Semiconductor memories dazzle with greater density, lower power, higher speed. They give more bits per board, per second, per buck, per watt. They want less support circuitry, too. But there are problems. For products that look real may not be and specs can mislead. For a look at hot developments, turn to page 50.
New Dale Fastpacks!

3/4” DIP Trimmers—wirewound or film—ready for automatic testing and insertion

Count us in when you design or specify trimmers for automatic assembly. New Dale 3/4” DIP trimmers give you a choice of wirewound or film element performance—plus full compatibility with your high speed automatic testing and insertion equipment. Shipped in ready-to-use magazines, these new DIP trimmers are ready to go now. Prices and delivery schedules meet or beat the best you’ve seen. Check the specs, then see your Dale distributor or call the number below.

NEW Space-saving 1/2” Film Trimmer

Dale’s new film element 800 Series lets you squeeze 10-turn adjustment and infinite resolution into a .500” x .100” x .150” space. Dissipates .3 watt over a resistance range of 10 ohms to 2 megohms.

For details call 402-564-3131 today

DALE ELECTRONICS, INC.
1300 28th Ave., Columbus, Nebr. 68601
In Canada: Dale Electronics Canada, Ltd.
A subsidiary of The Lionel Corporation

SPECIFICATIONS

<table>
<thead>
<tr>
<th>2600 Wirewound</th>
<th>8600 Film</th>
</tr>
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<tbody>
<tr>
<td>Resistance</td>
<td>10 ohms to 2 Megohms</td>
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<tr>
<td>Range</td>
<td>50K ohms</td>
</tr>
<tr>
<td>Tolerance</td>
<td>±10%</td>
</tr>
<tr>
<td>Power Rating</td>
<td>1 watt at 40°C, derated to 0 at 125°C</td>
</tr>
<tr>
<td>Power Rating</td>
<td>.75 watt at 25°C, derated to 0 at 125°C</td>
</tr>
</tbody>
</table>

INFORMATION RETRIEVAL NUMBER 241
Introducing the little counter that can.

It can become four different systems. It can go anywhere you do. It can protect you against obsolescence. It can make buying and maintaining a counter less expensive than ever before.

Meet the Hewlett-Packard 5300, the snap-together counter that's not much bigger than the palm of your hand. It has six digit accuracy, solid state display and autoranging. It'll make period, frequency, time interval and ratio measurements, operate on its optional snap-on battery pack and drive a printer. Rugged dust-proof aluminum case resists almost any bumps it might get in the field. Prices start at only $520 for one of the most amazing counters you've ever owned.

Start with the basic mainframe ($395). Then snap on any of the following modules (more on the way) to make just the counter you need, and avoid obsolescence, too:

- 10 MHz frequency module. Model 5301A, $125.
- 50 MHz all-purpose module includes period, time interval. Model 5302A, $250.
- 500 MHz module with both 50Ω and 1 MΩ inputs. Model 5303A, $750.
- 100 ns time interval module with: unique "time holdoff" feature, dc coupling, slope and trigger level controls, and period and frequency measurements to 10 MHz. All the functions you'd pay $1200 for in a universal counter. Model 5304A, $300.

Rechargeable battery pack module works with any of the other modules for cord-free operation. Model 5310A, $175.

The 5300 is one system you have to use to appreciate. If you've ever needed to accurately measure frequency or time interval, you owe it to yourself to call your nearby HP field engineer for further information. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

Counters that promise a lot and deliver it all.

INFORMATION RETRIEVAL NUMBER 2
Low-cost SVP™ devices can save your valuable equipment from destruction by voltage transients.

You can no longer overlook the need for protecting your circuits. New sources of transients are cropping up every day. And any one of them might cause operational failure of your equipment.

Now there is an easy low-cost way to protect your circuitry from these transients. It's a simple little gas-filled surge voltage protector. We call it an SVP. Only this Siemens SVP offers high-current capability (up to 50 kiloamps) in such a small package and a high impedance when not conducting ($10^{10}$ ohms, 1 to 6.8 pF depending on model).

Siemens is the world's largest manufacturer of surge voltage protectors. More engineers are using them every day. You can benefit by doing the same.

Siemens Corporation, 186 Wood Avenue South, Iselin, N.J., 08830. (201) 494-1000.

Siemens. A three billion dollar name in quality products.
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24 What time is it? Your TV set may tell.
26 New ceramic materials with low loss tangent and high dielectric constant make smaller microwave integrated circuits possible.
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45 Washington Report

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79 Improve your communications flexibility without increasing cost by using same-frequency repeaters. Each unit can originate and receive data.
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Cover: The largest available single-chip memory, a 12,288-bit dynamic MOS ROM from Electronic Arrays.
Having introduced the triac in 1962, who is better qualified to improve upon the original? General Electric solid state research has provided the answer with a proprietary glass formula and deposition process that improves upon the normal passivation techniques. GE's new POWER-GLAS process makes the clear difference. It provides for an intimate void-free bond between the silicon chip and the matched glass. The resulting stable low level off-state current significantly improves performance and reliability.

POWER-GLAS
Now General Electric introduces a new triac series which capitalizes on GE’s new POWER-GLAS process... the new SC240, SC245 and the SC250 series at 6, 10, 15 amperes respectively with voltage ranges of 200, 400 and 500 volts each. This new series features very low off-state currents (typically less than 100µA) and high commutating dv/dt (4V/µsec.). Like other GE triacs, the new series comes in three industrial packages... Press Fit, Stud and Isolated Stud.

GE’s POWER-GLAS is the clear difference—adding greater reliability and increasing AC blocking life stability.

**POWER-GLAS TRIAC PRICES** (1000 UNIT LEVEL)

<table>
<thead>
<tr>
<th>PACKAGE</th>
<th>RATING</th>
<th>200V TYPE</th>
<th>400V TYPE</th>
<th>500V TYPE</th>
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<tr>
<td>PRESS-FIT 6A</td>
<td>$1.63</td>
<td>$2.11</td>
<td>$2.37</td>
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<tr>
<td>STUD 6A</td>
<td>1.83</td>
<td>2.31</td>
<td>2.57</td>
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<tr>
<td>ISOLATED STUD 6A</td>
<td>2.53</td>
<td>3.01</td>
<td>3.27</td>
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<tr>
<td>PRESS-FIT 10A</td>
<td>1.98</td>
<td>2.35</td>
<td>2.81</td>
<td></td>
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<tr>
<td>STUD 10A</td>
<td>2.18</td>
<td>2.55</td>
<td>3.01</td>
<td></td>
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<tr>
<td>ISOLATED STUD 10A</td>
<td>2.66</td>
<td>3.25</td>
<td>3.71</td>
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<tr>
<td>PRESS-FIT 15A</td>
<td>2.10</td>
<td>2.49</td>
<td>2.98</td>
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<tr>
<td>STUD 15A</td>
<td>2.30</td>
<td>2.69</td>
<td>3.18</td>
<td></td>
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<tr>
<td>ISOLATED STUD 15A</td>
<td>3.00</td>
<td>3.39</td>
<td>3.88</td>
<td></td>
</tr>
</tbody>
</table>

The prices above for the SC240, SC245 and SC250.

Write for your copy of "IMPROVED TRIAC RELIABILITY THROUGH POWER-GLAS" for the full story on improved performance under worst case electrical stress conditions.

**More Power-Glas Semiconductors To Come.**

Additional new series of SCR’s, Triacs and other semiconductors with the GE POWER-GLAS process will be introduced soon. To familiarize yourself now with the superior performance of the new GE Triac Series, send for product specifications. For prices and availability, call your local GE authorized distributor.
If You Need A Power Transformer Tomorrow - Call Abbott Today

Now Abbott Stocks 60 Hz and 400 Hz Transformers

With Output Voltages from 5 to 5000 Volts

Both the 60 Hz and the 400 Hertz transformers are built to meet the specifications of MIL-T-27C. Long life and reliability are inherent in these hermetically sealed, ruggedly built power transformers. The 60 Hertz line comes in eleven power ratings from 5 to 300 watts. The 400 Hz line comes in six power ratings from 2 to 175 watts. Most all of your power transformer needs can be found in this line of Abbott transformers.

60 Hertz

| Input Primary | 115 VAC, 60 Hz ± 5 Hz, 1 phase |
| Insulation    | 1750 VAC or 150% of secondary voltage (whichever is higher) |
| Construction  | To MIL-T-27C, grade: 4, class: "S", life: "X" (10,000 hrs.), case: steel |
| Environment   | To operate in 105°C maximum ambient temperature. Encapsulated to meet MIL-E-5272C and MIL-E-5400H for vibration, shock, acceleration, sand, dust, humidity, salt spray, fungus, sunshine, rain, explosion, and altitude (to a vacuum) |
| Secondary     | From 5 volts to 5000 volts at 32 milliamperes to 20 amperes |

400 Hertz

| Input Primary | 115 V, 400 Hz ± 20 Hz, 1 phase |
| Insulation    | 2500 VDC or 150% of secondary voltage (whichever is higher) |
| Construction  | To MIL-T-27C, grade: 5, class: "S", life: "X" (10,000 hrs.), case: smaller |
| Environment   | Encapsulated to meet MIL-E-5272C, including vibration to Proc. XII, temperature to 105°C, shock, sand, dust, humidity, salt spray, fungus, sunshine, rain, explosion, and altitude (to a vacuum) |
| Secondary     | From 5 volts to 5000 volts at 14 milliamperes to 35 amperes |

A complete description of all of these power transformers together with their prices is contained in Abbott's 10 page transformer brochure, available FREE on request.

Please see pages 2848 to 2851 of your 1970-71 EEM (ELECTRONIC ENGINEERS MASTER Catalog) for complete information on Abbott transformers.

Abbott Laboratories, Incorporated

5200 W. Jefferson Blvd., Los Angeles 90016
(213) 936-8185

1224 Anderson Ave., Fort Lee, N.J. 07024
(201) 224-6900

INFORMATION RETRIEVAL NUMBER 5

Electronic Design 19, September 16, 1971
letters

A profit-motive system or a loss-motive one?

I would like to comment on the letter from David Wald in ED 16, Aug. 5 ("A Cheer for Editorial, a Razz for the System") and ask a question or two.

I agree that engineers should exercise responsibility to their planet as well as to their jobs—for example, the decision an electric power company sometimes must make: pollution or reduced profit. Profits may soar, but the quality of life may plummet.

I would like to question Mr. Wald's "sacred cow" comment, though. If the "profit motive ... is now inherently incompatible with the needs of humans," what alternative would he propose? If his job isn't secure now, would it be more secure if he were working for a "loss motive" company? Or would he prefer all companies to be nonprofit organizations?

Alan L. Falk
86A Old New Brunswick Road
Piscataway, N. J. 08854

Mr. Wald's letter stating that the Free Enterprise System is inherently incompatible with the needs of humans proves that Mr. Wald is the "emperor with no clothes." Free enterprise is the only system compatible with human life. What Mr. Wald refuses to see is that we do not have free enterprise. He probably refuses to see that the Government just nationalized the railroads. Face the truth, Mr. Wald. Stop blanking out. Is your alternative to have the Government take over engineering, to hold your hand, to tuck you into bed.

Each year, because of government, there is a lower percentage of people in this country producing the goods we all need. Think that over and you will see why government is lowering our standard of living, and you will also see that such nonsense can only lead to a permanent depression.

Richard J. Savadel
11 Clifford Blvd.
Hauppauge, N. Y. 11787

Modular television sets? He remembers when

I noted that Motorola finally received credit for "pioneering" modular construction in its TV sets (see "In Consumer Packaging, It's Modules, Modules Everywhere," ED 15, July 22, 1971, p. 22).

Doesn't anyone recall Setchell-Carlson's modular construction of TV assemblies as far back as 20 years ago? At the time I recall other engineers shaking their heads at such an unorthodox method of construction.

The "quick-service" feature (each set involved a main chassis with five or more plug-in modules) was not a success because owners were worried about having "older" parts exchanged for their "newer" parts. I wonder if Motorola has had this experience with its Quasar sets?

Dan A. Armstrong, B.E.E.
East Waupun
Oakfield, Wis. 53065

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.

19, September 16, 1971

50% more capacity in the same size is now available in these new Johanson extended range capacitors. Beautiful for microwave, VHF and UHF applications, they offer fine tuning, ultra high Q, low temperature coefficients and "sizes" for hybrid and microcircuit as well as standard applications.

For detailed specifications on Johanson air capacitors, send for our current catalog.
We have no RAMs, ROMs, PROMs nor PRAMs

Just now.

But we do have a variety of shift registers plus CMOS and PMOS multiplexers. Like these:

- RD 65 426 bit dynamic SR
- SL-6-2050 Dual 50 bit static SR
- SL-6-2064 Dual 64 bit static SR
- SL-6-4025 Quad 25 bit static SR
- CM 110 16-ch CMOS digital multiplexer
- DG 506 16-ch CMOS analog multiplexer

All of these are also available with internal pull-up elements for true TTL compatibility without need for external resistors.

If you were one of our present customers you would enjoy the advantages of our MOS-LSI capability for standard and custom design.

And who knows? Downstream we may have an equally attractive line of products in RAMs, ROMs, and PROMs. Not PRAMs, though.
Our filter/capacitor family takes experimentation out of circuit design.

We provide the comprehensive data you need for every one of our filter and capacitor components. Attenuation curves (by current, voltage or in combination at room temperature and maximum). Test procedures. Application aids. Specs. Dimension drawings. That's why the Allen-Bradley family is easier to work with. We also give you high volumetric efficiency and a wide variety of styles. Backed by our famous track record for quality and improved performance. Request your personal copies of our literature. Call our nearest appointed electronics distributor, or write: Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, New Jersey 07003. Canada: Galt, Ontario.

Publication 5409: type FA, FB, FW, SB, SS ceramic disc capacitors for VHF/UHF.
Publication 5410: type FCS, SMFB, SMFO filters for the 50 MHz to 10 GHz range.
Publication 5411: type CL multi-layer, coaxial capacitors for connectors.
Publication 5414: type MT, MS by-passing capacitors for 50 KHz to 1 GHz.
Publication 5416, 5417: type BE, SF filters for RFI/EMI suppression.
Publication 5418: type AB broad band filters in Pi, T and L configurations.
The first PROM to offer an extra bit...
...for greater reliability!

Introducing the MCM5003A, the industry's first field-programmable ROM with a built-in reliability feature. Basically a 512 bit bipolar device organized as 64 eight-bit words, the MCM5003A offers "instant customizing" by merely "blowing" nichrome resistors and thus breaking metalization links. The blown links change the initial logic "0" state to a logic "1" state to meet specific program requirements.

**A bit more for reliability**

Since unprogrammed ROM's have all outputs low regardless of address, testing does not detect many faults in amplifier inverters, address decoders, memory array and sense amplifiers. Special consideration is required in the areas of Program Element Testing, Functional Testing and AC Testing. To solve these problems, Motorola expanded the memory from a 64 word, 8 bit memory to a 64 word, 9 bit memory with the 9th bit dedicated to testing.

By blowing some of the 9th bits, we can assure that the links can be blown without using up any of the normal 64 x 8 bit array. With some of the links blown, functional and AC performance testing is now possible. This is important in that all of the 64 x 8 bit array elements are in a logic "0" state regardless of the address selected, and no way would be available to determine whether the functions are correctly operating without the 9th testing bit.

The MCM5003A circuit contains six address inputs to select the proper word and two chip enable inputs, as well as outputs for each of the eight bits. Supplied in a hermetic 24-pin dual in-line ceramic package, the MCM5003A has positive enable with open collector outputs. Another version, the MCM5004A, has positive enable with 2.0 kilohm pullup resistors on the collector outputs. Both devices are MDTL/MTTL compatible and access times are less than 75 ns.

By stocking the MCM5003A you can work up custom microprograms, lookup tables, code and number conversions without the worry of turn-around time and costly mask charges. And speaking of costs, either the MCM5003A or 5004A is available for $45.00 (100-up price) — less than 9¢/bit. Programming can be accomplished at your facility, through your distributor, or here at Motorola.

Take advantage of the MCM5003A's "instant customizing" by calling your local Motorola distributor for evaluation devices today. Or write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036. We'll send complete specifications plus our latest application note describing several programmers that can be built specifically for programming the MCM5003A/5004A.

It'll pay to evaluate the MCM5003A... A Memory To Remember For Reliability

Motorola can now supply memories to meet your specific requirement, whether it be high-speed, low power, or custom products. In traditional Motorola fashion we can draw from the technologies of MOS (Ion-Implanted, Silicon Gate CMOS, N-Channel) or advanced bipolar techniques — each technology offering specific advantages to meet your application.

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**MEMORIES TO REMEMBER**

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>FUNCTION</th>
<th>TECHNOLOGY</th>
<th>ORGANIZATION</th>
<th>ACCESS TIME</th>
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<tr>
<td>MC1660/81</td>
<td>4 Bit RAM</td>
<td>ECL-Bipolar</td>
<td>2 x 2</td>
<td>4 ns</td>
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<td>MC1663/84</td>
<td>4 Bit RAM</td>
<td>ECL-Bipolar</td>
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<td>MC1680/37</td>
<td>16 Bit RAM</td>
<td>ECL-Bipolar</td>
<td>4 x 4</td>
<td>50 ns</td>
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<td>MC4004/5</td>
<td>16 Bit RAM</td>
<td>ECL-Bipolar</td>
<td>8 x 1</td>
<td>22 ns</td>
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<tr>
<td>MC4006/7</td>
<td>64 Bit RAM</td>
<td>ECL-Bipolar</td>
<td>16 x 4</td>
<td>60 ns</td>
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<td>MC4008/9</td>
<td>64 Bit RAM</td>
<td>ECL-Bipolar</td>
<td>16 x 4</td>
<td>60 ns</td>
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<td>MC4010/11</td>
<td>64 Bit Static RAM</td>
<td>Metal Gate P-MOS</td>
<td>64 x 1</td>
<td>200 ns (typ.)</td>
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<td>MC1173/72</td>
<td>1024 Bit Dynamic RAM</td>
<td>Metal Gate P-MOS</td>
<td>1024 x 1</td>
<td>400 ns</td>
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**MEMORIES TO COME**

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<td>MC10256/7</td>
<td>256 Bit RAM</td>
<td>ECL-Bipolar</td>
<td>256 x 1/1</td>
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<td>MC2372</td>
<td>1024 Bit RAM</td>
<td>Metal Gate P-MOS</td>
<td>1024 x 1</td>
<td>300 ns</td>
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<td>MC2374</td>
<td>1024 Bit RAM</td>
<td>Metal Gate P-MOS</td>
<td>1024 x 1</td>
<td>180 ns</td>
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<td>MC2377</td>
<td>2048 Bit RAM</td>
<td>Metal Gate P-MOS</td>
<td>2048 x 1</td>
<td>360 ns</td>
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</tbody>
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**IC Systems for the 70's**

MOTOROLA MEMORIES

INFORMATION RETRIEVAL NUMBER 9

MDTL, MTTL Trademarks of Motorola Inc.
Our new DIP gives you just what you need

and no more.

First we put four fixed resistors and a trimmer in one module. We called it our TRN (Trimming Resistive Network) package. Great.

Now you can get the same module, with the same dimensions for automatic insertion and the same excellent characteristics, in a DIP trimmer. And just a trimmer.

Not just a %3/4-inch commercial trimmer turned on its side, but one that has been developed from the ground up to meet all dimensions in accordance with EIA Microelectronic Outline DIP Family with 0.300-inch-row spacing.

Resistance range of our new DIP is from 10 ohms to 1 megohm. The resistance tolerance is ±10%.

And like the TRN, the DIP offers excellent TC of 100 ppm standard with 50 ppm available. The operating temperature range of this DIP is —55°C to +125°C. Power rating is 3/4-watt at 40°C.

So if you want the whole works—trimmer and from 1 to 4 fixed resistors—in one package, get our TRN. But if you want a trimmer and no more, then our new DIP will give you just what you need. Both are now available through Amphenol's distributor network.

For more information write Amphenol Controls Division, Bunker Ramo Corporation, 120 South Main Street, Janesville, Wisconsin 53545.
**designer's calendar**

<table>
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**Oct. 4-5**
CIRCLE NO. 409

**Oct. 11-13**
International Microelectronics Symposium (Chicago) Sponsor: International Society for Hybrid Microelectronics, 1410 Higgins Road, Park Ridge, Illinois 60068
CIRCLE NO. 410

**Oct. 11-13**
CIRCLE NO. 411

**Oct. 18-20**
CIRCLE NO. 412

**Oct. 31-Nov. 4**
Engineering in Medicine & Biology Conference (Las Vegas) IEEE, John Hanley, Brain Research Inst., Univ. of Calif., Los Angeles, Calif. 90024
CIRCLE NO. 413

---

These versatile building blocks give you absolute display control

IEE rear projection readouts let you display everything from single alphanumeric to complex multiword, multiline messages in any type font or style, in your choice of colors, in any language from hieroglyphics to Sanskrit, using any set of symbols known to man, in all sorts of combinations, on a variable brilliance, single-plane viewing surface, all in a variety of sizes from 1/3-inch up to a huge 3¾-inch-high characters readable from 100 feet away, and you can get up to 64 different messages, numbers, letters, symbols, or combinations thereof in one single readout.

**Be The Master Of Your Display**

You can even change messages or characters right in the field to conform the display to programming changes in your system.

That's what we call absolute display control, an order of versatility unapproached by any other display system.

**Where To Get Your Building Blocks**

And you can get all the rear projection readout building blocks you need to configure a display system that will say just about anything you want it to from IEE.

For instance, we have big 3¾-inch by 2¾-inch viewing area readouts that let you display such things as 12 different 70- to 80-character messages or giant alphanumeric. Also handy little fit-anywhere readouts about 1/8" by 3/4" that display 0.37 inch-high characters.

We have readouts that display 11, 12, 24, 48, or 64 different things, like a complete 64-step operator prompter program. And readouts that snap in from the front panel and readouts that display 2-inch characters on compact 2-inch centers.

**New Can-Do Driver/Decoder**

Now we have a nifty little low-cost hybrid driver/decoder that will drive any one of them, too. It's DTL and TTL-compatible, it puts out a big 300 ma at 30 volts from a .7" by 1.2" 24-pin DIP package, and you can get it separate or attached to the readout.

Ask for the Series 7610. Or information on our wide variety of other driver/decoders.

**Our Short-Form Catalog Tells All**

Get all the details on our rear projection readout building blocks. Send for our short-form catalog today.

IEE rear projection readouts. For machines with more to say.
A better way to specify oscillators.

We have a special coding sheet that lets you specify one or more models from over 700 different temperature compensated and clock oscillators.

Our oscillators are made with a unique cold weld crystal which eliminates heat and flux contamination found in regular sealing methods. As for size, we have models as small as 1.16 cubic inch.

So now, the only paper you need is one of our brochures. Write to Motorola Component Products Dept., 4545 W. Augusta Blvd., Chicago, Illinois 60651.
this power/mate laboratory power supply got bent out of shape,,,

but our customer didn’t!

He never got it. Just as well.

When you ship as many power supplies as we do . . . day after day . . . to almost as many places . . . day-in-day out, these things are bound to happen.

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Write for your free 1971/72 Product Guide.
Industry leaders laud Nixon's economic moves

Reaction in the electronic industry to President Nixon's new economic package—a 90-day price-wage freeze, a 10% investment tax credit and a 10% surcharge on imports—is universally favorable, according to those surveyed by ELECTRONIC DESIGN.

Even manufacturers with offshore plants that produce TV and radio sets or components subject to the 10% import tax are behind the moves.

Typical of industry reaction is this comment by Leslie H. Warner, chairman and president of General Telephone and Electronics, New York City: "The President's actions will prove to be a vitally important factor in promoting strength and stability in the nation's economy."

Magnavox, which recently established a policy against buying Japanese components and said it would return all of its color television set manufacturing to this country (see "Magnavox Cuts Its Buying of Japanese Components," ED 15, July 22, 1971, p. 20), is backing the Nixon package.

"Its construction and psychology are favorable to consumer electronics business," a spokesman for the company's president said.

Motorola expects the new policies to have favorable long-range impact on the economy, but it does not expect the Nixon moves to have any significant impact on its earnings this year.

"In the short term," a spokesman in Chicago said, "our costs will be increased in certain areas by the 10% surtax. On the positive side, the 10% investment tax credit will offset the increased cost due to the import tax."

Joseph Wright, chairman of Zenith Radio Corp., Chicago, welcomes the Nixon moves as showing that "the Government, at the highest level, has shown awareness of some of our major problems and given them high priority." In the past, he notes, trade matters often took a back seat to diplomatic and other international considerations.

Wright believes that "the new measures should help get our trading partners overseas to understand that we expect trade relations to be conducted on a fair and equitable basis."

The Electronic Industries Association says importers will be permitted to pass the new 10% surcharge on imports along to consumers. But this will make American-made electronic products more competitive with the foreign.

LED makers reaching for consumer markets

The optoelectronic industry sees light-emitting diodes (LEDs) replacing small tungsten bulbs in consumer applications. A glimpse of this future appears in LED-illuminated house numbers, fabricated by Earl Cole, application engineer for Monsanto Electronic Special Products Div., Cupertino, Calif.

The numbers on Cole's plastic sign were originally lighted by two toy-train bulbs, supplied by a 16.3-V ac bell transformer. The Monsanto engineer removed the bulbs and drilled holes for 48 LEDs in the numbers. He connected the LEDs in two parallel strings.

Half of the diodes light up on one-half the cycle, the rest on the other. Total current drain is 10 mA for each string, with a power drain of 320 mW. To limit the current to safe values, Cole installed 15-ohm resistors in series with the strings. The sign has operated 24 hours a day for 18 months.

In another LED development, a line of interchangeable lamps and light-emitting diodes with IC compatibility has been developed by General Instrument's Chicago Miniature Lamp Works.

Miniature lamp users now have the option of using LEDs, which have the advantages of long life and high resistance to shock and vibration, or miniature lamps, which excel in brightness and the number of colors available.

The interchange is possible because the LEDs are packaged for direct replacement with submidget-flange-base and bi-pin-base miniature lamps. The light sources operate on 1.5 to 5 V and 8-30 mA, producing .001 to .030 candlepower.

