MARCH 18, 1976

A NEW LOOK AT I²L/80

Reliable design with solid-state power devices, part 2/101

Resistive gate arrays form unique converters and scanners/111

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Electronics
The International Magazine of Electronics Technology
Vol. 49, No. 6 • March 18, 1976

Highlights

The cover: Rms voltages have signal honesty, 93
The true rms voltage of a wave form gives a precise measure of its power capability, whatever its shape, and this knowledge is essential to economical system design. But some methods, instruments, and procedures for making rms measurements are more accurate than others.
Cover is by Art Director Fred Sklenar.

Aerospace firms enter house-warming business, 84
Spiralling energy costs drove three aerospace companies to streamline their procedures for heating, cooling, and ventilating their huge plants. They've been so successful that one is setting up as a consultant in building management and two are marketing computerized environmental-control systems.

How to design reliable power circuits, 101
The second and last of two articles on the pitfalls of industrial equipment design deals with rectifier, inverter, and chopper circuits. High reliability depends on selecting the appropriate power semiconductors and protecting them properly.

Resistive gates do a-d conversion with aplomb, 111
MOS devices in which resistive electrodes replace metal gates acquire a welcome talent for digitizing analog signals. Already developed are a 5-bit a-d converter and a 100-element light-pattern scanner.

And in the next issue . . .
How new processes are squeezing higher performance out of MOS technology: a special report . . . an all-solid-state TV tuner with memory . . . preview of the 26th Electronic Components Conference.

Publisher's letter

Noise can be more than just annoying, it can be downright damaging. That holds as much for the kind of noise, rife in industrial environments, that upsets electronic circuits as it does for the kind that sets human ears ringing.

Yet noise is just one of a number of pitfalls that await the engineer as the solid-state power equipment that he designs takes on more and more industrial jobs. To help those who are not yet versed in the peculiar demands of industrial electronics, we are publishing a two-part series on designing reliability into equipment using power semiconductors. The first part appeared in the March 4 issue, and the second part can be found on page 101.

The team of authors responsible for the series, by the way, has a wide and varied experience in industrial electronics and power equipment. Alexander Kusko, a prolific author who has written five books and numerous technical articles, has taught electrical engineering at the Massachusetts Institute of Technology for three decades. For the past 20 years, too, he has run his own engineering consulting company, taking on projects in semiconductors, magnetics, and transportation, as well as other areas.

In addition, he is serving as a consultant to the Department of Transportation on electric power and propulsion problems and to the Federal Aviation Agency. He has also helped the Social Security Administration on high-reliability electric power and the Department of Housing and Urban Development on urban-renewal power problems.

His co-authors, Thorleif Knutrud and John J. Cain, are members of his consulting company and have done extensive design and development work on power equipment. Cain is presently involved in automotive electronics development and electric transportation systems, including the conceptual design of a 6-megawatt computer-controlled mass-transit substation system. He has also analyzed the litigation brought by San Francisco's Bay Area Rapid Transit District against suppliers of its mishap-plagued mass-transit system.

Knutrud's work has ranged from design of controls for optical tracking and power supplies to the development of medical electronics. He, like Kusko, is a lecturer at MIT and advises a law office on patents.

The energy crisis may not be grabbing the headlines it once did, but it is far from being over. Of all its aspects, perhaps the least mentioned has been conservation of present energy resources.

On page 84, you'll find one of those unheralded stories. It's about how the work of a couple of big aerospace companies in controlling their own usage of energy has led to contracts to help other companies cut their energy bills and save fuel. At the heart of the work, of course, is electronics—the use of the power of electronics in controlling the usage of power. Maybe, once electronics has had a chance to show what it can do, the big news will be not the energy crisis but energy conservation.

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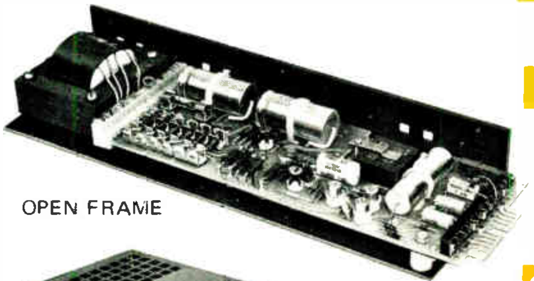

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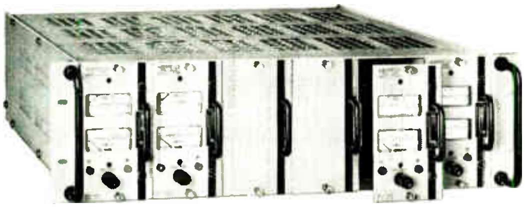

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1 FOR THE OEM, PCX are available as an open frame module with a massive heat sink that requires no other cold plate for non-derated operation to +71°C.

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3 FOR THE SYSTEM DESIGNER, PCX are available in a convenient plug-in configuration. You can mount six instruments side-by-side in a 5¼" X 19" rack panel, configured either as remotely programmed modules or as metered instruments with 10-turn high resolution voltage controls and full metering.

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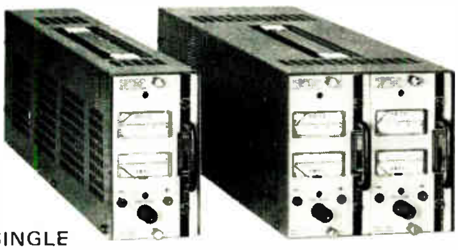
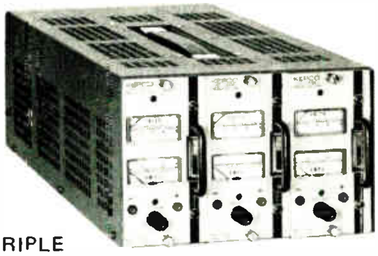


SINGLE

DUAL



TRIPLE

4 FOR THE LAB BENCH EXPERIMENTER, PCX can be configured as single, dual or triple output power supplies, each with separate, recessed dual-scale voltmeters and ammeters, plus 10-turn voltage controls.

In any of these configurations, the Kepco PCX is a first-rate **high performance** voltage stabilizer offering better than 0.0005% immunity to source (mains) variations, less than 0.005% output change for a 100% load shift, and a real quiet output whose ripple and noise is under 0.1 mV rms (3 mV p-p measured 20 Hz–10 MHz). They're fully adjustable and programmable 0–7V, 0–15V, 0–21V, 0–40V, 0–72V and 0–100V. 6 models offering approximately 20 watts of honest power with no derating necessary up to +71°C.

PCX is the multi-purpose voltage stabilizer that you can depend upon.

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Circle 5 on reader service card

Readers' comments

Adding the carry

To the Editor: My thanks to several readers for pointing out that my binary-coded-decimal adder circuit [Nov. 13, p. 120] omitted the dependence of corrected sums upon the carry signal C_{16}. This signal leads to additional terms in S_8', and S_4'. Their expressions should be:

$$S_8' = \bar{C}_0 S_8 + C_{16} S_2$$
$$S_4' = S_4 S_2 + \bar{C}_0 S_4 + C_{16} \bar{S}_2$$
$$or = S_4 S_2 + \bar{S}_8 S_4 + C_{16} \bar{S}_2$$

The corrected circuit will require three additional NAND gates—two 2-inputs and one 3-input—but the speed remains unchanged. One inverter can be deleted if the first expression for S_4', is implemented.

D.P. Agrawal
University of Technology
Baghdad, Iraq

No visits made

To the Editor: In my four visits to Moscow, I have not seen American-made semiconductor production equipment that is at the top of the U.S. Government's restricted export list, contrary to the statement in your article on high-technology flow from the U.S. to the Soviet bloc [Jan. 8, p. 68].

I have never visited a Soviet semiconductor factory, and so I do not know what kind of semiconductor production equipment the Soviet Union has, or whether such equipment is Soviet-made or purchased elsewhere.

As a company, our policy is to make certain we do not sell to any country anything that is on the restricted list without receiving the appropriate export licenses from the U.S. Government.

Lewis Solomon
General Instrument Corp.
New York, N.Y.

Correction

Mitsubishi Electric Corp. is the manufacturer of the integrated circuit that is shown bonded to a three-layer 35-millimeter tape-carrier in Fig. 8 of the special report on use of film carriers in IC production [Dec. 25, p. 61].

Tired of "selecting" 741's to get premium performance? Take a look at our new OP-02.

If your design requires premium 741 performance that right now can be met only by a costly and time consuming "selection game," the PMI OP-02 is for you.

A high performance general purpose Op Amp that really fills the gap between standard 741's and precision 725's, the OP-02 fits **all** 741 sockets. It's even better than the PMI SSS741! Input offset voltages are guaranteed better than the 725, but the speed of the 741 is retained. MIL STD 883 processing is available—level B right from stock.

Prices run higher than standard 741's, of course, but well below standard 725's. For a little bit extra you get **guaranteed** better performance across the board, low noise, low drift, low TCV_{OS}, low TCI_{OS}, and insensitivity to output load conditions. Check the specs.

Three steps to end your selection worries:

1. Get a complete OP-02 data sheet to compare to your selected 741 and 725 requirements.
2. Call your PMI distributor for a few OP-02's to convince yourself that PMI's specs are for real.
3. Specify the OP-02 as the **preferred** source. (You can still use the selected stuff as the second source.)

	Input Offset Voltage mV MAX		Input Offset Current nA MAX		Input Bias Current nA MAX	
	MIL	Comm.	MIL	Comm.	MIL	Comm.
Industry Standard 741	6.0	7.5	500	300	1500	800
PMI SSS741	3.0	7.5	10	50	100	200
PMI OP-02	**1.0**	**3.0**	**5**	**10**	**50**	**100**
Industry Standard 725	1.5	3.5	40	50	200	250
PMI SSS725	0.18	1.6	4	25	120	180

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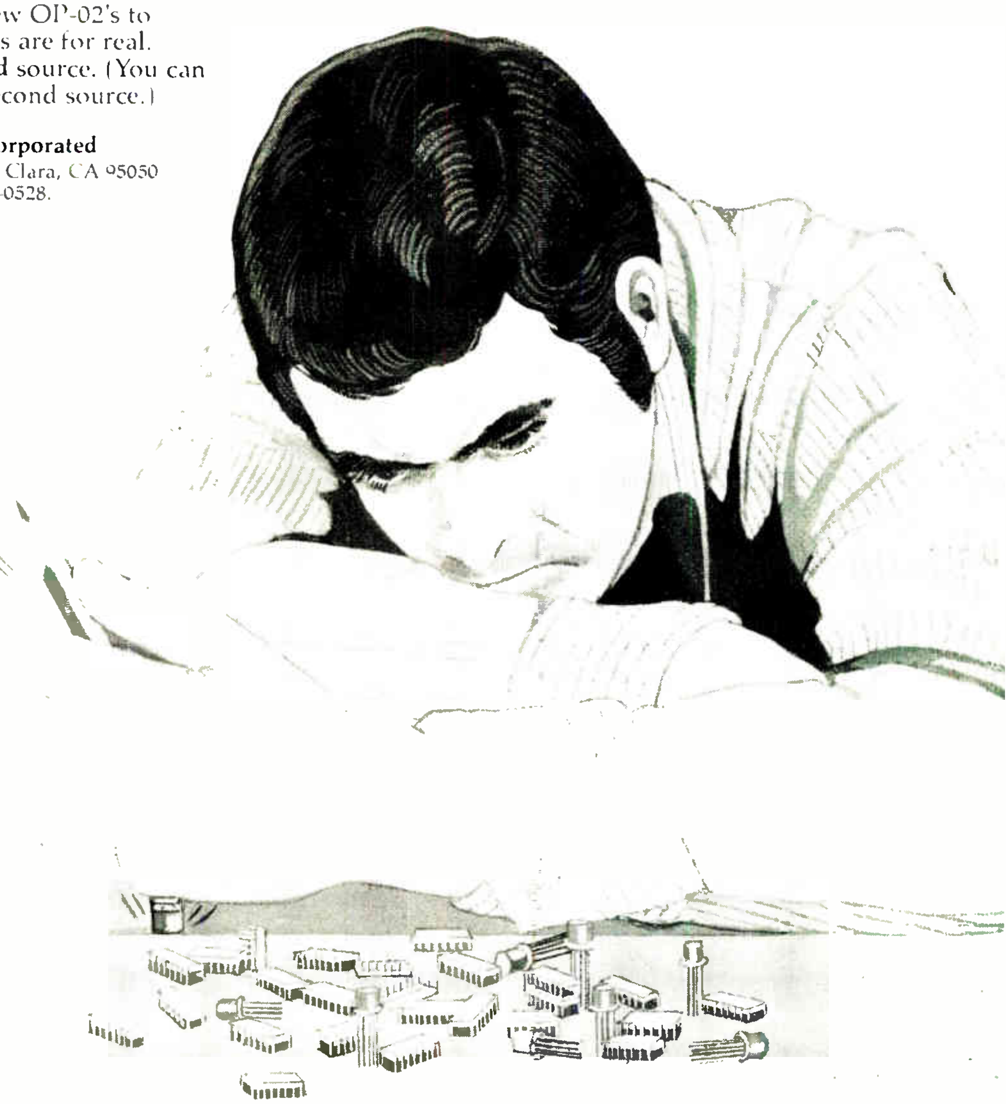


News update

■ At the 1974 IEEE Intercon show, something of a stir was created by the introduction of what promised to be the fastest logic analyzer on the market [*Electronics*, March 7, 1954, p. 150]. From Biomation Corp. of Cupertino, Calif., the model 8200 digital waveform recorder was designed to handle emitter-coupled-logic speeds while displaying eight channels of input simultaneously. Its sampling frequency was 200 megahertz.

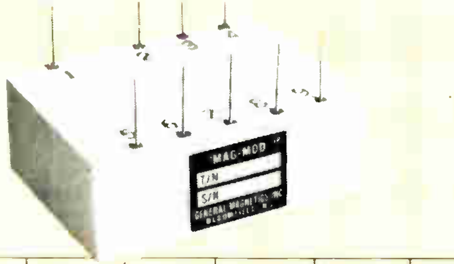
Now, two years after that introduction, Biomation has begun shipping units—and the 8200 is still the fastest logic analyzer around. The production delay was caused by problems with the stability of the unit's master 100-megahertz oscillator and frequency doubler. Those were solved by installing a 200-MHz crystal not available when the original design was set. The price of the 8200, meanwhile, has risen from the originally announced \$15,000 to \$18,450.

The 8200 compares digital signals against two threshold levels. When the instrument is in a sample mode, it displays a 0 if the sample is below the threshold level and a 1 if it is above. The second mode of comparison, latch, detects noise pulses that may occur on a signal between clock pulses.

