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   C Control Data
   D Data General
   E Data General
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Just ask Management Systems Technology in Chicago.

**THE HEWLETT-PACKARD MX/65 DISCOMPUTER AT A GLANCE**

<table>
<thead>
<tr>
<th>Minicomputer:</th>
<th>Controller:</th>
<th>Disc:</th>
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</thead>
<tbody>
<tr>
<td>8K to 128K words</td>
<td>Links to multiple CPU's</td>
<td>25 msec average</td>
</tr>
<tr>
<td>Solid state 4K RAM memory</td>
<td>Combined seek/data transfer</td>
<td>seek time</td>
</tr>
<tr>
<td>Microprogrammable</td>
<td>Built-in error detection and correction</td>
<td>15 Mbytes of storage</td>
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<tr>
<td>Parity, EAU, floating point standard</td>
<td>Automatic track switching</td>
<td>expandable to 120 Mbyte</td>
</tr>
<tr>
<td>Brownout-proof power supply</td>
<td>Data protect and recovery features</td>
<td>Exceptional 937 Kbyte transfer rate</td>
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<tr>
<td>Optional Dynamic Mapping System</td>
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<td>Operates over wide</td>
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CIRCLE NUMBER 123
Solar ‘eyeball’ arrays can follow the sun

Plastic “eyeballs” that follow the sun’s movements to convert sunlight into electricity are being developed by Standard Telecommunication Laboratories, Harlow, Essex, England. These bowling-ball-sized spheres use a new type of self-contained magnetic drive to follow automatically the sun’s movement.

Each of the eyes can produce up to 1 V. Higher voltages are obtained by connecting several of the units in series.

To allow the eyeballs to move freely, they are floated on water in a tank. The sunlight shines through the eyeball’s lens and is focused onto the solar cell. As the sun moves, its light tends to wander off the solar cell, which is surrounded by four gas reservoirs like four large petals on a flower. When the sunlight falls on one of these cells the gas expands, moving a small magnet inside the eyeball. This reacts with the earth’s magnetic field (or an artificial one) and the eyeball is rotated to look again directly at the sun.

A gallium-arsenide solar cell is used, and a Fresnel-lens radiation collector/concentrator. Because the gallium-arsenide cell withstands high temperatures and does not saturate at high solar radiation intensities, it is used at the focus of the lens system.

The design has several advantages. Motive power and motion direction are provided by the sun. All moving components are wear-free and sealed within the sphere. The modules can be assembled into arrays to give high output powers. Hot water is a convenient by-product and there are no environmental problems.

The area of each cell is typically 2 cm². Experimental cells have an efficiency of 16% without anti-reflection coatings. A 20% efficiency is predicted when all parameters are optimized.
FET array controls linear LED circuits

A novel FET array that can be used to control linear LED circuits displaying analog voltages has been developed at the Philips Research Laboratories, Eindhoven, the Netherlands. The key to the new process is the replacement of the low-resistance metal gate in the standard IGFET by a polycrystalline-silicon gate. The resistance between the ends of the gate is typically 10 kΩ, which results in a relatively large voltage gradient along the length of the gate when a small current passes through it.

With a linear voltage gradient along the gate, the depth of the inversion layer under the gate decreases linearly, reaching zero at the point where the gate voltage equals the threshold voltage. Varying the gate-to-threshold voltage shifts this point along the length of the gate, turning on the IGFETs arranged in a row underneath the gate. To avoid a gradual turn-on or turn-off, a meander gate with a width-to-length rate of 1000 is used. Experimental devices have been made with a row of 12 IGFETs, a gate resistance of 10-kΩ and a threshold voltage of 0.3 V.

Versatile OCR system tested by British

The first optical character recognition system capable of reading and converting intermixed alphabetic and numeric characters from hand-print to computer-compatible form has been tested by the British Dept. of Health and Social Security at Newcastle-Upon-Tyne, England.

Built by Information International, Los Angeles, the Grafix I system is also the first to recognize the full alphabet, special characters and numbers as they are written by a variety of people; the system was designed to recognize more than one shape for most characters.

"If Grafix I fails to recognize the character automatically, it stores a picture of the unrecognized shape—maintaining an index of the character's position and the file from which it came," explains A. L. Fenaughty, Information International's president.

In a second operation, the unrecognized image is presented to an operator on a CRT who enters the letter into the system through a keyboard terminal.

During factory tests the system achieved sustained recognition rates exceeding 160-characters-a-second reading mixed hand-print and computer-print. Less than 2% of the characters were unread by the machine requiring human interpretation later. The error rate was under 0.05%. 
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CIRCLE NUMBER 58
More alarm power output with less energy input

C. A. Briggs Co., P.O. Box 151, Glenside, PA 19038. (215) 885-2244.

The new MK2 Cybertone provides the flexibility of the original multifrequency design, but with an increased sound-power output at a reduced energy input and at lower cost. When used with a "snap-in" horn, the unit can produce a sound-pressure level of 95 dBa at 1 m average (relative to $2 \times 10^{-4}$ dyne/cm² in free-field conditions). The MK2 provides selectable and programmable combinations of sweeping and continuous sounds of compelling characteristics. It is designed to operate on 12 V dc ±25% with a typical current drain of less than 25 mA. Ten different sounds are available from the same device.

CIRCLE NO. 301

Thermal sensor flakes only 40 to 50 Ω

Victory Engineering Corp., Victory Rd., Springfield, NJ 07081. (201) 379-5900. $6: free standing, $9: substrate (100 up); stock to 4 wks.

Low-resistance (40 to 50 Ω at 25 C) thermal sensor flakes are dimensioned 0.080 × 0.080 × 0.0015 in. as free-standing flakes. Also, they come mounted on substrates of such materials as BeO or Al₂O₃. Standard wire termination is 0.001-in. gold-plated Pt-Ir, 1-in. minimum length with opposite or adjacent configurations. Protective coatings for substrate-backed devices, and optional wire diameters, lengths and tabs are available upon request.

CIRCLE NO. 302

Ceramic bandpass filter comes in seven widths

Vernitron Piezoelectric Div., 232 Forbes Rd., Bedford, OH 44146. (216) 332-8600. $0.25 (OEM qty); 4 wks.

A new miniature 10.7-MHz ceramic bandpass filter for high-fidelity FMs, the FM4, features customized bandwidths for different industry segments. Segmented 3-dB bandwidths, ranging from 170 kHz to 330 kHz for seven center frequencies around a nominal 10.7 MHz, are available. The filter is fully compatible with conventional and integrated circuitry, and it allows the design of straightforward filtering circuits.

CIRCLE NO. 303

Nonindicating controller offers 1% accuracy


Panel-mounted Model 5850 nonindicating limit controllers cover a wide range of voltage, current and temperature inputs. All units offer ±1% of full-scale typical accuracy, a sealed all-metal housing, solid-state circuitry with a 10-A relay output and on/off control with a manual reset. Both single and double-setpoint models are available. Double setpoints overlap and are adjustable over 100% of the scale. Options include time proportioning and special ranges, nonstandard hysterisis, low-limit setpoint and down-scale thermocouple break protection.

CIRCLE NO. 304

Transformers couple to phone lines


New Microtran telephone-type coupling transformers, F234-4/76, are designed for interconnect to the nationwide telephone network under the new FCC Part 68 Registration Program. These transformers permit use of voice-grade telephone lines for both voice and data telecommunications. The units are open-frame PC-construction types and weigh from 0.4 to 9.5 oz. Sizes range from approximately 5/8 to 1-1/2-in. cubed.

CIRCLE NO. 306

Single-turn pot incorporates knob

Panel Components Corp., 2015 Second St., Berkeley, CA 94710. (415) 518-1966. Typical $4.23 (1000-up); 3 to 4 weeks.

A new single-turn pot, Model K200, incorporates a knob, dial and wire-wound pot in a single package. It offers a power rating of 1 W at 40 C and a minimum life expectancy of 10,000 turns. Nominal linearity is 0.7%, total maximum temperature coefficient is ±70 ppm/°C and CRV is 0.1% or 100 Ω max. Standard colors are black, grey and red. It requires only one hole and one mounting nut for the entire assembly. Wires can be soldered or attached with crimpable slip-on terminals.

CIRCLE NO. 305
Hermetic resistor nets meet military specs

American Components Inc., 8th Avenue at Harry St., Conshohocken, PA 19428. (215) 825-6200. $4.10 to $12.20; stock of 10 wks.

A family of 14 and 16-pin hermetically sealed DIP resistor networks conforms to the requirements of MIL-R-83401. Standard in-out and pull-up circuits are offered. Information on nonstandard networks is factory available. Resistors are capable of handling 0.1 to 0.2 W at 70 °C. The resistor networks are rated at 1.3 to 1.6 W at 70 °C and derated linearly to 0 at 125 °C. Temperature coefficients of 100, 50 or 25 ppm/°C and tolerances of 1.0, 0.5 and 0.1 percent are available.