14 to 18 GHz obtained with transistor amplifier

What are believed to be the highest high-frequency transistorized amplifiers and oscillators ever developed have been fabricated at the IBM Research Laboratory in Zurich, Switzerland. To obtain their (14-to-18-GHz) performance, the experimental units employ gallium arsenide Schottky-barrier FETs.

These transistors, which IBM calls MESFETS (for metal-semiconductor FETs) have provided as much as 8 dB of gain at 15 GHz. A three-stage amplifier made from these devices had a power gain of 6 dB at 16.9 GHz, with a 3-dB bandwidth of 520 MHz and a noise figure of approximately 14 dB.

A four-stage narrowband ampli-
A MESFET produced 4 mW at 17 GHz.

When operated as an oscillator, a MESFET produced 4 mW at 17 GHz.

IBM expects the transistors to be used mainly in space and satellite communications.

**Threefold rise foreseen in Japanese exports**

Exports of Japanese electronics should triple from some $2-billion in 1970 to $6-billion in 1980, thereby giving the United States intense competition in world electronic markets, says Robert Peters, senior industrial economist of the Stanford Research Institute, Menlo Park, Calif.

Peters, commenting on the conclusions of a recent institute report, "Electronic Equipment in Japan," points out that while in the past the Japanese threat has been in consumer electronics products, in the future it will come from industrial and telecommunications exports, which should increase more than fivefold over the decade.

The recent Nixon economic moves will not change this picture much, says Kenneth W. Taylor, another senior industrial economist at the Stanford Research Institute. Japan, he notes, will be exporting to countries other than the U.S., such as to Western and Eastern European markets, while at the same time she is penetrating the developing countries—Southeast Asia, for example.

Taylor points out that the industrial electronic market in Japan alone is expected to rise from $1.5-billion in 1970 to more than $10-billion in 1980—a 21% annual growth rate. Imports into Japan are also expected to increase— from $325-million this year to $1.6-billion over the next decade.

**Machine-tool makers see spurt in sales to Red bloc**

A potential boom in machine-tool sales to East European countries could reverse what may be the worst depression to hit that industry since the early Thirties, according to James A. Gray, executive vice president of the National Machine Tool Builders Association.

Gray led a group representing 15 American machine-tool makers to Moscow this summer, and he plans another trip this winter to the Soviet Union and Poland on behalf of 25 companies. On his recent trip, he returned with inquiries for prices on $45-million worth of machinery.

Gray’s reaction is reported in International Market Letter, a new publication put out by GMS Associates International of Arlington, Va., which reports on U.S.-East European trade matters. The publication forecasts a $1-billion market for U.S. machine tools and associated control and measurement instrumentation in East Europe by 1974.

According to Gray, the Soviet machine-tool industry is large and modern, but production still can’t keep up with demand. The market, he says, includes “sophisticated machines with numerical control as well as equipment of more conventional design.” He emphasizes that he is speaking of “machine tools to build everything from pencils, ballpoint pens and other consumer goods to heavy construction and read-making equipment.”

**New U.S. patent policy draws mixed reviews**

Proposed changes in the Government’s patent policy are stirring mixed reactions in the electronics industry.

The changes are intended “to provide greater utilization of inventions paid for by Government contract and more flexibility on the part of Government agencies in achieving this,” according to O.A. Neumann, executive secretary of the Committee on Government Patent Policy in the Federal Council for Science and Technology.

A patent expert for a large electronics company, however, says the change will simply make it easier for the agencies to do whatever they like.

One proposed change will be to add another reason for the Government to take title to an invention. Besides “public welfare” and “public health,” now “public safety” has been added.

“This was done at the request of the Dept. of Transportation, to make it easier to take complete title to all inventions they have under contract,” the electronics patent specialist, who requested anonymity, told ELECTRONIC DESIGN. “This presumably is for DOT’s Federal Aviation Administration.”

On the other hand, other changes give each agency more discretion in giving title to an invention to the contractor. “How this is handled will depend on how each agency interprets the case, which makes for a bureaucratic boondoggle,” the expert continued.

A benefit to the public, Neumann says, is a clause that permits the Government to give exclusive licensing to a contractor after two years. Nonexclusive licenses don’t promote the private investment to produce an invention, for fear that after a company spends money for production and promotion, competitors will jump in and take away the business.

**More power added to Arecibo antenna**

A high-power transmitter being added to the 1000-foot-diameter radio telescope near Arecibo, P.R., is expected to make it the most powerful antenna available for making radar studies of the planets and their satellites.

The addition of a 1 MW, S-band radar transmitter and receivers—plus other modifications to the antenna’s surface—will allow the radio telescope to be operated on a 10-cm wavelength. It presently operates at 70 cm and seven meters.

The modifications will make Arecibo useful for such studies as these:

- Mapping the surface of Venus to a resolution of from 1.2 to three miles using doppler techniques.
- Mapping the surface of Mercury with a resolution of about 31 miles.
- Getting the first recognizable radar signal return from the four brightest satellites of Jupiter and attempting detailed studies of at least the two largest, Callisto and Ganymede.
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...creating components that simplify circuitry
Located on Manhattan's West Side, Roosevelt Hospital has all the drama of the big city hospital so often seen in television serials. A century old this year, the 595-bed hospital averages about 700 surgical procedures a month in more than a dozen operating rooms.

Large and venerable though it may be, the institution is still most proud of its very special scientific skills. For one thing, the hospital has an innovative medical electronics department that is often charged with keeping this machine-dependent institution running. Its newest development is an extensive patient monitoring system, designed largely by its own staff.

Mr. Ronald Conners, the department’s director, thinks the mere existence of such a separate electronics department in a hospital is unusual, but is certain that the idea is spreading. Conner’s department, which is responsible for specifying and maintaining all medical electronics used in the institution also must see to its safe operation. In cases where special equipment must be designed—as when several pieces of hardware must be interfaced, or for safety and maintenance checkouts—his department designs and builds it.

But what he feels is his department’s special contribution is one of the largest data processing systems for patient monitoring in existence. According to Conners, most systems now working in other institutions are different from his in two basics:

- They can monitor only one to four patients while Roosevelt’s system can monitor up to 20 intensive-care patients, simultaneously.
- They are mainly oriented toward research and can only answer specific questions posed by the user. As such, they are expensive.

Conners says that the goal of his system is to keep cost-per-patient down by being able to cover all intensive-care patients in the typical community hospital. “We believe that our kind of approach is the only valuable one for the computer in medicine,” he says.

The system is comprised of Xerox Data Systems Sigma-5 computer with 32,000 words of core storage; peripherals include two disc files, each with a 3-million byte capacity and fast access time, two high speed magnetic tapes, card readers, line printers and teletype. Analog waveforms obtained from the patient are displayed on bedside monitors and cabled to buffer amplifiers which are used to eliminate ground-loop problems and provide a low-impedance output to an analog-to-digital converter.

So far, the system is connected to operating rooms, a cardiac catheterization laboratory (see box), a surgical research laboratory which employs animals and three five-bed intensive care units—a respiratory unit, a coronary care unit and a surgical unit for postoperative patients.

Useful in operating rooms

Most of the experience with the system at Roosevelt has been in the operating rooms. It was here that Conners felt it would be exposed to the widest range of patients with whom to evaluate its effectiveness, and also it was here that it was first completed. “What we’ve found,” says Conners, “is that the system provides the sur-
Heart-data monitoring in real time

Probably the most outstanding feature of Roosevelt's monitoring system is the analysis it can do for a cardiologist performing a heart catheterization while it is underway. Catheterization is performed on patients to obtain blood samples and pressure readings from within the heart. It is done in the operating room during open-heart and other major surgery, and at Roosevelt Hospital, in the cardiac-catheterization laboratory shown in the photo.

The catheter (blurred in foreground) is a thin tube which is usually made of woven plastic to which blood will not adhere. It is inserted into a vein or artery in the arm and threaded into the heart, guided by the physician who watches its progress on a fluoroscope.

Pressures sensed by the catheter are converted into electrical signals by transducers and fed, via cable, through the floor to the monitoring equipment shown on the table. This allows the cardiologist to observe raw analog signals while these same signals are fed to buffer amplifiers and then to the main computer room where they are processed.

A number of sub-programs are available to analyze wave forms emanating from various locations in the patient's cardiovascular system. For example, programs can perform a complete pattern recognition on left or right ventricular pressures, right atrial pressure, and aortic pressure. These programs take the raw pressure wave from the appropriate heart chamber, analyze it, pick out its important points and present the results to the cardiologist on the keyboard display shown at left.

If the cardiologist were to desire left ventricular pressure, the display would show end diastolic pressure, systolic pressure, diastolic pressure (each occurs during a different phase of the heart cycle), heart rate, mean ventricular pressure, maximum rate of change of pressure and the time at which it occurred. This would give him the ability to calculate the gradient across the aortic valve by comparing the aortic pressure tracing with the left ventricular pressure tracing. By calculating the pressure drop across the valve, he could determine if it were defective.

Tracings are displayed in graphic form on an oscilloscope chart recorder and on paper. The cardiologist can obtain a hard copy of the entire procedure by dumping the data onto a line-printer when he is completed.
MAG head solves a tilt problem

A new magnetic recording head allows accurate recording when the head is displaced or tilted by as much as 45°. Present recording heads can only stand about 15° of angular displacement and 10° of tilt off the vertical axis.

The main application of the new head will be for point-of-sale terminals, says its developer, Keonics, Inc., of Glendale, Calif. The head will be built into a probe that a sales clerk will hold and pass over magnetic tags that have been attached to each item being sold. The tags will have magnetically encoded information identifying the merchandise and giving the price. Passing the magnetic head over the tags will automatically send the information to a computer for charging to the customers’ accounts.

James Flora, president of Keonics, notes that such hand-held probes already are in use. However, he asserts, a small angular displacement of the probe can result in an erroneous reading. The Keonic probe can read the tag even if it is passed over it backwards.

The usual recording head contains an almost rectangular magnetic core, with a small gap at the recording surface and a coil around one of the vertical legs of the core. The Keonics head looks like a square core, with a break in the bottom leg. Protruding through that break is a vertical rod that is attached to the middle of the core’s top leg. There are two gaps, each about 1 mil wide, on either side of the vertical rod where it passes through the lower leg of the core. The vertical rod extends below the lower leg of the core for a short distance, and the coil is wound around it.

Keonics guarantees that flux through the coil will be the same, no matter how the head is moved. In the more conventional head, the direction of the flux through the coil depends upon the direction of motion of the head. A patent is pending on the Keonics design.

Flora explains: “It is because of the extension of the vertical rod below the rest of the core, and the fact that we have two gaps, that the probe can stand as much angular displacement and tilt as it does.”

He notes that the head is capable of reading densities of up to 200 bits per inch. The head’s output impedance is 200 ohms. Its output signal level is 0.5 to 1 mV, for a velocity range of about 5 to 15 inches per second. The faster the head is moved, the faster the rate of change of flux, and therefore the higher the output level.

Since 1 mV is a low level for a noisy environment, Keonics plans to incorporate an op amp after the head to increase the level to about 1 V. The company has built a prototype, using a Fairchild μA741 op amp. It expects the OEM price for the probe to be about $75 in quantity.

In operation, the probe will read such tags as the Kimball, a widely accepted one made by the Kimball Div. of Litton Industries in Orange, N.J. It has two magnetic stripes, each about 1-1/4 inches long and consisting of a layer of gamma-Fe₃O₅ covered by a 3-mil protective layer of a paper-like material. These tags have phase-encoded information on them—that is, a positive-going pulse is a ONE and a negative-going pulse is a ZERO.

Other applications envisioned for the Keonics head include the automatic reading of tags in warehouses for inventory and the reading of encoded credit cards.

David N. Kaye
West Coast Editor

What time is it? Your TV set may tell

With components costing $10 to $20 extra, television sets of the future will display the time in hours, minutes and seconds—accurate to a tenth of a second—in the lower lefthand side of the screen. Viewers will be able to get the time by pressing a button on the TV set.

That’s how it’s envisioned by the National Bureau of Standards in Boulder, Colo., where the experimental system is being developed.

The system consists of a precise time-code signal that can be sent to the home by TV networks along with ordinary programs. The TV receiver would contain a special
LSI circuit with decoding and display logic.

If a resettable clock is built into the TV set, the circuit will automatically reset the clock every time it loses or gains time.

For more money—up to $1000, depending on whether the modified TV sets are mass-produced or custom-made—a much more sophisticated time service could be bought. It would display the time to the microsecond, and it would display a 1-MHz frequency standard.

The time and frequency would be transmitted by network broadcasters on cues from atomic clocks installed by the Bureau of Standards in television stations. The accuracy of the clocks would be monitored on TV receivers at the bureau's center in Boulder.

The time code would not affect TV broadcast operations. During four of the 60 frames per second that appear on the screen, the time-code signal sent by the station would impose a coded 1-MHz signal on the active trace of line 1 on the screen, without disturbing the equalizing pulse. The code would carry information designating hours, minutes and seconds. This part of the code would contain a unique digital prefix, enabling the decoder to recognize it and display it in proper sequence. To avoid error, the code would be sent twice.

Once the code is received and recognized, it would be displayed as small numerals, 20 lines high, at the bottom of the screen. The numbers would change in exact step with the master clock at the broadcast station or network origin.

For frequency standards, the system would transmit a 1-MHz carrier frequency during the active portion of line 1. During the interval between the first and second equalizing pulses of line 1 and line 262 1/2, the stable 1-MHz carrier would be transmitted without code modulation. At the decoder, this signal would be recovered by a phase-locked oscillator, in much the way the color subcarrier is detected in a color-TV receiver.

**CRT faceplate screens out glare and RFI**

Protection from glare, RFI and implosion are all achieved with a unique CRT faceplate design. This faceplate could also be used as a filter for any other type of display.

Developed by Tektronix, Inc., of Beaverton, Ore., for use on its line of interactive graphics terminals, the faceplate is a sandwich of coated glass and plastic.

According to Roger A. Frankland, project manager and developer of the faceplate: "We have a sandwich consisting of two pieces of coated glass surrounding a layer of blue-green polyvinyl buterate. Blue-green was selected in this instance because it well matches the wavelength of the trace on the CRT."

Sandwiching plastic between the two pieces of glass not only reduces glare through filtering but also provides protection against implosion and the resultant shattering of glass. RFI shielding is provided by a coating on the glass.

To match the refractive index of the faceplate to the air, the outside layer of glass is coated with one layer of magnesium fluoride and two of rare earth oxides. The coating has a transmission efficiency of greater than 99% at the desired wavelength. Two layers of coating are used on the inside layer of glass. First transparent tin oxide is deposited and then magnesium fluoride. The tin oxide provides RFI shielding, and the magnesium fluoride provides impedance matching.

Total transmission efficiency of the faceplate is about 70%, according to Frankland, and total thickness of the sandwich is about 0.150 inches.
New high-k ceramic materials make smaller MICs possible

Two new ceramic materials that combine low loss tangents with high dielectric constants promise greater microwave miniaturization than materials now available.

Because of their high dielectric constants, the materials make it possible to use microstrip fabrication techniques in the construction of low-frequency—say, below 1 GHz—circuitry without the penalty of excessive size.

Although the materials are not yet being produced commercially, pilot quantities are available for evaluation by prospective users.

One of the ceramics, K-38, is part of a family of materials developed by the Research Div. of the Raytheon Co. in Waltham, Mass., under contract with the Army Electronics Command, Fort Monmouth, N.J. The material has a dielectric constant of 38 and a loss tangent of approximately 4 x 10^-4 at X-band (see table). Chemically, K-38 is composed of pure barium tetratitanate, BaTi_4O_9.

**TC is kept down**

Perhaps the most important property of K-38 is its relatively low temperature coefficient (TC = (1/k)dk/dT ≈ -49 ppm/°C). Alumina, by contrast, with a dielectric constant of approximately 10, has a TC of +150 ppm/°C.

According to Dennis W. Readey of Raytheon's Research Div., materials with essentially zero TCs can be produced for dielectric constants below about 30. Mixtures of titanium dioxide, TiO_2, and various titanates are used to achieve these results. For higher values of dielectric constant, Readey says, it has not been possible to obtain zero TCs.

Mechanically the K-38 material is quite similar to alumina. Because of its small grain size and high density, it can be polished to a surface finish on the order of 0.5 micro-inch rms.

The material exhibits excellent adherence characteristics when metallized with a conventional chrome-gold metallization system. The test metallization consisted of evaporated layers of 100 Å of chromium and 2000 Å of gold followed by a layer of 5 µm of electroplated gold.

K-38 is available in samples up to 2 inches square.

**'Mystery' material has k of 66**

A second high-k material with a dielectric constant of 66 and a TC of 0 ±30 ppm is being produced in small quantities by American Technical Ceramics, Huntington Station, N.Y. According to Victor Insetta, the company's president, who declined to disclose the composition of the material, the ceramic has a Q of 5000 at 100 MHz, which corresponds to a loss tangent of 2 x 10^-4. Its properties have not yet been measured at higher frequencies.

Samples of the new material have been supplied to the Army Electronics Command for evaluation of their high-frequency properties, Insetta said.

In tests of its suitability as an MIC substrate material, the new ceramic has been polished to a finish of 1 micro-inch using standard alumina-polishing techniques.

Like Raytheon, American Technical Ceramics is not yet producing its material in commercial quantities. However, samples up to 1 inch square are available.

Although small-quantity costs are high, both manufacturers emphasize that there are no technical obstacles to high-volume, low-cost production. In fact, Readey claims that, in principle, K-38 can be produced more cheaply than alumina, because it is easier to machine.

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**Summary of properties of K-38 ceramic**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition (single phase)</td>
<td>BaTi_4O_9</td>
</tr>
<tr>
<td>Water Absorption (per cent)</td>
<td>&lt; 0.00</td>
</tr>
<tr>
<td>Specific gravity (per cent theoretical)</td>
<td>98.6 ± 0.3</td>
</tr>
<tr>
<td>Color</td>
<td>tan</td>
</tr>
<tr>
<td>Hardness (Moh's)</td>
<td>7</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion (°C^-1)</td>
<td>9.4 x 10^-4</td>
</tr>
<tr>
<td>Modulus of Rupture (psi)</td>
<td>16,000 ± 1400</td>
</tr>
<tr>
<td>Dielectric Constant (X-band)</td>
<td>37.97 ± 0.29</td>
</tr>
<tr>
<td>Dielectric Loss Tangent (X-band)</td>
<td>3.9 ± 0.8 x 10^-4</td>
</tr>
<tr>
<td>Temperature Coefficient of Dielectric Constant (X-band, ppm °C^-1)</td>
<td>-49 ± 3.9</td>
</tr>
</tbody>
</table>

Note: All properties are room-temperature values and tolerances are standard deviations.
The new LM118 may well be the ultimate true differential operational amplifier. It not only has the fastest slew rate ever offered (a minimum of 50 volts per microsecond at $A_v=+1$), but guarantees it for every single device. In writing.

As if that weren't enough, the highly versatile LM118 is pin for pin compatible with general purpose op amps, has a 1MHz full power bandwidth, a unity gain crossover frequency of 15MHz, is internally compensated, can be offset nulled to zero with a single potentiometer, doesn't sacrifice dc performance for speed, comes in a TO-5 package and will soon be second sourced. (Once again giving testimony to the now-famous National Linear Circuit Motto: "In order to be followed you have to lead.")

Naturally, the entire LM118 series is available for immediate delivery at the following (100 up) prices: LM318H, $9.95; LM218H, $19.95; LM118H, $29.95.

For more information, contact your nearest National distributor. Or write, phone, TWX or cable us direct.

National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051. Phone (408) 732-5000. TWX: (910) 339-9240. Cable: NATSEMICON.
An Electronic Design Survey

7% industry growth in 1972 predicted by EOEM companies

What is the business outlook for the electronic original equipment market for the rest of this year and 1972? A survey conducted by ELECTRONIC DESIGN last month reveals a positively bullish view of the industry's future.

More than 70% of the top executives of leading EOEM companies expect both sales and profits to increase in the latter half of 1971. For 1972, over 90% expect sales increases and over 80% look for a profit increase.

626 executives polled

On July 21, 1971 questionnaires were mailed to 626 EOEM executives across the nation. They were asked to comment on their company's plans (see table) for capital equipment and research and development expenditures, new product introductions, gross sales and profit, as well as percentage growth of the electronics industry and primary growth areas in the years ahead.

On August 11, a few days before President Nixon's new economic policies were announced, the results of the survey were analyzed. On the basis of nearly a 15% return, here are some of the key findings:

- The respondents predict a 5.2% growth for the electronics industry this year compared to 1970.
- They foresee an even healthier 7.1% boost for the industry in 1972 compared to 1971.
- Over one-third of the respondents expect capital equipment spending to increase in 1972 compared to 1971.
- Slightly over half expect an increase in new product introductions during the second half of this year, while a whopping 75% predict an increase in new products in 1972.
- Over 60% of the respondents expect their share of the market to increase, while about 37% expect it to remain the same during the second half of 1971. Nearly 80% expect to increase their market share in 1972.
- More than 60% expect their overseas sales to increase during the remainder of this year, while nearly 80% envision an increase in 1972. Less than 3% expect a decline in overseas business.

Critical economic factors

The respondents were asked what economic or market factors do they see as critical in assessing their company's outlook for the second half of 1971 and into 1972. The answers to this question were varied, ranging from tight money—to wage stabilization to cost of labor and materials. But, not surprisingly, the majority of executives tied their company's business outlook to the following factors:

- Control of inflation.
- General economic recovery and an end to the recession.
- Government spending programs.
- Role of investment in new capital equipment.
- Consumer spending.
- Competition from abroad.
- Growth of the computer industry.

 Asked to predict the primary growth areas for the electronics industry over the next three years, the respondents came up with the following list in order of importance:

- Computers, including minicomputers and all types of peripheral equipment.
- Microwaves and data communications hardware.
- Industrial processing and control equipment.
- Medical electronics.
- All solid-state product areas including semiconductor memories, MOS in general and linear ICs.
- Consumer electronics.

In view of the considerable impact that President Nixon's new economic policies are expected to have on the general business picture, ELECTRONIC DESIGN will repeat this survey in November.

---

EOEM business predictions for 1972

<table>
<thead>
<tr>
<th>Total</th>
<th>Increase</th>
<th>Increase</th>
<th>Remain</th>
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<tr>
<td></td>
<td>responses</td>
<td></td>
<td></td>
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<tr>
<td>a. Expenditures for capital equipment</td>
<td>96 -- 100.0</td>
<td>50 -- 52.15</td>
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<td>b. Expenditures on research and development</td>
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<td>56 -- 58.35</td>
<td>2 -- 2.1</td>
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<td>c. New product introductions</td>
<td>96 -- 100.0</td>
<td>72 -- 75.95</td>
<td>24 -- 25.95</td>
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<td>d. Expenditures on marketing programs</td>
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<td>67 -- 69.85</td>
<td>28 -- 29.25</td>
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<td>e. Employment</td>
<td>80 -- 100.0</td>
<td>54 -- 67.55</td>
<td>24 -- 30.56</td>
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<td>(1) engineering</td>
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<td>40 -- 43.05</td>
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<td>(2) production</td>
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<td>65 -- 69.95</td>
<td>50 -- 53.75</td>
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<tr>
<td>(3) other sales</td>
<td>93 -- 100.0</td>
<td>25 -- 30.55</td>
<td>10 -- 20.45</td>
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<td>f. Gross sales</td>
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<td>85 -- 90.55</td>
<td>40 -- 43.25</td>
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<td>g. Profit</td>
<td>96 -- 100.0</td>
<td>77 -- 80.25</td>
<td>15 -- 15.65</td>
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<tr>
<td>h. Market share</td>
<td>92 -- 100.0</td>
<td>72 -- 78.25</td>
<td>17 -- 18.55</td>
</tr>
<tr>
<td>i. Overseas sales</td>
<td>93 -- 100.0</td>
<td>74 -- 79.65</td>
<td>16 -- 17.25</td>
</tr>
</tbody>
</table>
I

on

Stackpole ferrites

can cut a power supply
down to size

Tektronix, Inc. uses Ceramag®
ferrite materials to achieve effi-
ciency and significant savings.

Conventional power supplies are
bulky, heavy and inefficient. Tek-	ronix, Inc. changed all that. With
ferrites and a fresh idea.

By rectifying line voltage, con-
verting it to 25kHz and rectifying
it again, Tektronix, Inc. engineers
produced a power supply that
was 50% lighter, over 25% smaller
and consumed ½ less power. And
the overall operating efficiency
of 70% is a big improve-
ment over the 50% typical
of conventional power supplies.

Ferrites can offer the unique ad-
vantages, design freedoms and
electronic characteristics that
produce exciting new ideas.
Stackpole Ceramag ferrites were
used throughout the power sup-
ply design. Because Stackpole
has a wide variety of materials
and configurations, designers
can unleash their imaginations.

Tektronix, Inc. selected 24B for
their "U" and "E" cores. This
proven material has seen years
of service in flybacks for tele-
vision. Ideal for power applica-
tions, it can be operated at higher fre-
quencies than laminated steel. It
is cool running, due to low losses
under power conditions and con-
trolled power permeability. Tool-
ing is available for a wide range of
"U", "E" and "I" configurations.

Ceramag 24

Toroids of Ceramag 24 were used
by Tektronix, Inc. for transformer
cores. Again, this is a proven
material, widely used by the com-
puter industry for pulse trans-
former cores. It has a tightly
controlled initial permeability,
and tooling for a variety of sizes
is also available.

Ceramag 7D and 27A

Multiple material selection for
coil forms allowed Tektronix, Inc.
maximum flexibility and design
freedom. Proper inductance
values could be achieved in the
allotted amount of room. In addi-
tion, the high resistance of 7D
material prevents accidental
shorting on printed circuit boards.

Great new designs happen when
you start with the idea of ferrites.
Particularly Stackpole Ceramag
ferrite components. Why? Be-
cause Stackpole offers the vari-
ety of materials, numerous tooled
configurations and the technical
back-up you need. Twenty-four
years of television and computer
experience makes Stackpole one
of the largest and most experi-
enced domestic suppliers of
quality ferrites.

Consider ferrites on your next
prototype or redesign. But give
us a call when you start. Perhaps
we (and some Ceramag® ferrites)
can help you cut a problem down
to size. Stackpole Carbon Com-
pany, Electronic Components
Division, St. Marys, Pa. 15857.
Phone: 814-781-8521. TWX: 510-
693-4511.