■ The AIL division of Cutler-Hammer in Deer Park, N.Y., has won a \$3.7 million Coast Guard contract to provide radar surveillance systems for three harbors. To be completed by April 1978, the work covers the Ports of New York, Valdez in Alaska, and Houston-Galveston in Texas. The deal also provides \$5.5 million for 10 years' maintenance of AIL's Vessel Traffic Maintenance System in each port.

Information from the systems' radars will permit the Coast Guard's vessel traffic centers to separate shipping traffic and relay navigational safety information to ship masters or pilots. Also, each system will be backed up by the regular bridge-to-bridge radio-telephone communications.

Solid State Sine-Cosine Synchro Converter



This new encapsulated circuit converts a 3-wire synchro input to a pair of d-c outputs proportional to the sine and cosine of the synchro angle.

- Complete solid state construction.
- Operates over a wide temperature range.

UNIT	DMD 1436-1	DMD 1430-1	DMD 1403-2	DMD 1361-6	DMD 1361-4	DMD 1193-4	DMD 1361-8	DMD 1446-1	DMD 1193-5	DMD 1193-6	DMD 1361-10	DMD 1472-2
L - L SYNCHRO INPUT (VRMS)	11.8	90	95	90	11.8	11.8	11.8	11.8	11.8	11.8	11.8	90
FREQUENCY (Hz)	400	400	60	400	400	400	400	400	400	400	400	60
FULL SCALE OUTPUT (VDC)	±10	±10	±3	±3	±3	±10	±10	±10	±10	±10	±10	±10
OUTPUT IMPEDANCE	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<10Ω	<1Ω	<1Ω	<1Ω	<1Ω
L - L INPUT IMPEDANCE	>10K	>30K	>5K	>30K	>5K	/5K	>5K	>5K	>5K	>5K	>5K	>5K
REFERENCE VOLTAGE (VRMS)	26	115	115	115	26	115	26	115	115	115	26	115
ACCURACY SIN/COS (+25°C)	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±0.5%	±6MIN	±6MIN	±6MIN	±6MIN
FULL TEMPERATURE RANGE ACCURACY SIN COS	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±0.5%	±15MIN	±15MIN	±15MIN	±15MIN
D.C. SUPPLY (VDC)	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15
D.C. SUPPLY CURRENT	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA
BANDWIDTH	>10Hz	>10Hz	external set	>20Hz	>5Hz	>10Hz	>10Hz	>10Hz	>2Hz	>40Hz	>5Hz	external set
SIZE	1.1x3.0 x1.1	2.0x2.25 x1.4	1.1x3.0 x1.1	1.5x1.5 x0.6	1.85x0.85 x0.5	2.01x2.25 x1.4	0.85x1.85 x0.5	2x2.25 x1.4	2x2.25 x1.4	2x2.25 x1.4	2.15x1.25 x0.5	1.1x3.0 x1.1
NOTES	–	dual channel unit	–	–	–	dual channel unit	–	dual sine output	dual channel unit	dual channel unit	–	–
TEMPERATURE RANGE	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C

High Precision Analog Multipliers

PRODUCT ACCURACY (MCM 1519-1) ± ½% OF ALL THEORETICAL OUTPUT VALUES OVER FULL MILITARY TEMPERATURE RANGE OF −55 C TO +125 C. ZERO POINT ERROR FOR ANY INPUT COMBINATION IS ± 2MVRMS

Features:

- No external trims required
- Distortion free AC output over entire dynamic range
- Linearity, product accuracy and zero point virtually unaffected by temperature
- All units are hermetically sealed and are not affected by external fields
- High analog product accuracy and wave quality allows dual multiplier assemblies to be matched with 1% of point over the specified temperature range
- Full four quadrant operation
- Package size, power supply requirements and other specs. may be altered to your exact requirements at no extra cost.

Specifications:

- Transfer equation: Eo=XY/10
- X & Y input signal ranges: 0 to ±10V PK
- Maximum zero point error (X=0; Y=0 or X=±10; Y=0 or X=0; Y=±10): 2MVRMS
- Input impedance: Both inputs 20K min.
- Full scale output: ±10V peak
- Minimum load resistance for full scale output: 2KΩ
- Output impedance: 1Ω
- Short circuit duration: 5 sec.
- Frequency response characteristics (both inputs) 1% amplitude error: DC to 1200 Hz (min.) 0.5 DB Amplitude error: DC to 3500 Hz min. 3 DB point: Approx. 10K hz Roll off rate: 18 DB/octave
- Noise Level: 5MV PK-PK @ 100K Hz approx.
- Operating temp. range: See chart
- Storage temperature range: -55°C to +125°C
- DC Power: ±15V ±1% @ 30MA
- Dimensions: 2" x 1.5" x .6"

Type No.	Product Accuracy	Operating Temperature Range
MCM 1519-1	±0.5%	−55 C - +125 C
MCM 1519-2	±0.5%	−25 C - +85 C
MCM 1519-3	±0.5%	0 C - +70 C
MCM 1520-1	±1.0%	−55 C - +125 C
MCM 1520-2	±1.0%	−25 C - +85 C
MCM 1520-3	±1.0%	0 C - +70 C

Precision AC Line Regulator

Total Regulation 0.15% Max.

Features:

- Low distortion sinusoidal output
- Regulation control better than ten times superior to commercial AC voltage regulators transformer product lines
- No active filters or tuned resonant circuits employed resulting in immunity to line frequency changes
- 6.5 watt output level
- Small size
- Output set to ±1% accuracy — this includes initial set point plus line, load, frequency and temperature changes
- Foldback short circuit protection provided resulting in protection against overloads and short circuits of any duration
- Low profile package with straight pins makes the unit suitable for PC board mounting (unit is hermetically sealed)
- Transformer isolation between all power inputs and the outputs.

*Other units available at different power levels. Information will be supplied upon request.

Specifications Model MLR 1476-2:

- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Output: 26V RMS ±1% (for any condition)
- Load: 0 to 250 MA, RMS
- Total regulation: ±0.15% maximum (any combination of line, load or frequency)
- Distortion: 2% maximum
- AC input line current: 100 MA. max. at full load
- DC power: ±15 V DC ±5% @ 15 MA. max.
- Phase angle: 1° max.
- Temp. Range: -40°C to +85°C
- Case Material: High permeability nickel alloy
- Terminals: Glass to metal hermetic seal pins

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Circle 9 on reader service card

Editorial

What direction for citizens' band?

Citizens' Radio Service has mushroomed recently and now represents the greatest single class of two-way radio users outside of the military. But citizens' band occupies a very small portion of the radio spectrum in comparison with other uses. The Federal Communications Commission, which has been considering expanding the existing Class D CB allocations, is expected to increase the broadcasting space from 23 to 50 channels shortly. Indeed, there is a lot of merit in going even further and giving it the space all the way to 28 megahertz instead of just to 27.505 MHz, since there's little activity there.

The question must be asked, however: will more of the same channels, which use a-m transmissions, really help? The majority of users, whose numbers total more than 6 million right now, won't see much difference. There will still be channel interference problems, especially in and around large cities. What's more, the publicity surrounding 50-channel CB will probably trigger another round of set sales and bring in yet more users. Indeed, some observers argue that with more a-m channels, channel interference will actually increase. Besides, whether there are 23 or 50 channels, long-distance skip problems will grow worse as sun-spot activity mounts toward 1980.

Yet there is a good alternative available. The proposed Class E service, which uses frequency modulation in the 200-MHz region, would eliminate skip problems and help reduce noise problems, too. Although originally proposed by the Electronics Industries Association in 1968, the FCC hasn't acted on Class E service, even though the White House's Office of Telecommunications Policy has requested that it do so quickly. The amateur radio operators and the military groups using those frequencies are, of course, opposed to the idea. And, Canada and Mexico, whose border areas are within range of CB traffic, would have to agree to such a change.

The benefits of fm operation at the very-high- or ultra-high-frequency bands are considerable. The inherent noise immunity of fm will minimize effects of skip, carrier-beat and adjacent-channel interference, as well as the headache of ignition noise. Furthermore, fm operation exhibits a "capture effect" that gives receivers the ability to lock onto the stronger signal and cut the weaker ones completely at the output.

There is, of course, no universal solution to citizens' band allocations. Most likely, a mixture of transmission techniques and allocations would be best. Thus, the establishment of fm transmission at vhf or uhf, even if not at exactly 220 MHz, would make the service a lot more usable in the future, particularly in urban areas.

True, vhf transceivers initially will cost about double Class D a-m rigs, but since they will have a minimum of noise and interference, they will be more useful communication tools. With more and more semiconductor manufacturers and high-technology aerospace companies turning their attention to the communications marketplace, LSI circuits and digital techniques are certain to bring the price down.

Weighing the public interest in such a situation isn't easy, but the FCC has a deadline and must act fairly soon. It must sort out the CB allocation problem, among others, before the World Administrative Radio Conference in 1979. Then, spectrum usage around the world will be discussed, and allocations will be locked in for another decade or so.

Nobody ever made a 4K static RAM family.

Until today.

Advanced Micro Devices announces the Am9130 and Am9140. They do things that have never been done before.
Look at it this way:

There have always been a lot of static RAM's. And 4K RAM's. But there's never been a 4K static RAM family.
Until today.

Look:

Fully static—no refresh required.
Single 5V power supply.
High speed: Access times to 200 nanoseconds
Two organizations for flexibility: Am9140-4K x 1
Am9130-1K x 4
All input and output logic levels identical to TTL—full 400mV noise immunity.
Low power dissipation:
700mW maximum (½ power per bit)
350mW typ compared to 2102)
High output drive: 3.2mA @ 0.4V

Full military range available:
−55°C to +125°C ambient
DC standby mode reduces power dissipation by 80%.
Memory status signal indicates when data are valid, allows improved overall performance, and simplifies timing. (And if you don't want to use it, just ignore it. It won't affect conventional memory operation.)
MIL-STD-883, of course.

Like the picture? Send for the family album.

Advanced MOS/LSI

Advanced Micro Devices • 901 Thompson Place, Sunnyvale, California 94086 • Telephone (408) 732-2400 •
Distributed nationally by Hamilton/Avnet, Cramer and Schweber Electronics.

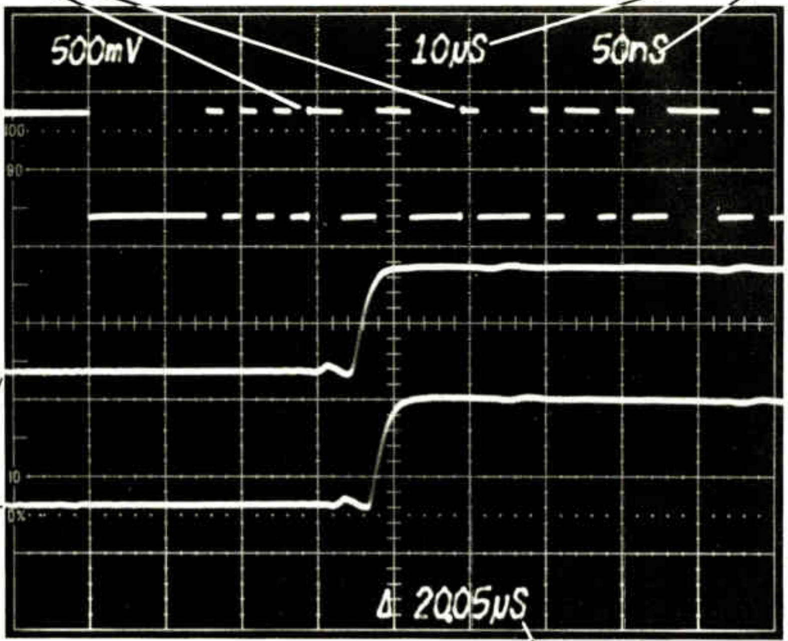
This display makes oscilloscope timing measurements easier, faster and more accurate.

Main sweep has two intensified zones.

Two intensified zones on the main sweep correspond to the two expanded, delayed sweeps shown below. They are quickly and independently positioned to provide a visual approximation of the △ time measurement.

Sweep rates displayed digitally.

Digital crt readout displays both sweep rates for measurement ease and convenient photographic documentation. To the left is the main sweep rate and to the right is the sweep rate for the two alternate (or delayed) sweeps.



Two expanded sweeps.

Both intensified zones are expanded at a faster rate for better resolution and are swept alternately with the main sweep trace for a complete, powerful measurement display. △ time accuracy is enhanced by superimposing one trace over the other, yet they can be vertically separated for independent analysis.

Time difference is computed and displayed digitally.

The time difference (△ time) between each of delayed sweeps (or intensified zones) is digitally computed and displayed directly on the crt for swift and convenient measurement. When similar points on each of the alternate delayed traces are aligned, the △ time readout gives you a highly accurate measurement of the time between the points.

CRT display, photographed on a 7904 oscilloscope, shown full size.

Fill out and mail to: Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077

Please send me

- ☐ The new 7B80-Series brochure
- ☐ △ time measurement application notes.
- ☐ A catalog of 7000-Series oscilloscope mainframes and plug-ins.

☐ Please have a Tektronix Field Engineer contact me about a demonstration.

Name ______ Position ______

Company ______ Mail Sta ______

Address ______

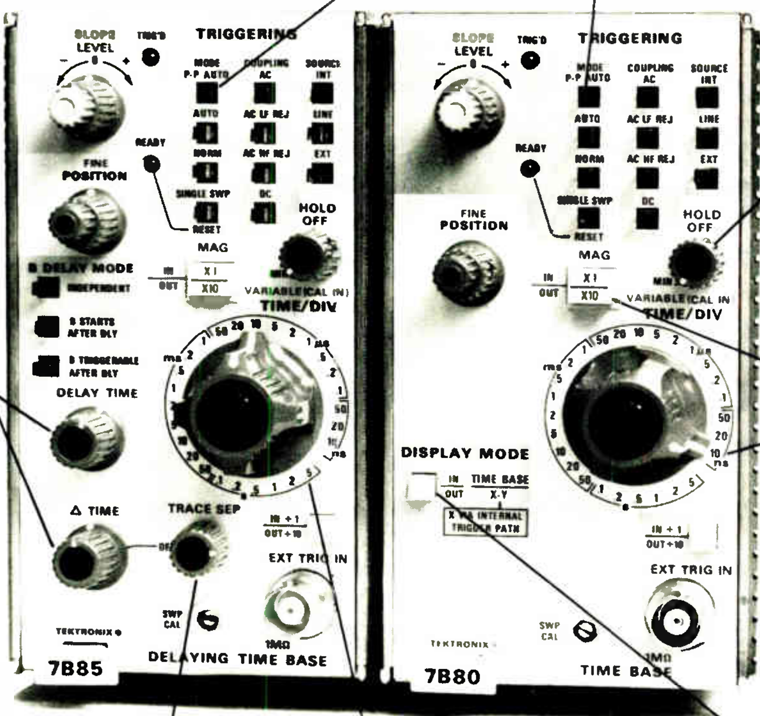
City ______ State ______ Zip ______

Phone ( ) ______

Only these new plug-in time bases make it possible.