CIRCLE NO. 308

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A compact dc tachometer for industrial applications is less than 2-in. thick and operates over the range from 0 to 6000 rpm. Brush life is up to 5000 h. Other features include a low ripple of 1% at 100 rpm, a low output impedance of 0.85-Ω resistive, and a linearity of 1%. The unit’s 117-bar commutators provide a high ripple frequency. Output-shaft diameters of 1/2 in. or greater help control torsional resonance. Ball-bearing shaft support ensures a high radial-load capacity.

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CIRCLE NUMBER 60
**INTEGRATED CIRCUITS**

**Driver, receiver meet tight specs**

*Fairchild, 464 Ellis St., Mountain View, CA 94042. (415) 962-3816. $1.79 to $2.43 (100); stock.*

The 9636 line driver and the 9637 line receiver meet EIA standards RS-422 and RS-423, as well as the requirements of CCITT standards X.26 and X.27. The circuits also can withstand EIA standard RS-232C fault conditions. The 9636 is a dual single-ended line driver that provides TTL and CMOS-compatible inputs and operates over the military and industrial temperature ranges. The 9637 is a Schottky dual differential line receiver that has a threshold accuracy of ±200 mV over a ±7-V common-mode range.

**Adjustable regulators output 1.5 A**

*Lambda Electronics, 515 Broad Hollow Rd., Melville, NY 11746. (516) 694-4200. $2.85 to $4.05 (500 up).*

Adjustable IC regulators provide load currents up to 1.5 A. The LAS 15U is adjustable from 4 to 30 V; the LAS 18U, from -2.6 to -30 V. The new circuits have a maximum line regulation of 2% of \( V_{\text{out}} \) and load regulation of 0.6% of \( V_{\text{out}} \), with a guaranteed maximum tempco for the output voltage of 0.03% of \( V_{\text{out}}/°C \). Other guaranteed specs are: minimum input-output differential of 2.4 V (positive) and 2.1 V (negative); and maximum output noise voltage of 10 \( \mu V \) rms per volt. Built-in functions include thermal shutdown, current limiting and safe operating-area compensation.

**Chip controls switching supplies**

*Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, CA 92705. (714) 530-9879. $6.80 (100).*

A control circuit for the switching of power supplies and inverters—the SL442—operates at frequencies up to 40 kHz, withstands short circuits between adjacent pins or ground, and includes internal regulation of the chip supply rail. The SL442 has an internal oscillator that may be phase-locked for use with external synchronization; variable ratio space/mark pulses for controlling an active series or parallel element; and “soft” starting, with the output voltage increasing at a predetermined rate to the required level.

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<table>
<thead>
<tr>
<th>PARTS</th>
<th>I (Amps)</th>
<th>Volts AC</th>
<th>Insertion Loss—Db</th>
<th>150KHz</th>
<th>10MHz</th>
<th>1GHz</th>
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</tbody>
</table>

For other ratings—see EEM 1-376 to 1-583

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CIRCLE NO. 324
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Texas Instruments, P.O. Box 5012, M/S-84, Dallas, TX 75222. (713) 494-2621. $2.25 to $7.34 (100); stock to 12 wks.

Three registers and two bus-buffers/line drivers provide byte-size µP-interface functions. Each octal unit has three-state outputs to facilitate direct interface with system bus, full parallel access for data inputs and outputs, and MOS-compatible inputs. The SN54S/74S373 and SN54S/74S374 registers offer a transparent latch and clocked D-type flip-flop bus interface, respectively. The SN54S/74S412 transparent-latch register features a high-level output of 3.65 V minimum. The two drivers offer a choice between inverting or non-inverting logic elements and are designated the SN54S/74S240 and SN54S/74S241, respectively.

CIRCLE NO. 325

CMOS analog switches offer full protection

Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. $14 to $30 (100); stock.

A family of CMOS analog switches eliminates SCR-latching problems and provides full overvoltage protection for analog-input voltages up to ±25 V greater than the power supplies. The AD7510DI and AD7511DI (with inverted logic inputs) quad SPST, and AD7512DI dual SPDT switches exhibit 75-Ω ON resistance, 400-pA leakage current, 350-ns switching speeds, 3-mW power dissipation, and TTL/CMOS interfacing. The new dielectrically isolated units switch a 1-kΩ resistor in series with the power-supply line whenever the analog-input voltage exceeds the power-supply voltage. The resistor limits the current and is automatically removed when an overvoltage disappears, allowing the switch to operate normally and exhibit the low ON resistance.

CIRCLE NO. 326

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**Darlington drivers ease interfacing**

*Fairchild, 464 Ellis St., Mountain View, CA 94042. (415) 962-3816. $1.55 to $2.46 (100); stock.*

Six new high-voltage, high-current Darlington-array drivers interface TTL and MOS logic circuits with devices such as solenoids, relays, lamps, small motors and LED displays. The devices provide output voltages of 50 or 80 V and output currents up to 350 mA. The basic circuits are the 9665, 9666 and 9667, all of which spec 50-V maximum. The three devices are available in 80-V versions, designated with A suffixes. The 9665 can be used with any kind of logic. Input current limiting is set by connecting a discrete register to each input. The 9666 eliminates the need for external resistors, and is specifically designed for direct interfacing of PMOS logic to solenoids. It operates from supplies of 14 to 25 V. The 9667 has a series base resistor connected to each Darlington pair for direct operation with TTL or CMOS logic operating from 5-V supplies.

**ICs trigger thyristors**

*Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, CA 92705. (714) 540-9979. SL449: $2.96 (100).*

Three ICs can be used to control thyristors. The SL447 through 449 (second-sources for the RCA CA3058, 3059 and 3079) generate thyristor trigger pulses only at zero-voltage points in the supply voltage cycle. All three ICs feature direct connection to thyristor gates, supply voltage range of 20 to 300 V, frequency range of 10 to 1000 Hz, stabilized internal supply and a gate pulse driver. The SL447 and SL448 also include a de-gate drive capability, and may be programmed to shut down system power in case of sensor malfunction. The SL447 and SL449 operate over the temperature range of -20 to 85 C, while the SL448 operates over the MIL temperature range of -55 to 125 C.
Here's a six decade bidirectional counter-controller especially designed to give long, uninterrupted service in industrial environments. C/MOS circuits and special internal filters allow it to be used in high electrical noise environments. LED displays, 10 amp relay output, six decade presets are standard. A six decade set point control is available. Let a Theta Application Engineer help you team an industrial controller with a decitrak® shaft encoder or other transducer.

LITERATURE:
Write for descriptive literature and your free copy of Digital Solutions to Automatic Control

Theta
INSTRUMENT CORPORATION
Fairfield, New Jersey 07006 • Phone: 201-227-1700
CIRCLE NUMBER 64
13-mil diameter cores are temp independent

Ampex Corp., P.O. Box 33, Marina del Rey, CA 90291. (213) 821-8933. About $0.50/1000; stock.

The Model 1370 Unibit computer memory cores have diameters of 13 mils. Typical operating parameters for the cores include: drive current of 780 mA; disturbed ONE output of 34 mV; disturbed ZERO output of 4.5 mV; switching time of 125 ns and peaking time of 65 ns. Performance is uniform over any 75-C temperature range without compensation of the drive current and with a drive current compensation of 0.4 mA/°C the performance is uniform over a -55 to +110°C.

CIRCLE NO. 329

Connector withstands environmental hazards


The Sure Seal connector has been tested to depths of 3 ft in a 5% salt and detergent-filled water solution. It resists exposure to dusty roads, salt-covered highways, various fluids and chemicals, as well as temperatures from 40 to 220 F. And despite these environmental hazards, the connector reliably will transmit low-level electrical signals. Sure Seal water-resistant car/trailer harness kits contain all wiring and interconnection hardware required for simple hookup.

CIRCLE NO. 330

Adhesive backed plastic film holds wafers

Aremco Products, Inc., P.O. Box 429, Ossining, NY 10562. (914) 762-0685. 3 in. wafer carrier: $0.55 (10,000); 2 wks.

Called Wafer-Mount 559 this semi-rigid, adhesive-backed plastic film holds silicon wafers, alumina or glass substrates for dicing and scribing. In use, paper backing is peeled from the plastic, and wafers are firmly pressed against the exposed adhesive, with no heating required. The wafer can then be held against a vacuum manifold for dicing and scribing. The parts are separated from the plastic by washing in acetone.

CIRCLE NO. 331

Aluminum handles come with choice of 6 colors

Des Tek, P.O. Box 24163, Los Angeles, CA 90024. (213) 474-5093. From $2.04 (100-up); stock.

A line of equipment handles is available in clear or black anodized aluminum, and comes with a choice of six trim colors. Three heights of handles are available. The M-10 and M-40 series measure 1.63 in.; the M-20 series, 1.13 in.; and the M-30 series, 1.38 in. Seven lengths, from 3.5 to 14 in., in increments of 1.75 in. are also available. The 10-24 mounting-screw posts are completely adjustable, so these handles will mount at any center distance.

CIRCLE NO. 332
The one variable the world can standardize on.

Our new Type M conductive plastic variable resistor is hard metric. A 10 mm cube that's tiny, flexible and rugged. The MINI-METRIC is the smallest dual pot available today. Manufactured in the United States, it's dimensioned the way the rest of the world thinks. Allen-Bradley has what you need; or, it can be ordered through our distributors. Ask for Publication 5239.