INFORMATION RETRIEVAL NUMBER 28
On your left, the 12-bit PDP-8/M. On your right, the 16-bit PDP-11/05. Our brand new additions to the world's most popular families of minicomputers.

Complete computers — at incredibly low prices. Like $3,069.00 for the 11/05, and $2,362.00 for the 8/M in quantities of 100. Even the discount schedule is new. Very attractive.

In addition, they're compatible with the rest of the family members. Their options. Their peripherals.

They have the features of their bigger brothers. And, a full instruction set. OEM-oriented architecture. Both the UNIBUS™ architecture of the 11/05 and the OMNIBUS™ architecture of the 8/M permit easy, flexible configuring and interfacing. Real pluses for the OEM.

They're built with the kind of reliability that comes easy after delivering over 11,000 minicomputers.
And, they're supported with more field backup than you can get anywhere else. Worldwide.
PDP-11/05. PDP-8/M. Designed for the OEM. Priced for the OEM. Choice for the OEM. From the leader in OEM computer applications.

Now there's a whole new set of standards to measure up to.

Write for more information.

Digital Equipment Corporation, Main Street, Maynard, Massachusetts 01754, (617) 897-5111.

INFORMATION RETRIEVAL NUMBER 98
When you don't need a custom circuit...

AMI, the leader of custom MOS, has a completion record of a new circuit every three days. Filling the needs of over 650 specific applications. But, we don't stop there. Knowing the need for standard products in design, we have engineered, tested and put into production reliable lines of devices for you to choose from. If standard products fill your needs, we have them. If your needs are better filled by a custom circuit, we'll design it.

For the full story call or write today to...

American Micro-systems Inc., 3800 Homestead Road, Santa Clara, California 95051 (408) 246-0330

---

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
<th>LEADS/PKG.</th>
<th>FREQUENCY RANGE</th>
<th>NUMBER OF BITS</th>
<th>TYPICAL POWER DISSIPATION</th>
<th>CLOCK LEVELS</th>
<th>GATE THRESHOLDS</th>
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<tr>
<td>RD55G</td>
<td>Dual 50</td>
<td>10 T05</td>
<td>10KHz - 1MHz</td>
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<td>2400mW</td>
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<td>S1708</td>
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<td>S1709</td>
<td>FIFO 8 'x 13</td>
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<td>104</td>
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<th>NUMBER OF BITS</th>
<th>TYPICAL POWER DISSIPATION</th>
<th>CLOCK LEVELS</th>
<th>GATE THRESHOLDS</th>
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<td>S1406</td>
<td>1024 x 1, Static</td>
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<td>1024</td>
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<td>LVT</td>
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<td>S1210</td>
<td>1024 x 1, Dynamic</td>
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<td>T137</td>
<td>Quad</td>
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<td>Yes</td>
<td>-2V</td>
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</tr>
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</table>

*HVT is a registered trademark of the American Micro-systems, Inc. Ion Implant Process . . .

INFORMATION RETRIEVAL NUMBER 20
Belden the **Special "Specials" specialist**

Here’s what to do when cable catalog specs just won’t do the job: Dial Area Code 317

Then dial 966-6681 You’ll get action From a man who devotes full time to solving engineered cable problems A Belden specialist that “lives” with your design parameters from engineering through the actual production run Cables for underwater-underground devices ... extra-high voltage and pulse applications ... medical instrumentation ... low-level signal interference problems ... unusual environmental conditions ... he’s tackled them all Phone now.

**DIAL (317) 966-6681**

---

Belden Corporation, P. O. Box 1100, Richmond, Indiana 47374. TLX 20-7127, TWX 810-345-1393.
A Ledex rotary solenoid gives you a down-hill solution to an up-hill problem.

The force of an electromagnet is inversely proportional to the square of the distance between the pole faces. Most solenoids live with this problem, which means less force in the beginning, where you need it, and wasted energy at the end, where you don't need it.

The Ledex rotary solenoid starts off working where the force is really at, about .030" between the pole faces. Then the armature rides a helical ramp, to distribute the force over the stroke you need. It gives you efficient, direct rotary action and uniform linear movement.

The Ledex rotary solenoid delivers a lot of power for its size. That's because it works in the tiny area where magnetic attraction is highest. It's efficient because it spreads this high concentration of energy over a longer useful stroke.

For rotary or linear positioning it's hard to beat its simplicity and high output. Choose from a family of eight models, with strokes from 20° to 95° and torque to 117 pound-inches. For a quick prototype, there are over 250 shelf models. Then, for a custom snap/lock/index/punch solution, you just talk to our positioning technology people.

LEDEX INC.

LEDEX INC.
123 Webster Street
Dayton, Ohio 45401
(513) 224-9891

If you're working with a control signal that can only deliver 10 milliamps and you really need 5 to 7 amps, consider the Ledex LMD-5 power driver.

With the LMD-5 you can switch up to 325 watts. It has an expander node terminal, so you can add multiple inputs. An internal diode protects the circuit from damage when driving inductive loads.

Available from the shelf in 1-9 quantities at $32.07 each. Only $14.30 each in 1,000 lots.

If you're working with a control signal that can only deliver 10 milliamps and you really need 5 to 7 amps, consider the Ledex LMD-5 power driver.

With the LMD-5 you can switch up to 325 watts. It has an expander node terminal, so you can add multiple inputs. An internal diode protects the circuit from damage when driving inductive loads.

Available from the shelf in 1-9 quantities at $32.07 each. Only $14.30 each in 1,000 lots.
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WORLD'S WIDEST LINE OF MINIATURE CERAMIC FILTERS
AND FILTER SYSTEMS

FIRST— in subminiature design capability
FIRST— in total in-house production capability
FIRST— in Quality and Volume Production
FIRST— to develop a complete line of subminiature EMI Filters

ERIE's stature as undisputed world leader in subminiature high performance Ceramic EMI Filters has been earned by our ability to apply 35 years of sophisticated ceramic and related technology to developing superior EMI Filters. Virtually all other presently known ceramic EMI filters are a copy of an Erie design. Yet, no firm has been able to equal Erie’s combined in-house filter capability and proprietary ceramic technology.

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Write for our new EMI Filter brochure
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Erie, Pennsylvania 16512

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  Binary or BCD

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• No Switching Transients

• 0.001 Hz Resolution

• Direct Digital Technique
  No mixing or phase locking

• High Spectral Purity —70 db SPURIOUS
  —60 db HARMONIC

• High Stability
  ±2 x 10^-8/°C STANDARD
  ±2 x 10^-10/°C OPTIONAL

• Precision Attenuator
  0 TO 85 db IN 1 db STEPS PLUS CONTINUOUS CONTROL
  (PROGRAMMABLE ATTENUATION OPTIONAL)

• High Output Voltage
  10 VOLTS P-P, 50-0HM SOURCE IMPEDANCE

ROCKLAND SYSTEMS CORPORATION
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There, on the top of the largest line of multipliers available, is our 530. It's not quite the fastest: our #422 module slews at 120v/usec. Nor the most accurate: #427 provides 0.1% of full scale. But by jingo, it's the only complete monolithic multiplier - divider - squarer - square rooter on a chip, op amp included. The specs are exhilarating and the price is right. Why the 530? That and other questions pertaining to multipliers are dealt with at length in a unique document published by us: "Evaluating, Selecting, & Using Multiplier Circuit Modules for Signal Manipulation & Function Generation." Unlike this ad, it's not so commercial as to dwell crassly on the 530. Rather, it is an impartial 16-page booklet that sets forth the theory and applications of multipliers in general. Just ask for "the multipliers booklet." Analog Devices, Inc., Norwood, Mass. 02062. (617) 329-4700.
if we can supply memory cores at $.001 each...

can you produce memory systems at $.005 per bit?

If you need bulk quantities of cores, we can meet our part of the bargain... at a profit.

And we think you can do the same. In fact, if you use our new 18-mil "low-drive" cores, it's almost a certainty. These devices have very low switching currents... and they don't need a lot of costly electronic support.

If you'd like to cut the cost of your next memory, but not its reliability, contact us for a down-to-earth talk about core quantities and prices... even design. Remember we produce memories too. For quick reaction write MEMORY PRODUCTS GROUP, PHILIPS ELCOMA, EINDHOVEN, THE NETHERLANDS.

Test conditions and typical values at 25°C.

<table>
<thead>
<tr>
<th>Core type</th>
<th>18PH2*</th>
<th>18PH4</th>
<th>18PH5</th>
<th>18PH6</th>
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<tr>
<td>I&lt;sub&gt;f&lt;/sub&gt; (mA)</td>
<td>213</td>
<td>425</td>
<td>500</td>
<td>580</td>
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<tr>
<td>I&lt;sub&gt;p&lt;/sub&gt; (mA)</td>
<td>130</td>
<td>259</td>
<td>305</td>
<td>354</td>
</tr>
<tr>
<td>I&lt;sub&gt;V1&lt;/sub&gt; (mV)</td>
<td>11</td>
<td>31.4</td>
<td>36</td>
<td>39</td>
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<tr>
<td>W&lt;sub&gt;V&lt;/sub&gt; (mV)</td>
<td>1.2</td>
<td>6.8</td>
<td>6.0</td>
<td>6.2</td>
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<tr>
<td>t&lt;sub&gt;p&lt;/sub&gt; (ns)</td>
<td>230</td>
<td>142</td>
<td>136</td>
<td>123</td>
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<tr>
<td>t&lt;sub&gt;s&lt;/sub&gt; (ns)</td>
<td>490</td>
<td>290</td>
<td>270</td>
<td>230</td>
</tr>
</tbody>
</table>

*With this core, wired in a 2D configuration and used under asymmetrical drive conditions, read/write switching times of 150/300 ns can be obtained, applying read-, write- and digit currents of about 440, 220 and 110 mA respectively.

Philips designs and produces memories of all kinds... core and non-core. We are sure that, for some time to come, only the core technology will offer the full combination of low price, assured non-volatility of information, realistic system speeds, and 100% component reliability... and be able to prove it.

Philips' advanced production methods can make more memory cores... to highest standards... cheaper... than anybody else. Make us prove it!

PHILIPS
It not only looks good, the Series 67000 Illuminated DW "Multi-Switch"® switch is a glamorous bit of switch packaging. It's compact, low-cost and operates beautifully, too!

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For full information on the “Scotchflex” systems approach to circuitry, write to Dept. EAH-1, 3M Center, St. Paul, Minn. 55101.
A new class of ceramic dielectric with a permittivity three times that of a conventional alumina substrate has been developed by GEC Hirst Research Centre. A size reduction of 2-to-1 can be obtained in the fabrication of microstrip circuits. The new material has a very low dielectric loss (\( Q = 2000 \)) and a low, controllable temperature coefficient. Stable resonators can be made in small size. The material may also possibly be used in bandpass filters.

CIRCLE NO. 451

An all solid-state unit that will switch high-voltage induction motors from one supply to another with an interruption of less than 60 ms has been developed by Brown Boveri. The unit, which incorporates a thyristor output stage, contains three independent measuring channels for phase-angle, frequency and residual voltage. And if these quantities are not within limits the circuit automatically triggers a circuit breaker.

CIRCLE NO. 452

A civilian warning system that could be operated over the public telephone at 12 different sites was called for by the Israel Ministry of Defense after the six day Arab-Israeli war. The system had to be secure against false alarms and also needed a facility to check that the alarms which triggered air-driven sirens were working properly. The system, offered commercially by Telrad Telecom and Electa Industries Ltd., comprises a central control unit and 12 terminal units. The alarms—attack, all-clear, or danger—are sounded by blasts of three tones operated in different combinations.

CIRCLE NO. 453

A ruggedized magnetic-disc memory that can withstand a jouncing ride in a tank and still perform with an error rate of less than one in 10 billion has been developed by Process Peripherals, a new company in Berkshire, England. The secret of its performance lies in a flying magnetic read/write head designed to a very high order of stiffness by the Royal Aircraft Establishment at Farnborough. Also novel is the use of a quartz crystal oscillator to control disc speed. The crystal is also used to clock data both on and off the disc, eliminating the need for control tracks. The memory has 64 tracks with a 4.2-million-bit capacity and a typical access time of 10 ms. However, this may be halved by switching rapidly from track to track.

CIRCLE NO. 454

A new image-storage electroluminescent panel that is a reusable industrial X-ray plate has been developed by scientists at the Enfield laboratories of Thorn Lighting in England. The new device is similar to a standard electroluminescent panel but functions in a completely different way. In the conventional panel, a layer of phosphor (zinc sulphide) is embedded between flat layers of protective materials and an electrically conductive layer. When ac is applied to the panel, it glows. In the new tube the phosphor glows only when it is simultaneously activated by the application of voltage and an external source of radiation such as X-rays. The image can be retained on the plates for a half hour or more. Among its applications are the detection of faults in encapsulated electronic components, or the detection of explosive devices in sealed parcels or luggage.
Half the length (11.5") of conventional cathode ray tubes, and operating up to 24 KV for improved visual and photographic writing speed, the Thomson-CSF F 8071 (right) requires no transmission line technique for operation up to 150 MHz at 0.2 dB.

Capable of high frequency (800 MHz), yet only 14" long, the OEE 1108 (left) utilizes the transmission line technique for operation up to 350 MHz bandwidth at 0.2 dB, with a sensitivity of 3.2 V/inch.

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INFORMATION RETRIEVAL NUMBER 31

Electronic Design 19, September 16, 1971
You get 25 ranges. We only get $595.

Go ahead. Try to compare the new Weston 1242 with the other good multi­meters. They usually cost $700 or more with options that add still more cost.

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(actual size)
NASA fighting severe budget cuts for next year

The National Aeronautics and Space Administration is locked in a bitter struggle with the Office of Management and Budget—formally called the Budget Bureau—and the outcome may well determine the shape of the country's space effort over the next decade. The President is not due to present his fiscal year 1973 budget to Congress until sometime late in January but Federal agencies are now dealing with the OMB to see just how much money they will be allowed to "request" in the January budget. OMB has told NASA that it wants the space agency to hold its request to $2.8-billion, a cut of some half billion from this fiscal year's funding. NASA brass feel they cannot live with that figure or even this year's money which they say was merely bare bones funding. At stake is the space shuttle, for which Congress appropriated $100-million this year. If the program encompassing the reusable booster continues, NASA will have to have somewhere near $400-million in the coming fiscal year and this now seems impossible. NASA, therefore, is studying, very quietly, the possibility of going to an expendable booster and putting off the development of the reusable booster—in effect stretching out the program to a time when funding may be more likely. The booster switchover is called "phasing" and a decision is expected within NASA in a month or so. Meanwhile, this year's budget entailed a job cut of 1500 in NASA and it is not certain whether the President's announced 5% across-the-board cut in Government personnel will be added to the 1500. The Apollo 16 and 17 shots scheduled in the next calendar year will probably not be affected one way or the other, say NASA sources, since they are virtually already paid for.

U.S. airlines opposition to aeronautical satellite continues

Aeronautical Radio Inc., the communications arm of the U.S. airline industry, says the industry is still opposed to the aeronautical satellite system being pushed by the Federal Aviation Administration and the European Space Research Organization because it is "unsound." Arinc made its views known after a briefing at FAA on the developments in a Madrid conference last month on establishing pre-operational satellites for the Atlantic and Pacific. Arinc said the experimental work could be done better and cheaper with NASA's ATS-F and ATS-G satellites, already in the works. The crux of the matter continues to be the airlines' desire to stick with the vhf band while the Europeans and FAA want to go to uhf.

Import surcharge liable to be around a long time

Opposition from the European common market countries, Japan and others notwithstanding, the 10% surcharge on imports into the U.S. is liable to be around for awhile, say Treasury officials. Treasury Secretary John Connally himself has added that the surtax will stay until
U.S. products and manufacturers start getting a better shake in the world markets. The balance of trade situation—the difference between exports and imports—is what triggered the Administration's action as it faced the fact that the U.S. would probably have an unfavorable balance of trade for the first time since 1893. Typical of the flood of goods pouring into the U.S., Treasury said, was the surge in electronics imports this year. Electronics imports in the first half of this year totalled $998-million compared with $798.4-million over the same period last year. The Commerce Department noted that almost 30% of the consumer electronics goods sold in the U.S. are now imports. Commerce also said that although the policy was not yet firm, articles entering the U.S. under Section 807 of the tariff code would have the surcharge added if they are currently taxed at all—value added products. If they were not subject to any tax before, the surcharge will not apply.

Laird sees defense spending increase next year

Defense Secretary Melvin Laird says that he will probably seek a defense budget of around $80-billion for the coming fiscal year, an increase of around $4-billion to $5-billion over this year's request, and the Joint Chiefs of Staff say they see a defense budget need of $83-billion. Their friends in Congress, however, say Defense will be fortunate if it can hold the line at the current rate of spending, let alone succeed in getting any increases. Sources on the Appropriations Committees are reluctant to even look ahead to next year, uncertain as they are about what will happen this year when the defense appropriations bill comes before both houses. About the only thing certain for next year, one congressional source told ELECTRONIC DESIGN, is that the Navy will not get an appropriation for its long delayed nuclear attack carrier.

Capital Capsules: NASA and Japan's Hitachi Central Research Laboratory have reached agreement for swapping computer programs. Four programs were included in the initial agreement . . . . The Army and Lockheed Aircraft will try again on the Cheyenne gunship helicopter. The Army has issued a $47.8-million development contract for work on the helicopter which originally was cancelled by the Army in 1969 after Lockheed failed to meet specifications. Lockheed agreed to take a $120-million loss on the old contract with the provision that the government would resume paying for continued development work . . . . NASA is asking for bids on an eight-month, $100,000 study to determine the possibilities of converting its Nerva nuclear engine to a dual mode which could provide power for spacecraft . . . . The Pratt & Whitney Division of United Aircraft has filed a complaint with the General Accounting Office claiming that NASA's $500-million contract award to North American Rockwell for development of the space shuttle engine "violated statutes, regulations, GAO decisions, and reports and prudent procurement policies." P&W and Aerojet General were losers in the engine bid . . . . Western Union International has asked the FCC for permission to bid on the contract covering communications services for the Apollo flights now handled by Comsat. The Comsat contract is nearing expiration date . . . . Treasury turned down a special exemption request from the 10% import surcharge on the Rolls Royce engines for Lockheed's L-1011 Tristar. A new levy could up the cost as much as $300,000 per airplane and would presumably be passed on to purchasers.
For those who have requirements in between 500 MHz and 50 MHz there’s the 150-MHz 7704 (R7704 rackmount), 90-MHz 7504 (7514 storage), all with 4 plug-in compartments; 90-MHz 7503 with 3 plug-in compartments.

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The economic outlook is beginning to brighten

President Nixon's new economic policy provides the U.S. electronics industry with a unique opportunity it hasn't had in years. First, it should enable U.S. products to compete on equal terms with foreign imports—particularly from Japan. Secondly, the expected upward revaluation of foreign currencies will mean opportunities for manufacturers to sell overseas.

These policies along with the investment tax credit and the increase in personal tax exemption should help get the industry out of the doldrums its been in during the past 18 months. Many economists are now forecasting real growth next year of 6% or better for the whole economy. This rate of growth would be at least twice the slow rate for 1971 and significantly higher than was indicated by forecasts before the President's speech.

To further add to the bullish outlook, a survey of the electronic original equipment market (see page 28) was completed by ELECTRONIC DESIGN just before the President's new policies were outlined. The study revealed that more than 70% of the top executives of leading EOEM companies surveyed expect both sales and profits to increase in the latter half of 1971. For 1972, over 90% expect sales increases and over 80% look for a profit increase. It's likely that another survey planned for later this year will reveal an even more optimistic business outlook for the months ahead.

These cheery predictions are, of course, much welcome in an industry that has been pretty much steeped in pessimism but there is a qualification. The electronic industry has got to watch its costs. While the President has indicated that there will probably be an increase in the flexibility of wage-price restraints after the 90-day freeze expires, it's still up to business and labor to restrain itself. Costs must be kept in line with productivity, otherwise the industry will in a short time be right back in its present predicament.

RALPH DOBRINGER
While a few dozen vendors compete vigorously for what may one day become a huge IC-memories market, it can prove fruitful to examine their product specs and delivery promises with more than usual caution. For young technologies don’t lend themselves to early standardization. And vendors, under pressure to announce new products, may often announce ICs before they are fully characterized—or even manufactured.

“Hope,” said Alexander Pope, “springs eternal in the human breast,” and even, one might add, in the breast of the man who prays that production quantities of his new memory will show the performance he found in one good chip.

Problems

It can prove valuable to hang some warning signs at a few pitfalls and roadblocks. Of these, the most typical is “typical.” One vendor, whose data sheets abound in “typical” specs, warns: “Never read a typical spec; always insist on minimum-maximum specs. You can’t design with typs.”

And yet, they have their value. For they demonstrate a product’s capabilities. A vendor can screen devices to meet a particular spec—but not all specs. For a price penalty, he may guarantee a maximum access time or a maximum power dissipation—but not both in the same device.

Or a manufacturer may modify a device to meet a particular spec. But “O! that way madness lies,” said Shakespeare’s King Lear—and many a memory vendor. But it happens. A customer samples a device, likes it, then asks for a small modification. So does another customer. And another. Pretty soon the vendor is selling a device his manufacturing people can’t make.

In the heat of competition, a vendor may prepare a spec sheet with apparently guaranteed “min-max” specs. But the sheet may be headlined, “Tentative” or “Preliminary”—which may be variants of “We hope we can make this part.” Unfortunately “tentative” specs, like “projected” prices for a brand new device, are invariably more attractive than firm specs and market prices for an established device.

Prices deserve almost as much attention as specs. For the best price may come from the vendor who can’t make the device. And he may have the best specs. Further, the IC-memory business has some peculiarities: In many cases the laws of supply and demand are completely abandoned. Prices can plummet for a memory that everybody wants and nobody can make.

Because memories are complex devices, their data sheets can be awesomely complicated. The man feeling secret shame because he can’t understand some spec sheets is not alone. When a vendor writes, for example, that a device is also available for different voltage levels, a user may need more than clairvoyance to know what else changes.

That crucial question, “What else changes?” must be raised often. Vendors are always pushing the edge of the state of the art. With admirable frequency, they break through. But not on all fronts. They advance one spec—or two. Not all.

The one or two selected specs are important milestones and thus form the bulk of this report. But it’s necessary to ask, “What else changes? What sacrifices were made? What tradeoffs?”

It’s necessary, too, to determine if a particular advance is useful in a specific application. A de-
sign approach that may be fine in a small terminal may prove ridiculous in a central processor.

Nothing is free

A vendor may hail the fact that his RAM or ROM has full decoding on the chip. But in a given system it may be more economical, in nanoseconds and dollars, to have undecoded storage chips share a decoder/driver.

One MOS array may boast its compatibility with TTL, perhaps forgetting its need for external pullup resistors. Resistors are cheap but they eat board space. So another MOS array boasts full compatibility with TTL. Yet a particular system may find it better to use level translators external to the MOS memory chips.

To an enormous extent, memory specs influence each other. So it's formidably difficult to characterize a device fully, even for an extremely conscientious vendor with time on his hands, and even for a well-established device. So a user must be particularly aware of his own requirements, and amply prepared to ask lots of questions.

An unwary user could assume that if a device can work well with a 3-MHz clock rate, it ought to be fabulous at 10 kHz. But dynamic shift registers, for example, have minimum clock rates, too. They would be better characterized if specs were to read: "Clock rate must be no greater than x MHz and no less than y kHz."

Further, data rates in shift registers and access times in RAMs and ROMs depend on voltage and temperature. So does power consumption. So a spec sheet that calls out access time for a high voltage and power for a low voltage is less than useful.

Those chip shots

Some engineers feel they can learn a lot about a device by studying what's inside the package. Magazine editors help by publishing pictures of memory dice. But the main reason editors publish chip shots is a simple one: They're pretty.

It's certainly true that chip shots (or the chips themselves) can convey information. A hawk-eyed observer might detect metal necking (variations in line width) which could suggest process difficulties. Using the die-bonding pads (usually four mils on a side) as size references, he might try to determine if the chip is too large for reasonable yield or too small to permit adequate control of practical tolerances.

In a packaged device (before encapsulation or lid-attach), he might look for cross bonding—wires going over others. He could look for leads that might touch. And he could check that wire bonds are centered in the pads. Many vendors would be happy to help him. Others could say he's wasting his time.

Vendors in the second school maintain that an engineer needs to know only the black-box parameters of a memory. He doesn't have to know if it's MOS or bipolar, or if it uses metal gate or silicon gate, n- or p-channel transistors, 111 or 100 crystal orientation, Schottky clamping or none. He shouldn't care, these vendors feel, if there's a small man in the package, as long as the device can store and retrieve data at the proper speed, with the proper voltage levels, with proper power consumption and heat dissipation and with adequate longevity.

Unfortunately, it's difficult to generate instant reliability data. And engineers want some assurance that a vendor won't discontinue a product next year because its yield is too poor. So most engineers take a mid-stream course. They want to learn something about the chip, but not everything.

Those processes

For bipolar memories, the attention-getting process is Schottky clamping. This uses reverse-polarity aluminum-silicon diodes shunting base-
Gold-beam-lead chips on a ceramic substrate form a 2048 X 1-bit static MOS RAM from Texas Instruments.

Collector junctions to enhance speed. The diodes turn on before the collector-base junctions can saturate, holding the transistors out of saturation so they can be driven hard, thus fast.

They provide high speed without saturation, because there's almost no charge storage, and without gold doping, which can contaminate wafers and processing equipment.

Opponents of the process (and those who aren't using it now) may argue that Schottky is an excuse for people who don't know how to gold-dope. Nevertheless, it allows the use of high-gain pnp transistors with high speed npns. And it cuts power dissipation. Intel was first to use the process in production.

In MOS memories, the silicon-gate process (also pioneered in production by Intel) has caught on to a great extent. In this process the gate electrode, of polycrystalline silicon rather than aluminum, serves as the diffusion mask that defines the edges of the source and drain regions of a FET. So the gate is automatically aligned, making overlap unnecessary.

This cuts gate and Miller capacitances while allowing FETs to be smaller, giving better chip density. A layer of silicon dioxide and glass over the entire chip (except for bonding areas) is impervious to ion and other surface contamination, so the device can be packaged in low-cost plastic—an important merit. And the technology lowers threshold voltage, making for easier interface with bipolar devices.