Triggering.
Peak-to-peak automatic triggering offers a continuously triggered display regardless of changes in signal amplitude or frequency. Trigger bandwidth is 400 MHz with trigger sensitivity at least 250 mV.

Trigger holdoff adjustable.
Variable trigger hold-off allows you to obtain stable displays on complex signals like digital data trains.



Controls position both intensified zones.
DELAY TIME positions the first intensified zone. △ TIME positions the second intensified zone relative to the first. The △ delay time value — the time between the two intensified zones — is presented digitally on the crt.

7B80 sweep rates.
The alternate (delayed) sweeps can be set to any rate up to 1 ns/division on the 7B80. Naturally, other 7000 Series time bases with different performance features can be used with the 7B85 to make △ time delay measurements.

Alternate traces can be separated.
TRACE SEPARATION activates the △ delay time mode and permits the two delayed traces to be vertically positioned with respect to each other for your most convenient display.

7B85 sweep rates.
Sweep rate for the main sweep can be set from 1 ns/division to 5 s/division.

Optional X-Y mode.
For phase relationship measurements, an optional X-Y mode routes the X (horizontal) signal from an oscilloscope vertical amplifier to the horizontal sweep unit without changing input probes.

Here's how to get more information

Your nearby Tektronix Field Engineer will be happy to show you how these new time bases combine with a 7000-Series oscilloscope mainframe and other 7000-Series plug-in instrumentation to fit your measurement needs. Just call your local Tektronix Field Office or send the coupon to Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077. In Europe, Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

TEKTRONIX®
committed to technical excellence

The 7000 Series...more than an oscilloscope

For Technical Data circle 13 on reader service card
For Demonstration circle 12 on reader service card

People

Bowen sees his group's sales setting pace for Fairchild

Fairchild Camera & Instrument Corp.'s recently restructured Systems Technology group is expected to outpace the rest of the semiconductor company in rate of growth. So says James Bowen, newly appointed vice president and general manager of a group that had been a single division producing general-purpose testers of large-scale integrated circuits. Bowen expects growth of 50% to 100% in 1976 for his group, which now also consists of divisions devoted to memory testers, microprocessor hardware and software, and traditional test and measurement instruments.

Growing. New product introductions by his group will step up sharply, says Bowen.

"Most of the growth will come from an accelerated product-introduction schedule at twice to triple the previous rate," says the intense, 47-year-old executive, who joined Fairchild in Sunnyvale, Calif., two years ago.

New testers. One important new product will be a lower-cost version of the 48- to 60-pin Century II LSI tester, priced at $300,000 to $500,000, says Bowen. Also, he plans a larger 120-pin version aimed at very-large-scale integrated devices, as well as a distributed-terminal version. In addition, a dedicated distributed-terminal memory tester made by Zincom Inc., recently acquired by Fairchild, will come in the second quarter, Bowen says.

For now, the Instrument division will confine itself to equipment for data logging and acquisition plus process control. The first product will be a $68 3½-digit, 5-volt digital panel meter, he continues. This instrument will be followed soon by a 4½-digit unit priced at $99.

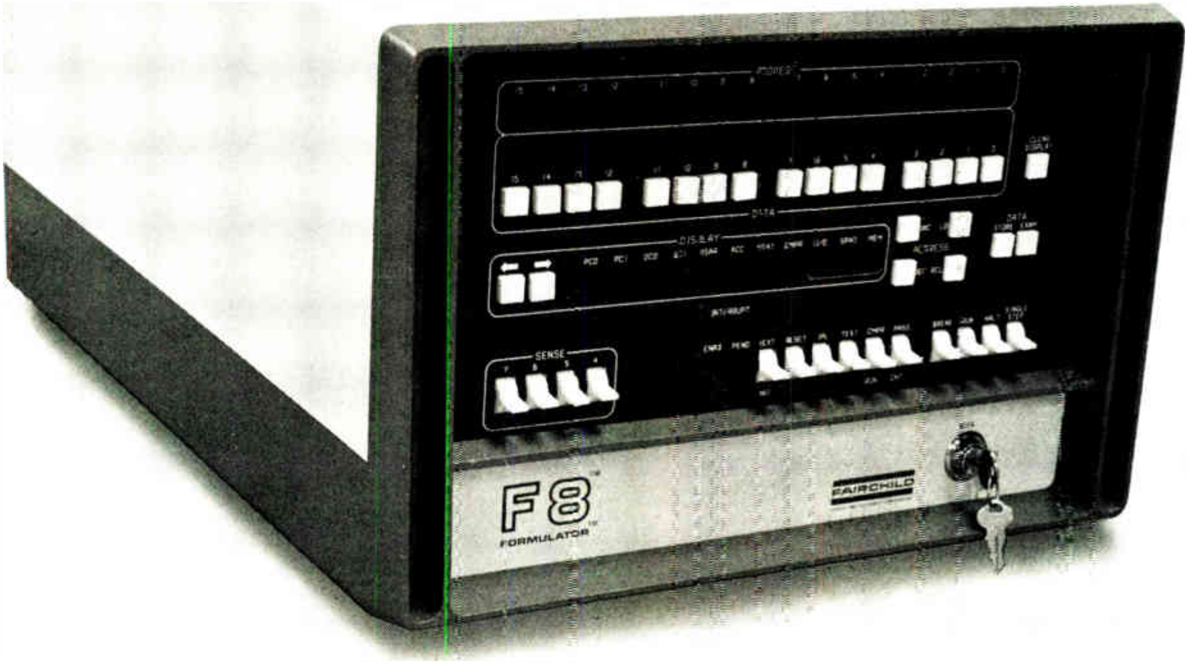
As for benchtop test and measurement instruments, Bowen concedes, "it's just too tough to start from scratch." If Fairchild enters, it will be through acquisition, he says.

Most effort. But the Microsystems division will be the object of most of Bowen's energies. This division now also develops most of Fairchild's F-8 microprocessor hardware and software, a task once performed by the now-defunct Memory and Logic Group. This year, Bowen's division will introduce several enhancements for the basic F-8 microprocessor, as well as several new products based around it and an F-8 hardware/software development system called the Formulator. There will also be at least one new microprocessor, and a 16-bit system is a definite possibility, says Bowen.

Data services look good to Control Data's Norris

It's been three years since the settlement of an antitrust case with IBM gave Control Data Corp. $101 million in cash and Service Bureau Corp., a pioneer in the data-services business. That settlement propelled the Minneapolis-based computer builder, previously known for mammoth "number-crunching" ma-

New view. Services, not hardware, are the answer for Control Data's Norris.



Fairchild's F8 Formulator: It gets you from μp design to hands-on prototype in half the time.

The Formulator is a powerful new microprocessor development tool that offers you all the design assistance you'll need to develop a microprocessor-based system or product. It saves time by:

1. Eliminating the need for an external system breadboard.
2. Putting your design energy where you need it: On the non-microprocessor circuits and on the operating features of your total product.
3. Providing real-time program execution. The system uses actual F8 I/O components to provide I/O to the system, ensuring an exact reproduction of F8 waveforms and circuit levels.
4. Enabling you to edit, assemble and debug fast and efficiently.
5. Keeping all the system software resident in the machine while developing your program. No loading and reloading of system software.
6. Providing an intelligent front panel which makes debugging effortless.
7. Letting you examine and alter storage, set hardware breakpoints and single-step the central processor
8. Providing self-test at the push of a button.

The Formulator can be interfaced with either an HP2644 terminal or an ASR33. Fairchild offers a fully integrated software package including an operating system complete with monitor, text editor, assembler and debug package.

The Formulator was designed by systems people with reliability and maintainability as a design criteria. Each Formulator is burned in for 120 hours at 120°F prior to shipment. The Formulator can be delivered immediately – lease or rental plans are available.

Write for more information to:
Fairchild Microsystems Division
of Fairchild Camera & Instrument Corporation, 1725 Technology Drive, San Jose, California 95110.
Phone (408) 998-0123

FAIRCHILD
MICRO SYSTEMS

People

chines, into activities that are making board chairman William C. Norris very cheerful these days.

"The wave of the future is not in building computers, but in applying them to improve productivity," says Norris. "New technology is no longer the name of the game. Anybody and his dog can come up with a faster piece of hardware."

What has happened to change Norris' mind? In a recent interview, he said crustily: "IBM kicked hell out of us in big computers. We had to re-examine, and we found data services was the key. When we settled the lawsuit, it was clear to me that we had gotten on a course different from IBM."

Growth to 20%. Since then, Control Data with sales of $1.3 billion in fiscal 1975, has built its data services—the Service Bureau Co. itself, the Cybernet timesharing network, and its American Research Bureau—to an annual growth rate of 12% to 20%, about twice that of the company's computer hardware. Comments Norris, "Data services also offer the company growth potential with much less risk than most hardware products."

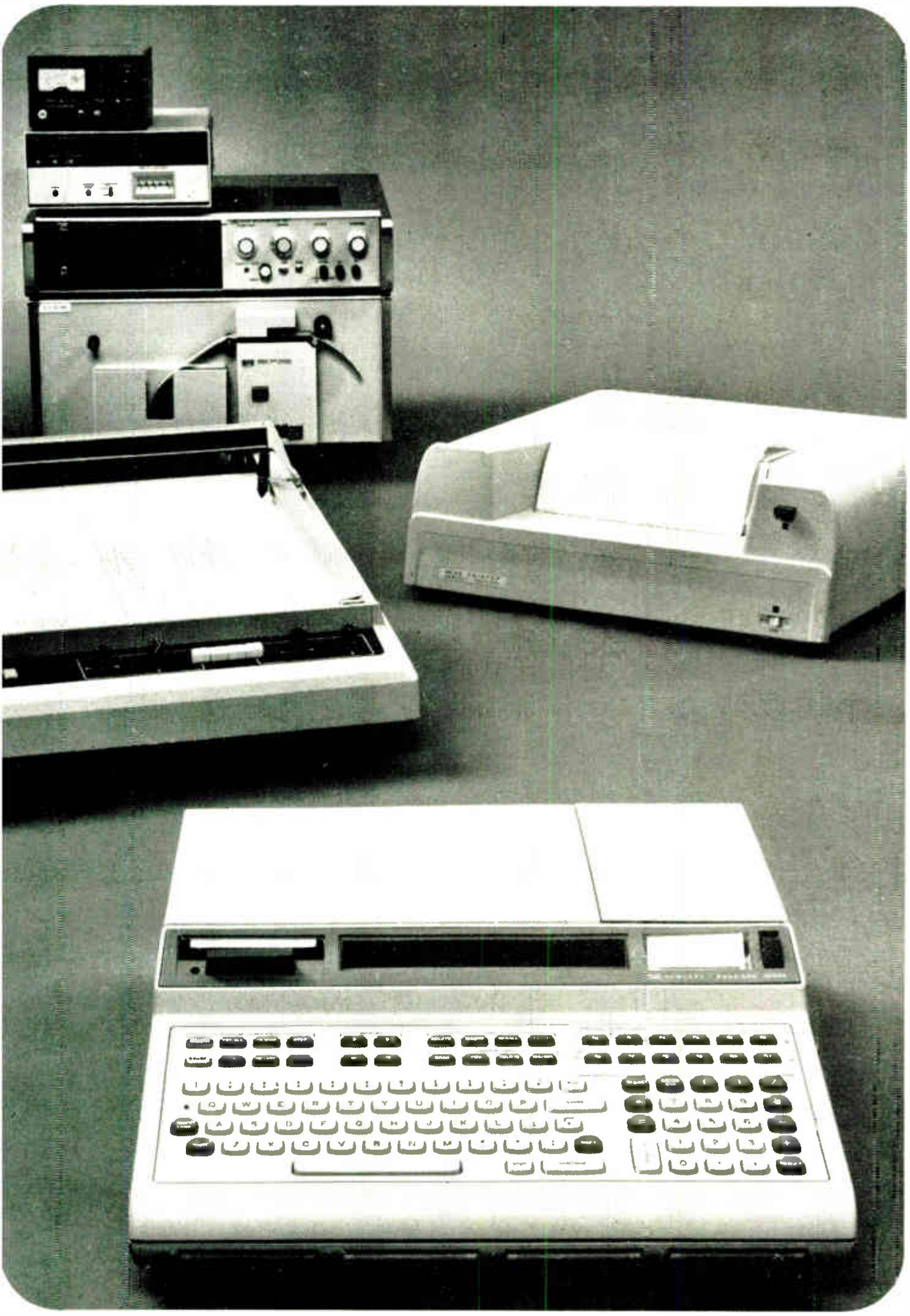
But while emphasizing the end use of computers, Norris says Control Data has no present plans either to get out of manufacturing computers and peripherals or to discontinue its joint-technology projects with other companies. These include a cooperative effort with NCR Corp. to produce a line of mainframe computers. Norris also recently announced a five-year contract valued at a possible $60 million to supply Honeywell Inc. with magnetic-tape transports.

The outspoken Control Data chairman expects fiscal 1976 to recover further from the recession low in 1974 when CDC's computer business lost $35.6 million and the company operated at a deficit. Computer operations recovered to a $13 million profit in 1975.

But to make sure observers understand Control Data's orientation, Norris states, "the name of the game now is software—the knowledge, the service, the people."

MEASUREMENT COMPUTATION NEWS
innovations from Hewlett-Packard

MARCH 1976



in this issue

HP's 9825A powerful new desktop computing system

Because of special features and high speed, the 9825A can compute, handle peripherals, and control instruments, all effectively at the same time.

Combining calculator and mini-computer features, HP's new 9825A offers you a "personal" computer oriented toward the solution of problems in the fields of engineering, research and statistics.

The 9825A has a combination of features never before found on a desk-top calculator. With the *live keyboard*, the user can examine and change program variables, perform complex calculations, call subroutines, and record and list programs while the 9825 is performing other operations.

A few more exciting features of this new calculator: *Multidimensional arrays*

(continued on second page)

New fully automatic LCR meter measures inductance, capacitance, and resistance over wider range

Measurements of capacitors, inductors and resistors have been speeded up to rates as high as one reading per second with HP's new 4261A LCR Meter. Autoranging and automatic selection of measurement equivalent circuits in C/D, L/D and R modes makes the 4261A LCR meter ideal for testing components used in electronic equipment ranging from stereophonic gear to lab-grade test instrumentation.

Applications such as the measurement of stray capacitance of cables, printed circuit board materials and other components become routine with the 4261A. To facilitate the wide variety of applications, the 4261A will be available with three options: BCD, remote control, and an interface for HP 9800 series calculators via the HP Interface Bus (HP-IB) (IEEE Standard 488-1975).