- Choices
  - single or dual pot or pot/switch combinations
- 10 mm cube (.394-inch) for all combinations.
- 100 ohms to 1 megohm conductive plastic resistance elements, ±20% tolerance, standard resistance values conform to IEC.
- Plastic case, bushing and shaft for electrical isolation.

Quality in the best tradition.

ALLEN-BRADLEY
Milwaukee, Wisconsin 53204

CIRCLE NUMBER 68
With some quick figuring your pencil can tell you that our SMA interface JCM Coaxial Connectors cost about half as much as MIL Spec. types. Yet, for many applications, there's virtually no difference in performance. Our JCM's provide excellent electrical performance from DC well into the gigahertz microwave range.

Johnson JCM connectors are available with gold finish that resists wear and abrasion. Or you can save additional money by ordering JCM's with a nickel finish. Either way, you'll get features like a brass body, Teflon® insulator and beryllium copper center contact.

Our JCM series includes both clamp-type and crimp-type connectors. All have five parts or less. And you can assemble them in three to five minutes without special tools.

Why pay for full SMA MIL spec. performance if you don't need it? Let your pencil tell you which connectors to buy. Fill out the coupon and mail it to us for more information.

E. F. Johnson Company/3005 Tenth Ave. S.W., Waseca, MN 56093

Please send me technical information on miniature JCM coaxial connectors. Please send me samples. You can call me at

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For fast service, contact your local Johnson Distributor.

CIRCLE NUMBER 69

Bar instrument handle for portable equipment

Buckeye Stamping Co., 555 Marion Rd., Columbus, OH 43207. (614) 445-8433. $2.90: 4-1/2-in. size; $3.25: 10 in. (OEM qty).

Econo-Handle is a new instrument-case handle designed especially for small to medium-sized instruments. The black vinyl-covered bar is accented with chrome-plated end caps. The handle folds flat in both directions, and is available in lengths from 4-1/2 to 10 in. The handle is ideal for converting individual bench instruments to portable instruments.

CIRCLE NO. 333

Dual-sided breadboard lets you use both sides


The Model 51X Klip-Blok breadboard, mounted on an aluminum chassis, allows components to be attached and interconnections to be made from both sides to increase wiring convenience and reduce clutter. Interconnections can be made with 22 gauge wire. Eight Klip-Bloks accommodate a maximum of twelve 14 or 16-pin DIPs, or four 24 or 40-pin devices. The 51X accommodates packages with 0.6-in. lead spacing as well as devices with conventional 0.3-in. spaced leads. The glass-epoxy mounting board measures $4.5 \times 8$ in., and has a 0.1-in. grid hole pattern. The 51X board is unclad, however, a Model 51X-GP may be ordered with an etched ground plane on the bottom side for breadboarding high-frequency circuits.

CIRCLE NO. 334

CIRCLING NO. 69

PACKAGING & MATERIALS

ELECTRONIC DESIGN 11, MAY 24, 1976
Wrap and unwrap tools come three to a kit

Jonard Industries, 134 Marbledale Rd., Tuckahoe, NY 10707. (914) 793-0700. $42 (KW-350), $48 (KU-360); stock.

Three piece wrapping and three piece unwrapping tool kits for wire connections handle the most popular wrapped-wire sizes. Contents of the wrap kit, Model KW-350, include: the WDI-2426 tool with standard, insulated, 0.073 in. diameter × 0.75 in. deep hole, WD-2225 single-ended tool with a 0.075 × 0.8 in. hole; and the WD-2000 single-ended tool with a 0.071 × 0.625-in. hole. The contents of the unwrap kit, Model KU-360, include: the UDL-2027 double-ended, left-hand tool with 0.052/0.07 × 1.25-in.-deep holes; the UDLR-2026 double-ended, left-and-right-hand tool with a 0.07 × 0.75-in. hole; and the UDR-2426 double-ended, right-hand tool with 0.066/0.073 × 1-in. holes.

CIRCLE NO. 335

Insert/extract 0.6-in. DIPs with safety

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, MA 02138. (617) 491-5400. $1.05 (100 up); stock.

A new DIP insertion/extraction tool for 0.6-in.-wide IC packages uses a spring-loaded clothespin-type action. The tool securely grips the IC between the leads and under the body, so fragile leads are not damaged.

CIRCLE NO. 336
Card guides use flame retardant materials

Bivar, Inc., 1617 E. Edinger Ave., Santa Ana, CA 92705. (714) 547-5832. For 1000-up lots: $0.18 (FR-650); stock.

A line of PC card guides is manufactured from 94V-0 U.L. rated material that has fire-retardant additives. Called Temp-O-Gides, they are brownish-red in color, rigid and strong. They snap easily, but firmly, into 11/64-in. holes in plates or channels that measure 0.47 in. wide x 0.09 in. deep. The guides are designed for 1/16-in. thick boards and are stocked in 24 standard lengths from 2.5 through 14 in.

CIRCLE NO. 337

Heat sinks installed before/after assembly

Ahah, 968 W. Foothill Blvd., P.O. Box 909, Azusa, CA 91702. (213) 334-5135. $0.07 (5000).

Ahah Model 135 heat sinks fit TO-5 cases. They are stamped and formed from aluminum 0.025-in. thick, 0.75-in. diameter and 0.480-in. high and require very little board space. These low-profile coolers can be installed before or after assembly and dissipate 1 W with a case temperature rise of 55 C above ambient.

CIRCLE NO. 338

Instrument cases hold up to 2000 cm³ of circuits


Instrument cases, suitable for amplifiers, test equipment and similar applications have internal capacity of up to 2000 cm³ (135 in³). The BIM 3000 Bimcase is available with either red, grey or orange 14 gauge aluminum top and bottom covers. The covers are attached by four self-tapping screws to the matte black 18 gauge steel chassis, the rear of which is prepunched to accept an I.E.C. power connector. The chassis has rigid upper and lower internal brackets onto which PC boards can be mounted.

CIRCLE NO. 339
CANNON
SMA CONNECTORS
MEET MIL-C-39012

This broad line of SMAs meets or exceeds MIL-C-39012. Cannon gives you engineering expertise—designs to fit your needs—large production capability, widespread distributor support, and extreme variety of configurations. There’s a lot of savings inherent in each of those factors.

For instance, in variety, our SMA series, QPL approved under MIL-C-39012, offers more than 120 part numbers to choose from. Designed for high-performance applications, the units are rugged, 50-ohm, miniature, RF connectors. They have excellent electrical characteristics from dc to 18 GHz and may be used in some applications at frequencies up to 26 GHz. Available in gold plating or in comparably performing but more economical passivated stainless steel versions.

Both finishes meet MIL-C-39012. Small size and superior electrical properties make these units especially adaptable to microwave-component applications such as couplers, dividers, and mixers.

We are fully prepared to meet any RF connector requirement. Our manufacturing facilities are in the production of Coaxial connectors and interconnection systems. Our quality testing department can perform in-house every test required by MIL-C-39012. Our capability is your assurance of maximum performance and lower total installed cost. Send for our "RF Coaxial Connectors" brochure today.ITT Cannon Electric, 666 East Dyer Road, Santa Ana, CA 92702. Toll-free, 24-hr (800) 854-3573; in Calif., (800) 432-7063.

Six decades on the leading edge of interconnect technology.

CANNON ITT
**Packaging & Materials**

**Contactor adaptable to irregular surfaces**

Tecknit, 129 Dermody St., Cranford, NJ 07016. (201) 272-5500. $0.30; copper, 0.125 × 0.187 in. (1000-up); 3-4 wks.

A fuzz button is a resilient, low impedance contactor formed by die compressing fine knitted wire mesh to a desired shape and density. It is applicable when the contacting surface is irregular and otherwise might require a special connector. It is also usable for EMI shielding and grounding, or as a shock mounting for equipment, or as a temporary contactor for device leads and printed-circuit boards. The wire material can be gold-plated copper, monel or copper of various thicknesses. The cross-section and height may be cylindrical or formed to any desired shape.

**Cable Intra-Connector permits easy line tests**

AP Products Inc., Box 110, 72 Corwin Dr., Painesville, OH 44077. (216) 354-2101. From $7; stock to 4 wks.

The Intra-Connector permits quick diagnostic testing of individual lines in flat ribbon cable systems. The unit is manually installed between any mating dual-row connectors and sockets that have contacts on standard 0.1-in. centers. An extra set of dual-row contact pins extending from the Intra-Connector may then be probed individually or connected to another cable assembly. Five models are available to fit the most common flat cable connector/socket sizes: 20, 26, 34, 40 and 50 contacts or lines. The Intra-Connector is molded of glass-reinforced polyester; contacts are noncorrosive alloy 770.

**Cast-aluminum boxes provide good shielding**

Andar Corp., 2230 S. Cotner Ave., Los Angeles, CA 90064. (213) 477-2111. $25 to $32 (unit qty); stock.