Another important process, ion implantation, was pioneered by Hughes. Involving ion bombardment of the chip surface, the process is used by Hughes and others to obtain self-aligned gates. It's used by Mostek and others to lower threshold voltage for bipolar compatibility and even for developing depletion-mode devices on the same chip with enhancement-mode transistors.

In bipolar memories, the newest offering is Fairchild's Isoplanar process, which uses silicon-nitride masking to permit oxide isolation instead of diode isolation, allowing substantial reduction in cell size. Fairchild hopes the process will give the high bit density that's common with MOS, along with bipolar speeds.

There are other processes, but these are the most significant today. Newer processes, like almost everything else in IC memories, are often subject to dispute.

If an engineer were to chat with key men at IC houses, he would likely find a wide range of views. Speaking in turn to experts A, B, C, D, E, F, G and H, he might find, for example:

A. "The process we use is best. It's inherently simple. The other fellow's process isn't practical; it's too difficult to use in production; it's too expensive."

B. "The other fellows think our process is too difficult. But that's only because they lack experience with it. When they learn how to control the process, as we have, they'll change their tune."

C. "When we come out with a product (or process) before the other fellow does, we have an advantage because, by the time he starts, we'll be at a more advanced point on the learning curve."

D. "When we come out with a product (or process) after the other fellow does, we have an advantage because we have learned from his mistake. We won't repeat them."

E. "His specs may look better than ours, but his process has never been proven. Nobody knows its long-term effects. The device is only experimental. His tolerances are too tight. He'll never be able to make it in production."

F. "The other fellow simply doesn't know how to control his process and work to close tolerances. We know we'll be able to use our process to make 10,000 circuits a month by next June. That's definitely achievable."

G. "Our process is inherently better because it reduces cell size."

H. "Cell size doesn't matter. Everything depends on smart circuit design and the number of metalization lines going to each cell."

In all these views, there is some truth. But there is almost no universal truth. Some generalizations have acquired such widespread acceptance that they're often accepted as fundamental truths. Yet they may be wrong.

Myths, pitfalls, tradeoffs

It is widely held, for example, that while bipolar memories are best for speed, MOS memories offer lowest power consumption and highest bit density, thus most storage per chip. But at the end of May, the largest single-chip memory for sale was
bipolar—it was not MOS.

In keeping with sanctified tradition, competitors praised the device, but said it was experimental and not really in production. The manufacturer, Monolithic Memories, insisted it was definitely in production and, in fact, being manufactured with good yields and sold in quantities normal for a new device.

**ROMs**

A read-only memory storing 1024 8-bit words, the unit, the MM6280, has the access time one might expect from bipolars—150 ns maximum. But its maximum power consumption, 60 µW/bit, matches that of MOS memories. Though output current is a full 16 mA, which is typical of TTL, address-line current is a mere 160 µA, one tenth that of TTL.

In quantities of 100 to 249, the MM6280 (for 0 to 70 C) costs $60 (0.73¢/bit). It includes four chip-enable lines and is available with open-collector output, so it's easily expanded from 8192 to 16,384 words or, to use industry parlance, from 8 k to 16 k. All decode and sense circuits are on the chip.

**Nobody holds records long**

Before Monolithic Memories introduced its bipolar ROM in May, the record for the largest single-chip memory belonged to Electronic Arrays, for a static MOS ROM introduced in November 1970. Part of the EA4000 series, the device stores 512 10-bit words on a 93 by 100-mil chip that includes all decode and sense circuitry.

Total power consumption is only 325 mW (about 60 µW/bit). Though selected devices are faster, maximum access is 700 ns for units rated at 0 to +70 C and -55 to +85 C. Full Mil versions, for -55 to +125 C, have 800-ns max access. In 100-up quantities, the units cost $34, (0.67¢/bit), $40 (0.78¢/bit) and $50 (0.98¢/bit), depending on temperature range.

Having lost the "largest memory" record in May, Electronic Arrays regained it in June with a slow, but big, dynamic MOS ROM on one chip. The EA5027, with 1024 12-bit words, has a maximum access of a rather leisurely 2 µs. But maximum power consumption is a mere 250 mW (20.4 µW/bit). A unit for 0 to +70 C operation costs $40 (0.33¢/bit) in quantities of 100 to 249.

While these ROMs from Electronic Arrays and Monolithic Memories are the largest available at the moment, earlier ROMs are still noteworthy from the viewpoints of size, speed or power consumption.

Monolithic Memories, for example, has a 4096-
bit bipolar ROM. Fairchild has a 4096-bit MOS ROM and a 1240-bit character generator with on-chip counter/decoder. Texas Instruments has the TMS 4400 static MOS ROM, organized as 1024 \times 4 or 512 \times 8, at $16.25 in 100 to 249. Signetics has static MOS ROMs or character generators with up to 3072 bits. Unisem has a 4096-bit dynamic ROM. And American Micro-systems will soon offer a fully decoded 11,648-bit dynamic ROM with 800-ns access.

The earliest large MOS ROM was the American Micro-systems MA51, introduced in 1969 with 256 10-bit words and 1-µs maximum access. Several MOS ROMs with similar size have been introduced since then. These include circuits from Collins, Intersil, ITT, MOS Technology, Solitron and Teledyne, with densities of 2048, 2240 or 2560 bits.

Most of these companies also have smaller MOS ROMs, with about 1000 bits. At that size, there are some very fast bipolar ROMs.

Computer Microtechnology, for example, has 1024-bit ROMs, the CM2800 and 2805, with 50-ns maximum access. Intel has the Schottky-clamped 3301, the first bipolar 1024-bit ROM. It has 90-ns' maximum access. And Kenics has a 1536-bit Schottky-clamped ROM with 60-ns typical access. These circuits—slow and fast, small and large, MOS and bipolar—all use transistors.

Why transistors?

Is the choice of semiconductor ROM restricted to bipolar and MOS transistors? Perhaps there's no need for any kind of transistor. Perhaps diode arrays can make a good ROM. North American Rockwell Microelectronics Co. (NRMEC) thinks so.

In its Model 15900 diode-array ROM, NRMEC uses silicon-on-sapphire construction and takes full advantage of the benefits of SOS—great isolation and very low junction capacitance—thus high speed and low power consumption.

The SOS ROM stores 3328 bits, organized in word lengths from one to 32 bits. The passive array, with a total of 5120 diodes, has on-chip decoding. The input is fully compatible with TTL but the output, which provides 150 µA, would require sense amplifiers for high-speed-TTL compatibility. The array, in a 42-pin flat pack or DIP is powered from a single 5-V supply, from which it takes no more than 60 µW/bit. Access time over 0 to +70 C is no more than 20 ns. That's quick.

In 100-to-999 quantities, the price is $45 (1.35c/bit). That price includes encoding, which NRMEC can provide very fast—in 24 hours if a user furnishes a properly coded IBM card. For small quantities, NRMEC programs the ROM with a laser beam that opens silicon links between diode rows and columns. For larger quantities, the company uses mask programming. But there is no added mask charge tacked on.

While some manufacturers include the mask (or coding) charge in the price of the ROM, others separate the charge. They generally charge $200 to $2000 (depending on complexity) when fewer than 100 circuits are purchased. Beyond a specified quantity, generally 100, they invariably waive the mask charge.

Dodging the mask cost

It's apparent that one way to avoid the mask charge for coding ROMs is to buy them in sufficient quantity. A second way is to buy pre-coded ROMs. Most vendors offer several ROMs with fixed program patterns that they hope will have wide market acceptance.

These circuits—code converters, character generators, lookup tables, microprograms and keyboard encoders—are off-the-shelf, standard products, generally available from distributors.

Almost always these fixed-pattern ROMs stem from uncoded ROMs in the manufacturer's line. For example: Teledyne's TM5423BO Hollerith-to-ASCII converter comes from its 256 \times 8-bit TM5423. Similarly derived standard, off-the-shelf ROMs include the Collins CRC3003 (1024-bit sine-lookup table), CRC3502 (2560-bit ASCII-to-EBCDIC converter) and the CRC3503 (2560-bit EBCDIC-to-ASCII converter). Still another is the ITT3257, with 64 \times 7 dot-matrix characters encoded in ASCII or EBCDIC.

pROMs

There's still another way to avoid mask charges. One can do his own ROM coding with electrically alterable, field-programmable ROMs—pROMs—which can be fine solutions for those who need few ROMs with any single code. (See, also, ED 17, Aug. 16, 1971, "A new era in digital design: program-it-yourself memories," p. 22.)

They can purchase pROMs in large quantities, then electrically code (or program) them singly or in small groups with as many different codes as they like. Then if the volume of devices required for a particular code should grow large enough, they can go back to the pROM vendor and order mask-programmed ROMs at a lower unit price. Maybe.

While some pROMs are backed up by pin-for-pin equivalent mask-programmed ROMs, some are not. There may be no mask-programmed ROMs behind the pROM or a mask-programmed version may have different specs.

The first important pROMs were introduced in 1966 by the Microelectronics Div. of Radiation, Inc.
(now Harris Semiconductor), who owns the "PROM" trademark. They were small (but fast) diode matrices with 25 to 48 diodes having reverse recovery ranging from 10 to 100 ns. Not much later, Texas Instruments offered similar arrays, the TIDM1 and TIDM2, with reverse recoveries of 10 and 25 ns.

**Zap programming for most pROMs**

These pROMs have narrow aluminum strips connecting each diode to the matrix. To program the device, a user opens (or "fuses" or "zaps") appropriate aluminum links by briefly passing relatively high currents through them.

Some vendors argue that fusing links is a bad approach. They feel that fused links may re-form and that zapped metal particles may splatter over the circuit (despite the protective glass coat) and cause shorts. Harris disagrees. By June 1971 the company had accumulated more than 120-million fuse hours on the HROM-0512 without a single failure.

Introduced in April 1970, the HROM-0512 uses nichrome instead of aluminum links. It was the first large pROM, with 64 8-bit words. The company now has a 256 × 1 HR1256 at $23.50 in 100 to 999 and a 32 × 8-bit pROM and plans to introduce a 1024-bit pROM with a performance-equivalent ROM within a few months.

Nichrome-resistor links are also used in pROMs from Monolithic Memories, Motorola and Signetics. But Intersil, a company that doesn't like to zap metal, effectively creates links by shorting base-emitter transistor junctions instead. The company feels there's an advantage here because link forming takes place under the chip surface.

*Ninth bits* in Motorola's MCM5003 permit testing a pROM that's sold as a 64 × 8-bit memory.

**Electronic Design** 19, September 16, 1971
Designed for code conversion, this American Microsystems 128 x 12-bit ROM with full decoding and TTL compatibility is one of the early products to use ion implantation for lowering threshold voltage.

The first erasable field-programmable ROM, Intel's 1601 on a 147 x 161-mil chip, can be erased by exposure to ultraviolet light, then reprogrammed.

One of the first 256 x 1-bit bipolar RAMs, Intersil's 5503, fits on a 120 x 120-fil chip.

By April 1971 Intersil had accumulated 250,000 device hours (40-million programmed bit hours) of high-temperature operating and storage life without a failure.

Intersil has four pROMs—the 32 x 8-bit IM-5600 and IM5610 (at $25.70 in 100 to 999) and the 256 x 4-bit IM5603 and IM5613 (at $51.20 in 100 to 999). The 5610 and 5613 are board-programmable versions of the 5600 and 5603. Twenty units can be programmed simultaneously.

Though Intersil has MOS ROMs to follow these bipolar pROMs, the MOS units don't have the same specs. The company feels it doesn't matter. It disagrees with the assumption that mask-programmed ROMs are necessarily more economical in large volume than electrically programmed pROMs.

For small quantities, Intersil or any of its distributors can deliver a programmed pROM in 24 hours. For large quantities, the user can do his own programming quickly, especially with board-programmable devices. Intersil sells a programmer for $700, but the price drops to $500 when an engineer buys 100 pROMs. The programmer is free when a man buys 1000 pROMs.

Taking the other point of view, Monolithic Memories offer bipolar ROMs that are direct replacements for its fusible-link, bipolar pROMs. The MM6200 ROM (at $21 in 100 to 249) has the same performance as the 256 x 4-bit MM6300 pROM (at $70 in 100 to 249). And the MM6205 ROM ($70) has the same specs as the 512 x 4-bit MM6305 pROM (at $100).

Programmers are available from Monolithic Memories at ($1400) or from programmer specialist Spectrum Dynamics. But Monolithic Memories says that no special equipment is required. Any test equipment that can deliver 90 mA can blow the links.

Does the pROM work?

There can be another problem with pROMs. When all links are intact—when a device is still unprogrammed—a unit can show zeros all over. A user cannot know—yet—if his address decoders, word-line drivers, inverters and buffers are working or if the pROM simply has a giant metal short or even missing metal paths. Further, he can't measure dynamic performance.

Motorola addresses these problems with the MCM5003 pROM which the company prefers to call a ROMP (Read-Only Memory, Programmable). By adding ninth bits to the device (sold as a 64 x 8) and a "T" to the acronym, Motorola gets a TROMP (Testable Read-Only Memory, Programmable), thus showing the world, among other things, how acronyms are developed.

The company programs ones in about half the ninth-bit locations. About 16 ones are mask pro-
grammed, allowing wafer-probe tests, while another 16 are electrically programmed (as a user might program them) during final test.

The zapped nichrome links are in locations that enable a user to measure worst-case propagation delay (less than 75 ns). If he likes he can blow some of the remaining ninth bits to check his programming circuitry. Or he can get the MCM5003 with no links zapped, as a 64 x 9-bit pROM. In 100-to-999 quantities, the device costs $45. To follow the pROM, Motorola is about to introduce a mask-programmed version, the MCM4003. Both devices use Schottky clamping.

Unprogramming programmed pROMs

The testing problem could be alleviated and other advantages could accrue if a programmed pROM could be erased, then programmed again. That's obviously impossible in devices that use any form of zapping to destroy or create links. Two devices use radically different approaches to make this possible.

The first, a 256-bit “Read-Mostly Memory” from Energy Conversion Devices, is a 16 x 16-bit matrix of amorphous glass and silicon diodes. The “Ovonic Memory Switch” (named after company founder and chairman Stanford Ovshinsky) at each matrix cross-point can be switched from a resistance of 300 kΩ to 500 ohms and back again—so a program is easily changed.

The RM-256 Read-Mostly Memory differs from conventional pROMs in that a program can be changed. It differs from conventional read/write random-access memories in that the “write” or “programming” current must be applied for a relatively long time.

A 15-ms current of 7.5 mA from a 25-V source changes the RMM from its high to its low-resistance state. A 6-µs current of 150 mA from 25 V reverses the structure. Read access is only 150 ns, including the delay in an external decoder. At 100-up levels, the unit costs $45 (25-199).

The first MOS pROM

Another approach to a reversible pROM appears in Intel's 1601, a 256 x 8-bit memory that embodies a challenging new concept, and the first pROM using MOS devices. Like many other MOS products, the 1601 depends on charge storage at the gate. But unlike any other, its gate (a silicon gate) has no electrical connection; it floats.

It gets its charge by avalanche injection of electrons from source or drain, which induces a conductive channel. The amount of charge on the gate of this “Floating-gate Avalanche-injection Metal Oxide Semiconductor,” or FAMOS, depends on the amplitude and duration of applied junction voltage. Once the programming voltage is removed, there's no discharge path for the accumulated charge and a zero has been written to replace the initial-condition one.

But don't charges leak? How stable is the programmed zero. Very stable, says Intel. Extrapolation of charge-decay measurements made at high temperatures (125 C and 300 C) suggest that the charge should be retained for at least 10 years at 125 C and for perhaps 100 years at normal ambients—unless the FAMOS is exposed to X rays. They erase all zeros and return the device to the initial, unprogrammed, all-ones condition.

But X rays aren't recommended for erasing. They can increase leakage and may adversely affect other parameters. The device is erased, safely, when the chip is exposed to ultraviolet light. In fact, Intel programs each 1601 with a magnetically held lid on the package, then tests each bit, then removes the lid and erases with ultraviolet.
then attaches the normal solder lid.

If a user wants to erase and reprogram a device, he must ship it back to Intel to have the lid removed. This may not be necessary for long. Intel just introduced a new FAMOS unit, the 1701 (at $200 in 1 to 999) with a quartz lid that permits a user to erase with his own UV source, without removing the lid.

Intel and its distributors can ship programmed 1601s in 24 hours if a user sends a properly coded TWX or telex or tape. Or a user can buy a programmer, the 7600, from Intel for a rather rich $5000. Or he can design his own from instructions provided by Intel.

The 1601 can expect some early competition from National Semiconductor's MM5203 which, too, will take UV erasure. The National device will offer full decoding, bipolar compatibility and 1-µs maximum access. In addition, it will include National's Tri-State output, which offers OR-tieable outputs without requiring pullup resistors.

Is it really available?

Like many other impressive devices, the 1601 has met with some competitors' challenges. The standard-repertoire argument, in this case, has been: "Can Intel really make it?" With barely suppressed enthusiasm, competitors pointed to Intel's May 10, 1971 price list which, for the 1601, quoted: "Not available until further notice."

Intel contends that, in May, demand so far exceeded supply that it would have been too disappointing to continue quoting. The June 25, 1971 price list, however, does give the base price—$100 in quantities of 1 to 999—which is quite a bit higher than the $58 (in 100 to 999) figure which was quoted in a January 1971 product-information sheet.

While mask-programmed ROMs and electrically programmed pROMs get their share of attention, the major battle against the dominant memory—cores—takes place on a different front. The bastion of cores is being battered by the semiconductor RAM.

RAMs

In technical articles, seminars and lofty discussions, the battle between core and IC RAM (which should, more properly, be called a Read/Write RAM, since ROMs and pROMs are also random-access memories), is fought in terms of speed, volatility, power consumption, power requirements, space consumption, sensitivity to unpleasant environments, reliability, system simplicity and other factors. In the last analysis, however, the battle will in all likelihood be won by dollars. And availability.

Everyone's the only one shipping

The two most widely discussed and probably most widely sold RAMs today are from Intel. Both are silicon-gate MOS devices; both are fully decoded on chip; both have chip-enable inputs and OR-tieable outputs to simplify system expansion. And both are extensively second-sourced (though second sources prefer "alternate source").

The 1103 is a 1024 X 1-bit dynamic RAM and the 1101 is a 256 X 1-bit static RAM. By late June, a dozen vendors were "the only one actually shipping" the 1103.

While many alternate sources (like American Micro-systems, General Electric, General Instrument, ITT, Microsystems International, Motorola, North American Rockwell, Signetics, Solid State Scientific, Solitron, Texas Instruments and Unisem) offer (or will soon offer) direct, almost-identical replacements for 1103s, several companies have (or will soon have) somewhat similar 1024-bit or larger memories with important departures from the 1103.

By year-end, for example, Computer Microtechnology hopes to introduce a 1024-bit bipolar RAM with 90-ns access and full decoding. The company already has prototype 2048-bit dynamic MOS RAMs. Signetics developed a 2048-bit dynamic RAM for Honeywell Information Systems and dynamic 2048-bit RAMs are now available, albeit in limited quantities, from Texas Instruments. Fur-
ther Mostek is working on a 4096-bit and General Instrument already has a 2048-bit dynamic RAM using—and this is dramatic—one transistor per cell.

A brief look at some circuits that compete more directly with the 1103 can be worth while. One advantage cited for silicon-gate technology is higher speed due to reduced capacitance. But Advanced Memory Systems uses conventional aluminium gates and gets higher speeds than does Intel's 1103.

The 1024 × 1-bit AMS 6002 boasts worst-case access of 150 ns while the 1103's access is 300 ns. The 6002, in a 22-pin ceramic DIP, costs $45 in 100-up quantities while the plastic-packaged version of Intel's 18-pin 1103 costs $38.40.

For compatibility with DTL or TTL devices, the 1103 needs external level shifters and sense amplifiers (which can increase access time and board-space consumption). National Semiconductor's MM4260 doesn't need them. Its input and output data levels are directly compatible with DTL/TTL. Level translation and low-level sensing take place on the chip.

Further, the 18-pin 1103 uses a separate bus for input and output, while National's MM4260 uses a common I/O bus—a feature whose merits can be disputed. But the common I/O bus allows National to package the RAM in a 16-pin DIP, the largest that can be handled by automatic-insertion machinery.

Another unusual 1024-bit dynamic RAM comes from Mostek, whose MK4006B uses ion implantation. While others (like Hughes) use ion implantation mainly to get self-aligned gates, Mostek uses II to lower threshold voltage of conventional, enhancement-mode p-channel transistors from about -4 to -1.5 V. A further II step lowers threshold through zero to +5 V, providing depletion-mode transistors on the same chip with the enhancement-mode devices.

The MK4006P uses depletion-mode transistors as constant-current sources, giving high speed-power product and low standby power (50 mW). In addition, the device—with static decoding and sensing—requires no precharging or clock input—so it fits in a 16-pin DIP. Further, the device can be ordered with on-chip pullup resistors to provide full input compatibility with TTL.

Varadyne's VO-18 is another 1024-bit RAM, this one with TTL compatibility at the input and output. The VO-18, too, requires no clocks. Access time is typically 200 ns. Price, in quantities of 100 to 499, is $50.

An extremely significant 1103 replacement is the SCL-5710 from Solid State Scientific. Like the 1103, this is a 1024 × 1-bit silicon-gate dynamic RAM. Unlike any other, however, it uses n-channel transistors instead of p-channel devices. With a +15-V supply it offers typical access of 150 ns.

The company expects to follow this in early 1972 with a similar RAM and a 2048-bit unit, both with on-chip complementary-MOS decoding for ultra-low power consumption.

The first one-transistor memory cell

The basic cell in all dynamic MOS memories—but one—requires three transistors—one to read, one to refresh old data or write new data, and one to store data as a charge in the gate capacitance. Now General Instrument has a large memory that uses a single-transistor storage cell.

The silicon-gate transistor serves as a bi-directional switch to write, refresh or read data stored as a charge in a source-to-substrate thin-oxide capacitor. Using this revolutionary development, GI has built and is now sampling the RA9-2048, a 2048 × 1-bit dynamic RAM.

On a 138 × 143-mil chip, not much larger than the 114 × 140-mil chip used in Intel's 1103, GI has twice as many data bits. The RA9-2048 offers 250-ns access and 400-ns cycle times, compared to the 1103's 300 ns and 580 ns; 300 nW dissipation instead of 400 mW; and a startling output of 10 mA at 70 °C instead of 400 µA.

Who makes larger memories?

It's a rare system that uses only a single memory chip—however large. For larger memories, somebody has to organize the memory chips and their "overhead" circuits (like row and column decoders, refresh amplifiers, clock generators, sense amplifiers and level shifters), package them, power them, and get data to them and from them. Who?
Bipolar RAM with 256 one-bit words, the 93410, is the first product to use Fairchild's isoplanar oxide-isolation process to boost on-chip bit density.

Sometimes the design engineer assumes the entire responsibility, even to designing and manufacturing the chips. Such was the case, for example, with Four-Phase Systems.

The company designed its own 1024-bit dynamic RAM and additional logic on a rather large, 165 x 165-mil chip in a 28-pin DIP. It went on to develop an 8096-bit, then an 18,432-bit dynamic ROM for use in its computer systems.

While design engineers sometimes assume complete responsibility for memory-system design, they more often shift some responsibility to vendors who specialize in building larger memories.

North American Rockwell, for example, offers 11 x 12-inch cards with 4096 x 16, 17 or 18 bits. These are multi-package, not multi-chip, cards.

Texas Instruments favors multi-chip arrays, with gold-beam-lead chips. TI now has two static 14-chip MOS RAM arrays, the SMA2001 (2048 x 1 bit) and the SMA2002 (1024 x 2 bits), both at $143 in 100-to-499 quantities, both with 125-ns access, and both decoded and fully compatible with TTL. They're in 1.6 x 1.2-inch 28-pin DIPs.

Another approach is taken by Semiconductor Electronic Memories Inc., who uses 0.4-inch square modules with 32 rigid pins emerging from the surface. SEMI separates the storage and support functions. It flow solders two 128-bit bipolar RAM flip chips in one module. A second module, with a single chip, has address registers, input and output buffers and read/write drivers.

The company mounts the modules on 5-1/2 x 7-inch cards. The RAM289B1024 x 9-bit card, for example, contains 36 storage modules and six support modules with 180-ns maximum access and 0.8 nW/bit consumption. This card costs $553 in 100 to 499. A 300-ns card costs $369.

Another chip manufacturer making modules is Computer Microtechnology, who prefers beam leads of aluminum. The company mounts almost two dozen chips in a 1-1/2 inch square package to provide a 4096-bit static RAM with all support circuitry. Storage and decoding are MOS while driving and sensing are bipolar. The entire memory with 400-ns access and 400 µW/bit dissipation, costs about 6¢/bit at the 100-up level. This month, the company plans to introduce an 8192-bit module with 250-ns access.

Another company, Advanced Memory Systems, goes even further. It covers all levels from chips to complete memory systems. At one end, AMS provides superspeed, but small, ECL memories with worst-case access times of 8 ns for 16 x 1 to 15 ns for a 128 x 1-bit memory.

In addition, the company offers TTL and MOS chips; memory cards, in bipolar or MOS, with capacities from 32 x 8 to 4096 x 9; and full systems, up to 32 k x 64, for use as add-on memories for IBM 360 computers.

Who makes smaller memories?

In larger memories, many vendors have been busy matching or beating Intel's 1103. In smaller memories, there's similar activity in second-sourcing the Intel 1101 and its variations, but not to the same extent. For the 1101, a 256 x 1-bit static MOS RAM, has bipolar competition.

Despite its following, the 1101 is not the largest static RAM. That honor belongs to Fairchild's 3532, a 512 x 1-bit RAM with full DTL/TTL compatibility, on-chip decoding, 600-ns typical access, 20-mW standby power, 150-mW operating power and a price of $20 in 100-999 quantities.

While there are several alternate sources for the 1101—including Computer Microtechnology, General Instrument, Mostek, National Semiconductor, Signetics, Solitron, Texas Instruments and Unisem—there can be substantial differences among them in speed, power dissipation, voltage requirements and price.

Mostek's MK4007P, for example, uses ion-implanted depletion-mode loads to provide the widest voltage range for VDD and VDD—6.5 to −15 V. Power dissipation doesn't vary rapidly with supply-voltage variation; it changes linearly.