Capacitance measurement capability is in eight ranges from 0.1 pF to 19.00 mF. Inductance can be measured in seven ranges from 0.1 μH to 1900 henries; resistance in eight ranges from 1 milliohm to 19 megohms. Dissipation factors of 0 to approximately 1.900 can be made with the 4261A. Measurements are made at 1 kHz for general applications and at 120 Hz for electrolytic capacitors. Accuracy is typically 0.2% of reading.

For details, check D on the HP Reply Card.

Automatic measurement is now possible for the parameters of semiconductors, pulse transformers, filter coils, electrolytic and film capacitors, or to determine the internal resistance of a dry cell or an electrolysis liquid.

New multi-family Logic Probe has built-in pulse memory, low price

Easy-to-use, simple, and rugged, the probe provides a highly effective solution to digital troubleshooting problems.

Troubleshooting of mixed logic families is now faster and more economical than ever before, thanks to HP's new 545A multi-family Logic Probe.

At the flick of a switch, the HP 545A Logic Probe changes to test most positive logic families including TTL and CMOS. An unambiguous single lamp display in the probe tip quickly indicates logic HIGH, LOW, bad level, pulses or pulse trains. Yet, this rugged overload-protected probe costs one-half the price of previous multi-family probes.

The 545A also has a separate built-in pulse memory with its own indicator lamp to catch those elusive pulses and transitions that occur when you're not there to watch. Use of the pulse memory in no way interferes with probe operation as there's an independent memory display circuit.

The 15μA/15pF input hardly loads your circuits, yet gives pulse train response to 80 mHz for TTL, 40 mHz for CMOS, and pulse width response to 10 ns.

HP's versatile new "grabber" connectors are provided so you can power the probe using IC test clips, test pins, or you can connect to power pins on an IC with little chance of shorting to an adjacent pin. The probe operates from a wide voltage range—3 to 18 Vdc—and in the TTL mode offers standard TTL logic thresholds over supply ranges from 4.5 to 15 Vdc.

Circle B on the HP Reply Card for your 545A data sheet.

New calculator/controller with outstanding interface capability

(continued from first page)

allow you to organize data logically, thus saving program space and execution time. *Memory load and record* allows you to suspend processing, store the complete contents of memory on tape—including programs, data, and pointers—for continuation later on.

Direct memory access (DMA) is yours with input speeds up to 400,000 16-bit words per second. Memory is expandable in 8K bytes to 32K bytes. Each bi-directional tape cartridge can store 250K bytes with an average access time of 6 seconds.

Accuracy to 12 digits with a dynamic range of 10^{-99} to 10^{99} and an internal calculation range of 10^{-511} to 10^{511} provides you with outstanding arithmetical capabilities.

Because of the 9825's *vectored priority* interrupt capability, available in the Extended I/O ROM, the calculator can act as a controller for several instruments or peripherals which require attention at unpredictable rates or times. Besides being used as a controller for instrumentation systems, it can also be used for pilot process control applications, remote data collection and production control.

As a controller, the 9825 can handle up to 45 measuring instruments simultaneously through its three I/O slots.

Three optional interface cards are available: one for 16-bit parallel data, one for BCD devices, and a third—the HP-Interface Bus—for instruments that conform to IEEE Standard 488-1975.

Upper and lower case alphanumerics are now available on both the 32-character LED display and the 16-character thermal printer.

The 9825's high level programming language (HPL) offers you power and efficiency for handling complex formulas and equations. HPL handles subroutine nesting and flags, and allows 26 simple and 26 array variables.

With all this versatility and speed and weighing just 12 kg. (26 lbs), the 9825 can legitimately be considered a portable computer.

For your free copy of the 16-page 9825A brochure, check O on the HP Reply Card.

:conomical pulse generators for TTL, CMOS, :CL, and educational applications

Meeting the requirements of digital logic laboratories, these pulse generators are extremely flexible with panel controls designed for easy operation.

HP's broad family of high quality ›ulse generators includes a cost-effec- ive pulser for every performance level ınd application. Model 8011A, for ex- ımple, is HP's lowest cost pulse genera- or. It's 16V amplitude and 20 MHz epetition rate are perfect for the re- ןuirements of CMOS and TTL logic de- ign. The pulse burst option (001) helps 'ou speed logic debugging by letting 'ou rapidly generate a precise pulse ›urst just by dialing the desired length ›n thumbwheel switches. The 8011A's ow cost of ownership also makes it an deal choice for education applications. 'he logical, easy-to-use panel control ayout, and short circuit proof output ninimize familiarization and down ime—important benefits in student labs.

Models 8012B and 8013B are ver- atile, general-purpose units which pro- vide you additional pulse parameter control for more complex testing appli- cations. The 50 MHz, ±10V perfor- mance of these models is ideal for TTL and basic ECL applications. The 8012B is HP's lowest cost 50 Hz pulser with variable rise and fall times. The 8013B has fixed transition times less than 3.5 ns and also provides simultaneous positive and negative outputs useful in analog applications.

For literature, check L on the HP Reply Card.

›recision Constant Current sources give output ıseful to microampere region

ecision performance, low price, small size, d light weight combine to make these supplies eful as general purpose laboratory constant rrent sources for semiconductor circuit velopment and component evaluation.

With a constant current source in the lab, you can:

- Evaluate reverse breakdown and forward V-I characteristics of PN junctions
- Measure silicon wafer resistivity and contact resistance
- Test relays, meters, potentiometers, and electrolytic capacitors
- Aid in coulometric titration and precision electroplating
- Determine dynamic and incre- mental impedance of devices

HP constant current sources supply precisely-regulated (30 ppm) dc cur- rent. Three models cover a range of rat- ings from 1 μA to 0.5A.

You can adjust the constant current output with the high resolution (0.02%) front panel control, or you can program the output current anywhere over an entire range with an external voltage or resistance. The maximum voltage compliance can also be set with a vol- tage limit control or by external pro- gramming.

These supplies have no output ca- pacitor. Output capacitance is mini- mized to reduce stored energy at the high impedance output, which along with specialized circuitry, reduces cur- rent transients in rapidly changing loads.

A separate monitoring terminal al- lows external voltage measurement without degrading constant current performance.

For technical data sheet, check J on the HP Reply Card.

The "Time Standard" Company offers a wide choice of proven precision frequency standards

Hewlett-Packard frequency/time standards in the HP Measurement Standards Lab in Santa Clara, Calif. contribute timekeeping data regularly to both the U.S. Naval Observatory and the U.S. Bureau of Standards.

As a leading manufacturer of cesium, rudibium and quartz standards, we at Hewlett-Packard offer you 35 years of frequency standards experience to help you make an optimum choice.

We can be of special help since many of our several thousands of frequency standards in the field are used in the most reliability demanding areas. These include LORAN C and OMEGA navigation, space vehicle tracking and guidance, satellite communication and basic timekeeping in numerous standards labs and observatories throughout the world.

One of the following precision frequency standards should meet your applications needs.

HP 5061A Cesium Standard

- Primary frequency standard with 7×10^{-12} accuracy (with high performance tube, 0° to 50°C)
- Proven reliability (MTBF in excess of 40,000 hours)

Your best choice for superior performance and reliability.

HP 5062C Cesium Standard

- Primary frequency standard with 3×10^{-11} accuracy (−28° to +65°C)
- Fast warmup (20 min. at −28°C)
- Rugged construction (passed 400 lb. hammer blow test)

Your best choice for harsh environments such as mobile navigation and communications systems.

HP 5065A Rubidium Standard

- Compact and light weight
- Long term stability less than 1×10^{-11}/month
- Short term stability less than 5×10^{-13}, 100 sec. averaging

Your best choice for a secondary atomic standard at a considerably lower price.

HP 105A/B Quartz Oscillator

- High performance economical frequency standard
- Excellent short term stability and spectral purity
- Aging rate less than 5×10^{-10}/day

Your best choice when excellent stability and versatility are needed at lowest cost.

HP 10544A Ovenized Component Oscillator

- Fast warmup
- Excellent aging rate at low cost (less than 5×10^{-10}/day)
- Rugged, compact, reliable

Your best choice for integrating into test and measurement equipment or communication and navigation systems.

For data sheets on all of these instruments, please check F on the HP Reply Card.

New Application Note for Low Input Current, High Gain Isolators

Optically coupled isolators are useful in applications where large common mode signals are encountered. Examples are: line receivers, logic isolation, power lines, medical equipment and telephone lines. This Application Note 951-1 has at least one example in each of these areas for the 5082-4370 series high CTR isolators.

HP's 5082-4370 series isolators contain a high gain, high speed photodetector that provides a minimum current transfer ratio (CTR) of 300% at input currents of 1.6 mA for the −4370 and 400% at 0.5 mA for the −4371. The excellent low input current CTR enables these devices to be used in applications where low power consumption is required and those applications that do not provide sufficient input current for other isolators.

For your free copy, check Q on the HP Reply Card.

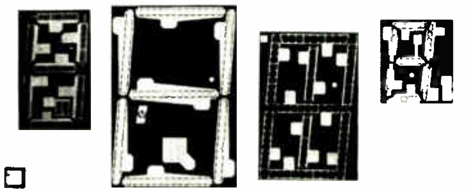
HP offers new monolithic LED chips for watch industry

The HP 5082-7800 series are common cathode monolithic chips designed for hybrid applications. Chips are available in seven segment, nine segment, and one digit fonts. Colons are available in discrete or monolithic form.

Four character sizes with a common cathode are available: 53 mil, 80 mil, 100 mil and 120 mil. These are easy to read, MOS compatible and offer an excellent aesthetic appearance.

The chips are packaged on vinyl film or in waffle packages.

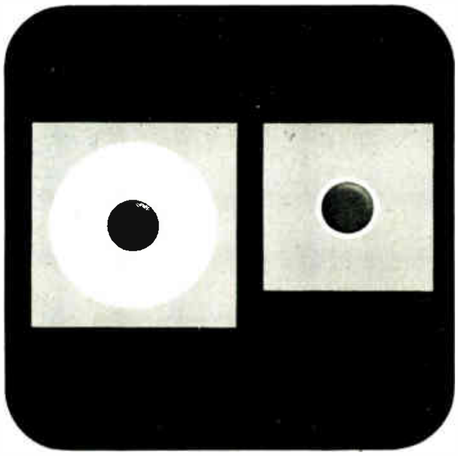
For detailed specific technical data, check I on the HP Reply Card.



New low power chips are 100% electrically tested, before shipment, to a high HP standard criteria.

HEWLETT-PACKARD COMPONENT NEWS

New Metal-Insulator-Semiconductor capacitors for microwave IC's



Magnified view of new MIS chip capacitor with oxide-nitride insulator yielding superior reliability.

These new 5082-0900 MIS chip capacitors have been designed for shunt rf bypassing and series dc blocking in amplifiers, oscillators, switches, limiters, mixers and modulators.

Eleven units are offered in the 0.5 to 45 pF range. Capacitance tolerance is ±15%. Tolerances to ±5% and values in the 45 to 100 pF range are available on special order. Minimum breakdown voltage for units from 0.5 to 2.0 pF is 250 V; 5.0 to 15 pF—150V; units from 20 to 45 pF—100 volts.

In the MIS structure, the metal is gold, the insulator is silicon nitride over silicon dioxide, and the semiconductor material is silicon.

For a technical data sheet, check G on the HP Reply Card.

Low V_F Schottky mixer diodes for better matching and lower noise

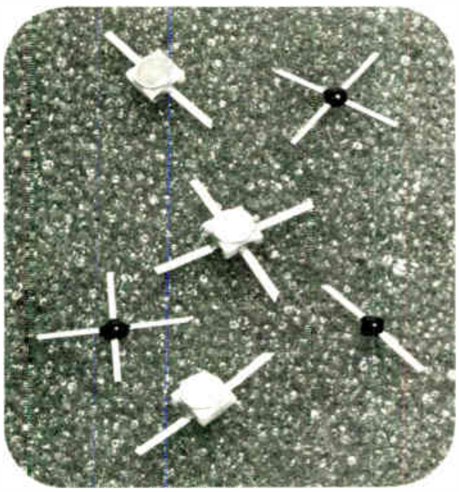
Low forward-voltage equivalents of HP's microwave Schottky diode line are now available. A rating of 200 to 300 millivolts forward drop versus the conventional millivolt droppage of 400 to 500 millivolts is now available in a total of 23 devices including chips, beam leads and quad configurations.

Intended primarily for mixer applications, the low V_F diodes are closer to a 50 ohm impedance than standard Schottky mixer diodes, resulting in lower VSWR over the band. At lower levels of l.o. power, the impedance is equivalent to standard units, a property useful in starved local oscillator mixers.

This new forward voltage rating applies to the following series of components:

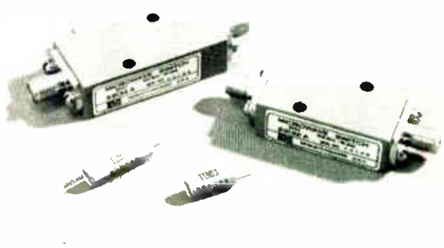
- 5082-2229 beam lead mixer diodes
- 5082-2231 hermetic microstrip quads
- 5082-2271 broadband microstrip quads
- 5082-2285 hermetic single chip coax packages
- 5082-2765 hermetic single chip microstrip packages
- 5082-2774 broadband single chip microstrip packages

For data sheets describing the above products, check H on the HP Reply Card.



Noise figure of low V_F diodes is typically less than 6 dB at 9 GHz for power levels ranging from −5 dBm to +5 dBm.

Insertion loss reduced by 20% in new SPST microwave switches



These SPST switches use PIN diodes in shunt across a 50 ohm transmission line. Control current for the 33132A/33632A is 30 mA for the 33134A/33634A is 200 mA.

Two new SPST microwave switches reduce insertion loss in X-Band and Ku-Band by 20% over currently available types. The HP 33130 series are complete switches, with RF connector, bias circuits, and built-in dc returns. Model 33132A is a complete 2-diode switch with insertion loss of 1.8 dB max from 12.0 to 18.0 GHz.

The Model 33134A is a complete 4-diode switch with insertion loss of 2.3 dB maximum over the same frequency range.

The basis of the HP SPST switch product line is the coaxial module. The 33600 series module is optimized for low insertion loss with high isolation. The modules are available with either two or four diodes. Three diode units are available on special order.

For a technical data sheet on the 33130 and 33630 Series switches, check P on the HP Reply Card.

A new ultra-low distortion analyzer gives you readings to −90 dB

The Hewlett-Packard 4333A Distortion Analyzer measures total harmonic distortion down to 0.01% full scale at 41 spot frequencies, each variable over a range of more than ±8%.