Boxes for off-the-shelf packaging are cast in A-356 aluminum alloy and black-anodized finished. Covers, made of 0.080-in. 6061-T6 aluminum plate, are grained and coated with a clear chemical film and tightly secured with closely spaced, flush screws in pretapped holes. Four sizes range in size from 1.96 × 3.39 × 1.16 to 5.76 × 3.14 × 1.40 in.

**Alignment Crosshairs Increase Accuracy**

Amtek, 23011 Moulton Parkway, Laguna Hills, CA 92653. (714) 581-9210. $185.

A micro-alignment device (MAD) that attaches to the end of a microscope enables more accurate positioning of ICs during manufacturing processes, according to Amtek. MAD projects a target, or crosshair, for aligning miniature ICs or any other small part under the scope. Unlike a reticle, which is a target that fits into the eyepiece, the crosshair for MAD fits onto the field view of the microscope and greatly increases the positioning accuracy. The MAD target is a replaceable photographically generated image, which can be positioned in the X and Y planes, and contains its own light source. Custom targets and target colors are optional.
Board for µPs allows easy system expansion

Vector Electronics Co., Inc., 12460 Gladstone Ave., Sylmar, CA 91342. (213) 365-9661. $19.95 (1-4); stock.

A universal board for microprocessors, Model 8800 V, allows Altair, IMSAI and other microcomputer users to add circuits in a convenient and inexpensive manner. Identical in size to those used in the Altair, it serves for RAM, ROM, or PROM memory expansion, for peripheral interface hardware requirements or for I/O circuits such as a/d, d/a converters, multiplexers and relays. The board’s 5.13 in.² area and 100 I/O terminals allow its use with any microprocessor-based system. The board is pre-punched with 0.042-in.diameter holes on 0.1-in. centers, so that the user can place DIPs in almost any location. Typically, the board holds two 40-pin DIPs, eight 24-pin DIPs and 36, 14 or 16-pin DIPs.

CIRCLE NO. 599

Splices for magnet wire pierce tough insulation

T&B/Thomas & Betts, 36 Butler St., Elizabeth, NJ 07207. (201) 354-4321.

Insulation-piercing fork terminals and splices for connection to aluminum or copper magnet wires have multiple sharp ridges on the inner barrel surface for penetrating tough magnet-wire insulation; thus the need for stripping, brazing and soldering is eliminated. These additions to the Dragon Tooth line accommodate a range of wire sizes from 20 to 14 AWG in a variety of combinations. Magnet wire can be combined with stripped-lead wire. The open barrel design permits easy mid-span splicing and tapping. The connectors can be installed with either the T&B Shure-Stake hand tool, or bench-mounted air/hydraulic tool when production speeds are desired.

CIRCLE NO. 600

BergPin .025"square terminals... supplied in over 35 standard sizes for design flexibility above and below the board.

BergPin terminals and the machines which stake them in circuit boards comprise a fast and reliable interconnection system. These machines stake pins—to within .015" diameter of true position from nominal—at rates from 1,500 to 12,000 per hour. With BergPin, you can stake boards ranging from .062" to .125" thick.

These features distinguish the BergPin terminal from ordinary wire-wrapping and connector-mate pins.

Pin tip is designed to facilitate wire-wrapping or disconnect lead-in.

Uniform cross-section. Made from drawn, not stamped, material. Result: smooth, flat contact surfaces.

Star-wedge shape provides 8 lbs. retention (at nominal hole size) before soldering; up to 50 lbs. retention after soldering.

Tapered lead-in will not damage plated through hole or multi-layer construction.

Pin tip is designed to facilitate lead-in when staking.

Berg-built machines stake pins to within .015" diameter of true position from nominal. Machine rates from 1,500 to 12,000 per hour.

Supplied in over 35 standard sizes for design flexibility above or below the board. Will stake in P.C. boards ranging from .062 to .125" thick.

Available in six types of surface platings.

.100" center minimum spacing allows for traces between holes.

BergPin terminals are a key component in the BergCon" line... the most complete interconnection system available today. You can use BergCon products to package .025" square mated pairs on .100", .125", or .150" grid. Complete details on the BergPin terminal and the complete BergCon line are yours for the asking. Write or call:

New Cumberland, Pa. 17070 Phone: (717) 938-6711
diodes have output voltages of 0 to 600 V, peak current of 75 A and output power of 50 kW. Pulse widths are 50 to 200 ns. Rise times (10 to 90%) are 50 ns with fall times variable—50 ns maximum. Polarities are positive and rep rate is 10 kHz. The Pulse 10 is intended for single laser diodes, and the Pulse 12 works with diode arrays.

Pulsers drive injection lasers

Simulation Physics, 41 B St., Burlington, MA 01803. (617) 272-5202. $1595; 60 days.

Two pulsers for injection-laser

VCOs specify ±0.075% stability

Microwave Technology, 840 W. Church Rd., Mechanicsburg, PA 17055. (717) 697-4681. $745 (1 to 3).

Voltage-controlled oscillators, with center frequencies in the 800-MHz-to-6-GHz band, have a frequency stability of ±0.075% or better over the temperature range of 0 to 50 °C. The Model EPH-134 tunes ±100-MHz bands, with center frequencies from 800 MHz to 1500 MHz. The Models EPH-135 and 136 tune ±30-MHz bands, with center frequencies in the range of 1.5 to 3.0 GHz and 3.0 to 6.0 GHz, respectively. Output power is 20-mW minimum with harmonics of —24 dBc or better, and spurious signals of —40 dBc or better. The tuning voltage required is in the range of 0 to +24 V dc. Frequency vs tuning voltage linearity is ±10% or better.

Gunn oscillators have high stability

Trak Microwave, 4726 Eisenhower Blvd., Tampa, FL 33614. (813) 884-1411. $795 to $895; 60 to 90 days.

The Series 6901-1200 Gunn oscillators, with center frequencies between 8 and 16 GHz, are said to be virtually impervious to voltage, VSWR, or temperature shifts. The oscillators have a stability of ±0.05% from —54 to +71 °C. They are mechanically tunable over ±0.5% of center frequency. Rf output is +13 dBm minimum to +19 dBm maximum. Also, the new units have a pushing factor of less than ±0.002% V from dc to 3 kHz, and a pulling factor of ±0.01% for 3:1 load VSWR. Harmonics are less than —50 dBc with nonharmonic spurs measured at greater than —90 dBc.

FOR PRODUCT DEMONSTRATION CIRCLE #290 FOR LITERATURE ONLY CIRCLE #289

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INTRODUCES
THE SMART COUNTER.

Series 9000: World’s First Microprocessing Timer/Counter.

The Dana Series 9000 is smart enough to make your work a lot easier. Microprocessing controls provide all the features of a premium timer/counter, a reciprocating counter and a calculator. Plus interfacing options and operating capabilities never before available in one instrument.

The Dana Series 9000 Microprocessing Timer/Counter goes so far beyond all other counters it takes a whole brochure just to explain its capabilities. Ask for it. It’s the smart thing to do.

Dana Laboratories, Inc., 2401 Campus Drive, Irvine, California 92664, 714/833-1234.

Others measure by us.

FOR PRODUCT DEMONSTRATION CIRCLE #290 FOR LITERATURE ONLY CIRCLE #289

122
Announcing the 1740A... a new 100MHz scope with fresh measurement ideas.

In the time domain—Push the third channel trigger display button, release, and you have a simultaneous display of the trigger waveform plus channel A and B traces. Now you can make accurate timing measurements from the trigger signal to events on either or both channels.

A X5 vertical magnifier provides 1 mV/div sensitivity on both channels to 40 MHz, without cascading, so you can monitor low-level signals directly. Signals such as the output of read/write heads of disc or mag tape units, low-level ripple on power supplies, or medical sensor and electro-mechanical transducer outputs.

In the data domain—You can combine the 1740A with HP's 1607A Logic State Analyzer and use the analyzer's pattern trigger or delayed trigger output for external scope triggering. Add the "Gold Button" (an optional logic-state push-button in lieu of A versus B) for just $105* and (with the 1607A) you have the convenience of logic-flow display or real-time display at the push of a button.

That means you can view the logic states of operational circuitry directly for pinpointing a program problem. Then—with a push of a button—take a look at the waveforms you've selected at that specific point in time.

Add to all this, features such as selectable input impedance (1 megohm or 50 ohms) and the time-tested 8 x 10 cm CRT used in our 180 System lab scopes for bright, easy-to-read displays. Priced at just $1,995*, the 1740A with its new ideas, simplifies both real-time and data-domain measurements. When you get your hands on this scope—you'll know you're working with a quality instrument. Give your local HP field engineer a call today.

*Domestic U.S.A. price only.

Data/Time Domain Oscilloscopes

FOR TECHNICAL INFORMATION CIRCLE #275
FOR IMMEDIATE APPLICATIONS ASSISTANCE CIRCLE #276

HEWLETT PACKARD
Sales and service from 172 offices in 65 countries.
MICROWAVES & LASERS

Detector offers 0.1-18-GHz coverage

Weinschel Engineering, Gaithersburg, MD 20760. (301) 948-3434. $180; stock to 30 days.