For another example, National Semiconductor has a family of five 1101 equivalents. One, the MM1101A2, has a maximum access time of 500 ns—just half of that available in the fastest traditional 1101. In 100-up quantities, prices range from $15.40 to $23.10. In the same quantities, Intel's 1101A costs $12.80, the 1101A1 $15.40.

Since RAM chips with 256 bits or less are often intended for cache or scratchpad memories, there's a great deal of emphasis on speed, hence on bipolar designs. In some earlier designs, speed was achieved, in part, by excluding decode, drive and sense circuitry, then assigning their delays to another chip. This can make sense.

For example, Intel quotes access time as a total
of 120 ns for the partially decoded $256 \times 1$-bit 3102 static bipolar RAM and the 3202 3-out-of-6 decoder-driver. But the 3202 can drive 32 3102 chips. Both units were introduced in August 1970.

A month later, Intersil announced the first $256 \times 1$-bit static bipolar RAMs with on-chip sense and decode—the IM5503. This was followed by the 5523 and 5533, all with 65-ns typical access.

A more recent bipolar RAM, the $256 \times 1$-bit Am2700 from Advanced Micro Devices, has similar speed—60 ns—as well as full decoding, three-state output and three chip-select inputs, all of which are available with Intersil's IM5523.

Two very recent $256 \times 1$-bit static RAMs deserve special attention—the MM6510 from Monolithic Memories (introduced in May) and the Fairchild 93410 (to be offered this month). The MM6510, with 70-ns typical access, uses cross-coupled silicon-controlled rectifiers for storage.

As a result, it has astonishingly low power consumption—$10 \mu W$/bit in the standby (storage-only) mode, $900 \mu W$/bit during read or write—and a degree of nonvolatility. The device retains data indefinitely if the supply drops from $+5$ to $+2$ V. And if the supply fails completely, the memory retains data for 5 ms—which may be enough to permit switching to standby power.

The Fairchild 93410 deserves notice, not so much for what it does, but for what it promises. It is, in fact, very fast, having address access of 40 ns and chip-select access of 20 ns. More important, however, is the fact that it's the first product to use the Isoplanar process, which Fairchild announced in February.

The 256-bit RAM, with full decoding, three chip selects and OR-tieable output, demonstrates feasibility of the high-density, low-capacitance Isoplanar process. The dramatic contribution, however, should appear when Fairchild announces the first 1024-bit Isoplanar RAM—in early 1972.

Though most activity in smaller memories is aimed at trimming nanoseconds, an important process—complementary-symmetry MOS—is aimed at chopping milliwatts. Several vendors like RCA, Intersil, Motorola and Solid State Scientific, use CMOS for logic and timing circuits, but the two leading ones using it for memories are RCA (who calls it COS/MOS) and Motorola (who, with a penchant for initial Ms, calls it McMOS, which a few people pronounce like the name of a Walt Disney character).

The basic CMOS structure uses enhancement-mode p-channel and n-channel transistors in series, forming inverters that are cross coupled to form flip-flops in memories. Since one transistor is always off, the circuit consumes very little quiescent (or "standby" or "storage only") power. CMOS RAMs have two principal disadvantages—lower bit density and higher cost due to the additional processing required.

But they have compensating advantages—in addition to low power consumption. They operate from a single supply voltage (unlike other MOS memories); they can be designed for a wide range of supply voltages, so they can be operated from batteries and can interface easily with bipolar; they can have high noise immunity; and because of high input impedance, they have high fanout.

RCA has two CMOS RAMs to be offered for sale this month—the TA6042 with 200-ns access, and the TA5974 with 500-ns access. In standby, both $256 \times 1$-bit memories consume a mere 1.2

Close-up (red) and closer-up (blue) photos, superimposed, of CM2400 module from Computer Microtechnology, show 16 $256 \times 1$-bit MOS storage chips in the center, five bipolar sense amplifiers and decoders around the periphery of this TTL-compatible $4096 \times 1$-bit, $2048 \times 2$-bit or $1024 \times 4$-bit static RAM. Combination of MOS and bipolar chips, all using aluminum beam leads, provides high speed with low dissipation.
µW/bit (about 300 µW total) with a 10-V supply. Both devices are fully decoded, the former with current sensing and the latter with voltage sensing. Both are compatible with TTL.

Since June, Motorola has been selling a smaller CMOS RAM, the 64 x 1-bit MCM 14505L, with full on-chip decoding, TTL output compatibility, and input compatibility if pullup resistors are used. The device operates from -55 to +125°C and costs $25 in quantities of 100 to 999.

With a 10-V supply, total standby consumption is 1 µW (about 16 nW/bit), making this the lowest-power RAM available. The unit has typical access of 200 ns and a supply-voltage range of 4.5 to 18 V, but 3-to-18-V units are available on special order. With a 5-V supply the RAM can operate with 1-MHz data rates and have a dynamic power consumption less than 4 mW.

RCA's 64-bit CMOS TA5577 consumes more standby power than does the Motorola unit, 450 nW/bit, and it has no decoding. But it's four times as fast, with 50-ns access.

Speed isn't everything. There are applications where speed is limited by mechanical devices like card readers, printers or other peripherals. There are applications where the memory is to be synchronized to relatively slow circuits — like those in CRT-display terminals. And there are applications where computation and memory can be very slow, as in calculators, because of the intervention of very slow devices — humans.

In these applications, the optimum memory is often a sequential-access device with very low cost — the shift register.

**SRs**

Like ROMs and RAMs, shift registers can be designed for static operation (which does not require clocking to retain data) or dynamic operation. The static SR can retain data forever, but it requires a bigger chip for the same number of bits and it consumes more power.

Many new SRs use silicon-gate technology. With the exception of those using CMOS, almost every one uses standard p-channel transistors with 111 crystal orientation. But not all.

Intersil hopes to be first with commercially available n-channel silicon-gate SRs. Since the carriers (electrons) in n-doped crystals have twice the mobility of p-doped carriers (holes), n-channel devices can be twice as fast with the same power consumption. But n-channel devices are far more susceptible to sodium-ion contamination — a problem Intersil feels it has whipped.

Taking a different tack, National Semiconductor used 100 crystal orientation, rather than silicon gates and 111 orientation, to achieve low threshold voltages in its new 1024-bit dynamic shift register, the MM4013.

Many manufacturers feel that 100-cut crystals reduce power consumption, but cut speed, too. National's 1024-bit dynamic MM5013 does, indeed, cut power. Maximum current drain at 2.5 MHz is 15 mA, compared to the usual 50 mA. But the device can still operate at a 2.5-MHz clock rate and that's the rate offered by many competitive devices. The unit offers internal recirculation, as do other 1024-bit shift registers, full TTL compatibility and active wired-OR output, requiring no external pullup resistor. In quantities of 100 to 999, the full-Mil version costs $24.

Though National is willing to pay a penalty in clock-line capacitance — 160 pF compared to 140 pF in many competitive 1024-bit SRs using silicon-gate technology, that capacitance is important enough so that most data sheets precede the clock-capacitance spec with the same adjective — "low." For clock power costs money. And that power equals $CV^2$.

So a company has an advantage if it cuts capacitance, and an added advantage if it cuts the clock-voltage requirement. Fairchild has done both in a line of 500-bit (Model 3331), 480-bit (3330), and 512-bit (3329) dynamic SRs. Capacitance is down to 45 pF (compared to competitive 80 pF) and clock voltage is 10 V instead of 17 V, slashing clock power by 80 per cent. In quantities of 100 to 999, the devices, which can take a 2-MHz clock, cost $4.90.

Clock-line capacitance is even lower, at 40 pF, for two phases of a four-phase 1024-bit dynamic register, the Collins CRC1501. The other two phases, however, have 110-pF input capacitance.

Dynamic shift registers of 1024-bit length are available from many vendors, often as dual 512-bit or quad 256-bit units. Data rates in some can be as high as 10 MHz (with 5-MHz clocks and two-
chip multiplexing).

Static registers are shorter. The Signetics 2511A, a dual 200-bit static SR, is the longest. In quantities of 100 to 999 it costs $5, complete with built-in logic, internal clock, TTL compatibility and wired-OR output requiring no external pullup. The silicon-gate device can operate at 3 MHz.

The fastest shift register is the Ragen Semiconductor MS612, a 64-bit static CMOS device. At 16 V and 25 C it can operate at 25 MHz. At 5 V it can operate at 5 MHz across the entire Mil temperature range.

In standby the device draws no more than 1 µA from supplies of 5 to 16 V. Units can be designed for 2 to 10 V or 1.5 to 5 V, sacrificing speed. In supplies of 5 to 16 V. Units can be designed and wired-OR output requiring no external pullup.

MS612, a 64-bit static CMOS device. At 24 four-bit words and, within limits, allows simultaneous insertion and extraction of data at different clock rates.

When words are loaded into the SR, they automatically advance to the last "empty" stage, an empty stage being one with a flip-flop at an intermediate "not-1, not-0, no-data" level.

So the unit, at $60 in 100 to 999, serves handsomely as a short buffer between systems with different clocks. **

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**Need more information?**

Products cited in this report have, of necessity, received only cursory coverage. They’ve been selected for outstanding or unique qualities, though other specifications, not discussed, may limit or enhance their value in specific applications. Readers may wish to consult the manufacturers, listed here, for further details.

ELECTRONIC DESIGN is deeply grateful to many individuals who generously gave time and patience to provide information for this report. To some of these men, listed here, we extend our special thanks for very special help.


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Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. 95014. (408) 257-6450. (Marshall Cox, Executive Vice President; Murray Siegel, Mgr. Prod. Mkgt.)

ITT Semiconductors, 3301 Electronics Way, W. Palm Beach, Fla. 33407. (305) 842-2211.


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machines that make data move

INFORMATION RETRIEVAL NUMBER 35

TELETYPE
Guarantee signal timing relationships
with one of these three methods. You can eliminate
spikes, fix pulse widths and clock signals.

Controlling pulse edges in digital systems be­
comes difficult when the problem is attacked cir­
cuit by circuit. The designer must have a sys­
tematic approach. Otherwise arbitrary decisions
made with each signal at various points in the
system can lead to significant over-all system
errors.

Likewise when it's necessary to eliminate spikes
and to clock signals, the timing relationships must
be guaranteed.

You can achieve such guaranteed timing rela­
tionships efficiently and systematically with one
of three methods. Let's examine them.

The basic terms used to explain these methods
are defined in Fig. 1. Inputs A, initiated at t a ,
and B, initiated at t b , give rise to outputs C, at
time t c , and D, at time t d . Time delays 
\[ \Delta t_a = (t_c - t_a) \]
and 
\[ \Delta t_b = (t_d - t_b) \]
are delays encountered by inputs A and B, respectively, through the
network. In terms of these parameters, the basic
problem in guaranteeing the correct time rela­
tions is stated as follows: How does one guarantee
\( t_c \geq t_a \) while minimizing the time delay to outputs
C and D?

**Method 1: Add a delay**

The easiest solution is to introduce another
delay whose value is chosen to satisfy the con­
dition \( t_c \geq t_a \) (see Fig. 2). There are three ways to
obtain the value of this delay.

(a) Worst case time delays are assumed and
the delay \( \Delta t_d \) is picked so that 
\( (\Delta t_d)_{\text{min}} \geq [(\Delta t_c)_{\text{max}} - (\Delta t_b)_{\text{min}} - t_a + t_b] \). This potentially
adds \( [(\Delta t_c)_{\text{max}} + (\Delta t_b)_{\text{max}} - (\Delta t_d)_{\text{min}}] \) to the de­
lay of D. This technique allows one to pick a
value for the delay that accounts for all possible
variations in the tolerances of the network. No
tuning of individual systems is required.

(b) One path is tuned, and \( \Delta t_d \) is set so that
\( (\Delta t_d)_{\text{min}} \geq [(\Delta t_c)_{\text{max}} - (t_b + \Delta t_b)_{\text{max}} + t_a] \). It is
assumed that worst-case delays exist in the path
not being tuned. Then the D path is tuned to
account for the actual delays in the D path. This
method is particularly useful when the C path
may be a group of data lines and the D path is
a strobe pulse. With this technique, one has only
to measure one path to determine the value of the
delay, and this value is sensitive only to changes
in its own path. This delay, however, must be
determined for each individual system. This meth­
method could add as much as \( [(\Delta t_c)_{\text{max}} + (\Delta t_b)_{\text{max}} - (\Delta t_d)_{\text{min}}] \) to the delay of D, reducing the delay of

---

**Fig. 1:** Obtaining \( t_c \geq t_a \) while minimizing time delays at the
output is the objective in guaranteeing signal timing re­
lationships. The required timing relationships are defined
for output signals C and D, which are responses to in­
puts A and B, respectively.

**Fig. 2:** Introducing a delay in one path is the easiest way to
obtain the \( t_c \equiv t_a \) criteria. The delay can be determined
by assuming a worst-case delay, tuning one path or tun­
ing both paths. The last option provides the least delay
to signal D.

---

W. W. Farr Jr., Honeywell Information Systems, Framing­
ham, Mass. 01701
the D signal by \[ \left[ (\Delta t_0)_{\text{meas}} - (\Delta t_0)_{\text{min}} \right] \] over the delay introduced by the worst-case technique of 1a.

(c) Both paths are tuned, and \( \Delta t_0 \) is set so that \( (\Delta t_0)_{\text{min}} \geq (\Delta t_0 - \Delta t_b - t_b + t_a)_{\text{meas}} \). The delay \( \Delta t_0 \) is adjusted so that \( t_c = t_o \) by measurement. The adjustment must somewhat overcompensate to allow for aging and drift. This technique is useful when there are only a few lines involved and their relationships are well-defined. Generally this technique adds less delay to D than technique 1b does. It could add as much as \( (\Delta t_0)_{\text{max}} + (\Delta t_b)_{\text{meas}} \) to the delay of D.

Comparing the three techniques of method 1:
- Method 1a is the easiest to specify, set up and maintain. It does, however, introduce the most delay to D.
- Method 1b is easier to implement than technique 1c, since it is dependent only on the components in its own path. When the other path is actually many paths, such as data lines, method 1b will add very little more delay to path D than technique 1c will. This is because some of the measured delays in the multiple path have a high probability of being close to the worst case (maximum delay).
- Method 1c achieves the least total delay. It is generally not useful for systems that are mass-produced or systems where paths C or D are multiple, parallel paths. The degree of improvement to be expected depends on the statistical distribution of the elemental delays in the network. This technique can be used, however, to obtain the least possible delay in a highly tuned system.

Method 2: Logically interlock C and D

Paths C and D can be logically interlocked as shown in Fig. 3 with a logic AND condition. To satisfy the requirement that

\[
\begin{align*}
t_c &\geq t_o, \\
(t_a + \Delta t_1) &\geq (t_b + \Delta t_3)
\end{align*}
\]

Either of the terms in the brackets can satisfy the inequality. However, if \( (t_b + \Delta t_3) \) satisfies the inequality, then the logic connection is not needed, and the equation reduces to that of method 1. If \( (t_a + \Delta t_1) \) alone satisfies the inequality, it reduces to \( (t_a + \Delta t_1 + \Delta t_2) \Rightarrow (t_a + \Delta t_1 + \Delta t_2) \), or \( \Delta t_i \geq \Delta t_2 \). This adds to the delay of D as much as \( [t_a + (\Delta t_1)_{\text{max}} + (\Delta t_2)_{\text{max}}] \).

Thus two conditions are required to optimize the system using this method:
1. \( (\Delta t_1)_{\text{min}} \geq (\Delta t_2)_{\text{max}} \)
2. \( (\Delta t_1 + \Delta t_2)_{\text{max}} \) must be minimized.

Method 3: Combine the first two methods

The number of places in a given system where one can perform the logic AND of method 2 are limited, and therefore so are the values of the time delays. By combining methods 1 and 2—adding an adjustable delay, \( \Delta t_5 \), into \( \Delta t_4 \) of method 2—you can compensate for the quantum nature of a sum of gate maximums and minimums, or the measured circuit delays in a given system, and further reduce the delay of the D path.

The two optimizing equations of method 2 then become:
1. \( (\Delta t_1 + \Delta t_3)_{\text{min}} \geq (\Delta t_2)_{\text{max}} \)
2. Minimize \( [ (\Delta t_1 + \Delta t_5)_{\text{max}} + (\Delta t_2)_{\text{max}} ] \).

This could add to the delay of D as much as \( [t_a + (\Delta t_1)_{\text{max}} + (\Delta t_2)_{\text{max}} + (\Delta t_5)_{\text{max}} - t_o] \).

Now let’s consider a practical example to demonstrate how the methods are applied.

Two input signals, A and B, are defined in the worst case as shown in Fig. 4a. The network is a series of NAND gates (Fig. 4b). The gate delays are defined to be 10 ns minimum and 20 ns maximum. All delay lines are assumed to have a ±10% tolerance. The requirement is that \( t_c \geq t_o \).
5. The optimum connection using logic interlock is shown, along with two other possible connections out of a total of nine (a). The optimum connection satisfies the required timing relationship, while providing minimal delay to C and D. A “truth table” (b) compares the possible connections.

With no compensation to the network, $\Delta t_{\text{max}} = 100 \text{ ns}$, $(\Delta t_{\text{min}} = 40 \text{ ns, } t_3 = 20 \text{ ns, } t_e = 0 \text{ ns} \text{ and } [(\Delta t_{\text{max}} - (\Delta t_{\text{min}}) \leq (t_e \text{, } t_3) \text{ yields } 60 \text{ on the left and } -20 \text{ on the right. Therefore D must be delayed by at least } 80 \text{ ns to satisfy the requirement.}

Using method 1a, we find that $(\Delta t_{\text{min}}) \geq 80 \text{ ns. If the delay line has a tolerance of } \pm 10\%$, then $\Delta t_5$ is chosen to be $89 \text{ ns, and D could be delayed by as much as } 158 \text{ ns.}$

In method 1b, the actual delay of D may be tuned to achieve a lower delay than that found by method 1a. Assume that the actual delays of the gates in the D path are measured to be a total of $60 \text{ ns. Using method 1b, we still assume the worst case delays in the C path, so that $(\Delta t_{\text{min}}) \geq 60 \text{ ns, without tolerances taken into account. With tolerances } \Delta t_3 = 67 \text{ ns and D can be delayed by as much as } 134 \text{ ns.}$

With method 1c, the measured delays of both C and D paths are tuned, and a further reduction in the delay of D can be achieved. Assume the measured delay of the D path is $60 \text{ ns, as in method 1b, and the delay of the C path is } 85 \text{ ns. Then } (\Delta t_{\text{min}}) \geq 45 \text{ ns without tolerances. With tolerances } \Delta t_3 = 50 \text{ ns, and D can be delayed by as much as } 80 \text{ ns.}$

Using method 2 one could—without adding any logic elements other than input nodes to the existing NAND gates—interconnect paths C and D. There are nine different ways to interconnect these paths. Three possible connections are shown in Fig. 5a.

6. The hybrid technique of method 3 results in the optimum connection shown (a). A table giving all possible connections (b) lists each in terms of the criteria of method 3. The delay $\Delta t_5$ is a variable used to solve the inequality $[(\Delta t_1 + \Delta t_2)_{\text{min}} + (\Delta t_3)_{\text{max}}$. The optimum connection has least over-all time delay.

A systematic way of finding the optimum connection is to use a chart similar to a truth table (Fig. 5b). With the chart, all possible interconnections are described and evaluated in terms of the criteria of method 2. Using this example and the worst-case delays, we observe that if $\Delta t_5 = 0 \text{ ns (zero gate delays), then } \Delta t_5 \text{ must be between } 40 \text{ and } 80 \text{ ns (four gate delays). Likewise if } \Delta t_5 \text{ is two gate delays, and thus has a value of } 40 \text{ to } 80 \text{ ns, } \Delta t_5 \text{ must also be } 20 \text{ to } 40 \text{ ns. If } \Delta t_5 \text{ is four gate delays, and thus } 40 \text{ to } 80 \text{ ns, then } \Delta t_5 \text{ must be } 0 \text{ ns. These are the only sets of values that } \Delta t_5 \text{ and } \Delta t_5 \text{ may have in this example. Likewise } \Delta t_5 \text{ and } \Delta t_5 \text{ are related in the same manner.}$

The axes explicitly show all of these possible values. The entries inside the table show whether $(\Delta t_{\text{min}}) \geq (\Delta t_{\text{max}} \text{ (item 1) is satisfied (YES) or not (NO), and the value of } (\Delta t_1 + \Delta t_2)_{\text{max}}$ (item 2) is given. Thus the table shows that there are two configurations that provide the correct timing and that the “b” interconnection is the optimum one.

You can also choose the interconnection based on measured delays. Assume a gate delay of $10 \text{ ns in C and } 15 \text{ ns in D. Then the optimum connection would have an added delay to D of } 70 \text{ ns.}$

A table can also be used in applying method 3. Assuming the worst-case gate delays of $10 \text{ ns minimum and } 20 \text{ ns maximum, we obtain the table shown in Fig. 6b. The optimum configuration is shown in Fig. 6a. One could also measure the element delays and use the measured values of } \Delta t_5.
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Phase locking—the key to success

The heart of each station in the system is an electronically tunable low-frequency oscillator. In normal operation, synchronizing signals are transmitted simultaneously by all stations, causing the oscillators to become phase locked (Fig. 1). Each cycle of the low-frequency oscillator causes the transmitter to send a pulse of rf. A practical pulse length is about one fifth of the repetition time, the optimum repetition time being determined largely by the expected data rate.

Since phase-lock is maintained at all times, all the low-frequency oscillators will assume the same frequency and phase. If the frequency of any of the oscillators is changed, the others in the system will also change to maintain the phase-locked relationship.

Communications between stations are provided by frequency modulating and demodulating the various low-frequency oscillators. All of the stations can receive and transmit simultaneously and each acts as a same-channel repeater.

As illustrated in Fig. 1, the transmitter and receiver at each station are connected to the same antenna. If a station is operating all by itself, its transmitter will send out pulses at a rate determined by the free-running frequency of the low-frequency oscillator. These pulses will be radiated by the antenna, and they will also be received by the station's own receiver. If a sec-

---

1. Both repeaters transmit synchronizing pulses simultaneously. Since each repeater receives its own and all other transmissions, the oscillators are phase locked at the same frequency and phase angle.

2. Adding a modulator and a demodulator to the basic repeater allows each station to originate and receive data as well as relay it. Data can be sent between any and all of the stations in the network.
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ond station is put into operation, it will send its pulses in a similar manner.

If the two stations are not in exact synchronism, then each will receive an early or late signal with respect to its own transmission. Early or late reception causes the low-frequency oscillators to speed up or slow down so the transmitted pulses from the two stations will be coincident.

The same principles apply when more than two stations are working in the system.

Since the output of the transmitter is connected directly to the receiver, the receiver must have a very short overload recovery time. This, of course, means that age cannot be used, and all interstage coupling components should be made as small as possible.

**Sending data over the system**

To transmit data over this system, it is merely necessary to deliberately change the frequency of one of the low-frequency oscillators; the others will follow. So, the addition of a frequency modulator and a demodulator to each repeater station converts it into a complete send/receive unit (Fig. 2).

With this system, it is possible to send and receive data simultaneously between any or all stations in the network. When several stations are transmitting at the same time, all of the low-frequency oscillators remain phase locked and their frequency-vs-time contours will contain the vector sum of all the data inputs.

This, of course, means that the demodulators will put out several signals at once. In voice communications this isn't much of a problem, because the listener can usually pick out the voice he wants to hear. In data communications, on the other hand, something must be done to prevent confusion.

The most straightforward approach is simply to send one message at a time. Alternatively, a system of subcarriers can be used, with each transmitter working on a different subcarrier frequency.

Of course, it is not always necessary to have a modulator and a demodulator at every station. If it is only necessary to transmit data in one direction, the sending unit is provided with a modulator and the receiving unit has a demodulator. Similarly, if a station is only required to act as a repeater, then it doesn't need a modulator or a demodulator.

A significant point to bear in mind when this new modulation technique is used is that each station in the system can have a relatively low power output, because it needs only to transmit as far as the station or stations adjacent to it in the network. Power output can be kept to a minimum to conserve the batteries. All transmitters may be turned off during periods when there is no data to be transmitted or relayed.

The required system bandwidth is dependent upon the data rate to be transmitted. The graph of Fig. 3 is based on practical considerations involving equipment size, weight, complexity and cost. For most data systems the ultimate bandwidth is dictated by crystal oscillator drift rather than by data rate.

In large quantities, data stations may be produced at low cost. In Fig. 4 the major components in each sub-section are called out. It is clear that the locked-oscillator principle lends itself to low-cost station design.

---

3. Practical, rather than theoretical, considerations led to this graph of required bandwidth vs data rate. These figures pertain to equipment for which size, weight, complexity and cost are kept at a low level.

4. Station design is uncomplicated and inexpensive. The design details will vary with the system designer, but the parts complement should be approximately as indicated in this typical-system example.
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If your document release system is sick, this guide will be helpful. It tells how to diagnose the strengths and weaknesses of your system, and improve its health.

When was the last time your engineering document release system had a complete check-up? The health of your release system should be evaluated as often as your own—if it’s below par it can undermine the best laid plans of management, engineering, and manufacturing.

Because of the wide-ranging impact of the engineering document, or as it is often called—data release system, managers and design engineers alike should know what, how, and when engineering data is released to manufacturing and procurement. Implicit in that knowledge is:

- what defects reflect a sick system and how to correct them.
- who's responsible for the system.
- how to improve the system.

The telltale signs of illness

Several defects characterize an unhealthy release system. One of the more recurrent ones is the use of multiple release desks and records. Any time more than one group controls the issuance of data, the risk of having different and even contradictory descriptions of the product is high. Thus, two different drawings may be used by assemblers on the production line, causing the manufacture of supposedly identical items with different configurations. In addition, if multiple records are used, they must be continuously reconciled with each other to assure uniformity. This process increases the chances for errors and adds clerical labor charges to the project.

Cure? Use one release desk and one set of records.

Another sign of illness is uncontrolled access to released vellums. In order for vellums to represent the authorized configuration, they must be untouched after release unless authorization is obtained to change them. While this may seem self-evident, some companies still have such an informal system of operation that a draftsman can enter the release facility, remove a vellum, make changes, and return it to the file—all without the designer's cognizance and approval. It is not surprising that the final product is sometimes different from what is wanted and that wrong parts are ordered.