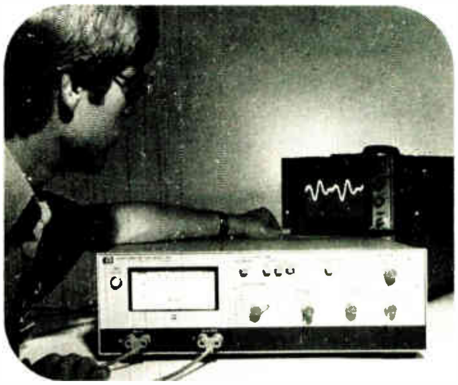
The new 4333A gives you ±3% accuracy over its entire 10 Hz to 100 kHz range.

The 4333A is easy to use. Automatic fundamental nulling reduces critical manual nulling operations. Select your measurement range in 10 dB steps and read distortion directly on the large, clearly marked panel meter. A front-panel monitor output lets you conveniently analyze the harmonic distortion using a scope or recorder.

A high sensitivity voltmeter mode offers 13 ranges in 10 dB steps; range is from 100 μV to 100 V rms full scale.

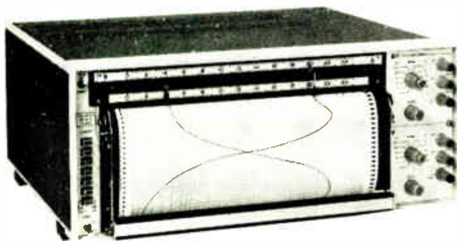
When you need believable amplifier or oscillator distortion measurements, rely on the 4333A.

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



New distortion analyzer with distortion input sensitivity of 1 Vrms for 100% set level reference.

Inkless writing for HP strip chart recorders



New thermal writing option produces a crisp, uniform trace.

For the first time, thermal writing is available for a series of Hewlett-Packard strip-chart recorders. Models 7130A and 7131A, one and two-pen, 10-inch OEM recorders can be equipped with thermal writing pens and event markers for long-term, unattended operation. Models 7132A and 7133A, laboratory versions, can be similarly equipped.

Each thermal tip contains a temperature sensing element used to maintain a constant tip temperature. The tip temperature is therefore independent of ambient temperature, paper speed, etc.

Designated Option 054, the inkless system includes beryllium-tipped pens designed to last the lifetime of the instrument. Recordings are of high contrast and are easy to read.

For more details, check K on the HP Reply Card.

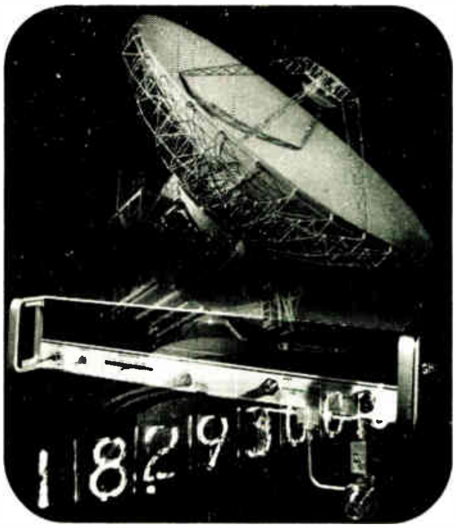
New Application Note helps match microwave frequency counters to measurement requirements

At one time there weren't many microwave frequency counters from which to choose. Now, there are a variety of these counters available with varying degrees of sophistication in design and measurement capability. The new Hewlett-Packard Application Note 144, "Understanding Microwave Frequency Measurement" discusses tradeoffs between microwave frequency counter designs which merit consideration when choosing a counter for a particular application.

The Application Note discusses in detail considerations of measurement speed, accuracy, dynamic range, and tolerance to modulations and unwanted noise on the signal for each of the three common down-conversion techniques: prescale, heterodyne, and transfer oscillator. It also suggests other useful considerations such as input characteristics, sensitivity, and input/output structure.

The booklet should prove useful to the microwave engineer in selecting a frequency counter to meet his needs.

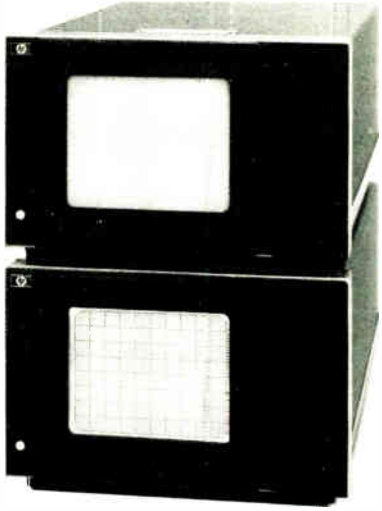
For your free copy of this Application Note, check N on the HP Reply Card.

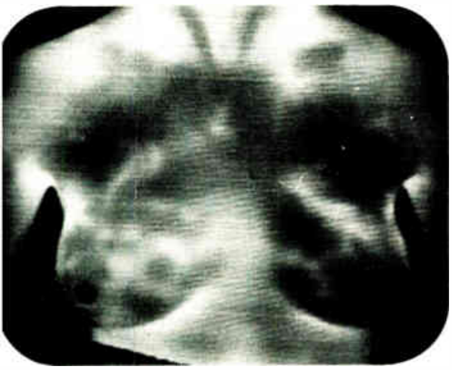


The successful 5340A Frequency Counter represents one of several designs described in the new AN 144, "Understanding Microwave Frequency Measurement".

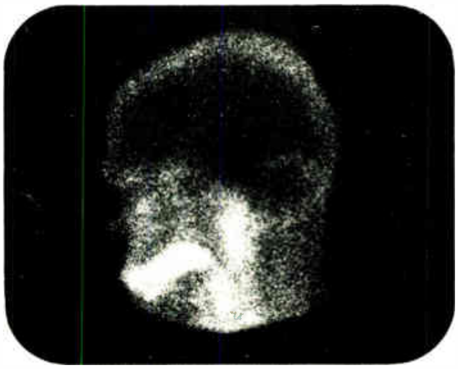
HP high resolution CRT displays for OEM applications

The CRTs in these displays have a totally new design, optimized exclusively for information display and to reproduce fine image detail with superior contrast and uniformity.

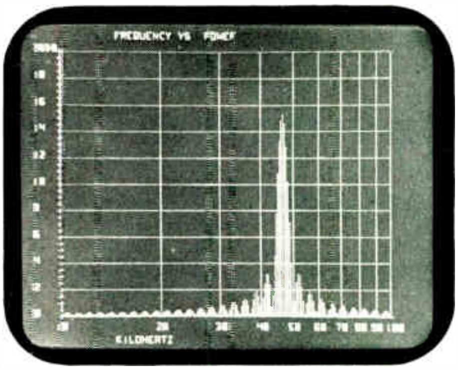




Stable light output for long scan periods permits ime exposure photograph to paint a picture of ody temperature versus location in a medical hermography application.



The 1333A CRT is optimized for photographic image quality with a wide range of gray shades, contrast, and uniformity as shown in this high resolution gamma camera brain scan.



Fine image detail and a well-focused spot at all intensity levels make the 1335A ideal for use in Spectrum, Fourier, Network, and Chemical analysis as well as automatic test systems.

Hewlett-Packard's Models 1332A, 333A, and 1335A CRT displays are designed to provide excellent images n all types of OEM systems. Applicaions for these displays include specrum, network and chemical analyzers, uclear medicine, medical thermographic ultrasound, and automatic est systems, among others.

Model 1332A is designed for the OEM that has both visual and some photographic requirements. CRT display parameters are optimized for such a combined application including large .6×11.9 cm viewing area. Display brightness is such that it can be viewed n high ambient light conditions while maintaining resolution and gray shades or photographic work.

Model 1333A is designed specifically for applications in which photographic recording of displays is the major factor. The small spot size of 0.20 mm offers exceptional image quality that makes evaluation of photographs easier and more accurate. A specified light output uniformity assures that the display information is an accurate representation of the input signals. The high resolution CRT display qualities make the 1333A ideal for recording rapid sequence dynamic studies in nuclear medicine and for capturing transient displays in ultrasound work. The 8×10 cm screen can be reproduced on Polaroid® film with very little optic reduction which allows the use of almost 1:1 optics and minimizes design difficulties encountered when using enlarging or reducing optics.

For applications requiring variable persistence and storage, the 1335A offers exceptional uniformity needed in OEM medical and instrumentation systems. The variable persistence mode can be used to eliminate flicker on some presentations with the ability to increase persistence to match the refresh rate. In the storage mode, resolution is over 20 lines per cm (50 lines per in.) permitting the retention of sharp details. For maximum flexibility, any operating mode—erase, store, write, conventional, or variable persistence—can be selected with manual front panel controls, remote program inputs, or a combination of both.

For detailed specifications on these CRT displays, Check C on the HP Reply Card.

Buy the HP-65 now* and get $195 worth of proven software FREE

During this special promotion, purchasers of Hewlett-Packard's HP-65 fully programmable pocket calculator will receive FREE with the calculator, a $195 coupon for the delivery of 4 Application Pacs and 5 Users' Library Programs of their choice. The promotion runs through April 30, 1976.

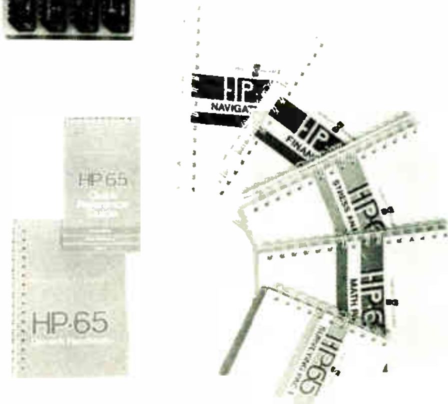
There are 14 Application Pacs currently available in electrical engineering, finance, mathematics, statistics, medicine, navigation, aviation, surveying, machine design, stress analysis and chemical engineering. You may choose any four of these Pacs, each containing up to 40 pre-recorded programs from that particular discipline.

In addition, each purchaser will be able to choose five of 15 popular programs from the HP-65 Users' Library of contributed programs. Each of these programs includes a complete keystroke listing, user instructions and supporting documentation. The entire library listing, available to HP-65 owners, contains more than 4000 contributed programs.

Software is the difference that sets our HP-65 Fully Programmable apart from all other calculators. This hardware/software combination permits the HP-65 to remain the most versatile hand-held computing system available. Like a computer, the HP-65 memorizes programs of any size that are fed into it on tiny magnetic cards, 100 program steps to a card. With just a few keystrokes by the user, it executes the program and gives the answer to complex problems with an accuracy of up to 10 digits. Five User Definable keys plus 51 preprogrammed functions and operations plus a superior editing capability add up to "a great deal".

Call, toll-free, 800-538-7922 (in Calif. 800-662-9862) for an HP dealer near you so that you can take advantage of this special $195 software offer before April 30, 1976.

For descriptive literature only, check A on the HP Reply Card.



*Offer valid until April 30, 1976 in continental U.S.A., Alaska and Hawaii.

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Europe-P.O. Box 349, CH-1217 Meyrin 1, Geneva, Switzerland, Ph. (022) 41 54 00.
Canada-6877 Goreway Drive, Mississauga, Ontario, L4V 1L9, Ph. (416) 678-9430.
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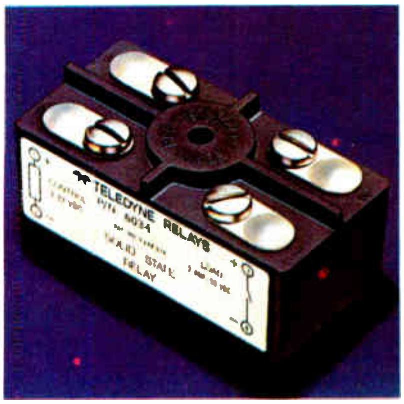
006

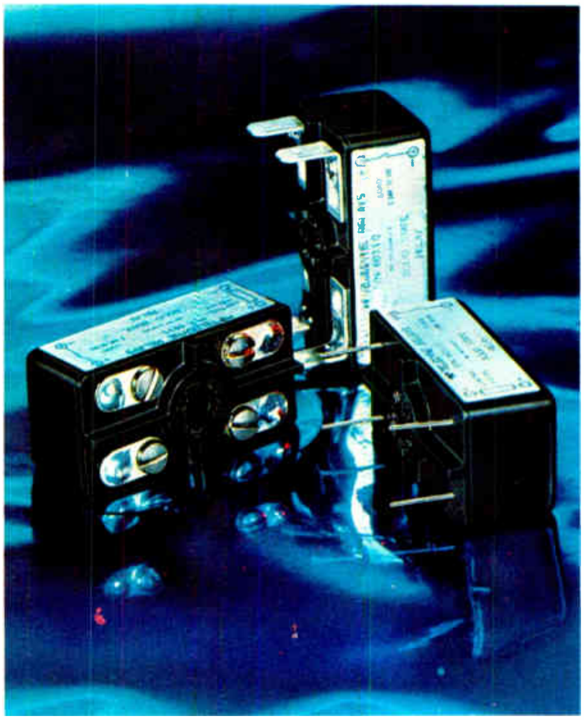
DC solid state update: new relays now handle five times the voltage.



Not long ago we introduced a line of 50VDC solid state relays. But a lot of circuit designers told us they needed higher voltage switching capability. To deliver meant coming up with an industry *first*. We did. Now Teledyne's new DC solid state relays provide a maximum load rating of *5 amps at 250VDC*, with two control voltage ranges.

PART NUMBER	OUTPUT CURRENT RATING (AMPS)	OUTPUT VOLTAGE RATING (VDC)	
603-1	2	50	
603-2	5	50	
603-3, -4	5	250	
603-21	2	50	Controlled Rise and Fall Time
603-22	5	50	

Our new 603-3 relay offers a TTL compatible 3-10VDC input, and the 603-4 a high level logic compatible 10-32VDC input. What's more, they feature transformer coupling to provide 1500V input/output isolation, and direct drive from the control source for low off-state leakage.



Package configurations provide three mounting options. You can select screw terminals, quick-disconnect terminals, or solder pins for direct pc board mounting.

All in all, Teledyne now has DC solid state relays to handle special high voltage switching problems — particularly for those heavy industrial machine and process control jobs.

For detailed information or applications help, contact your local Teledyne Relays people. They're sure to bring you up-to-date on high voltage DC switching.

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We try to be the best source of electronics for precision measurement and control."

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President

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What's real is our commitment to understanding and satisfying the needs of our customers. In innovative and imaginative ways. With electronic products that acquire, convert, condition and display process data used in precision measurement and control.