The Model 1113 coaxial crystal detector, for use in 50-Ω systems, offers a flatness of better than ±1.0 dB over the entire 0.1-to-18-GHz frequency range. Sensitivity is 0.4 mV/μW minimum at low levels and 100 mV/0.4 mW at high level. The detector has a maximum VSWR of 2.0:1 and a maximum power handling capability of 100 mW.

Comb generators output —2 dBm

Zeta Laboratories, 616 National Ave., Mountain View, CA 94043. (415) 961-9050. $600 to $1200; 45 to 60 days.

The CI Series of comb generators, operating in the frequency range of 25 to 18,000 MHz, features picket spacings from 25 to 500 MHz. The spacing is generated from an internal crystal-controlled oscillator. Power outputs up to —2 dBm are available from some models, though the output is nominally 20 to —30 dBm. The CI series, housed in a 4.4 × 1.5 × 1.47-in. package, needs only a 28-V input.

SWR bridge has 35-dB directivity

Wiltron, 930 E. Meadow Dr., Palo Alto, CA 94303. (415) 494-6666. $1400; 6 wks.

The Model 87A50 SWR bridge covers the 2-to-18-GHz frequency range with greater than 35-dB directivity. The reference termination is included internally. A precision APC-7 connector is used on the Test Port with stainless-steel Type N connectors on the input and output ports.
Germanium detector has 40 cm$^2$ active area


A germanium detector system—made by Ortec—is designed for in-vivo counting of heavy elements, whole body counting and environmental radiation monitoring. It consists of four, planar-germanium low-energy photon spectrometers that share a common vacuum cryostat. The active area of the array is 40 cm$^2$—claimed to be the largest ever made. System resolution is better than 800 eV full width, half max at 122 keV, and 650 eV at 60 keV. Cost of a typical system is about $50,000 per array, depending on resolution and active area.

CIRCLE NO. 348

Power transistors handle 600 V at 40 A

PowerTech, 9 Baker Ct., Clifton, NJ 07011. (201) 478-6205. From $123.50; stock.

The PT-3516 and PT-3526 silicon power transistors offer collector breakdown voltages, $V_{CEO}$ of 600 V. They have their gain, $h_{fe}$, specified at a collector current of 40 A. Devices have rise and fall times of less than 1.5 µs and are rated for a power dissipation of 325 W in a JEDEC TO-63 package.

CIRCLE NO. 349
Scanbe·gram

RE: STANDARD SOCKET CARDS AND PANELS

SCANBE'S STANDARD 40 AND 60 POSITION SOCKET CARDS MOUNT A WIDE VARIETY OF DIPS...INCLUDES FIELD PROVEN ME-2 SOCKETS AND PIN STRIPS....ALSO KIT CARDS AND UNIVERSAL MODELS FOR COMPLETE FLEXIBILITY.

SOCKET PANELS AVAILABLE...OFFERS 30 TO 180 ME-2 SOCKETS IN ZONES OF 30....PLUS UNIVERSAL PANELS...ALL CARDS AND SOCKETS PROVIDE FOR DECOUPLING CAPACITORS....STANDARD CARD FILES AND DRAWERS ALSO AVAILABLE.

SPECIFY SCANBE....
SAVE WITHOUT SACRIFICING QUALITY.
SEND FOR NEW I.C. PACKAGING CATALOG.

CIRCLE NUMBER 79

CRYDOM'S NEW LOW COST TRIAC SSR

New from Crydom. The TL Series of 10 amp triac solid state relays. Superior breakdown voltage ratings — 300V for 140VAC units & 500V for the 280VAC series. Input filter on control side prevents false triggering. Built-in snubber protects against false turn-on. Crydom quality throughout. Designed for resistive lamp loads or light inductive loads. Save 20% with our new triac output SSR.

Call or write today for details.

International Rectifier

1521 Grand Avenue, El Segundo, California 90245 • (213) 322-4967

CIRCLE NUMBER 80

DISCRETE SEMICONDUCTORS

Power transistors made for MIL requirements


Two series of silicon power transistors have been developed to meet military requirements. The JAN, JANTX and JANTXV 2N3716 series of transistors have current capabilities to 10 A at collector voltages of up to 100 V. The devices are housed in TO-3 cases. Prices for the transistors start at $9.12 to $17 for the JAN version and $13.65 to $25.65 for the JANTX and JANTXV versions, depending on quantity. The other series, the JAN2N1722 and JANTX version, handles currents to 7 A at collector voltages of up to 80 V. These transistors are available in TO-53 packages. Price in 100-up quantities for the JAN devices is $14.25 and is $24.25 for the JANTX version. Delivery for all units is from two to eight weeks.

CIRCLE NO. 356

IR LEDs offer response times of 50 ns, typical

International Audio Visual, Inc., 15818 Armitza St., Van Nuys, CA 91406. (213) 787-4400. From $7.95 (1000-up); stock.

A family of fast, infrared LEDs is designed for data transmission and general optical communications. They have a figure of merit of $F > 10^6$ W/s in pulsed operation and a response time of typically 50 ns. Power output in the continuous mode is over 10 mW. Several mounting arrangements are available, including the TO-5 and power stud cases, with different lens types for wide-angle and beamed-power applications.

CIRCLE NO. 357

Electronic Design 11, May 24, 1976
Fast-switching power transistors handle 3 A

Kertron, 7518 Central Industrial Dr., Riviera Beach, FL 33404. (305) 849-9606. See text; stock.

The 2N6506, 7 and 8 fast-switching power transistors are designed for use in off-line switching power supplies. The devices have a $V_{ce}$ of up to 700 V, a dc current gain of 15 to 75 at 3 A and a collector-to-emitter voltage of 5 V. They have a guaranteed $E_{s}/b$ rating of 180 mJ at a 5-A collector current. The transistors have a maximum rise time of 0.6 $\mu$s and a maximum fall time of 0.4 $\mu$s, also at a collector current of 3 A. Prices for the transistors (in 100-up quantities) are as follows: 2N6506, $3.02; 2N6507, $3.42; and the 2N6508, $4.43. All devices are housed in TO-3 cases.

CIRCLE NO. 360

Power Darlington have 0.4-$\mu$s fall times

International Rectifier, 233 Kansas St., El Segundo, CA 90245. (213) 678-6281. From $4.85 (100-up); stock.

A series of monolithic powerDarlington transistors has fall times as fast as 0.4 $\mu$s. The transistors are rated for operation to 25 A at 500 V. Designated the IR 6000, 6060 and 6250, the Darlington are rated for 15, 20 and 25 A, respectively. They have an internal diode that helps reduce turn-off time. The glass passivated transistors have a maximum power dissipation of 100 W for the 15-A units, 125 watts for 20 and 25-A units, at a case temperature of 25 C. Minimum dc current gain is 100 at 10 A for the 25-A Darlington, 140 at 3 A for the 15-A units and 150 at 5 A for the 20-A units. All transistors are housed in TO-3 cases.

CIRCLE NO. 361
This telephone keyboard is, and the others might as well be. The key legend that makes one keyboard different from another costs next to nothing. Prototyping?

The Chomerics approach makes small quantities of custom keyboards practical.


— Key in to the leader. CHOMERICS
77 Dragon Court
Woburn, Ma. 01801
(617) 935-4850

CIRCLE NUMBER 82

POWER SOURCES

It may be ugly, but it isn’t a duckling

Elexon Power Systems, 3131 S. Standard Ave., Santa Ana, CA 92705. (714) 979-4440. $18.50 (1000).

Solv-15, 15-W open-frame supply offers outputs from 5 to 24 V, 3 to 0.75 A. Operating temperature range is 0 to 55 C full rating, derated linearly to 40% at 70 C. Load regulation is ±0.1% NL to FL and line regulation is ±0.05% for a 10% input change. Output ripple is ±0.1% pk-pk dc to 10 MHz and temperature coefficient is ±0.02%/°C max.

CIRCLE NO. 362

Modules work over full MIL temp range


BBN-12A series of dual output power modules converts 28-V-dc input power to 25, 50, or 100 W of regulated ±12-V-dc power. The series is switching regulated and can operate over the full military temperature range of -55 to +100 C. Regulation of dc input voltages is to 0.5% over the full input range of 20 to 32 V dc. Load regulation is 0.5% for no load to full load at constant input voltage. PARD (ripple and noise) has been reduced to 25 mV rms, 100 mV pk-pk over the temperature range of 25 to 100 C.

CIRCLE NO. 363

ELECTRONIC DESIGN 11, May 24, 1976
Supply takes aim at floppy discs

Power-One, 531 Dawson Dr., Camarillo, CA 93010. (805) 484-2806. $120; stock-2 wks.

This new series is designed specifically for powering floppy-disc drive systems, including controller/formatter circuitry, from manufacturers such as Pertec, Diablo, CDC, Shugart, etc. First to be offered in this series is Model CP-162, a triple-output unit capable of powering two individual floppy-disc systems simultaneously. Outputs are +24 V at 5 A, +5 V at 3 A, and -5 V at 0.6 A, all with overvoltage protection. Of special interest is the 24-V regulator, capable of delivering up to 6-A output current for 500 ms upon initial system power-up.