To assure the integrity of the approved design, no one—including the project engineer—should be permitted to make changes to a released document without following a required procedure.

The lack of written procedures is another major obstacle to a smoothly operating system. Without them, staff members will have trouble finding out how the release system works. Changes will also run rampant and a firm operating system will be hard to maintain. And evaluation of engineering and quality control recommendations for improving the system will be difficult to do. Thus, the practical needs of other groups and the ideal requirements for an effective system cannot be merged to achieve the best system possible for company operations and requirements without written procedures.

Still another major deficiency is failure to control engineering data released for manufacture, procurement, or testing operations. A controlled document is one that is (a) stamped with unique identifiers, (b) issued only to manufacturing, testing, procurement, and quality assurance, and (c) retrieved when a revised document is issued. (Sometimes these documents are printed on pink paper for easier identification.) Superseded controlled documents must be destroyed to prevent their inadvertent use, except for one copy that is filed in the product's history file.

Who's who in the system

Who is responsible for the release system? Usually a data control supervisor designs the system, organizes the facilities, selects and trains personnel, writes procedures, and makes sure that the system is working as planned. However, the release system cannot work effectively without the cooperation and support of other organizations, especially the design, quality assurance, and configuration management groups. The designers should know the basic rules and follow them, and quality assurance engineers should.

Thomas T. Samaras, Configuration Management Consultant, Universal Monitor, 2361 E. Foothill Blvd, Pasadena, Calif. 91107
Changes are minimized with system cycles like this.

Below is a sample release system cycle. Note that proper review and approval of engineering documents before release is a key step, one that can save the company a lot of money by reducing the number of changes made in production.

This can provide bigger savings than many people realize. A large California company, for example, made a study of the efforts required to make engineering changes after production drawings have been released and work is in progress. It found that each design change required 82 distinct operations to rework the product so that it matched the new design. Poor review and checking, which may leave errors in new documents undiscovered, can have disastrously expensive effects in a system like this.

Another critical step in any release cycle is the proper control and implementation of changes. It is essential that engineering changes be reviewed and approved at an adequate level to assure control over the product's configuration, cost, and schedule. In addition, everyone who needs copies of the revised data must get them. Therefore, a formal system is required to ensure that (a) the responsible engineer and designer approve the change for technical accuracy and compatibility with customer requirements and (b) the project manager reviews the change for its impact on other project elements such as spare parts, manuals, work in progress, budget, and schedule. To assure that this process is being followed, the data control clerk should not release anyvellums from the facility without written authorization from the project manager. Also, the release of revised data or supplements (engineering orders) must follow the same procedures as followed during the original document release to assure the integrity of the product's configuration. The change procedure can be involved for some products, especially large systems, and may require a configuration manager to implement it properly.

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Use this list to check the health of your system.

This checklist will help you determine the state of health of your data release system. If your system is in good shape, the following information should be available from an inspection of records and released data.

1. Can you find out what part numbers are used in a particular component, sub-assembly, etc.? (This capability is usually not needed for standard parts.)

2. Can you determine the parts composition (by part and serial numbers) of each product built?

3. Can you determine the next higher assembly part numbers for a particular item? (This capability is usually not needed for parts assembled into standard parts.)

4. Can you identify the end product or model in which any lower level part is used?

5. Can you find out what change identification numbers were released for each product built?

6. Can you determine the effectivity (product serial numbers) for each change identification number?

7. Can you determine the change identification numbers released for each part in the product?

8. Can you find the company specification document numbers for parts built by other companies?

9. Can you determine the standard specification numbers or standard part numbers for parts used within any non-standard item?

10. Can you find the part numbers of items built by other companies to your specifications?

11. Can you find the product’s specification number?

12. Can you find the manufacturer's code identification number for all vendor and subcontractor supplied parts?

To make sure that it is working as planned and that it has not introduced new defects. Minor changes may be necessary to tune the system.

The system in summary

The complexity of the release system depends on the nature of the company's work, the sophistication of the product, the size of the company, and the customer’s requirements. When the product design is stable over the years and changes occur infrequently, the release system can be simple and fewer people can be in the release loop. However, when a new product is being developed or a major modification is being made to an existing product, much tighter and sophisticated controls are needed to avoid problems in interrelating administrative and technical data and in assuring that the completed product matches the design released by engineering.

While guidelines for appraising a release system are helpful in finding and correcting trouble-spots, it is not recommended that non-release system personnel begin looking for improvements to make. If the system is working well—a perfect system won’t be found—don’t start designing a new improved approach. However, if defects are obvious and changes seem necessary, be sure that they are not the result of personnel problems. There’s no point in changing a good system when its personnel are not following it. ■
Digitally Controlled Power Sources Include Added Systems-Oriented Functions

Digitally Controlled Power Sources (DCPS's) are complete, digital-to-analog links between a computer (or other digital source) and any application requiring a fast, accurately settable source of dc or low frequency ac power. Such applications generally require more than a programmable power supply or D/A converter with a power amplifier — the DCPS's include these added functions in a single compact trouble-free package:

**INTERFACE** Customized plug-in interface cards match the Digitally Controlled Power Source to the computer (8421 BCD or Binary).

**ISOLATION** All digital inputs are floating and isolated from the floating analog output, thus avoiding troublesome loops between the output ground and computer ground.

**STORAGE** Inputs from all digital data lines are stored upon receipt of a gate signal from the computer. Output levels are maintained until a new gate signal is received — thus, the computer is free to perform other tasks in the interval between voltage level changes.

**FUNCTION SELECTION** Selects the output voltage range, and isolates the three input bits to the current limit D/A converter.

**OUTPUT VOLTAGE D/A CONVERTER** Converts one polarity bit plus 16 BCD voltage bits or 15 binary voltage bits to an analog voltage for input to the power amplifier. Thus, resolution is 0.5mV for straight binary and 1mV for BCD operation.

**REFERENCES** Provide voltage for the Output Voltage and Current D/A Converters.

**CURRENT LIMIT D/A CONVERTER** Sets current limit of power amplifier to one of eight values.

**CIRCUIT POWER SUPPLIES** Provide all the necessary dc power — no external power supplies are required.

**FEEDBACK** Informs the computer when each programming operation is completed and when the output current is overloaded.

**BIPOLAR POWER AMPLIFIER** Programs either side of zero or through zero without output polarity switches or "notch" effects, with an accuracy of 1mV, 5mV, or 10mV depending on range and model. Outputs now available include ±50V @ 1A, ±50V @ 5A, and ±100V @ 0.5A.
High energy silicon for the 70's.

### Switching Regulator

**INPUT**
- 500 V
- 700 V

**DTS 723**

**OUTPUT**
- 500 WATTS
- 500 V
- @ 1A
- ± 1%

### DC Regulator

**INPUT**
- 1200 V
- 1500 V

**DTS 721**

**SHORT CIRCUIT PROTECTION**

**OUTPUT**
- 1000 V
- @ 100mA
- ± 1%

---

<table>
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<th>V_{CEO}</th>
<th>V_{CEO (sas)}</th>
<th>I_{C (cont)}</th>
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<td>1000V</td>
<td>750</td>
<td>3A</td>
<td>2 min @ 2.5 A</td>
<td></td>
<td>50W</td>
</tr>
</tbody>
</table>
Delco announces two new 1000-volt transistors for high power regulators in small packages.

Our new DTS-721 and DTS-723 1000-volt silicon transistors permit you to design solid state circuits for industrial applications with capabilities previously reserved for tubes. Now you can think small.

These two new silicon devices were developed specially for instrumentation and power supply builders, as well as for computer and military applications. They can operate from DC inputs of 1200 volts to 1500 volts. With 1% regulation at full load.

In a switching regulator, they can operate directly from a 220-volt line or from rectified 440-volt single or polyphase sources.

Both devices are NPN triple diffused, packaged in Delco's solid copper T0-3 cases. They are mounted to withstand mechanical and thermal shock because of special bonding of the emitter and base contacts.

These new high voltage silicon transistors make it possible for you to take advantage of reduced size, weight and component costs in designing circuits—and get far greater reliability.

The circuits shown are explained in detail in our application notes nos. 45 and 46.

Call the Kokomoans or your Delco Distributor for more information.
In many electro-optic scanning applications, a more accurate synthesis of the required signal can be obtained by comparing the ratio of two photomultiplier currents, a reference channel and the signal channel. In this way common-mode noise, such as variations in the scanning intensity (phosphor noise or CRT beam-current variations) or ambient-light are canceled out.

A circuit performing these functions is shown in the diagram. The ratio of two signals is determined by subtracting their logarithms and then taking the antilog of this difference. Using the log difference instead of the ratio provides a compressed version of the true ratio and lessens the dynamic-range requirements of the processing circuits.

The output current of the signal photomultiplier (PM) is applied to the summing junction of op-amp A1 through a transient suppressor. A range of PM signal currents of 3 to 300 $\mu$A is amplified by A1 to a voltage output of 0.03 to 3.0 V, which falls in the center of the linear portion of the logarithmic characteristics of log amp LA1. The reference PM current follows a similar path through the second channel. The two log-amp channel outputs are cross-coupled (A to B* and B to A*) to yield a difference signal output. Op-amp A3 provides a closed-loop gain of 10 to raise the log difference signal to a usable level.

Charles A. Herbst, 39 Lucille Ave., Dumont, N.J. 07628

Vote for 311
Our new analog gates switch even faster!
What's more, there are no design compromises.
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All other junction FET switch drivers trade one or more performance characteristics to gain a preferred characteristic.

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• <150 ns switching times
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Here's where they are:


Siliconix sales offices. Bethpage, New York (516) 796-4680/Norwood, Massachusetts (617) 769-3780/ St. Louis (314) 291-3616/Minneapolis (612) 920-4483/ Long Beach, California (213) 420-1307/Santa Clara, California (408) 246-8000.

Blank detector checks data ONE/ZERO message gaps

When data is transmitted so that a pulse on one line means a data ONE and a pulse on another line a data ZERO, it's often necessary to detect gaps between messages. A simple circuit can perform this function. The register resets whenever a pulse occurs on either data line. Flip-flop FF 1 sets a maximum of one clock pulse later. If there is a message gap, FF 2 sets on the next clock pulse, causing an output pulse of one clocktime duration. This indicates that a gap is detected. FF2 resets on the following pulse.

Flip-flop 3 sets on the third clock pulse and inhibits FF2 from setting again until additional data is received.

Frank Nesbitt, Senior Engineer, McDonnell Douglas Electronics Co., Box 426, St. Charles, Mo. 63301

Three flip-flops form the basis of a blank detector.
The circuit requires additional flip-flops when the external clock rate is significantly different from that of the internal clock.

Circuit inhibits transmission on busy digital party line

A design requirement for digital party-line systems is to prevent data transmission when the line is busy. A simple way to do this is to use the circuit shown in the diagram. It detects the busy condition of the line when a remote driver is using the line and does not allow the local driver to transmit until the line is free.

A sense amplifier (SN7524) detects zero crossings on the line during data transmission from a remote driver. Each zero crossing retriggers the multivibrator (SN74123), maintaining the inhibit low on the local driver (SN75109 or SN75110). Data transmission is thus prevented from the local driver until the line is free.

The driver (SN75109 or SN75110), receiver (SN75107 or SN75108) and sense amplifier (SN7524) have common-mode signal ranges of ±3 V on the line and differential-mode ranges up to ±5 V.

The transmission line is terminated only at its ends. Drivers and receivers may be located at any point along the transmission line.

Once the line is free and "acquired" by the local driver, the latch (SN7400) maintains acquisition until the inhibit of the driver goes low. The "line busy" signal can be used to prevent the dumping of data into the driver from a local data storage register.

James Talley, Texas Instruments, Inc., 13500 N. Central Expressway, P.O. Box 5012, Dallas, Tex. 75222.
Lowest distortion
and low cost in PIN diodes

If you are designing a VHF or UHF system with strict harmonic or intermodulation product requirements, Unitrode PIN diodes, with industry’s longest carrier lifetime (1-10 μsec typical) will put your mind at ease.

In addition to the low insertion loss and high reliability aspects on Unitrode’s fused-in-glass PIN diodes, we can now offer the additional advantage of low distortion switching and attenuating. By controlling certain key parameters in our patented manufacturing process we can guarantee second and third harmonic levels of 90 db below fundamental and intermodulation products as low as 60 db. This guaranteed low distortion performance costs no more. (Available under 90¢ in quantity.)

Applications from HF through UHF include TR switches, duplexer and receiver protectors in military and commercial two-way communications systems. They also reduce distortion in AGC loops and tunable filters in CATV systems.

For further information, samples and applications assistance, call Bob Tremblay at (617) 926-0404 or write Unitrode Corporation, Dept. 9B 580 Pleasant Street, Watertown, Mass. 02172
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---

Light-pulse generator works on variable supply voltage

The high current pulses for LEDs are usually generated with avalanche transistors requiring precise supply voltage. But with the circuit shown in the diagram (a), the supply voltage can be chosen between 5 V and 40 V.

The current-pulse amplitude depends on supply voltage as plotted in b. Rise time is 10 ns and the maximum PRF with the values shown is 100 kHz. Capacitor $C_1$ determines the duration of the pulse, and standby power is not required.

Both $Q_1$ and $Q_2$ are normally OFF. Capacitor $C_1$ determines the duration of the pulse, and standby power is not required.

![Diagram of light-pulse generator circuit](image)

An avalanche transistor is replaced by a transistor switch in this light-pulse generator circuit (a). A

---

**SEND US YOUR IDEAS FOR DESIGN.** You may win a grand total of $1050 (cash)!

Here's how. Submit your IFD describing a new or important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas-for-Design editor. You will receive $20 for each accepted idea, $30 more if it is voted best-of-issue by our readers. The best-of-issue winners become eligible for the Idea Of the Year award of $1000.
C, charges almost to the supply voltage, through D,. A positive trigger turns Q, ON. Then Vb, decreases, D, is reverse-biased and Q, turns ON and keeps Q, ON. The transistors drive each other into saturation so that C, discharges through the LED.

Resistor R, aids in measuring the current. Diode D, protects the LED in case of backswing. When the exponentially decaying discharge current drops below the hold current, Q, and Q, stop conducting and C, is charged again via R, and D,.


### VOTE FOR 314

Graph (b) relates the LED current amplitude to the supply voltage. Points plotted are measured data.

---

**IFD Winner for May 27, 1971**

Peter Stasz, Electronics Engineer, Medtronic, Inc., 3055 Old Highway 8, Minneapolis, Minn. 55418. His idea “Clean up switch closures with a fast UJT pulse” has been voted the Most Valuable of Issue award.

**Vote for the Best Idea in this Issue.**
AiResearch electronic cooling systems are built into the F-14.

We have designed and built complete electronic cooling systems for hundreds of airborne applications—both on board and pod mounted. In fact, a Garrett AiResearch built electronic cooling system is on board the Grumman F-14 air-superiority fighter. Whatever your specific airborne electronic cooling requirement, come to Garrett AiResearch for total system optimization.

Garrett AiResearch enclosures are also cooling the pod mounted ALQ-76 and ALQ-99 electronic countermeasures systems. The enclosure in the ALQ-99 pod (shown above) for the EA-6B utilizes surface heat exchangers as the ultimate heat sink.

AiResearch Manufacturing Co.
9851 Sepulveda Boulevard, Los Angeles, Calif. 90009
one of The Signal Companies

INFORMATION RETRIEVAL NUMBER 45

ELECTRONIC DESIGN 19, September 16, 1971
First, Solitron announced the high voltage silicon power SDT 1050 Series. Next, Solitron announced the high voltage SDT 400 Replacement Series offering higher gain and reliability. Now Solitron has gone a giant step further and developed the new and unique high voltage SDT 500 Series with sustained breakdown voltages (VCEO) from 200 to 700 V. All transistors in this series utilize hi-rel planar construction and are SiO2 passivated. Yet, there is no reduction of Is/b and Es/b ratings.

These new devices are ideal for power supplies, all CRT deflection circuits, converters, inverters, relay drivers and series regulators. And, you'll pay no more for the SDT 500 Series than the price you've been paying for other high voltage NPN silicon power devices.

**FEATURING:**
- Excellent HFE Stability
- Low Leakage Levels at Elevated Temperatures (10μA @ 150°C, 400 VCEX)
- Hi-Rel Construction
- Hi-Rel Mounting (Gold Molybdenum Pedestal)
- 100% Temperature Cycle from −55°C to +180°C
- Multiple Gain Ranges with beta from 40 to 120, 1 Amp to 5 Amp

---

**NORMALIZED CURRENT GAIN**

\[ V_{CE} = 5.0 \]

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<th>40%</th>
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</table>

**COLLECTOR CURRENT (AMPS)**

- 0.01A
- 0.1A
- 1.0A
- 10.0A

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**Solitron Devices, Inc.**

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TWX: (510) 952-7610
Here are five new hard working audio amplifiers from EEP. Which one best satisfies your needs? If you design radio receivers, phonographs, TV sets or sound systems these are naturals. But the world of audio is more than that and these amplifiers can handle just about any general purpose application you have in mind.

Select for the range of supply voltage and output power you require. All types feature low quiescent current, low distortion, excellent gain, self-centering bias, high input impedance and direct input coupling. A minimum of external components is required for operation. Packages are easy-to-use DIP's with built-in heat sinks.

The details provided here are only appetizers, intended, of course, to get your applications juices and the orders flowing. Send us an order and we'll send you our 32-page audio applications appetite appeaser. Write or call today.

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has amplifiers
(and applications data)
for audio appetites

LM351 AUDIO AMPLIFIER
- low cost
- 1.8W at 9V and 4Ω
- 6-12V supply voltage
- 68 dB gain (open loop)
- 1 mA quiescent current
- 0.75 MΩ input impedance
(open loop)
PRICE 1-24 25 up 100 up
LM351 $3.00 2.70 2.00

LM352 AUDIO AMPLIFIER
- 2.1W at 12V and 8Ω
- 6-15V supply voltage
- 1.2 mA quiescent current
- Gain (open loop): 70 dB at 12V
PRICE 1-24 25 up 100 up
LM352 $3.15 2.80 2.10

LM353 AUDIO AMPLIFIER
- 3W at 15V and 8Ω
- 6-16V supply voltage
- 1.8 mA quiescent current
- 72 dB gain at 15V
- Heat sink package with low thermal resistance
PRICE 1-24 25 up 100 up
LM353 $4.40 4.00 2.90

LM354 AUDIO AMPLIFIER
- 4W at 24V and 16Ω
- 6-24V supply voltage
- 3 mA quiescent current
- 74 dB gain at 24V
- 52 dB SVRR
- heat sink package with low thermal resistance
PRICE 1-24 25 up 100 up
LM354 $4.50 4.05 3.00

EEP has amplifiers (and applications data) for audio appetites
new products

Universal field programmer programs all types of ROMs


Designed to automatically or manually program read-only memories in the field, a new universal programmer can program all types of available ROMs—fusible-link, diode junction-shorting, electrochemical-fusing and floating-gate avalanche-injection types.

Known as the model 500, this handy instrument will automatically verify a ROM's "0" and "1" logic levels. Its present address capacity is 4096 words, however future plug-in cards will be available to easily modify the instrument, in the field, to a capacity up to 65,536 words.

Programming a ROM with the 500 is very simple. Data can be entered manually through 9 program switches (into a RAM within the model 500 programmer), which makes it possible to set up and check an entire word before a ROM is programmed.

If one desires automatic programming this can be done in one of several ways: from a master ROM, with an optional optical scanner, with an optional interface for punched paper tape or with optional interfaces for any other equipment.

The ROMs are addressed in binary code, but the word numbers are displayed decimally on a seven-segment four-digit readout.

Satellite units will become available for the model 500 programmer for programming several ROMs simultaneously.

A universal adapter module is available to verify programmed ROMs and mask-made ROMs for logic levels. The adapter will also permit the checking of access times.

The model 500 is constructed using circuit modules on plug-in cards to allow flexibility for simple word capacity expansion. It is designed to accommodate future programming techniques, as far as possible, through minor modifications.

The basic instrument costs $1500. Modules are available, for the different programming techniques, at prices ranging from $360 to $450 each.

A lower-cost programmer version (model 300) is available to program all fusible-link ROMs. It costs $250 (plus $95 for an adapter).

Test generator unit gives offline messages


A new economical offline message generator simplifies troubleshooting problems in telecommunications equipment. The device, the model 723 message generator, eliminates all online testing by producing off-line data messages. The operator can select standard Fox Test, Short Line or Composite messages, discrete characters, a checkboard test pattern or a binary progression of codes in ITA-2 and USASCII.

Software-less terminal makes hard-copy graphs


A new self-contained interface option (model 121) for the series 2000 digital plotters allows plug-compatible operation from TTY or CRT terminals for hard-copy graphic plots. An exclusive data protocol, hard-wired into the plotter, allows the plotter to bring its own software to the terminal.
CRT display terminal costs down to $2750


A new inexpensive display terminal is the model TelTerm 33 which is aimed at the teletypewriter replacement market. The visual-display system handles up to 80 characters/line and 27 lines of data. It blanks information on the screen so that important data can be called to the operator's attention. The TelTerm 33 has a numeric pad in addition to a standard teletypewriter keyboard.

CIRCLE NO. 253

Benchtop tester checks keyboards

Controls Research Corp., 2100 S. Fairview, Santa Ana, Calif. Phone: (714) 557-7161. P&A: $890; 4 to 6 wks.

A new tester provides laboratory and/or production testing capabilities for any size encoded electronic keyboard with up to 20-bit lines and either a positive or negative strobe. It also accommodates up to 12 non-encoded function keys. Designated the model 800, the unit compares a known standard keyboard against one under test or displays a bit line readout.

CIRCLE NO. 254

1-Megabyte memory speeds cycle to 2.5 µs

Core Memories, Inc., 2525 Charleston Rd., Mountain View, Calif. Phone: (415) 965-4080.

Cycle time has been decreased to 2.5 µs for the 1-million byte Large Core Store (LCS) memory. Compatible with IBM's system/360 model 50, its cycle time for the 2-million byte model has been decreased to 3 µs from 4 µs. Both models do not have price increases. A 524,288-byte 2.5 µs model compatible with the IBM system 360/50 has also been developed.

CIRCLE NO. 255

Compact data modem is for wall mounting

RFL Industries, Inc., Boonton, N. J. Phone: (201) 334-3100. P&A: $180 (without carrier detect); 30 to 60 days.

A PC card OEM modem designed for desk or wall mounting is housed in a 5-3/4 by 2-7/8 by 12-1/2-in. package. Model 5220 modem is a low-cost, compact, originate or answer-only unit with power supply and indicating lights. It is compatible with the Bell 101, 103 and 113 series and will operate full-duplex at up to 300 bits/s.

CIRCLE NO. 258

Optical ROM system uses fiber optics

Quadri Corp., 2950 W. Fairmont, Phoenix, Ariz. Phone: (602) 263-9555.

A new optical ROM system, the model 401-22, uses fiber optics rather than complex and delicate lens systems of conventional optical memories. This eliminates the need and expense of peripheral mask-making equipment. It also offers such features as user programmability, rapid and simple field alterability and elimination of costly and time-consuming mechanical alignment.

CIRCLE NO. 256

Impact print mechanism types out 30 char./s

Typagraph Corp., 7547 Convoy Court, San Diego, Calif. Phone: (714) 279-5690. P&A: $750; 30 days.

A new 30-character/s impact printer mechanism features all 94 standard USASCII characters including upper and lower-case alphabet, numerals, symbols and space. The DPM-30 accepts standard fan-fold, sprocket-fed paper in widths from 4 to 15 in. It can handle single or multiple copies providing up to four carbon copies.

CIRCLE NO. 257

7-in.-reel transport works at 18.75 in./s


A new 7-in.-reel, low-cost tape transport achieves a high speed of 18.75 in./s of tape velocity. An addition to the 7000/series of synchronous digital transports, it provides the OEM user with high data density to 30,000 characters/s. Its 8-3/4-in. rack height makes it ideal for minicomputer and data terminal applications.

CIRCLE NO. 259
Amperex high quality trimmer pots priced to help you beat inflation.

When you buy trimmer pots from a volume producer you have a right to expect volume prices. And here are three groups of carbon film preset trimmer pots that meet your expectations. They are all top quality in design and manufacture, available off-the-shelf in production quantities...and they sell at prices lower than anything the competition has to offer.

When you buy trimmer pots from a volume producer you have a right to expect volume prices. And here are three groups of carbon film preset trimmer pots that meet your expectations. They are all top quality in design and manufacture, available off-the-shelf in production quantities...and they sell at prices lower than anything the competition has to offer.

Write for detailed data sheets on these three examples of Amperex quality and pricing and for our catalog on the complete Amperex line of components...carbon film resistors, non-linear resistors, electrolytic capacitors, film dielectric capacitors...and much more. Amperex Electronic Corporation, Component Division, Hauppauge, New York 11787.

Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS
A NORTH AMERICAN PHILIPS COMPANY
Low-cost synthesizers raise spectral purity


Two new low-cost frequency synthesizers with a range of 0.01 Hz to 13 MHz feature high spectral purity. These fully programmable instruments include the model 3320A with a 1-V-rms output into 50Ω and a continuous 0 to +13-dBm amplitude vernier. The more expensive 3320B has a four-digit leveling loop with 0.01-dB level resolution. Both 10 and 100-Hz optional ranges are available.

Sweep/mark generator covers 2 to 100 MHz


The model 162A sweep and marker generator covers a frequency range of 2 to 1000 MHz in a wide and flat (±0.5 dB) sweep. It features a digital readout of center frequency and a selection of variable birdie or harmonic comb marker systems. Swept output is 0.5 V rms into 50 or 75Ω, with harmonic or spurious response down by 30 dB. Other features include 0 to 80-dB attenuators in 1-dB steps.

Digital thermometers optimize performance

Newport Laboratories, Inc., 630 E. Young St., Santa Ana, Calif. Phone: (714) 540-4914. Price: $750.

A new series of wide-range digital thermometers provide a wide choice of temperature measurements with readings for most thermocouple types made directly in Fahrenheit or Centigrade at resolutions of 0.1°C. The low-cost series 2600 thermometers provide readouts for type J,K,T,S, R or E thermocouples. They feature 58-segment “break-point” digital linearizing circuits.

The Compleat MOS Memory Card.