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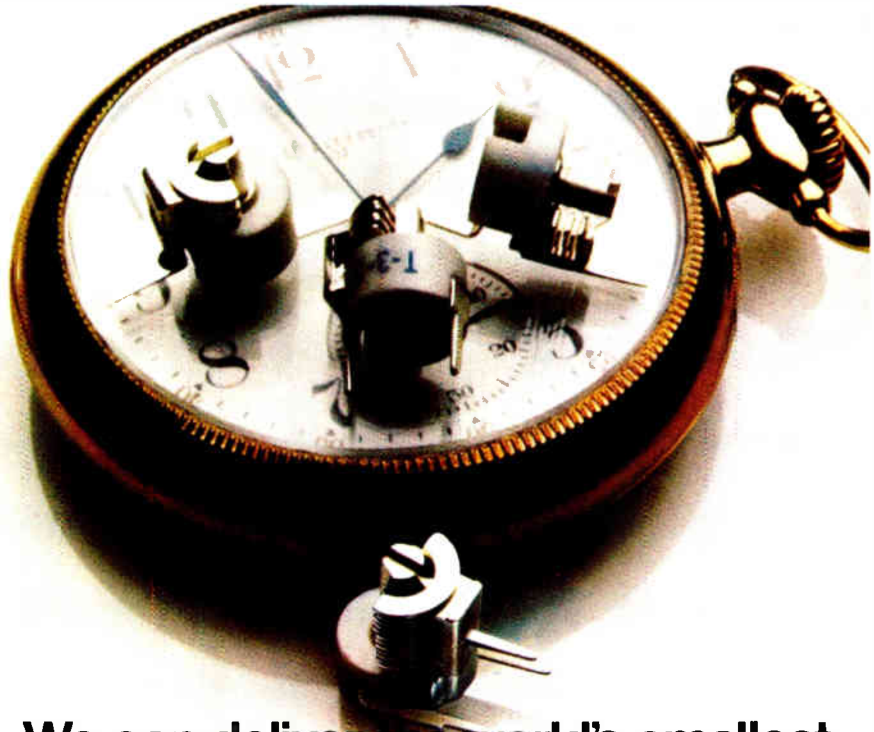

Meetings

NBS Seminar on Frequency Standards and Clocks, National Bureau of Standards, Boulder, Colo., April 6–9.

Acoustics, Speech, and Signal-Processing International Conference, IEEE, Marriott Hotel, Philadelphia, April 12–14.

Computer Software Engineering: Reliability, Management, and Design, IEEE, Barbizon Plaza Hotel, New York, April 20–22.

Reliability Physics International Symposium, IEEE, Caesars Palace, Las Vegas, April 20–22.

Eighth Annual Southeastern Symposium on System Theory, University of Tennessee and IEEE, Knoxville, Tenn., April 26–27.

Seventh Annual Pittsburgh Conference on Modeling and Simulation, IEEE, University of Pittsburgh School of Engineering, April 26–28.

Third FAA/Georgia Tech Workshop on Grounding of Electronic Systems, Federal Aviation Administration and Georgia Tech, Atlanta, April 26–28.

Electronic Components Conference, IEEE, Jack Tar Hotel, San Francisco, April 26–28.

Optical Computing International Conference, IEEE, Capri, Italy, April 27–29.

Circuits and Systems International Symposium, IEEE, Technical University, Munich, April 27–29.

Offshore Technology Conference, IEEE, Astrohall, Houston, Texas, May 3–6.

Carnahan Conference on Crime Countermeasures, IEEE, University of Kentucky, Lexington, May 5–7.

Electro 76—IEEE International Convention, IEEE, Hynes Auditorium and Sheraton-Boston Hotel, Boston, May 11–14.

ANNOUNCING

a totally new line of high performance, low-cost digital panel meters

Large, bright, easy-to-read LED display
High reliability LSI design

ew from Weston. The 2460 Series digital panel meters. An inno-ative line of meters that combines the best in semiconductor and isplay technology for all 3½ digit applications. The result is etter performance, better reliability, and better price. In fact, you an now get the best in Weston DPM performance at a price of nly $80.*

he unique Weston two-chip LSI circuit design in the 2460 Series educes the number of components. This provides added reliability nd helps to cut cost. And Weston has done it without sacrificing e outstanding characteristics of its patented Dual Slope Con-ersion** method of circuit design for long term stability—an in-ustry acknowledged superior method.

his LSI feature alone makes the 2460 Series a good buy. But eston took it one step further. We replaced the gas discharge isplay with an LED display. Better reliability. And—our LED hap-ens to be a big and bright 0.6″.

his is the basic story on the new 2460 line of Weston high reli-bility/low price meters. The rest of it is basic to Weston quality and performance. Single ended or balanced differential input—completely floating, with isolated systems interface. Industry standard pin connections to assure multiple sourcing and simple retrofit requirements. All of these outstanding features are pack-aged in the popular and industry standard Weston DPM case, re-quiring only seven square inches of panel space.

The 2460 Series is available in six models that include both AC line and DC powered units.

Ask your distributor for a look at the 2460 Series. It will improve your equipment's performance and reliability while it saves you money. Or, write direct to Weston for additional information. Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, NJ 07114

Canada: 1480 Dundas Highway, Mississauga, Ontario
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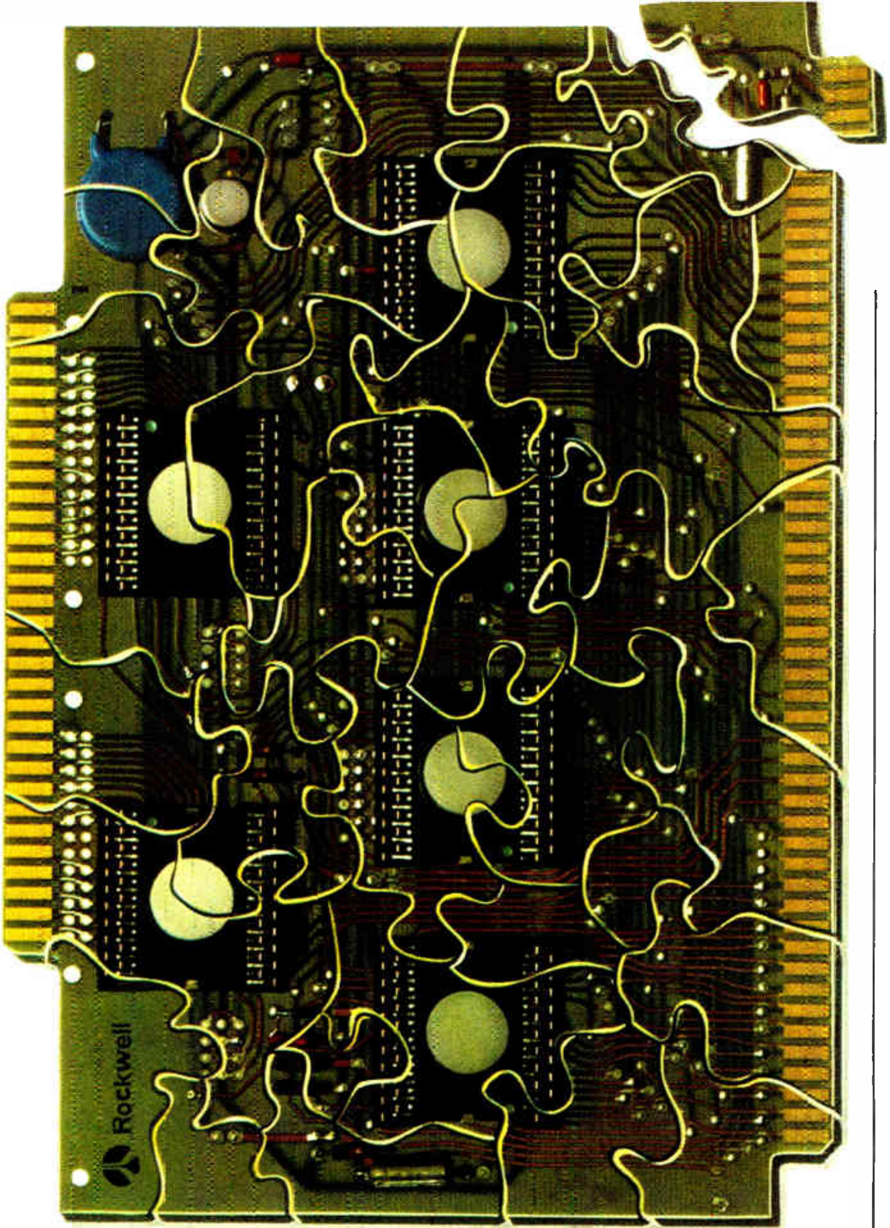
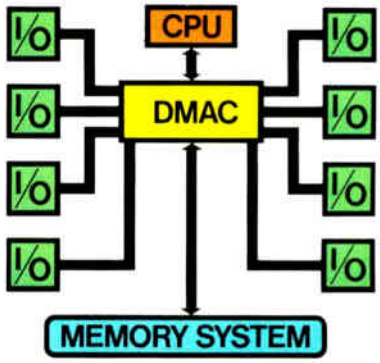


Rockwell a system

DMAC:
Another burden lifted from the CPU.

Our 8 channel Direct Memory Access Control (DMAC) gives priority to data flow between the I/O's and the system's memory. Once again, the CPU is freed from a routine, time-consuming chore.



Intelligent I/O's do the CPU's busywork.

We've identified many common tasks performed by microprocessing systems and designed intelligent LSI I/O's to control them — independent of the CPU. The CPU is thus able to delegate mundane chores such as running the peripherals, while concentrating on the serious thinking it does best.

The spreading of intelligence among the I/O's also reduces the amount and cost of program memory in your system. And because the CPU is no longer responsible for monitoring a multiplicity of functions all over the lot, programming becomes simpler, faster, and more flexible. You simply plug in or remove a chip with minor, not total, software changes to add or subtract functions.

is there with approach to microprocessing.

PARALLEL PROCESSING: HIGH SPEED RESULTS FROM LOW COST TECHNOLOGY

With so much independent intelligence spread through our system, many tasks can be executed at virtually the same time. With our parallel processing system (PPS) you can now perform tasks with MOS microprocessing that would otherwise require higher cost technologies.

A THRILLING CASE HISTORY

A fellow designed a new cash register whose I/O's sprawled over three PC boards and cost about $250. He felt there was a better way and went to a large microprocessing house, but one which sold chips, rather than systems. They reduced him to one large and two small PC boards, with a cost of about $160. Finally, he came to Rockwell, where we applied our LSI system approach to his problem. He walked out with his entire system in LSI on one PC board at a cost of about $85.

MILLIONS OF DOLLARS SAY WE'RE SERIOUS ABOUT ALL THIS

We've spent millions of dollars to develop more than 40 LSI microprocessor circuits to offer you LSI options for most of your electronic needs. As well as a worldwide sales and field service organization. Add to that a production capacity of tens of millions of circuits per year and you get the picture: giant Rockwell is very serious about tiny microprocessors. Don't let anyone tell you otherwise.

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...where science gets down to business

New C-MOS process enters production in microprocessor

RCA Corp.'s Solid State division has gone into production with its new C-MOS process. **The first product is an 8-bit microprocessor, the CDP 1802** (see p. 129). Called C^2L (for Closed C-MOS Logic), the process is a silicon-gate C-MOS technique that results in both "a common source structure and a gate electrode in the form of a closed circle that eliminates guardbands," according to Philip R. Thomas, the division's vice president for MOS. This increases gate density and makes the device three or four times faster than metal-gate C-MOS devices.

For its new microprocessor, RCA has reached an agreement in principle with Hughes Aircraft's Microelectronic Products division and with Synertek to establish them as second sources. RCA says that "definitive" agreements are to be reached in 90 days.

The 1802 microprocessor is already earmarked for the redesign of Chrysler's in-car spark-control computer, presently an analog system. Also, Cramer Electronics Inc., the Newton, Mass., distributor, will shortly announce a kit version of the device.

RCA is also still enthusiastic about C-MOS on sapphire for digital products. Besides the 1,024-bit SOS random-access memories already introduced, RCA plans to have an SOS microprocessor available late in the year.

Fairchild, National seek a piece of mainframe action

Not satisfied with supplying components and building add-on memories, National Semiconductor Corp. and Fairchild Camera & Instrument Corp. are eyeing the large computer itself. **Fairchild has acquired a 15% interest in Cray Research Inc.,** formed in 1972 by Seymour Cray, former executive vice president of Control Data Corp. Cray plans to enter the market in large scientific computers this year against CDC and Texas Instruments with the Cray-1. The machine has an internal bipolar memory capacity of up to 64 million bits with a cycle time of 50 nanoseconds.

National is quietly backing the credit line of a small spinoff of Digital Scientific in San Diego, Calif. Called Exsysco, **the firm is planning to compete head on with IBM Corp.** with a 30% to 50% lower-cost version of the System/370/158. Exsysco is developing its first prototype and, if successful, will be absorbed by National into its Memory Systems division, which would then be renamed the Computer Systems division. A key factor in the decision: is the whole deal worth the loss of IBM's component business?

Signetics pushes I^2L into the communications area

Signetics Corp. is making an aggressive push into telecommunications with its integrated-injection-logic technology. **It is currently developing a 10-megahertz single-chip digital frequency synthesizer** that can be programed for 1,000 different frequencies and used to generate multiplex carriers for the Western Electric and CCITT modulation plans. The chip will cost $5 to $6, says Gary Summers, manager of telecommunications marketing at Signetics.

Further down the line is a compressed single-channel pulse-code-modulated codec on two I^2L chips. And not far behind that is American Microsystems Inc. with a one-chip n-channel metal-oxide-semiconductor device using weighted MOS capacitor arrays, and National Semiconductor Corp. with a two-chip system built with complementary MOS.

Intel forms computer division from systems group

Intel Corp. of Santa Clara, Calif., a leader in semiconductor components, has formed a full-fledged division from its former Microcomputer Systems group, in effect confirming what the computer industry long suspected: Intel intends to become a major force in their field. William Davidow, who ran the System's group, will be new division general manager. And in a surprise move, to put muscle in the division, Intel's chief technical officer, Lesley Vadasz, has been named assistant general manager of the microcomputer division, with responsibility for manufacturing, engineering and software.

Materials handler is first to have microprocessor

Microprocessors have found their way into materials handling. In the first application, Control Logic Inc. of Natick, Mass., has deisnged a controller that is incorporated in an automatic crane system manufactured by its parent company, Harnischfeger Corp. of Milwaukee. Harnischfeger's $374 million volume leads the market in overhead traveling cranes, hoists, and materials-handling equipment. First customers for the crane include a major tractor manufacturer, a chemical company, and a steel mill.