CIRCLE NO. 366

Power modules provide 2.5 W/in^3

Etatex, Inc., 187-MW Orange-thorpe, Placentia, CA 92670. (714) 996-0981. $295 (5 V, 20 A); stock.

Output power capability of "A" series of 5-to-60-V power modules has been increased from 120 W max to 150 W max. This makes possible a power density of 2.5 W/in^3 for output voltages in the 47-to-60-V range. Minimum efficiencies of the series range from 75% at 5 V, 20 A to 82% at 60 V, 2.25 A. Ripple is 100 mV pk-pk maximum from all sources. The fully regulated (0.4% line/load), off-line modules provide short circuit/overload, input overvoltage and remote sensing as standard features.

CIRCLE NO. 367

If you've got a complicated problem with EMI, we've got a simple solution

Electromagnetic Interference. It shows up as static on radio and snow on TV. It can make computer terminals register input error. Make a pacemaker or an EKG malfunction. And interfere with sensitive navigation equipment.

Obviously, you've got to shield your equipment against EMI. You can use sheet metal. Or foil. Or a plating process. These are fine for small enclosures with flat surfaces. But when it comes to large cases and complex shapes, you need a better solution.

And here it is. Electrodog® coatings. We've engineered a whole range of them. To give you from 10-70 dB attenuation, from 1 MHz to 10 GHz. With varied physical properties that let you apply them to almost any material.

This means that you can build your enclosures out of light plastic, coat them with Electrodog, and still get perfect skintight shielding. Even on honeycomb structures and flexible parts made from foamed resins.

And you can forget about expensive techniques like plating, metallizing and vacuum deposition. With Electrodog, all you need is a spray gun, a simple dipping technique, or a paintbrush.

You can use these new coatings for everything from CB radios and EKG units to data terminals and microphones.

This is a new field, but we're the oldest company in it. With the greatest experience, the biggest R&D staff and the most EMI coatings. For technical advice on specific applications, write: Acheson Colloids Company, Electrical Products, Port Huron, Michigan 48060. Or call (313) 984-5581.
Battery Miniservo® recorder only $795

72-hour delivery
For field or remote applications. Input spans are 1, 5, 10, 50, 100, and 500 mVDC and 1, 5, 10, 50, and 100 VDC, with ±100% zero adjust. Eight chart speeds from 6 cm/hr to 20 cm/min. 10 cm wide, Z-fold chart. The rugged Miniservo recorder is powered by internal 12V 8-hour rechargeable battery, or from external battery, or plugged into line power. Replaceable throwaway pen/ink cartridge. For fast delivery, order stock number S22243-1A. Call Lama, 317/244-7611. For more information, write Esterline Angus instrument Corporation, Box 24000, Indianapolis, Indiana 46224.

Low cost dc motors with a Pancake difference.

Longer life. Higher torque. Flat profile.

This motor combines excellent performance and higher reliability in a flat-profile package. All because of its Pancake armature. The flat lightweight copper-disc armature not only gives our low-cost motor a thin profile, but low inertia and high-pulse torque capability as well. With no iron in the Pancake armature, low-speed cogging and armature inductance are negligible and field demagnetization is zero. Features include: variable speeds from 0 to over 3000 rpm, low mechanical time constant, brush life up to 10,000 hours, available with integral tachometers, 10 models from 1/115 to 1/8 h.p., priced for volume O.E.M. applications. PMI offers a complete line of dc motors with a Pancake difference—prime movers, gearmotors and high performance servos up to 4 h.p. For more information call PMI Customer Service at (516) 448-1234. Or write.

PMM Division
Kollmorgen Corporation, Glen Cove, New York 11542

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DATA PROCESSING

Unit controls PDP-8 over phone line


The AFP-8 allows control and maintenance of a PDP-8 over a telephone line. It plugs into any OMNIBUS slot of the DEC computer, replacing both the usual teletypewriter controller and front panel. It duplicates all the functions of the DEC KL8 console teletypewriter controller and is compatible with all ASCII terminals. The AFP-8 also emulates the DEC KC8 programmer's panel to give complete front-panel remote control. A user can load any program, start it, observe its detailed operation, and even execute maintenance diagnostics without physical access to the remote PDP-8. No software changes are required.

CIRCLE NO. 368

Time-sharing computer sells for under $400

Digital Equipment Corp., Maynard, MA 01754. (617) 481-9511. $250,000 to $400,000.

Said to be the industry's lowest-priced general-purpose time-sharing computer system with full large-scale capabilities, the DEC-SYSTEM-20 features a new 36-bit word-length system. Other features include a full complement of high-level languages, a new field-proven operating system, and a newly designed systems architecture, with the central processing unit, core memory, controllers and a front-end PDP-11 processor integrated into a single functional unit. The system offers concurrent time-sharing, batch and transaction processing capabilities.

CIRCLE NO. 369

Naked floppy controller takes over mini's job

Dicom Industries, 715 Pastoria Ave., Sunnyvale, CA 94086. (408) 762-1060. $772 (OEM); stock to 90 days.

Model 121 "Naked" floppy-disc controller is functionally a complete, multipurpose, multidrive floppy-disc memory device. It is optimized for both μP and mini-computer applications and is compatible with DMA and programmed I/O channels. Since the 121 contains all formatter and controller logic, the mini or μP is freed from performing the time consuming tasks of issuing track stepping commands to the floppy, generating and checking CRC codes on the data, or keeping track of sector and track positioning on each connected floppy.

CIRCLE NO. 370

Floppy disc is DEC compatible

Data Systems Design, 1122 University Ave., Berkeley, CA 94702. (415) 849-1102. $2995, 2 drive assembly; 30 days.

The DSD-210 floppy-disc drive uses a μP-based controller with PDP-11, LSI-11 or PDP-8 instruction set and plug-in compatibility. It's interchangeable with DEC's RX8 and RX11. IBM format (256-k bytes per diskette) is available with either two or four diskette drives. Data transfer at 10-k bytes/s. The controller is also available separately.

CIRCLE NO. 371

Deltron slashes the price of μ Processor Power Supplies

MPS-1: $77
MPS-2: $88
In any quantity!

Automatic overload and adjustable overvoltage protection. Dual input voltage. 9.3% regulation. 1.5% ripple and noise.

Data Processing

Electronic Design 11, May 24, 1976
NEW CONVENIENCE IN RESIN SYSTEMS

11-part epoxy

Emerson & Cuming, Inc. one-part systems — epoxies, silicones, thermoplastics, solvent containing compounds, and others — eliminate weighing, metering, mixing, bring new convenience, speed, and accuracy to production processes involving coating, bonding, casting, molding, sealing, etc.

CIRCLE NUMBER 271

FLAME-RETARDANT EPOXIES & URETHANES

Stycast® Casting Resins and Eccocoat® Coatings, already spec’d in thousands of electrical/electronic applications, now offer an extra feature: Flame Retardancy! New E&C products, with the designation "FR", pass UL, Federal, and ASTM tests, including stringent UL 94 VE-O.

CIRCLE NUMBER 272

NEW THICK SECTION CURE SILICONE OFFER A WIDE RANGE OF PROPERTIES

Three new ECCOSIL® silicone rubber casting resins can be cured in thick sections and offer a range of special properties. One has low, low viscosity; another has ultra-high thermal conductivity; the third has specific gravity only 0.75.

CIRCLE NUMBER 273

Emerson & Cuming, Inc.

CANTON, MASS.
GARDENA, CALIF.
NORTHBROOK, ILL.
Sales Offices
in Principal Cities

EMERSON & CUMING EUROPE N.V., Oevel, Belgium

DATA PROCESSING

Unit prints labels with 2-in. characters

Diamond Engineering, 1635-150th NE, Redmond, WA 98052. (206) 883-1071. $14,000 to $20,000; 120 days.

The Label Printer is designed to print alphanumeric characters up to 2 in. high. The unit receives data via an EIA RS-232 serial line. It can print a line of one inch high characters on an 11 x 14.875 in. label in 1.8 seconds. The printer is designed to operate in an industrial environment, and has a heavy duty blower and filter for reliable ventilation.

CIRCLE NO. 371

PDP-11 configured for Fortran IV

Digital Equipment Corp., Maynard, MA 01754. (617) 897-5111. From $61,000; May, '76 delivery.

The PDP-11T55 is configured for data-processing "number crunching" operations, where maximum Fortran execution speed is required, in addition to traditional EDP-related problems. The system incorporates a new PDP-11/55 processor, a new floating-point processor, and 16-k or 32-k words of high-speed bipolar memory. It operates under Digital's RSX-11M operating system in a twin disc-pack configuration. The system employs Fortran IV plus an extended version of ANSI Fortran IV for high-speed systems throughput applications.

CIRCLE NO. 373

Reader for mag cards expands card uses

Tycom Systems Corp., 26 Just Rd., Fairfield, NJ 07006. (201) 227-4141. $3995 (unit qty); 30 to 60 days.