73,728 Bits. With Address, Data, Refresh and Timing Logic. Single Unit Just $1859.

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The Compleat Memory Makers
It started with a seed of microwave technology. The first fruits were tunnel diode amplifiers. Then came mixers, detectors, transistor amplifiers, solid state sources, and YIG and ferrite devices. From this component base, we branched in both directions—to semiconductor chips and modules and to subsystems.

Now Aertech is a leading producer of a wide variety of microwave products. In our catalog you will find standard products that will satisfy most of your needs. But if you need something really special, our broad line proves that we have the experience to design to your specs.

Many of our products have been "space qualified"; they have undergone as rugged a reliability program as you'll find anywhere. Much of what we learned in earning this rating is incorporated into our standard products. And to maintain this high standard, quality assurance is an independent project review function at Aertech.

Our facilities are described in a comprehensive brochure—yours for the asking; a lab full of microwave engineers is available to provide applications assistance; a nationwide network of representatives is ready to serve you.

For standard UHF/microwave products or custom devices and subsystems, call Aertech, 825 Stewart Drive, Sunnyvale, CA 94086; 408/732-0880. You won't have a complete bid package without word from us.
INSTRUMENTATION

Dynamic curve tracer tests most devices

Tektronix, Inc., Box 500, Beaverton, Ore. Phone: (503) 644-0161. P&A: $795; 7 wks.

The new Telequipment CT71 curve tracer is a dynamic tester designed for displaying the characteristic curves of a wide range of transistor, FET and diode devices on its 10 by 10-cm CRT. It has a collector supply voltage of 0 to ±1 kV, 2 A of peak current and series resistances from 0 to 1.7 MΩ in 11 steps.

50-MHz pulse generator has variable rise/fall

Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, Calif. Phone: (213) 871-0410. P&A: $850; 90 days.

Model 116 pulse generator features repetition rates from 1 Hz to 50 MHz with a continuous vernier adjustment through all ranges. Its rise and fall times are linear and independently variable from 5 ns to 0.5 s in eight ranges. Baseline offset is variable from 100 mV to 5 V into 50 Ω. Repetition rate, delay and width jitter is less than 0.1% of setting or 50 ps, whichever is greater.

Interface package drives many instruments


A new computer interface package can drive programmable waveform generators and other programmable instruments. The model 67 interface package includes an interface card that fits any 1/0 slot of Hewlett-Packard and other compatible computers, cable, connectors and software (paper tape). It can be adapted for other instruments by different software.

At 4 cents a terminal, it’s easy pin money.

Cut terminal connection costs with Lear Siegler Pin Bars.™ Unlike most common connection methods, no soldering is required, so installation time and production costs are significantly reduced. In fact, Pin Bars offer more current-carrying ability, equalized resistance, enhanced terminal contact, and minimum electrical noise—for as low as 3 or 4 cents per terminal.

If you’d like to simplify your bussing operation while increasing your electrical integrity, pin us down for details and a free sample.

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ELECTRONIC INSTRUMENTATION DIVISION
14 NORTH BROOKHURST STREET
LAHAINA, CALIFORNIA 96761
PHONE: (808) 661-1100
TWX: 510-851-1157

*Patented

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There is just no match for miniature thermocouples in these critical criteria: full temperature range, convenient size yet rugged and adaptable, repetitively fast and accurate response. Consequently Thermo Electric's unique experience and dependable quality are most often specified. Tight schedules? Select from stock standards. Use our custom service for the unusual problems. Write for our miniature thermocouple catalog. Thermo Electric, Saddle Brook, N. J. 07662 or Brampton, Ontario.

THERMO ELECTRIC

INFORMATION RETRIEVAL NUMBER 52
INFORMATION RETRIEVAL NUMBER 53
Electronic Design 19, September 16, 1971
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Digital data logger is a system in a case

Digitrend 210 is a low-cost and complete instrument system for scanning, conditioning, measuring, displaying and digitally recording multiple low-level dc signals from thermocouples, transmitters and millivolt transducers. Reference junctions, FET scanning, automatic zero drift correction and digital linearization are built into the 210.

Fast pulse generators offer 1-ns rise/fall

5-digit time-interval meter costs $450

Digital data logger is a system in a case

Digitrend 210 is a low-cost and complete instrument system for scanning, conditioning, measuring, displaying and digitally recording multiple low-level dc signals from thermocouples, transmitters and millivolt transducers. Reference junctions, FET scanning, automatic zero drift correction and digital linearization are built into the 210.

Fast pulse generators offer 1-ns rise/fall

5-digit time-interval meter costs $450

Philips Electronic Instruments, 760 S. Fulton Ave., Mount Vernon, N. Y. Phone: (914) 664-4500.

PM5775 and PM5776 pulse generators offer repetition rates from 1 Hz to 100 MHz in nine ranges and adjustable 0.3-to-3-V output pulses with rise/fall times under 1 ns. A single positive or negative output is provided with the PM-5775, while two outputs are available with the PM5776. The generators are suited for testing digital computer and control systems.

Zero In On Your Computer Needs Today —With Toko’s Split-Second Memory System

Now heading your way—a brand new breed of memory system hot on the computer market. It’s Toko’s high-speed, woven plated-wire memory system, HS 150. Dual-designed to operate on the non-destructive readout mode, it can be used partly for random access, read-write memory and partly for read-only memory.

General Specifications:
- Memory Capacity 16K Byte
- 12K words of 72 bits
- Read Access Time 125 nanosecond
- Read Cycle Time 150 nanosecond
- Write Cycle Time 300 nanosecond

Toko’s advanced electronics technology has developed other top-quality computer components, such as memory stacks, pulse transformers, and delay lines.

For further information, just call or write

TOKO, INC.

What You Should Know About...

**Miniature High Voltage Resistors**

new Mini-Mox resistors offer 100 ppm TCR plus low noise characteristics

If you are responsible for design of high-voltage, highly-stable miniaturized electronic networks and equipment, the new Mini-MOX resistor can be a life saver. Mini-MOX resistors have all the ingredients you need to cook-up new designs for ultra-critical applications. For instance, Mini-MOX resistors are a fraction the size of conventional types; they meet or exceed MIL-R-10509-F for environmental parameters ... 100 ppm or less; stability better than ±2% for 2,000 hours at full load; low-voltage coefficient less than 5 ppm/volt, measured between 100 volts and full-rated voltage; in addition, typical quantum noise at 20 megohms is less than 0.5 microvolt/volt.

All these characteristics combine to provide extremely-rugged and highly-stable resistor configurations that are virtually immune to environmental extremes. Available off-the-shelf in a wide range of resistance values, Mini-MOX resistors are ideally-suited for high-voltage applications where long-term stability and power-to-size ratios are critical.

Write for complete Technical Data Sheet on Mini-MOX Resistors:
Victoreen Instrument Div. of VLN Corp.,
10101 Woodland Avenue, Cleveland,
Ohio 44104. Telephone: 216/795-8200

**TYPICAL TCR CURVE for 100 MEGOHMS**

<table>
<thead>
<tr>
<th>Ambient Temperature (°C)</th>
<th>TCR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-100</td>
<td></td>
</tr>
<tr>
<td>-80</td>
<td></td>
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<tr>
<td>80</td>
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<tr>
<td>100</td>
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</tbody>
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**TYPICAL LOAD STABILITY**

<table>
<thead>
<tr>
<th>Time (Hours)</th>
<th>%/ΩR</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
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<td>16</td>
<td>0.1</td>
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<td>18</td>
<td>0.1</td>
</tr>
<tr>
<td>20</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Model**
- **MOX-400** 1-2500 megs
- **MOX-750** 1-5000 megs
- **MOX-1125** 1-10,000 megs

**Resistance**
- 1-2500 megs
- 1-5000 megs
- 1-10,000 megs

**Maximum Operating Volts**
- 250 V
- 2000 V
- 5000 V

**Dimensions**
- Length
- Diameter

Victoreen
Expertise in high voltage

CIRCLE NO. 270
Here are seven super-useful examples:

- Dual 50-bit (Three-State) 2509
- Dual 100-bit (Three-State) 2510
- Dual 200-bit (Three-State) 2511
- Hex 32-bit 2518
- Hex 40-bit 2519
- Dual 128-bit 2521
- Dual 132-bit 2522

Here's what makes them tick:

1. Single TTL level clock (0 to +5v).
2. Clock rate DC to 3 MHz.
3. Recirculating logic path on chip.
4. TTL compatible inputs; drive direct from TTL.
5. TTL compatible outputs; drive TTL directly.
6. Static operation.
7. Silicone DIP packages.
8. Lowest cost system implementation.

And here's how you get them all together.

All the user-oriented benefits: the remarkable adaptability, application-ease and versatility. Together in the static shift registers from Signetics Silicon Gate MOS series. Call your nearest Signetics salesman, rep or distributor for the new MOS handbook, price list and samples.

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- FET-and-BIPOLAR Inputs  
- Low Input Current: 3 pA (±10 V)  
- High Input Impedance: 10¹¹ ohms  
- Gain Range: 1–1000  
- CMR: 96 dB

Two new instrumentation amplifiers, Models ZA702M1 and ZA703M1, offer low cost and excellent general purpose performance to industrial, commercial, and military users. High input impedance virtually eliminates input loading when using sensing devices such as strain gauges and bridge amplifiers. It also allows accurate measurement of low-level signals produced by thermocouples, phototransistors, and magnetic pickups. Amplification of these signals is accomplished with minimal ground loop effects.

Each amplifier includes CMR and output level adjustments and can be operated with or without voltage offset trim resistor. Low profile module measures only 0.4" high and total board space is less than 1.27 square inches.

Send for data sheet describing complete specifications.

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New LOWCOST INSTRUMENTATION AMPLIFIERS

INDEXING DRIVE/STEPPERS EASE KINEMATICS DESIGN

Machine Components Corp., 55 Werman Court, Plainview, N. Y.  Phone: (516) MY4-7222.

A new line of cyclic drives and indexing steppers provides the mechanism designer with the important option of selecting the precise kinematics to match a particular requirement. These may pertain to the length of the index dwell angle from 0 to 240 degrees of input, the shape of the acceleration and velocity profiles and the kinematic mechanism of a prescribed mathematical or empirical function.

CIRCLE NO. 273
Three-tube display operates from 5 V

Apollo Corp., 5-1, Togoshi 6-chome, Shinagawa-Ku, Tokyo, Japan. P&A: $45 (1000 quantities); 50 to 60 days.

The new pulse-driven DN-3130 display unit may operate at a low voltage level of 5 V. It is suited for high-speed decimal counting and storage display and consists of three seven-segment, incandescent, digital readout tubes, decoder/driver, quadruple bistable latch and decade counter. Its dimensions are 2.95 by 1.57 by 4.72 in.

CIRCLE NO. 274

Fast-settling op amps drive 5000-pF loads


Two new fast-settling op amps, models FST-158A/B and FST-159A/B, are capable of driving 5000-pF loads. Both have 7-MHz bandwidths, settle to 0.01% in 1 µs, gain 500k, and have input impedances of 10¹² Ω.

CIRCLE NO. 275

PC-board supply delivers 5 W

Computer Products, Inc., 1400 Gateway Dr., Fort Lauderdale, Fla. Phone: (305) 971-5500. P&A: $58.95; 1 to 5 days.

The PM572 encapsulated modular power supply is designed for mounting on PC boards. Measuring 3.5 by 2.5 by 1.25 in., it has an output of 5 V dc at 1000 mA. The supply is load regulated at ±0.4% and line regulated at ±0.2%. Its ripple and noise is 1 mV rms. Temperature coefficient is 0.03%/°C and input frequency is 47 to 440 Hz.

CIRCLE NO. 277

Multi-deck switches can handle 6000 V rms

Shalleo, Inc., Highway 301 at Holt Lake, Smithfield, N.C. Phone: (919) 934-3135.

High-voltage switches are available on a custom-design basis to withstand 6000 V rms to ground. Switches are 4-in. square, employ silver alloy contacts and include 1 pole/deck and 24 positions/pole. Multi-deck models are possible.

CIRCLE NO. 276

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INFORMATION RETRIEVAL NUMBER 61

This unit makes the output typewriter in the Facit 3851 — the conventional typewriter with input/output. It is also available in two other versions — output only and input only. All three provide full utilization of the 7-bits code. There is further interesting information on the new Facit 3851 in this publication.

Facit 3851 — the conventional typewriter with input/output

For further information, contact in US: Facit-Odhner Inc., 501 Winsor Drive, SECAUCUS, New Jersey outside US: Facit AB, Albygatan 102, 171 84 Solna, Sweden

INFORMATION RETRIEVAL NUMBER 61

Electronic Design 19, September 16, 1971
Got an empty 1101 socket?

Fill it with the coolest 256-bit RAM around... from MOSTEK

Whether you've already got an empty 1101 socket—or just considering a replacement—you'll find MOSTEK's new MK 4007 P your ideal choice in 256 x 1-bit RAMs. Here's why:

- **Low power:** 250 mW!
- **Wide voltage range:** +5V, -7 to -15V, fully covers the range of any other existing part.
- **Full DTL/TTL compatibility** including the outputs which have a fan-out of 2 with tightly controlled sink currents.
- **High performance:** This exceptional combination of low power/high performance is made possible for the first time by ion-implanted constant current (depletion) devices.

**Speed:** All 4007s operate at less than 1 µsec access time up to +75°C...ambient.

**16-pin ceramic package:** You get ceramic hermeticity at plastic prices!

Now, add-up these key benefits and compare them with what you get in any other 1101 replacement. Wouldn't it be smart to switch now rather than try to fix? Find out for yourself how MOSTEK makes it easy to use MOS by calling Gordon Hoffman or Dave West at (214) 242-1494. Or contact your nearest Sprague Electric Company representative or distributor.

MOSTEK CORPORATION
An affiliate of Sprague Electric Company
1400 Upfield Drive
Carrollton, Texas 75006

The Calculator-on-a-Chip Company

INFORMATION RETRIEVAL NUMBER 63
LED readout assembly has 2 character heights

Dialight Corp., 60 Stewart Ave., Brooklyn, N. Y. Phone: (212) 497-7600. P&A: $32 (3-digit unit in 100 quantities); 2 to 3 wks.

Designed for electronic thermometers, keyboards, clocks and counters, the series 749 assembly contains groups of Diode-Lite readouts, decoder-drivers and a stylish black bezel assembly that provides for ease of installation in a panel. The readout is a 6-by-8 dot matrix connected for seven-segment driving. Character heights of 0.125 or 0.205 in. are available.

Alphanumeric displays feature 2-ft characters

Power Technology, Box 4403, Little Rock, Ark. Phone: (501) 565-1750.

Giant numeric and alphanumeric displays feature 6, 12 and 24-in. character heights in either 7 or 13-bar configurations. Readability ranges from over 200 ft for the 6-in. units to over 1000 ft for the 24-in. ones.

Fast-setting op amp slews at 1000 V/µs


Model 46 FET differential op amp offers a unique combination of 1000-V/µs slew rate, 300-ns settling time to 0.01% (inverting mode) and ±100 mA of output current. It has the same high slew rate and settles to 0.05% in 150 ns in a unity-gain non-inverting mode. The amplifier handles ±10-V common-mode inputs in the non-inverting mode.
ICs & SEMICONDUCTORS

IC voltage regulator controls over 10 A


A new voltage-regulator IC features an adjustable output of 4.5 to 40 V and controls output currents in excess of 10 A. The second-source Am105 can be operated as a series or as an efficient switching regulator. It offers 1% temperature stability over -55 to +125°C and 1% load regulation.

CIRCLE NO. 281

Color processor IC simplifies TV design


The MC1398P TV color processor, a single IC, is a chroma i-f amplifier with automatic chroma control, color killer, and an injection-lock reference system that generates the required chroma subcarrier reference signal. It’s internal-feedback oscillator locks into phase above 200 µV. DC control is used for hue and chroma amplitude adjustments.

CIRCLE NO. 282

BCD decoder/driver has high noise immunity

Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. Phone: (415) 968-9241. Price: $6 (100 quantities).

A new BCD-to-decade decoder/driver features over 4 V of typical noise immunity and has a guaranteed 70-V output. The 382 decodes BCD 1-2-4-8 code and drives gas-filled cold-cathode indicator tubes requiring 7 mA or less of cathode current. The 382 operates from 12 to 15-V power supplies.

CIRCLE NO. 283

“PLASTIC” PHOTOCELLS

Actual size, priced as low as .25 each (±33% tolerance) in 10,000 quantities.

EVEN LOWER FOR ±50% TOLERANCE

Low Cost Way to Meet Most Photocell Requirements

Here is a complete line made with the same quality characteristics and precise tolerances by the originator of the first stable plastic coated cell. Six different thin-film materials of CdS and CdSe deposited on ceramic substrates. A VACTEC development with almost 10 years of production experience. When others said it couldn’t be done — we were doing it! NOW improved passivation processes make them better than ever. Why experiment — buy where the experience is. The proof — they have been used in millions of cameras all over the world!

The newest addition is the VT 800/2 series, a dual element cell with bifilar type electrode for two-cell controls from a single light source. The expanded line also includes the epoxy encapsulated VT 700E series for protection against humidity and salt spray.

Costing less than ½ of hermetically sealed cells, they have excellent resistance to humidity, eliminating need for hermetic cells in most applications. VACTEC “plastic” photocells are conveniently controlled by ambient light or from closely coupled low voltage lamps. Industrial and commercial applications, like controlling relays in line voltage circuits; switching SCR’s on or off; phase control and proportional circuits; audio controls; and feedback elements for motor speed controls in consumer appliances.

Series Type

<table>
<thead>
<tr>
<th>VT 100</th>
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<tbody>
<tr>
<td>VT 700 and VT 700E</td>
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<tr>
<td>VT 800 and VT 800/2</td>
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<td>VT 900</td>
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Substitutes for hermetic type

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<th>TO-8</th>
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<td>TO-5</td>
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<td>TO-18</td>
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Write for Bulletin PCD-6 PCD-41, 57, 58, and 59

VACTEC, INC.

2423 Northline Ind. Blvd. • Maryland Heights, Missouri 63043

(314) 872-8300

Monolithic dual JFETs drop input current to femto-amps

A new family of monolithic dual junction field-effect transistors features devices with the lowest input currents available—currents down in the femto-ampere region (a femto-ampere is $10^{-15}$ A).

This makes these dual transistors ideal for such applications as instrumentation and op amp signal-handling circuits where high input impedances are necessary.

Specifically, typical input offset currents of the new FM1100A family of JFET duals are only 20 femto-amperes at 25°C. Maximum input offset currents at 25°C are only 100 femto-amperes.

Input bias currents are also quite low—typically less than 20 femto-amperes and a maximum of 1 pA at 25°C.

At room temperatures, the new monolithic JFET duals compete with electrometer tubes.

Even at temperatures as high as +125°C input currents are approximately an order of magnitude better than those of super-beta monolithic transistors. Most transistors in the FM1100A family exhibit about 40 femto-amperes of input offset current at this high temperature.

Voltage offset and drift characteristics of the new JFET duals are better than MOSFETS. They offer offset voltages as low as 2 mV and drift only 5 $\mu$V/°C.

The FM1100A transistors can be used over the normal op amp power supply range of ±15 V, with drain-gate voltages as high as 35 V, without any worry about input current degradation.

Another advantage of the new devices is a forward admittance, $Y_{fs}$, of 100 $\mu$mhos minimum. This is ten times the usual rating for low-leakage JFET pairs. And common-mode rejection is 100 dB.

A new family of monolithic JFET duals features devices with ultra-low leakage and offset currents down in the femto-ampere region. These new JFETs can handle drain-gate voltages as high as 35 V with no input current degradation. Drain current for the above curves was set at 100 $\mu$A.

**CIRCLE NO. 284**
GaAsLITES
for your panel

or circuit board,
or anywhere else you need lasting light

Panel indication is a SNAP with the MV5020 series of Gallium Arsenide Phosphide LED's. This bright, long lasting light can be easily seen in most ambient light situations. It emits 750 footlamberts at only 20 mA.

The easy-mount bezel supplied with this unit makes it ideal for 1/16 or 1/8 inch panels. Just pop the mount through your panel and SNAP in the light.

You also have a wide choice of lens types to give you the exact effect you need. There are clear, clear red, diffused and diffused red plus the new diffused red flooded lens.

And now Monsanto offers two variations of the MV5020 with shorter lenses for use on circuit boards. These are: the MV5010 series with a .212 inch lens in clear, clear red, diffused and red diffused epoxy and the MV5030 series in clear and red diffused epoxy.

Both of these units offer the same reliability and low power requirements as the MV5020.

Remember, when your thinking about light, think Monsanto. GaAsLITES are available through your major distributor or from

Monsanto - Electronic Special Products - 10131 Bubb Road - Cupertino, California 95014 - (408) 257-2140.

CALL TODAY AND ORDER YOUR SUPPLY.
ICs & SEMICONDUCTORS

Monolithic RAM drivers optimized for 1103s

Texas Instruments, Inc., 13500 N. Central Expresway, Dallas, Tex. Phone: (214) 238-2011. P&A: Under $3 (100 quantities); 6 wks.

Two new monolithic drivers have been optimized to drive the 1103 MOS RAM. With a 100-pF load, the SN75360 switches high to low in 13 ns and low to high in 24 ns. The SN75361 switches the same load from high to low in 18 ns and low to high in 25 ns. Both are dual NAND drivers with TTL/DTL-compatible inputs.

CIRCLE NO. 285

Monolithic power amp delivers 2.5-A output

Societa Generale Semiconduttori, Via C. Olivetti, 1, Agrate Br., Milan, Italy.

A new monolithic power amplifier, designated TBA641, can achieve a peak output current of 2.5 A. Coupled with a supply voltage range from 6 to 18 V, it is suitable for applications requiring high output power, low distortion and high reliability. With a 9-V supply, the TBA641A will produce an output of 2.2 W into a 4-Ω load. The TBA641B will produce an output of 4.5 W into a 4-Ω load with a 14-V supply.

CIRCLE NO. 286

COMPONENTS

Mercury wetted relay responds under 950 ms

C. P. Clare & Co., 3101 Pratt Ave., Chicago, Ill. Phone: (312) 282-7700.

The low-profile HGQ is a new ultra-high-speed mercury wetted relay with low noise and bounce-free operating characteristics. Its response time at nominal coil power is less than 950 ms. The HGQ can be driven to 500 Hz with a minimum of jitter. Contact noise settles to less than 5 µV in 2 ms. Transfer action is random, bridging or non-bridging, with transfer time typically less than 100 µs.

CIRCLE NO. 287

Time-delay relay has low profile

Vanguard Relay Corp., 225 Cortland St., Lindenhurst, N. Y. Phone: (516) TU4-5000. Price: $13.50.

The compact model TDP hybrid time-delay relay features a low behind-the-panel profile of only 2-3/4 in. Its spdt output contacts are rated at 10 A, 115 V ac or 26 V dc resistive. The relay repeats to within 3% nominal voltage and temperature, and is polarity protected on dc. It is only 2-in. wide and rear-mounts with 4 screws.

CIRCLE NO. 288
Use our high-powered contacts.

And use them with confidence.

For materials to be used in high-powered, demanding contact applications, such as motor starters, circuit breakers, ignition points and heavy duty relays, you need tungsten or non-alloyable sintered metals. H. A. Wilson's engineering expertise and knowledge of special powder metallurgy processes, make these available.

Regardless of your application, whether it's to be rivet form, steelbacks, faced screws, discs, washers or any special shape, you can't go wrong by relying on Engelhard. Our engineering and manufacturing facilities will produce the proper contact assemblies in riveted, hot upset, welded or brazed form.

Let the H. A. Wilson Technical Service Department advise you as to the best form, type and size of contact . . . type of material, method of attaching and best spring to use.

ENGELHARD

ENGELHARD INDUSTRIES DIVISION
ENGELHARD MINERALS & CHEMICALS CORPORATION
2656 U. S. ROUTE 22, UNION, NEW JERSEY 07083

INFORMATION RETRIEVAL NUMBER 70

 Celco Amplifiers

60 Volt
6 amps
9 amps
12 amps
35 Volt
4 amps
8 amps
12 amps
20 Volt
4 amps
8 amps
12 amps

for CRT DISPLAYS

MAHWAH, N. J. 07430
UPLAND, CAL. 91706

INFORMATION RETRIEVAL NUMBER 71
Electronic Design 19, September 16, 1971

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INFORMATION RETRIEVAL NUMBER 72
NOW, A COMPLETE REFERENCE ON CIRCUIT DESIGN, APPLICATIONS, OP AMP THEORY AND TEST METHODS

OPERATIONAL AMPLIFIERS

DESIGN & APPLICATIONS
PUBLISHED BY McGRAW-HILL
WRITTEN BY BURR-BROWN

This is the first handbook to present complete information on operational amplifiers, both ICs and discretes. Written by the applications and engineering staffs of Burr-Brown, this practical reference contains over 500 pages and 300 illustrations. It details both the design of op amps and their use — including insight into factors which determine performance and techniques for their control, an extensive selection of practical applications, basic theory, and complete definitions of parameters and associated test circuits. Truly a valuable reference of daily use to circuit and systems designers.

U.S. PRICE 15 DOLLARS
ORDER YOURS TODAY
Outside USA Write for Details

COMPONENTS

Npn transistors are performance optimized


A family of monolithic dual npn transistors, designated AD810, AD811, AD812 and AD13, are high in current gain (400 minimum for a 10 to 5000-µA emitter range) and low in base-emitter voltage differential (as low as 0.5 mV). They are also low in voltage drift (2.5 µV/°C maximum), low in base-current differential (less than 2.5 nA), and high in breakdown voltage (45 V minimum).

CIRCLE NO. 289

Optical encoders come as modules


A new modular line of optical rotary encoders is available. Known as the Mod-Coder/R line, it includes a complete “do-it-yourself” assembly kit, incremental encoders with direction sensing and zero index, tachometers up to 5000 cycles/revolution and plug-in lamp modules with 100,000-hour lifetimes.

CIRCLE NO. 290

Snap-on thumbwheel switches stack easily

A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn. Phone: (203) 756-4481.

A new line of miniature thumbwheel switches snap together, side-by-side, on 5/16-in. centers in any quantity. They are available in versions which include encoders, decoders, decimal and BCD switches. Max current capacity for the switches is 2 A de and working voltage is 60 V de. Switch wipers and tracks are gold-plated for reliable contact.