Built around the Intel 8080, the controller will probably be **the first in a series of programable processors for materials handling.**

Computer group suggests industry finance body

The Computer Industry Association has formally proposed the establishment of an industry finance committee, as part of a settlement of IBM Corp.'s antitrust litigation. It would be called Computer Industry Acceptance Corp. According to Jack Biddle, CIA president, such an organization would provide a finance alternative, a "discount window," **that would accept standard contracts executed between IBM and its customers and between the non-IBM portion of the industry and their customers.** "With IBM's 65% to 70% share of the general-purpose data-processing equipment market," says Biddle, "it simply isn't feasible to put more resources and emphasis into their traditional markets without accelerating their antitrust problems."

Nielsen to test distributor index

The A. C. Nielsen Co. may get its distributor-reporting program off the ground even though Schweber and Hamilton/Avnet won't participate. Nielsen, the Northbrook, Ill., TV ratings firm, **plans to start West Coast pilot operations this spring.** It figures that it needs a base that accounts for 65% to 75% of distributor sales, and it has in hand 60%, according to an official. Participants include Cramer, Kierulff, Wyle, Weatherford, Marshall, Powell, and Bell. The Nielsen Electronic Distribution Index will report distributor sales by product category to client manufacture.

Addenda

Motorola's Data Products division has developed a logic analyzer for microprocessors. Called the MPA-1, **it interfaces via a 40-pin test clip.** . . . Sprague Electric Co. will become **a wholly owned subsidiary of Cabot Corp.** of Boston if the boards and stockholders of both firms approve. . . . National Semiconductor Corp. will introduce a monolithic sample-and-hold circuit **made by its Bifet technology** to achieve high accuracy, large bandwidth, and quick settling.

Announcing a giant reduction in the Nova line.

You're looking at a whole new family of NOVA® computers. microNOVA. A microprocessor chip, a microcomputer board and a complete MOS minicomputer. All based on the little thing on the tip of the finger.

mN601. The microNOVA CPU.

It's a full-blown, 16-bit NOVA computer. Manufactured by Data General. And fully supported by NOVA software.

And it's not a NOVA computer in name only. This chip has all the NOVA registers, internal data paths and computational elements. The NOVA multifunction instruction set. The NOVA multiple addressing modes. And the NOVA 3 hardware stacking. Plus things that used to be NOVA options: multiply/divide, real-time clock and power fail/auto restart. All standard at no additional cost.

The difference is, all that NOVA has been reduced to a single chip that measures only 225 mils by 244 mils.

Which was no small accomplishment.

For those who need more than a chip, there's the microNOVA computer-on-a-board. A complete, fully-buffered microcomputer that comes with 2K or 4K words of RAM on a single 7½" by 9½" board. You can add on more RAM in either 4K or 8K increments, or PROM boards with up to 4K words. Plus terminal interfaces, general purpose interfacing boards, card frame, power supply and PROM burner.

And for those who need more than a board, there's a fully-packaged 4K word MOS microNOVA mini. It comes with power supply and turnkey console. In 9 and 18 slot versions. Into which you can place as much as 32K words of RAM or PROM. And still have plenty of room left over for I/O.

There's even a microNOVA system specifically for program development. A complete system, with dual diskette drive, terminal and our RDOS-compatible Disc Operating System. Or you can use a Nova 3 system with RDOS. The best development software you can get.

And no matter which microNOVA product you get, you get to use NOVA software like FORTRAN IV. Software that's in use in over 20,000 installations all over the world. So you know it's going to work right the day you get it.

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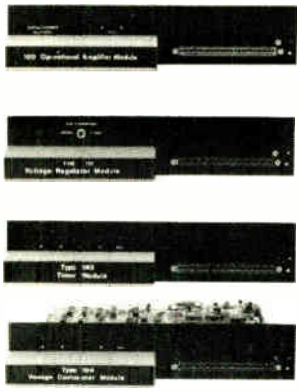

Use it for incoming inspection, quality control, production testing, and engineering evaluation. Do comprehensive testing. Test op amps, voltage regulators, timers, voltage followers, comparators, and custom linear IC's. Device diagnostics and program verification are easily performed with the DVM and mode controls on the front panel. With our blank module and design handbook you can adapt the 550B to special test requirements including custom and new linear circuits.

Plug-in modules currently available include op amp, voltage regulator, timer, voltage comparator and voltage follower units. Universal limit boards, autohandler interface, and data logger options are also available. Device under test adapters feature frequency compensation, critical gain and bias networks right at the socket where they're needed. Program limit boards conveniently establish measurement limit values.

Compare specifications. For example, Alma's VR module offers the best specs on the market today. Only Alma offers dual limit comparators and high speed test sequences.

And our package price for the mainframe, op amp module, program board and device under test adapter, is extremely competitive. But enough talk. Try the new 550B on your own bench. Call your local Alma sales engineer or contact us directly.

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ALMA

The bench-top tester people

Zenith TV tube woos U.S. set makers with low-cost quality

100° color tube developed with Corning uses less glass; tri-potential gun increases resolution and brightness

Zenith Radio Corp., as it has often said, intends to use extensive stateside automation to fight Japan's encroachment into the U.S. television market. It underscored its position earlier this month in Chicago as it unveiled a radically different—and inherently simpler to manufacture—TV picture tube.

Color tube. Zenith's tube breaks down to (background): a 100° narrow-neck funnel (left), slotted aperture mask (center), and faceplate (right) that is fabricated without the usual heavy glass skirt.

The new tube, developed in conjunction with Corning Glass Works, should slice both raw material and assembly costs. Moreover, Zenith has coupled it with a new tri-potential in-line gun that leapfrogs the resolution, brightness and contrast advantages of 110° tubes principally installed in sets from Japan.

"This is a further significant extension of our attempt to automate the manufacture of television receivers," says Karl H. Horn, the Zenith senior vice president for engineering and research, who directed the multimillion-dollar project for almost five years.

As with all Zenith-built picture tubes since the mid-1940s, this one will be offered for sale or license to other manufacturers, and Corning will offer the glass components of the tube to its customers. But Horn cautions: "This tube was designed for automation and could not be produced efficiently by the means we use now." Zenith will have a lead on competitors because it would take a manufacturer a year, even going all out, to begin pilot operations, he says.

June production. Zenith plans to build 200,000 to 250,000 of the 19-in. tube this year—about a tenth of its total production—and plans other screen sizes in the future. When the pilot line in Elk Grove Village, Ill., begins full production in June, the savings will come fast: "Certainly, well before the end of the year, we'll be getting significantly higher efficiency out of this converted line than out of our standard lines."

The 100° deflection angle of the tube gives it a smaller picture spot and 2½ inches less depth than the 90° tube Zenith now uses. "We figure we can get most of the advantages of the 110° deflection angle at about the costs and power consumption of the 90° tube," says president John J. Nevin. The 100° tube uses the same solid-state deflection circuits as the earlier tube; they are cheaper, as is the pin-cushion correction, than circuits for 110° tubes.

Skirtless faceplate. The key to the lowered manufacturing and assembly costs, however, is a skirtless faceplate that permits higher-density shipping, storage, and processing. The faceplate also has glass studs in

Tri-potential gun hits the (smaller) spot

While tube costs are cut by redesigned glass parts and shadow-mask system (estimates on savings in glass alone run $4 or $5), the tube gets its improved performance mainly from a new tri-potential in-line gun. Moving the gun closer to the screen in the 100° tube accounts for a 5% reduction in spot size. Further, the new gun design makes the spot up to 46% smaller than is possible with the bi-potential in-line guns used in the 90° tubes of most U.S. TV manufacturers.

Zenith uses the two usual potentials—a 25-to-30-kilovolt anode potential and applies a focus voltage of about 20% of the anode potential to a single grid—then adds a third focus potential. All told, Zenith focuses three gun elements instead of the usual one. It applies a 43% focus voltage to one grid and a 24% voltage on the third and fifth grids.

The smaller spot can show up as a sharper picture, but Horn emphasizes that the set manufacturer may trade off that resolution any way he wants. "He can drive the set harder to reach the same spot size as his current gun and roughly double his brightness," he says. "Or at that brightness, he can darken the faceplate to pick up well over 50% improvement in contrast." More likely, especially on smaller screen sizes, the manufacturer may opt to retain his present levels of sharpness, brightness, and contrast, and lower the high voltage to 20 kV—or even 15 kV—to cut circuitry costs.

each corner that allow the automation of mask insertion and frit (glass solder) sealing steps.

The tube's two-pound weight drop results partly from the faceplate's loss of its heavy 2-inch skirt, but more from a new shadow-mask design. Current shadow masks are welded into a heavy steel frame that's mounted to studs on the skirt. In addition, since the mask is about a half inch smaller all around than the faceplate, shields are needed to prevent stray electrons from bouncing onto the tube face and diluting the color. The Zenith design eliminates both frame and shielding—the slotted mask is fitted directly onto the faceplate studs with low-cost mounting springs.

Thermal problems in the current shadow-mask assembly are corrected with the bimetallic springs. As the metal assembly heats up, the springs keep it precisely aligned with the phosphor screen.

"Besides holding the shadow mask in place, the unique stud arrangement lends itself beautifully to precision alignment of the panel [faceplate] and funnel," Horn points out. The studs engage notches in the funnel, aligning the two tube parts during the frit process that permanently seals the panel to the funnel. "For the first time, we don't need precision alignment fixtures; we send it through the ovens on a simple bulb holder," he says. And frit-sealing may be combined with exhausting the tube.

The skirtless design also speeds coating the screen. (The tube uses the same phosphors as current Chromacolor tubes.) "Since there are no skirts to disturb the thickness of the [edges of the] phosphor slurry, we can run the screening process significantly faster," Horn says. Any excess phosphor drops over the side of the panel, where it's collected and re-used, instead of running down the side of the skirt, where it must be cleaned off. □

IEEE

Expert takes over standards program

To end the disruption of its standards activities created by the March 1 resignation of Sava Sherr, the Institute of Electrical and Electronics Engineers has named a top-notch standards veteran to head its program. Sixty-year-old Ivan G. Easton, semiretired from a 37-year career at GenRad Inc., is taking on the job. Meanwhile, Sherr has become deputy managing director for energy matters at the American National Standards Institute [*Electronics*, Feb. 19, p. 32].

Ironically, Easton was chairman of the IEEE Technical Activities Board's standards task force that in 1967–68 helped set up the institute's present standards operations and hired Sherr as the first director of the revitalized program. Having reviewed the recommendations, Easton commented recently, "I was gratified to see how thoroughly the work of [our] voluntary task force had been implemented."

Recommendations. However, Easton takes over an operation troubled by the staff layoffs that precipitated Sherr's decision to quit. In resigning, Sherr left IEEE's board of directors with six recommendations, which the new standards director is considering closely.

The first, to put the manager of the standards program on the board of directors, was one of Easton's original recommendations. He expects this step will be taken soon. However, Easton believes the IEEE board will not buy the recommendation that the standards manager have stronger control over his department's budget.

Debate is also continuing on Sherr's recommendation that standards activities be supported by membership dues rather than by funds from the IEEE's groups and societies. At present, its major support, almost $500,000, comes from funded projects and sale of publications, and another $125,000 comes from membership dues.

Another proposal, to support the activities of the International Electrotechnical Committee with U.S. Activities Board funds, is already being carried out, according to Easton. But no action will probably be taken on Sherr's other suggestion that IEEE initiate certification programs, such as the certification of instrumentation systems used in nuclear power plants. "I expect some participation in certification by IEEE in certain areas," Easton remarks. "But this is a broad issue, still in discussion."

Sherr's final request was for a qualified successor. In Easton, the IEEE has such a person. Besides his 37 years at GenRad, he has been active on the International Electrotechnical Committee and is currently chairman of Technical Committee 66 on Electronic Measuring Instruments. Easton has also held posts with the American Society for Testing and Measurement, the National Conference of Standards Laboratories, National Bureau of Standards, the Conference on Precision Electromagnetic Measurements, and others. □

Military

Hughes, Navy deny Phoenix problems; DOD seeks to upgrade performance

Criticisms within the Pentagon that the long-range Phoenix missile used on the Navy's F-14 fighter performs poorly and requires basic redesign are being vigorously repudiated by Hughes Aircraft Co., the air-to-air missile's prime contractor. Citing missile firing tests in which "85% of all valid launches have hit the target," Hughes Aircraft's Phoenix program manager Walt Maguire calls the system "the most successful air-to-air guided missile in Naval aviation history."

The Hughes position gets support from the Navy. Cdr. Sven Nelson, weapons assistant in the F-14/Phoenix project office at the Naval Air Systems Command, says, "We're happy with the performance of the present missile." The aim of the Phoenix R&D improvement programs that are identified in the fiscal 1977 defense budget, according to Nelson, is to improve reliability and maintainability by simplifying the initial 1962 design. One goal, for example, is to cut the electronics parts count by 80%. The investment, he points out, "is modest compared to the $250–300 million that would be required to design and develop a new missile." Of the Navy's 92 Phoenix test firings, Nelson says 89% were successful.

Problems nevertheless. Yet one ranking Pentagon tactical-missile specialist insists that the AIM-54 Phoenix is "a problem program" that has to "get the performance up and, if we can, the cost down." For two years, defense budget requests showed fairly stable missile costs at $292,600 and $297,100 per missile. But now the Navy's fiscal 1977 proposal to spend $84 million for 240 missiles—100 less than in each of the two prior years—raises that unit cost to $350,000, an increase of about 18%.

To date, total spending on the Phoenix program has reached about $1.7 billion, a figure that covers the AN/AWG-9 weapon control system, the missile itself, spares, and testing. The first version of the Phoenix was built for the Navy's F-111B in the mid-1960s, then revised beginning in 1968 for the F-14. Hughes has delivered more than 900 missiles out of the 1,200 contracted for.

As for the missile's performance amid the multitude of electronic transmissions encountered in heavy combat, the Pentagon source says, the Phoenix has difficulty discriminating friend from foe [Electronics, March 4, p. 49]. Phoenix electronic countermeasures need improvement, it was indicated. Also, the missile needs more tests of its capacities for dealing with multiple targets, making evasive maneuvers, and using electronic countermeasures in fully simulated combat. Hughes did not specify the missile test conditions that produced the 85% kill ratio.

Improvements. The performance issue arose following the disclosure to Congress by Malcolm R. Currie, Department of Defense research and engineering chief, of a new $67.1 million, five-year program "to extensively modify the present Phoenix system" as part of "a basic design effort to improve reliability." At the same time, Currie said the Pentagon wants to spend another $28.6 million in R&D money through 1979 to raise the performance and reliability of another Navy air-to-air missile, the AIM-7F Sparrow built by Raytheon Co.