A new magnetic-card reader allows the use of IBM magnetic-card libraries with the Tycom MCR automatic send-and-receive terminal and other ASCII-compatible terminals. In this way users of the mag-card libraries can use the cards with a variety of other non-IBM equipment. The Tycom Model 38 KSR, for example, incorporates a standard IBM Selectric I or II with Tycom baseplate, an electronics control unit and a variety of optional equipment. The options can include ASCII-compatible CRT displays, Philips tape-cassette units, paper-tape punch and read attachments, acoustic couplers for direct telephone transmissions, minicomputers and calculators.

CIRCLE NO. 375

Unit transforms analog data for tape storage

Western Laboratories, 110 S. Rosemead Rd., Pasadena, CA 91107. (213) 793-0148. $169.

Models SMT-12 and SMT-13 Memory Translators convert low frequency analog signals of up to ±1.5 V pk into wide-deviation FM and vice versa. The FM signals can then be stored on a standard tape recorder or transmitted over a phone line. The SMT-12 has a bandwidth of 300 Hz and the SMT-13 a bandwidth of 150 Hz. Linearity when using a tape recorder is 0.08% for ±1-V peak inputs, plus tape-recorder error. When used over a phone line linearity for a ±1-V peak range is 1% typ.

CIRCLE NO. 374
OUR NEW MICRO TROUBLE SHOOTER SOLVES YOUR IC TESTING PROBLEMS

The XM Micro Hook is designed for difficult IC test connections. Light weight (less than 1 gram) and Finger-eze Hypo Action permit direct hookup to delicate wires where weight and leverage may damage component. Fully insulated to a single contact point for true readings.

Construction: One-Piece Beryllium Copper, Gold-Plated Conductor and Hook, made for connections over leads up to .025" diameter. Durable Heat and Chemical Resistant Nylon Body. Stainless Steel Spring. Available preconnected to a wide variety of interface connectors.

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CIRCLE NUMBER 91

CIRCLE NUMBER 92
How to Remain Un-obsolete:

101 circuit designs employing the most modern technology. Not just application notes of some new IC somebody is trying to sell you. Practical, tested functional blocks with all component values worked out, with performance data and descriptions.

You can obtain it painlessly for $3.00. And remain an up-to-date designer.

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SCR/diode modules handle up to 200 A

Semikron, 542 Columbian St., P.O. Box 59, South Weymouth, MA 02190. (617) 337-7220. See text.

The Semipak power semiconductor modules can handle up to 200 A. The high-power plastic-encapsulated SCR/diode modules are available with two SCRs, two diodes, one SCR/diode and free-wheeling diode. PIV ratings of up to 1400 V (3-phase bridge) are available and 2.5-kV dielectric isolated heat-sink bases are easily connected with supplied bus-bar hardware. The cost of a 40-A, 600-V PIV (2 SCR) module is $82 when purchased in 100-unit quantities. Delivery is from stock.

CIRCLE NO. 376

Low-pass active filter has choice of 7 cutoffs

Analogic, Audubon Rd., Wakefield, MA 01880. (617) 246-0300. $50 unit qty.; stock.

The MP230 low-pass three-pole active filter has a Butterworth response characteristic. It exhibits a maximally flat passband from zero out to the -3-dB cutoff frequency of 2 Hz. A rapid rolloff of 60 dB/decade beyond the -3-dB point filters out unwanted higher frequency components. Seven fixed cutoff frequencies (0.5, 1, 2, 3.3, 10, 33 and 100 Hz) are available. The filter has a low offset voltage of 2 µV, maximum, and an output noise of only 1.4 µV pk-pk. The MP230 passes an input voltage range of ±10 V with unity gain, ±0.01% at dc. Depending on the selected cutoff frequency, the filter output impedance ranges from 16 to 42 kΩ. The MP230 draws ±2 mA from ±15-V-dc supplies and operates over 0 to ±70 C.

CIRCLE NO. 377

Log-ratio modules keep conformity for 6 decades

Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700, $69 (1 to 9); stock.

A complete temperature-compensated, dc-coupled log ratio module, the Model 757, has six decade dynamic range. It also maintains log conformity to within ±0.5% maximum from 10 nA to 100 µA. Log conformity error over the entire six-decade range (1 nA to 1 mA) on both inputs is less than 1%. The symmetrical FET input stages, with bias currents of less than 10 pA, allow either input to operate within the specified dynamic range regardless of the other channel's signal level. Both input amplifier summing junctions, each with only ±1-mV maximum input offset voltage are available. The module has a ±0.04%/°C maximum scale factor drift and a ±0.3 mV/°C output offset-voltage drift. The scale factor may be adjusted for values over 1 V/decade, and the ±10-mV maximum output offset voltage can be externally trimmed to zero. The Model 757 is available in two versions, one for negative and one for positive input currents. Each version comes in a 1.5 × 1.5 × 0.4 in. (38.1 × 38.1 × 10.2 mm) encapsulated module, specified for operation over 0 to 70 C.

CIRCLE NO. 378

Three-phase monitor has 4 phase-to-phase ranges

Time Mark Corp., P.O. Box 15127, Tulsa, OK 74115. (918) 939-5811. $68.50 (1 to 9); stock.

The Model 263 three-phase power monitor can protect three-phase motors and other types of three-phase loads. The unit continuously monitors each of the three phases for low voltage, loss of phase, or phase reversal. Sensitivity of the trip point can be adjusted from the front panel with a small screwdriver. A trip indicator is also provided to show when the output relay is de-energized. The units are available from stock in four phase-to-phase voltage ranges: 85 to 130, 160 to 250, 340 to 500 and 420 to 600 V. Output relay contacts are rated at 4 A.

CIRCLE NO. 379
Rf amplifier spans 2 to 200 MHz with 12-dB gain

Q-Bit Corp., P.O. Box 2208, Melbourne, FL 32901. (305) 727-1838. $29 (1 to 99); 2 to 4 wks.

The QB-614 rf amplifier offers a 12-dB gain that is flat over a 2-to-300-MHz bandwidth. The noise is only 3 dB and the input/output VSWR is less than 1.2:1. When operated at 15 V and 15 mA, the amplifier has a typical +22 dBm, 3rd order intercept point. Operation is specified for a supply as low as 9 V. The amplifier is housed in a 0.7 x 0.7 x 0.34-in. module.

CIRCLE NO. 380

Data-acquisition systems reduce measurement $ 

Data Translation, 109 Concord St., Framingham, MA 01701. (617) 879-9595. See text; stock.

A complete 12-bit, 16-channel, data-acquisition module, the DT-5701, is claimed to cut costs to the bone. It contains a 16-channel multiplexer, buffer amplifier, high-speed sample/hold amplifier, 12-bit a/d and all control and programming logic. The DT5701 costs only $175 (100-pc lots). All outputs are three-state TTL buffered for direct connection to microcomputer busses. Additional features include: 35-kHz throughput rate, random or sequential multiplexer addressing and multiple shielding against EMI/RFI noise. Pin strappable input ranges of ±5, ±10, 0 to +10, 0 to +5 V are available.

CIRCLE NO. 381

Need an RF amplifier?

DON'T BUY ENI....

until you consider the wide selection of quality amplifiers available from Amplifier Research. We offer the world's largest selection of standard high-power RF broadband amplifiers. So, if you're considering an ENI unit, simply tell us the model number and we'll send you specifications on our competitive unit.


CIRCLE NUMBER 96

CIRCLE NUMBER 97

ELECTRONIC DESIGN 11, May 24, 1976
RELIABLE HIGH-VOLTAGE INTERCONNECTIONS
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Bodine's PM drive family grows—
New 32D permanent magnet Control Motors and 32D-5F right angle gearmotors, perfectly matched with Bodine speed/torque controls. Continuous duty ratings of 1/2, 1/4 and 1/8 Hp at 2500 Rpm. See your Bodine Distributor or write for Cat. CDC-PM.

New 32-frame PM motors and gearmotors!
BODINE ELECTRIC COMPANY
ADE (After Delivery Economies) make Bodine a better fhp buy
Bodine Electric Company, 2500 W. Bradley Place, Chicago, IL 60618.

The GOULD/Brush 2600. Versatility unlimited in a direct writing recorder.
Announcing the new, high performance Gould 2600—undoubtedly the most versatile recorder available today. The 2600 features an unequalled frequency response of 30 Hz at 100 mm and 50 Hz at 50 mm with 99.65% linearity. A servo-controlled penmotor assures precise response, while the famous Gould pressurized inking system produces the highest quality rectilinear traces.
You can order the 2600 with three 100 mm channels. Or with one 100 mm channel and four 50 mm channels. Or with six 50 mm channels.
Call your nearest Gould Sales Engineer or write Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Gould Alco SA. 57 rue St. Sauveur, 91160 Ballainvilliers, France.
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Bodine's PM drive family grows—
New 32D permanent magnet Control Motors and 32D-5F right angle gearmotors, perfectly matched with Bodine speed/torque controls. Continuous duty ratings of 1/2, 1/4 and 1/8 Hp at 2500 Rpm. See your Bodine Distributor or write for Cat. CDC-PM.

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BODINE ELECTRIC COMPANY
ADE (After Delivery Economies) make Bodine a better fhp buy
Bodine Electric Company, 2500 W. Bradley Place, Chicago, IL 60618.
Graphics system offers storage tube & refresh

Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 638-8411. $27,000; 16 wks.