CIRCLE NO. 291

Edgewise meters: • most sizes • dual movements • custom designs

The patented, pivot-jewel flat movement used in these integrally-shielded meters not only allows maximum space economy by flush stacking, but provides higher vibration immunity and greater ruggedness as well. Unique dual-movement models save even more space, simplify comparison of two variables, have optional interchangeable slide-in scales. Ruggedized 5"-scale models are ideal for adverse military and production/process environments. Write for data on any of 16 models in 40 standard ranges... or movements custom-designed for your needs.
PC-board trimmers cost as low as 10¢


A new line of PC-board imported carbon-film trimming and adjusting potentiometers are priced for use in industrial, commercial and consumer applications—10¢ to 15¢ each in 1000 quantities. They have 10 different solder lug and plug-in styles and both screw-slot and finger-knob adjustment. Resistance ranges from 500 to 1 MΩ and tolerance is ±20%.

CIRCLE NO. 292

Reed relays lower thermal emf to 1 µV

Coto-Coil Co., Inc., 65 Pavilion Ave., Providence, R. I. Phone: (401) 941-3355.

A new line of low-thermal-emf reed relays features offsets of less 1 µV. Designated as the CR-3200 series, the relays offer high isolation, speed and a long life expectancy under practically any environmental conditions. Units are also available at less than 500 nV switch, or at less than 1 µV of differential between switches.

CIRCLE NO. 293

Tiny high-voltage diodes lower reverse current

Scientific Components, Inc., 350 Hurst St., Linden, N.J. Phone: (201) 925-4022.

Miniature high-voltage diodes are available with maximum reverse currents of 2 nA at PIV ratings from 1000 to 4000 V and continuous forward currents of 20 mA. The new diodes have a maximum capacitance of 1 pF at 0 V. Only 0.06-in. square by 0.13-in. long, they can be used in multiplying circuits that require high efficiency and a low battery drain.

CIRCLE NO. 294

Raytheon puts design simplicity at your fingertips.

Low profile. Low cost. Reliable conductivity. That’s the design convenience offered by Raytheon’s new elastomer-contact keyboards.

Our new encoded switch arrays combine conductive plastic technology with a totally integrated keyboard design to provide compact, reliable outputs that do not require diodes or external logic circuitry. Unlike other low profile keyboards, Raytheon offers snap-action keys with positive feel. Standard, custom or multiple codes are available.

Our numeric keyboards are the most economical, most reliable elastomer-contact keyboards available. The unique and patented silver-filled silicone elastomer contacts provide extremely fast, clean contact closure. Both 12-key and 16-key versions are available, with single pole or touch contact configurations.

Put our keyboards to use in your next panel design. They’re perfect for use in the computer, communications and control industries. To put more information at your fingertips, write Raytheon Company, Distributor Products Operation, Fourth Avenue, Burlington, Massachusetts 01803.

CIRCLE NO. 295

INFORMATION RETRIEVAL NUMBER 75

ELECTRONIC DESIGN 19, September 16, 1971

RAYTHEON
SYNCHRON®

When you need a lot of motor in a little package

The Esterline Angus Minigraph recorder is so small (3¾" x 5¼" x 4½") that it can go practically anywhere—by itself or OEM. Some of its demanding applications include laboratories and the aerospace industry. So it's designed for precision and reliability as well as compactness. That includes specifying a Hansen Synchron motor to drive the chart and to activate the impact plate, which in turn causes a stylus to write a record consisting of dots. Precise. Reliable. Compact. That's Synchron. Maybe it's what you need.

HANSEN MANUFACTURING COMPANY, INC.
PRINCETON, INDIANA 47670


Export Department: 2200 Shame Drive, Westbury, N.Y. 11590

INFORMATION RETRIEVAL NUMBER 76

ULTRA LOW DUAL-IN-LINE SOCKETS

PRECISION MACHINED CONTACTS

- Sockets available with 14, 16, 18, 24, 28, 36 and 40 contacts in PC termination.
- Directly interchangeable! Terminal pattern and size identical to IC package.
- Molded glass filled nylon insulator with polarization notch.
- Raised numbers permit easy identification of contacts.
- .125 inch insulator.
- Printed circuit or wire wrap termination.

Request Catalog 166

AUGAT INC.
TEL: 617/232-2202
31 PERRY AVE., ATTLEBORO, MASS. 02703

INFORMATION RETRIEVAL NUMBER 77

COMPONENTS

Small proximity switch gives precision control


A compact solid-state proximity switch provides precise control without physical contact and will sense ferrous and non-ferrous metals at up to 1000 operations/minute. Sensing range can be varied from 0.048 to 0.5 in. with a potentiometer sensitivity control. The switch provides accuracy to within 0.0005 in.

CIRCLE NO. 295

Multipole 10-A relay shrinks down in size

Sigma Instruments, Inc., 170 Pearl St., Braintree, Mass. Phone: (617) 843-8000.

A new 10-A multipole relay, designated series 76, provides twice the switching capacity per contact volume than existing electrical equivalents. Available in two and four-pole ac/dc types, the 76 is designed for plug-in front-panel mounting. The two-pole version has a standard 8-pin plug; the four-pole one has a 14-pin plug.

CIRCLE NO. 296

INFORMATION RETRIEVAL NUMBER 77

ELECTRONIC DESIGN 19, September 16, 1971
Solid-state hybrid relay handles 5 A

A new solid-state hybrid relay designated AZ-1400 is rated to handle 2 to 5 A across its contacts. The relay's mechanical side consists of a cradle-type relay with dpdt contacts. Its electronic part utilizes a unijunction transistor, a thyristor, and tantalum capacitors. The relay measures 3/4 by 1-3/16 by 1-3/8-in.

CIRCLE NO. 297

Thin, industrial relays complement PC boards

A new lift-off contact system which assures chatter-free operation, higher sensitivity and longer life are features of a new line of thin industrial relays. Known as the series NF, these extremely thin units for PC-board applications are available in 2 and 4-pole models, for operation at 2 A. Voltage ratings are 6, 12, 24, 48 and 60 V.

CIRCLE NO. 298

BREAKTHROUGH BY VISHAY
THREATENS WIREFOUND RESISTOR PRICING

New BULK METAL film resistors stated to be superior replacement for wirewounds at less cost!

Malvern, Pa.: G. V. Gerber, Vishay Resistor Products Vice President and General Manager, announced today a significant breakthrough in resistor technology: a low T.C., virtually non-inductive, BULK METAL film resistor available at less cost than precision wirewounds...and with superior specifications. According to Gerber, this new line of resistors is the result of a two year research and development program initiated to expand Vishay's share of the precision resistor market.

Size comparison between V-53 and RB-53 type wirewound. Vishay V-53 requires only 1/8 the space needed by the RB-53.

Consisting of a BULK METAL film on a ceramic substrate, this new series V-53 resistor has a max. temperature coefficient of (-) 10 ppm/°C over the range of -55°C to +125°C, capacitance is only 3 pf, noise is non-measurable, all values will track to ± 3 ppm/°C without selection, tolerances to ± 0.02% are standard, and stability is 30 ppm/year.

INFORMATION RETRIEVAL NUMBER 78
HOW MANY
PRECISION
COMPARATORS

CAN MATCH THIS PERFORMANCE?

- 0.4 mV offset voltage (2.8 mV max.)
- 100 nS response time
- 110 V/µ sec input slew rate
- 5 nA offset current
- 1 µV/°C nulled offset voltage drift
- Standard Supplies ±5V to ±18V
- Full TTL Compatibility
- Accuracy consistent with 15 bit A/D applications
- $3.15 @ 250 pieces

ONLY ONE!
THE
CMP-01CJ
IMMEDIATE DELIVERY FROM DISTRIBUTOR STOCK

REMEMBER — for A/D applications the CMP-01 is an ideal companion to the AIM DAC-100 (10 bit) and mono DAC-01 (6 bit) D/A Converters

PRECISION MONOLITHICS
INCORPORATED
1500 SPACE PARK DRIVE, SANTA CLARA, CALIFORNIA 95050
TEL. (408) 246-9225 • TWX 910-335-0588 • CABLE MONO
A BOURNS Affiliate

INFORMATION RETRIEVAL NUMBER 79

MICROWAVES & LASERS

1-GHz double balanced mixer costs only $14.95

Mini-Circuits Laboratory, 2913
Quentin Rd., Brooklyn, N.Y.
Phone: (212) 252-5252. Price: $14.95 (500 quantities).

Offering isolation greater than 45 dB over the lower portion of its 0.5 to 1000-MHz range and 30 dB at 1000 MHz, the inexpensive SRA-2 double balanced mixer exhibits a low conversion loss of 5.5 dB typical (7.5 dB at 1000 MHz). The unit is designed for PC-board mounting and is packaged within an emi-shielded metal enclosure. Its volume is 0.1 in. cube and it has a hermetically sealed header.

Diode/X-band oscillator optimized for mini-radar

General Electric Co., Microwave Devices Product Section, 316 E. 9th St., Owensboro, Ky.
Phone: (502) 683-2401. Price: $146, $257.

A new GaAs bulk-effect diode and a companion X-band oscillator microwave circuit designated the Y-2109 and C-2070, respectively, are available for mini-radar and motion-detection studies. The Y-2109 Transferred Electron Effect Diode (TEED) and its C-2070 Microwave Circuit Module (MCM) feature low side-band noise and low-voltage operation. They are designed for systems operating at 10.5 GHz. Typical output power for the diode and oscillator is 100 and 50 mW, respectively.

Son of Armadillo.

Our W Series subminiatures now have a stainless steel shell like our D Series Connectors. Smaller, lighter than others. Yet more fully packed. 110 contacts to the inch.
Great little fellows. Like father, like son!

JFD Electronics Corp., 15th Ave. at 62nd St., Brooklyn, N.Y.
Phone: (212) 381-1000.

Designed for use at frequencies up through microwave, new miniature ceramic-dielectric capacitors measure only 0.546-in. square by 0.172-in. thick. UFP series capacitors exhibit 8-A ratings at +25°C. Capacitance values are available from 10 to 3000 pF. Their leads are of flat fine-silver ribbons to carry high currents. Wire leads are also available.

CIRCLE NO. 301

INFORMATION RETRIEVAL NUMBER 80

ELECTRONIC DESIGN 19, September 16, 1971
Aluminum heat sink mounts parts vertically

Thermalloy Co., 8717 Diplomacy Row, Dallas, Tex., Phone: (214) 637-3333. Price: 14 to 35¢.

An inexpensive aluminum heat sink accommodates most single-mounting tab and hole-through-case devices with vertical mounting. The model 6025 is a 1.75-in. high vertical cooler that requires only 0.25 by 0.875 in. of board space. It is available in black anodize, or nickel plate finishes.

CIRCLE NO. 302

High-temp coating withstands 3200°F

Aremco Products, Inc., Box 145, Briarcliff Manor, N.Y. Phone: (914) 762-0685. P&A: $40/kit (1 qt. paste, 1 qt. thinner); stock.

Cerama-Dip 538 is a single-component alumina ceramic-base adhesive coating that can be used at temperatures up to 3200°F. It is available in a paste form with a liquid thinner used to produce a soup-like thixotropic consistency. The material can then be brushed on, or a component dipped in the mixture.

CIRCLE NO. 303

Recording-head ferrites increase their density

Labtek, Inc., Box 103, Middleton, Mass. Phone: (617) 777-1233.

A family of high-density sintered ferrites are designed for uhf magnetic recording-head applications. Single-crystalline equivalent-surface finishes of 0.1 µ-in. can be attained without the usually characteristic edge chipping of single-crystal ferrites.

CIRCLE NO. 304

14-pin DIP sockets show 0.218-in. profiles

Vero Electronics, Inc., 171 Bridge Rd., Hauppague, N.Y., Phone: (516) 234-0400.

New 14-contact DIP sockets are designed with a low profile of 0.218 in. for high-density packaging. Their large tapered-entry channels aid IC insertion and reduce lead damage. Dual-leaf wiping contacts are available to accept round or flat leads.

CIRCLE NO. 305
**Connector patterns**

A new line of continuous connector patterns is said to introduce several important advantages and time-saving features for designers, draftsmen and engineers preparing master artwork for printed wiring boards. Offered in varied scale sizes (1X, 2X and 6X), the line has seven basic patterns available in three basic connector types: insertion, staggered or in-line. Pre-printed on Accufilm*, a special anti-static, stable-based, pressure-sensitive, 2-mil polyester film, the patterns are easy to fit and position before removing the backing material. Non-cumulative tolerances are guaranteed to ±0.002 in. over an 18-in. span. Accuracy exceeds IPC and Mil-Std 275 guidelines. A free sample and literature are available. Bishop Graphics, Inc.

*CIRCLE NO. 306

**Wire terminals**

Newly designed and low in cost, a line of ring and spade wire terminals in strip form are optimized for mass-production application. The terminals, in both rings and spades, are for use on wires ranging from AWG #16 to #20 and are available for stud sizes 2 to 10. Terminals are 0.16-in. thick and are of plain brass or are pre-tinned. Both insulation grip and non-insulation grip styles are available. Samples are available. Kent Corp., subs. of Thomas & Betts Corp.

*CIRCLE NO. 307

*Trademark Bishop Graphics, Inc.

**Electronic slide rule**

Design engineers, technicians and students involved with circuitry and circuit design will find the new 535 electronic speed rule of particular use. In addition to basic mathematics, trigonometry and log problems, the speed rule can be used for circuit trigonometries, determining frequencies, reactance, impedance, resonance and for determining the size and ratings of resistors and capacitors. Basic formulas and values are shown for easy reference on this $16.95 slide rule. Pickett Industries.

*CIRCLE NO. 308

**Corners template**

The CornerGraph is a template for locating and drawing sharp square corners. Dimensions to both legs of the corner are marked anywhere along their lengths, the instrument is positioned, and the entire corner is drawn with a single pencil stroke along the inner edges of the template. There is neither overshoot and erasure nor undershooting and extending. Squareness and parallelism are within 0.01 in. It is available in three inside-size dimensions: 3-1/2 by 3-1/2 in., 6 by 6 in. and 9 by 9 in. Devonics Inc.

*CIRCLE NO. 309

**The “Relay Handbook”**

The revised fifth edition of the “Designer’s Handbook & Catalog of Reed and Mercury Wetted Contact Relays*” is now available to qualified readers. This 120-page handbook assists the designer in specifying the proper reed relay for a given application. The book contains a glossary of relay terms, principles of operation, applications and design requirements and testing data. A separate section contains a catalog of new reed relays. For a free copy, write to: Magnetcraft Electric Co., 5575 N. Lynch Ave., Chicago, Ill. 60630.

**Microprogramming book**

A 352-page handbook is available covering the subject of microprogramming in a practical and comprehensive manner. In precise terms, it tells how to microprogram, why the concept is effective and when it is most appropriate. Copies are available to those who write on their company letterheads to Microdata Corp., 644 E. Young St., Santa Ana, Calif. 92705.

**Subscriber loop design**

Voice-frequency subscriber loop design principles are described in detail in an engineering bulletin. The 68-page bulletin entitled “Principles of Voice Frequency Subscriber Loop Design” is used in conjunction with two subscriber line calculators showing the most economical combination of gauges, for a given distance, that meets all current transmission, pulsing and ringing requirements. In addition the bulletin describes design considerations of loaded and repeater loaded loops, expected performance of repeater loops, one-man tests for loaded loops, tabulated attenuation, resistance and miscellaneous loss data. Anaconda Wire and Cable Co., Communications and Electronics Div.

*CIRCLE NO. 310

116

ELECTRONIC DESIGN 19, September 16, 1971
If you need rugged accuracy over a wide range of measurements...

Buy Triplett’s 630-NA

Its diode overload-protected suspension meter movement; simplified, long-scale, mirrored dial; and 70-range measurement capability to 6,000 V AC and DC, 12 A DC and 100 meg-ohms demonstrate that Triplett’s Model 630-NA V-O-M can handle practically any electrical measurement you may need. All these features add up to 1½ % DC accuracy (3% AC) and the ruggedness necessary to make this a take-anywhere tester that’s ideal for design, maintenance, quality control and production applications. It’s a real value at $103 so see it right now at your local Triplett distributor. If you’d like 200,000 Ohms per Volt DC and 20,000 Ohms per Volt AC sensitivity rather than the 630-NA’s 20,000 and 10,000 Ohms per Volt DC and AC, respectively, and you’re willing to use a special high-voltage probe for the 3 and 6 KV ranges in order to get that extra sensitivity, ask your distributor for Triplett’s Model 630-NS at $122. For more information, or for a free demonstration, see him or your Triplett sales representative. Triplett Corporation, Bluffton, Ohio 45817.

Model 630-NA

$103

1. 70-range V-O-M with single range switch and DC polarity-reversing switch.
2. Accuracy 1½ % DC and 3 % AC; mirrored scale.
3. Diode overload-protected suspension movement; temperature compensation.

INFORMATION RETRIEVAL NUMBER 83
Newark catalog

A completely new 750-page electronics data book is the latest Newark catalog, a most detailed source on electronics and related components. Some 162 pages are devoted to directories, detailed listings with specifications, tables, charts and illustrations of ICs, transistors, diodes, rectifiers, micro and optoelectronics devices. Other components include tubes, resistors, potentiometers, controls, capacitors, switches, relays, fuses, circuit breakers, transformers, connectors, sockets, wire and cables, test instruments and meters. This publication is available to qualified readers. Newark Electronics.

Diode/microwave devices

A new 16-page brochure concisely summarizes pertinent specifications of a broad line of semiconductor diodes, transistors, and microwave modules. Hewlett-Packard Co.

DIP reed relays

A four-page product bulletin describes new DIP eight-pin reed relays. Magnecraft Electric Co.

Resistors

A revised catalog is available on fixed-composition resistors. Airco Speer Electronics, Inc.

Tone controls


PC-board hardware

A new 12-page catalog describes a line of hardware components for users of PC boards, for both military and commercial applications. Calabro Plastics, Inc.

NBS time system

A proposed NBS TV time and frequency system is described in a 12-page booklet. The system proposes to distribute accurate time and frequency over the nation's commercial TV networks. National Bureau of Standards, U.S. Dept. of Commerce.

Used-computer blue book

A new blue book issue for used-computers lists market prices of all makes of computers. Time Brokers, Inc.

Indicator lights/LEDs

Indicator lights, LEDs and incandescent lamps, in both miniature and subminiature sizes are shown in a catalog. General Illumination, Inc.

Bus bars

A complete technical bulletin covering bus bar design parameters, both electrical and mechanical, along with test data and dielectrics, is available. Eldre Components, Inc.

Detection/alarm products

A new 64-page catalog describes over 350 intrusion and fire-alarm products. The alarm equipment ranges from relatively simple open-loop hardware to the latest ultrasonic, radar, and IR intrusion detectors. The catalog features 6 pages of application notes. A general alarm system discussion is followed by notes on how to apply the many detector options. Some basic installation procedures are also presented. Mountain West Alarm Supply Co.

Thin-film coatings/optics

A 32-page catalog covers an entire line of thin-film coatings and precision optics. A conversion table for optical density vs transmission percentage is also included. Broomer Research Corp.

Rotary switches

A complete set of rotary switch specifications and features are contained in a new switch handbook. RCL Electronics, Inc.

Semiconductors

A condensed semiconductor catalog shows an entire line of transistors, FETs, diodes, and linear, digital, hybrid and MOS ICs. The 72-page catalog lists significant parameters for each device. Teledyne Semiconductor.
WORLD'S SMALLEST 5VDC/100AMP POWER SUPPLY. Off-the-shelf.

The world’s smallest 5VDC/100AMP supply gives you:
- Volume under 500 cubic inches!
  8½” x 6¾” x 8¾”
- Lightweight. Less than 22 pounds.
- High Efficiency: 70% typical.
- Cool Operation. No forced air or external cooling for full rated output to 55°C.
- Low Cost. Priced lower than the large brute force supplies.

If our 500 watt supply overpowers your requirement, let us talk with you about our complete line of off-the-shelf high power density supplies, which offer you the same advantages as above: small size, lightweight, high efficiency, cool operation, low cost.

They come in single, dual, and triple outputs with voltages from 5VDC to 30VDC. Military and Export models also available.

We also custom develop/produce to specific needs.

Call collect — or write Dept. ED

Trio Laboratories, Inc.
80 Dupont Street, Plainview, L.I., N.Y. 11803
Tel: (516) 681-0400  TWX: (510) 221-1861
Everything about our new fine tuner is fine. Even the price.

Precise fine tuning has always been a problem. Until now. Raytheon's new Microvernier control knob utilizes the principle of harmonic drive to provide a new, low-cost method of obtaining high-resolution tuning or precise zero setting.

The patented performance-proven Microvernier control knob is more economical. Because it's gearless. Yet its zero-backlash performance is precise enough to meet the most sophisticated electronic standards. It's available now in three sizes to keep all your fine tuning under control.

Write Raytheon Company, Distributor Products Operation, Fourth Avenue, Burlington, Mass. 01803.

NEW LONG LIFE LITHIUM BATTERY

The G2600-B1 battery (1 and 3/8" long x 1.0" diameter) provides a nominal 3.2 volts over the temperature range of -40°F to +165°F. Hermetic sealing and glass ampule electrolyte storage make possible a shelf life of 10 years or more. In addition, the G2600-B1 is ideal for low drain, long life applications. This battery demonstrates our advanced state-of-the-art capability in solving your battery problems.

The performance tables below tell the G2600-B1 story the best way possible:

For more complete information on this new power source, call or write Marketing Manager, Honeywell Power Sources Center, Route 309, Montgomeryville, Pa. 18936. (215-699-3585)

INFORMATION RETRIEVAL NUMBER 86

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<th>Current</th>
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<th>Life to 2.5 Volts (Hours)</th>
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*Cut-off to 2.0 volts

INFORMATION RETRIEVAL NUMBER 85

NEW LITERATURE

Western Union services

New brochures on two Western Union communications services, Mailgram and Telex, are available. One brochure explains Mailgram, a new economical telegram-letter service developed by Western Union and the U.S. Postal Service. The other describes Telex, a world-wide, direct-dial teleprinter-to-teleprinter exchange service. Western Union.

CIRCLE NO. 354

Microwave transistors

A 14-page brochure lists minimum-performance parameters of a line of microwave transistors. These include frequency, noise figure, gain compression and power output. Application notes, S-parameters, suggested circuits and free sample transistors are also available. KMC Semiconductor Corp.

CIRCLE NO. 355

Quad power drivers

A new engineering bulletin describes quad power drivers. Sprague Electric Co.

CIRCLE NO. 356

Resistor handbook

A 32-page expanded precision and power wire-wound resistors engineering handbook is available. RCL Electronics, Inc.

CIRCLE NO. 357

Ferrite magnets

A revised catalog describes a line of hard ferrite permanent magnets. Arnold Engineering Co.

CIRCLE NO. 358

Modular power supplies

An expanded catalog contains information on plug-in power supplies. These include rack-mounting, premium-performance, low-profile, miniaturized, dual-output and unregulated models. Acopian Corp.

CIRCLE NO. 359
designing with
PERMANENT
MAGNETS?

For design work on magnet materials, you need

MAGLAB the 2 in 1 Design Tool!

MAGLAB is a magnetic multimeter designed to measure maxwells and gauss accurately, quickly, efficiently. T & S' combination fluxmeter/gaussmeter is most useful where an integrating fluxmeter and a Hall-effect gaussmeter are frequently but not simultaneously required.

Write for full details and prices on Model ML-40.

**NEW PRODUCT INFORMATION**

**LSI IMAGE SENSING**

The RETICON RL-64 is one of a family of self-scanning linear arrays. Designed for OCR, OPR, facsimile and industrial control applications. FEATURES: 64 photodiodes on 2 mil centers • On-chip scanning for serial video output • On-chip driver for TTL compatibility • On-chip video preamplifier • Charge storage mode for high sensitivity • Scan rates from 1 KHz to 10 MHz • Standard DIP package with sealed glass window. For immediate delivery contact:

**INFORMATION RETRIEVAL NUMBER 87**

**INFORMATION RETRIEVAL NUMBER 88**

The newest, fastest and easiest way to specify indicator lights, push button switches and readouts.

Dialco's new 56-page product selector guide helps you select from over 1,500,000 visual indicators

This book is the result of an all-out effort to provide you with fingertip data on all Dialight components and to make it very easy for you to locate the detailed specs and information you desire. Designers and engineers will find the "Product Selector Guide" invaluable in their work. Send for your copy today. Dialight Corp. 60 Stewart Ave., Brooklyn, N.Y. 11237.

**DIALIGHT**

A North American Philips Company
Lab measurement system

An eight-page catalog contains information on a versatile, low-cost electrical/electronic measurement system. Basic components, arranged for easy interconnection, provide Wheatstone, Kelvin, inductance or capacitance bridges; differential voltmeters; millivolt potentiometers and ac-de transfer units. They also provide lead and phase compensators; inductive voltage dividers; programmed dc sources and sine, square or triangle-wave sources. Laboratory Systems Research, Inc.

Sample-hold module


DPMs and DMMs

A revised short-form catalog includes the latest products in a line of digital panel meters and multimeters. Digilin, Inc.

Conductive elastomer

A data sheet describes an electrically conductive silicone elastomer formulated to provide high to moderate conductivity. Technical Wire Products, Inc.

Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card. (Advertisement)

Peripheral Equipment Corp., Chatsworth, Calif. has reduced prices on its incremental tape transports, across the boards, by up to 25%.

Wesco Electrical Co., Inc., Greenfield, Mass. has announced up to 50% price reductions on its standard 32MPC metalized polycarbonate capacitors.

Video Systems Corp., Pennsauken, N. J. has reduced the price of its VST-1200 CRT data terminal from $2760 to $1795.
Smallest latching relay with 1 Amp contacts meets MIL specs. Coils for 6, 12, 24 VDC. Other QPL Relays to MIL-R-5757/19 and MIL-R-5757/90. Send for free catalog. Branson Corp., Box W, Denville, N. J. 07834. Phone: 201-625-0600.

Low-Cost Internally bussed terminal connectors feedback or feedthrough styles designed to accept insertable/ removable pin contacts, crimp terminated to 16, 18 or 20 AWG. wire. All terminations petected within the dielectric body. Combinations are available to your requirements. Appleton Electronics Div., 1701 Wel­lington Ave., Chicago, Ill. 60657.

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