The 4081 graphics system is the first of a series of computer-based systems combining both refresh and storage graphics. The new product is designed to serve as an intelligent graphics terminal, which performs scaling transformations, translation, zooming, clipping, rotation and character generation. Users can now combine dynamic picture manipulation with a highly detailed picture display having up to 20,000 in. of total image. The 4081’s price includes two processors, a 19-in. display, a tape cartridge drive, an ASCII keyboard, 12 function keys, a joystick and an RS-232-C communications interface.

1.5-MHz analyzer gives ±0.01% accuracy

Quan-Tech, Randolph Park W., Randolph, NJ 07801. (201) 361-3100. $3750; 10-12 weeks.

Wave and spectrum analyzer, Model 2525, provides frequency measurement over a range of 1 kHz to 10.5 MHz with selectable bandwidth of 200, 1000 and 3000 Hz. Accuracy is ±0.01%, with a resolution of 100 Hz. Outstanding features include electronic tuning with a stable VCO that can be manually tuned or automatically scanned. Electronic sweep time is selectable at 5, 50, and 500 s and covers analysis windows of 15 kHz, 150 kHz and 1.5 MHz. Frequency readout is provided by a 5-digit LED display.
Interconnections

The 64-page M400 printed-circuit interconnection catalog includes drawings and specifications of sockets, connectors and interconnection systems. Molex, Lisle, IL

50-A triacs

The 50AC series of triacs is described in a four-page data sheet. The data sheet presents device ratings and electrical and mechanical specifications. International Rectifier, Semiconductor Div., El Segundo, CA

Digital panel meters

A 20-page guide to selecting and applying a digital panel meter contains discussions of digital vs analog displays, definitions of DPM specifications, circuit and system applications and general DPM configurations. Analog Devices, Norwood, MA

Terminal & data station

Three data sheets describe plug-in options for the HP Model 2640A CRT terminal and 2644A mini data station. Hewlett-Packard, Palo Alto, CA

Semi screening report

An "Annual Screening Summary Report" on electronic components for 1975 contains information gathered on over 5-million parts. It includes type of part, industry part number, total quantity screened and the number failing in each test to which the lot was subjected. Continental Testing Laboratories, Fern Park, FL

1-k RAM

Detailed dynamic and static electrical characteristics, temperature characteristics, test circuits, waveforms and typical driving and sensing circuits for the MW-7001ID NMOS RAM are given in a data bulletin. RCA Solid State Div., Somerville, NJ

PROMBiTS newsletter

PROMBiTS, a bi-monthly newsletter, is designed to inform readers about programmable logic, which encompasses PROMs and FPLAs. Data I/O, Issaquah, WA

Custom hybrids

Design advantages of custom hybrid circuit packaging are covered in an eight-page brochure. Tips for the designer, ordering guide and quality and reliability notes make this brochure a handy tool. Teledyne Crystalonics, Cambridge, MA

Data logger

A detailed description, specifications and prices of the Digi­ trend 200 digital multipoint data logger and/or alarm scanner are provided in a 16-page brochure. Doric Scientific, San Diego, CA
Thick-film products

A short-form catalog describes almost 100 products used in the manufacture of thick-film, micro-circuit and optoelectronic products. Methode Development, Chicago, IL

CIRCLE NO. 582

Rental instruments

Within a 60-page catalog are detailed descriptions on more than 5000 test instruments available from the country's leading manufacturers that GE offers on either short or long-term rental. Equipment is cross-referenced alphabetically and by manufacturer. General Electric, Instrumentation & Communications Equipment Service, Schenectady, NY

CIRCLE NO. 583

Audio indicators

Solid-state audio indicators, in a wide range of shapes and sizes, plus two models of plastic panel mounts and a solid-state circuit test set are pictured in a 16-page catalog. The catalog shows dimensions and lists specifications and characteristics for all models. Projects Unlimited, Dayton, OH

CIRCLE NO. 584

Synchronous motors

Dual-speed unidirectional and single-speed reversible synchronous motors are highlighted in a 4-page catalog. Provided are dimensional drawings, performance specifications, wiring diagrams and parts selection information. North American Philips Controls, Cheshire, CT

CIRCLE NO. 585

Transformers & filters

Over 3000 standard transformers and filters are covered in a 40-page catalog. Decco, Dallas, TX

CIRCLE NO. 586

Electronic connectors

Commercial electronic connectors are described in a 16-page brochure. Competitive cross-references and ordering information are furnished. Bunker Ramo, Industrial Div., Chicago, IL

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Electronic Design 11, May 24, 1976
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CIRCLE NO. 596

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.

MSI Data. Data entry products and systems.

CIRCLE NO. 591

Astrosystems. Industrial controls and automatic test equipment, automatic drafting systems and plug-compatible memories.

CIRCLE NO. 592


CIRCLE NO. 593


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Intelsat. Telecommunications satellites.

CIRCLE NO. 595


CIRCLE NO. 596

Electronic Arrays. MOS/LSI products, semiconductor masks, microprocessors and memories.

CIRCLE NO. 597

Sperry Rand. Computers; fluid power equipment; gyroscopic, radar, microwave and avionics instruments; navigation, guidance and control system instruments for aviation, and consumer products.

CIRCLE NO. 598
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Editor
Electronic Design
50 Essex Street
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Electronic Design 11, May 24, 1976
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*Electronic Design 11, May 24, 1976*
This is what the designer sees.

A REPLACEABLE LAMP LIGHTED PUSH BUTTON SWITCH

10400/10410
10420 Series

DESCRIPTION
Molex has introduced a new U.L. listed replaceable bulb/lens lighted push button switch family. The buttons may be molded in an assortment of colors and shapes to enhance the appearance of your assembled unit. Switch actions include SPST, SPDT, DPST, and DPDT with momentary or alternate action. Applications include office machines, appliances, computers and the home entertainment field.

FEATURES
50,000 minimum life cycle. In addition to the 10.1 AMP rating, the entire series offers reliable switching action at low levels (100 milli-amps at 30 volts), and a replaceable T 1 3/4 bulb in all but the 125 Neon version.

Molex offers a wide variety of button colors, bezels, and legends as well as a square or pyramidal shaped lens. Recommended panel cutout dimensions include an .875 x .875 (10410 and 10420) and .875 x 1.050 (10400 versions) which are compatible with most comparable switches presently available today. The 10400 with integrally molded mounting ears will accommodate a panel thickness from .030 to .093, while the 10410 and 10420 versions offer a front removable feature from .030 to .125 thick panels. Spade terminals are .02 x .19 x .30 length.

FOR "UNDER A BUCK"
The Molex product is designed as a reliable, low cost unit with features usually found only on expensive switches. In 5M quantities SPST are 99¢ each (including bulb). An example of Molex "affordable technology".

MOLEX SERVICE
Molex has a nationwide network of representatives and authorized distributors to handle your off-the-shelf and large quantity orders. Field engineers are at your service to solve your tooling problems.

LITERATURE
For your FREE 16-page Switch Catalog including photos, line drawings and specifications of the Molex line, call (312) 969-4550; or write Molex Incorporated, 2222 Wellington Court, Lisle, IL 60532.

...Affordable Technology
Gold CHIP LICs pile up 18 million hours with near-zero failure rate.

Test results from 18.2 million unit-hours and 1.5 million unit-cycles are in—and the verdict is unanimous. RCA Gold CHIP LICs are significantly more reliable than their counterparts with aluminum metalization. Here is a summarized report based on testing by three different kinds of users, plus—perhaps our severest critic—ourselves.

**U.S. Army jungle/salt air tests**

In Panama, the Electronics Technology and Devices Laboratory of the U.S. Army Electronics Command tested 63 Gold CHIP LICs to 1,479,000 unit-hours. The tests were done under conditions designed to reveal potential electromigrative shorts and metal corrosion: 27°C, 90-98% R.H., 4.5 V reverse bias. Result: zero failures. Or a failure rate of 0.062%/1000 hrs. at 60% confidence level.

**OEM reliability tests**

A major OEM systems manufacturer has completed extensive testing of Gold CHIP bipolar ICs. These were operated at high power and high junction temperature. After 15,000,000 unit-hours: 2 degradational rejects not related to metalization. That's a 0.02% failure rate.

**U.S. Navy plastic IC program**

The Naval Electronic Systems Command has awarded RCA Solid State Division a $1.44 million contract to apply Gold CHIP technology to plastic packaged ICs for military use. MIL-M-38510 specifications will be used.

RCA reliability tests

In a continuing program, RCA has run the following tests under industry accepted testing conditions.

- Operating Life: 332 units, 376,500 unit-hours.
- Temperature/Humidity Bias: 314 units, 1,244,000 unit-hours.
- Thermal Fatigue: 30 units, 750,000 unit-cycles.
- Pressure Cooker: 510 units, 92,460 unit-hours.
- Thermal Shock: 673 units, 214,760 unit-cycles.
- Temperature Cycle: 1,630 units, 510,000 unit-cycles.

Results: 1 failure in the pressure cooker test. It was caused by a bond wire break at the frame and was not chip related.