With the money to be spent on the Phoenix modification program, Currie said, "electronic countermeasures capability will be improved." In addition, "a new transmitter and digital autopilot will be developed to increase the missile's performance as well as a new warhead and fuze design to increase lethality." Hughes' Maguire maintains the modification does not impugn the existing missile's performance. "In the interest of cost savings and commonality," he said, "the Navy will upgrade the Phoenix rather than procure a new long-range missile to meet the future threat" in the 1980s and 1990s. □

Picatinny becomes armament HQ

Picatinny Arsenal has made a complete turnabout. From Pentagon-level statements last year that it would be closed down in an economy move, the development facility near Dover, N.J., has been made the headquarters for munitions development for the U.S. Army. That means more electronics work at the arsenal than ever before.

"I can't think of a single new system program that we're proposing that doesn't involve electronics," says Col. Kilbert E. Lockwood, since last June the arsenal's commanding officer. "Things are possible now that weren't possible just a few years ago because of the very rapid advancements in electronics technology. We definitely want to take advantage of these developments. As we go along, there will be more opportunities here for electronics firms."

As the newly designated Armament Development Center of the U.S. Army, Picatinny will over the next four years absorb weapons development divisions now scattered at Rock Island, Ill., Aberdeen Proving Grounds, Md., and Watervliet Arsenal at Troy, N.Y. In addition, Picatinny will inherit research and development in small-caliber weapons systems, as well as fire control functions now conducted at other locations.

The plans call for expenditure of $30 million to $40 million over the next 10 years to construct new research and engineering facilities at Picatinny. Furthermore, Lockwood estimates that 70% of 2,218 jobs opened up at the arsenal by the consolidation there of the Armament Development Center will be for scientists, engineers and other professionals.

To keep track of new technological developments, Lockwood has formed the Advanced Concepts and Technology Group at Picatinny. The group consists of 10 senior civilian engineers and scientists, working under the direction of Sidney Jacobson. It will also evaluate proposals from industry, establish R&D priorities for the arsenal, and make R&D budget recommendations. Says Jacobson, "We've had new concepts groups here before, but they were less formal, and they didn't have any budget responsibilities." The group will also identify the low-priority programs should it ever become necessary to cut budgets.

New companies. Lockwood, meanwhile, says he would like to see more purely electronics firms ("if there is such a thing") take an interest in his development programs. "Munitions could be a new market for a lot of electronics companies," he says. "Most of the contractors we see are the same ones we've been seeing here for years. We want to see more companies. The opportunities will be there."

He cites, by way of example, the development at Picatinny of a television-camera system that would be fired from a howitzer over a battlefield, where, suspended by a parachute, it would pick up pictures of the terrain and ground action and transmit them to a command post [*Electronics*, Oct. 16, 1975, p. 31]. The crucial element in the TV camera is a sturdy array of charge-coupled devices, which serves the same function as a fragile vidicon tube. "This is an excellent example of a project we couldn't handle without an advanced technology like CCDs," the colonel says.

Similarly, arsenal engineers have breadboarded a programable calculator for use in determining trajectories, but this might be switched to microprocessors before getting to the advanced development stage.

Money available. Lockwood says he's particularly interested in companies willing to take on technical challenges. "If someone has a good idea, I think the money would be available," he says. Getting rid of the need for batteries in gear that must remain on the shelf for many years is one thing he'd like to do.

Lockwood: All of Picatinny's new systems programs will involve electronics.

Secure command communications is "another area where a lot of work remains to be done."

He also is studying a larger number of unsolicited proposals from industry. "Last year, we accepted over 40% of the unsolicited proposals made to us for R&D studies." Although total expenditures for these study contracts amounted to only $1.8 million, Lockwood indicates that many of these can be expected to receive follow-on funding. □

Commercial

Rockwell readies fingerprint systems

After spending more than 10 years and nearly $2 million, a hitherto small operation of Rockwell International Inc. is getting off to a flying start in the untapped market for completely automated fingerprint identification systems.

With a $4.7 million showcase contract for five systems from the Federal Bureau of Investigation, the Anaheim, Calif., Identification Systems department of the Autonetics Group is out on the road and selling hard. The first FBI system was delivered in November, and a California city and a state agency have bought smaller and slower latent-print ID systems. Autonetics officials believe, in fact, that the worldwide market could reach the $400 million level by as early as 1980.

Digital techniques. The Rockwell system, selected by the FBI in 1974 over one developed by Calspan Corp., Buffalo, N.Y., applies digital techniques to solve one of the most labor-intensive tasks faced by law enforcement—to classify and file the sets of fingerprints used at all levels of police work. The FBI alone adds more than 22,000 new sets each day to a repository that already holds 21 million. Since this avalanche of cards is still processed manually by clerks, it often takes days to answer an inquiry about the identity of an unknown print.

Although data-processing tech-

niques could remove this bottleneck, the problem has been one of first digitizing the fingerprint patterns and then finding a way to encode them for automated processing, filing, and retrieval. In 1966, Rockwell began a program using "minutiae," the relative location and direction of points where print ridges end or fork, as the basis for pattern recognition and classification.

The Rockwell system consists of three cabinets, the first containing a high-speed card transport and flying-spot optical scanner for reading and digitizing the prints. The middle unit holds a keyboard and monitor for calling up prints, two preprocessors that aid in the pattern recognition and classification, and tape transport gear. The third cabinet has a Digital Equipment Corp. PDP-15 computer that controls the system and support equipment.

The system can digitally encode 600 10-finger cards per hour. But it does not derive this ability from special hardware, according to Richard E. Snyder, who manages the Autonetics department. Rather, the key lies in the proprietary programing developed over the years into the firmware that directs the two dedicated preprocessors. These select relevant minutiae from digitized fingerprint pattern and classify them.

Patterns. Upon receiving the digital pattern of each print, the first preprocessor converts it from levels of gray to an enhanced, binary image. Then the second preprocessor takes this image, and by means of pattern-recognition algorithms, identifies and locates minutiae, through X-Y coordinates. At the same time, another algorithm divides each set of prints according to the traditional "Henry classification" method using whorls, loops, and arches. With 32 data bits required to describe each minutiae point, which average 100 per finger, each set of 10 fingerprints uses 32,000 bits.

Once a law-enforcement agency has built its data base of prints, the system can compare an unknown print against the known file at the rate of 250 prints per second. □

Components

Datel backs off on hybrid prices

Setting prices too low has gotten Datel System's new hybrid facility off to a shaky start. The Canton, Mass., company, one of the country's top five module houses for data-conversion products and signal-conditioning circuits, is taking its initial hybrid data converters off the market. It is replacing them with a more extensive line of somewhat superior devices at considerably higher prices.

Originally, Datel aimed directly at competitive devices. Its first products were a pair of pin-programmable self-contained 12-bit digital-to-analog converters, priced at only $29 each, and a high-performance complete 12-bit successive-approximation analog-to-digital converter, selling for $79 in single-unit quantities [*Electronics*, Sept. 18, 1975, p. 117].

Competitive prices. By way of comparison, Burr-Brown Research Corp., Tucson, Ariz., had just two weeks earlier introduced a completely self-contained 12-bit a-d hybrid converter with a single-unit price of $129 [*Electronics*, Sept. 4, 1975, p. 131].

At the same time, National Semiconductor Corp., Santa Clara, Calif., entered the hybrid arena [*Electronics*, Sept. 4, 1975, p. 136] with an array of low-cost hybrid converters and converter building blocks. Unlike the Datel devices, National's converters are not entirely self-contained. However, its 12-bit d-a converter was pegged only slightly lower than Datel's, selling for $25 each in 100-unit quantities. National's 12-bit a-d device was only $15 to $20 each in lots of 100.

According to a company spokesman, Datel's rock-bottom prices were based on what turned out to be optimistic yield expectations—and as of April 15, the introductory products will no longer be available. Instead, Datel will be offering replacements providing improved gain-temperature stability and power-supply rejection that sell for over 50% more. In single-unit quantities, prices will be $49 each for the replacement d-a device and $149 each for the replacement a-d unit. □

Microprocessors

Signetics readies chip, design aids

Even though now lagging in the microprocessor market, Signetics Corp. is taking steps to catch up. The company is readying a three-pronged announcement: a faster, smaller version of its 2650 n-channel 8-bit microprocessor, a prototype development system, and a high-level programing language referred to as PLμS (pronounced "plus"), which is a second-generation version of PL/M, the language Intel Corp. developed for its microprocessors.

With these additions to its repertoire, the company is hoping not only to have an impact in the U.S., but also in the European market, where its parent, Philips Gloeilampenfabrieken of the Netherlands, is a formidable force.

The new chip, to be called the 2650A, has a 1.2-microsecond cycle time, twice as fast as the 2650. The chip area also will be decreased by half, implying potentially much higher yields for the device and, thus, lower costs.

Similarities. The prototype development system, called TWIN for test-wave instrument, will offer 2650 users capabilities generally similar to those that Intel's Intellec microcomputer development system with its in-circuit emulation modules [*Electronics*, May 2, 1975, p. 95] offers to users of the 8080 microprocessor. The other leading 8-bit microprocessor, Motorola's M6800, is due to be supported soon by a similar capability, called USE—user system evaluator—to be announced as an enhancement

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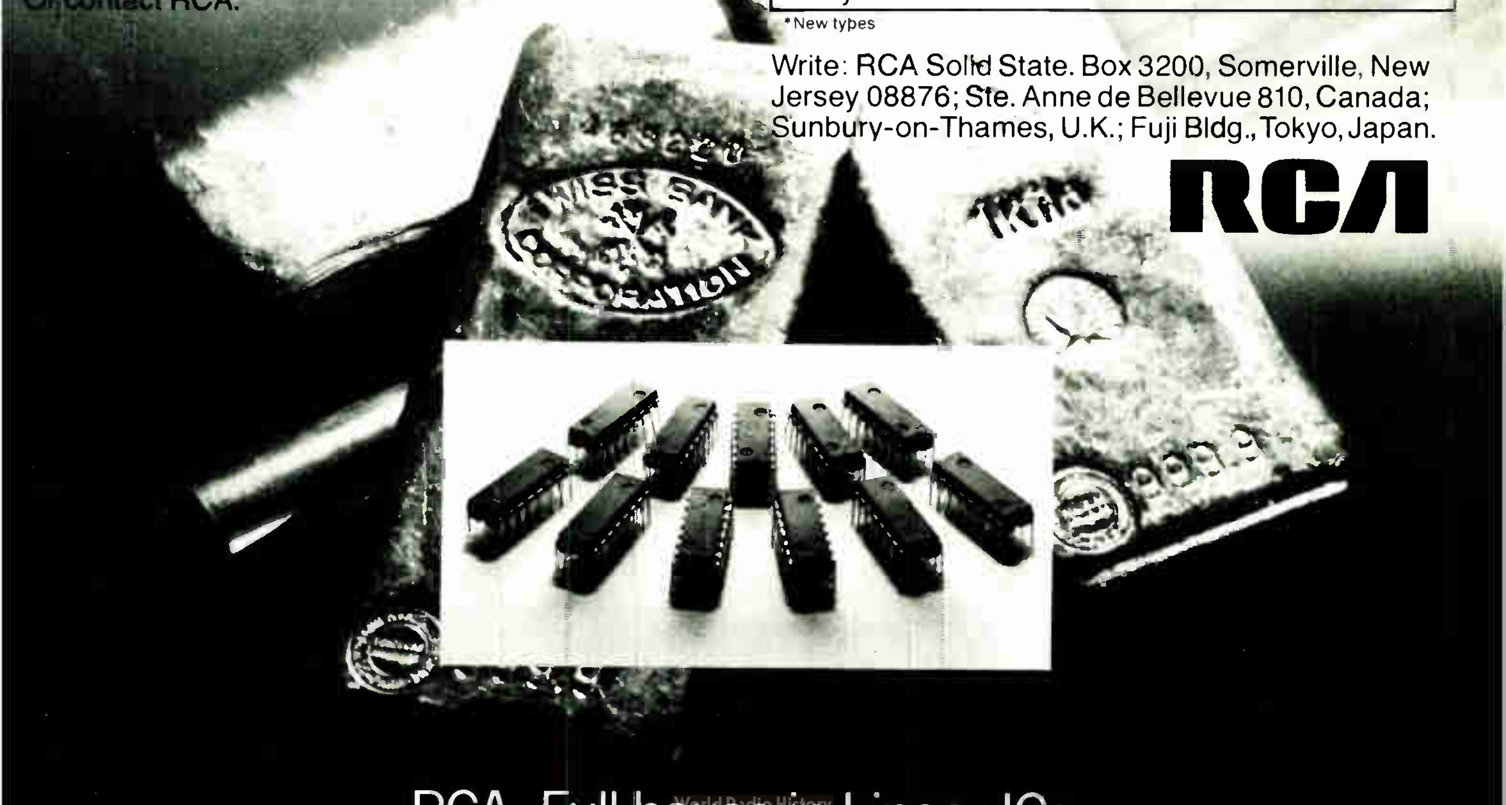

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to the company's Exorciser development system.

TWIN in-circuit emulation allows the designer to check out new software while developing the hardware that's peripheral to the microprocessor chip. This is done by connecting TWIN to the 40-pin dual in-line socket where the microprocessor will eventually operate. A microprocessor inside TWIN then emulates the action of the bread-boarded central processor. At the same time, TWIN gives the designer complete control of the processor through program-debugging. This allows such things as single-step execution of programs, insertion of breakpoints in the programs, and immediate modification of the program when an error occurs.

Master/slave. The name TWIN is derived from the use of two central processing units—a master and slave. The master executes those programs, such as the disk operating system, that are independent of the particular microprocessor chip that the designer is using. These programs are permanent—they are protected from being overwritten by the slave. The slave, on the other hand, executes programs, such as assembler and editor, that are related to the microprocessor being used. In the present version of the TWIN, both master and slave are Signetics' 2650s, but future systems could be made to handle new microprocessor chips simply by changing the slave CPU.

The TWIN processor and its floppy-disk operating system were designed for Signetics by Millenium Information Systems Inc. of Santa Clara, Calif. The PLµS compiler design effort was headed by software consultant Gary Kildall, who did much of the work on Intel's earlier PL/M compiler [*Electronics*, June 27, 1974, p. 103].

The compiler is a multipass type that can run on either 16-bit or 32-bit host processors. Price of TWIN begins at $7,000 for a minimum disk-based system.

Millenium president Gerald Casilli says that TWIN can handle any 8-bit or 16-bit microprocessor, since it uses this master and slave CPU concept. In contrast, Intel's MDS can only handle 8080s, since it uses one CPU to run the operating systems and the user programs. And, unlike the MDS, Casilli points out, the master CPU's operating system is fully protected—"It's like one big ROM," he says, and cannot be wiped out during operation. □

Consumer

National adds color to television games

Full color will hypo the already booming sales of home video games. At least, that's the hope at National Semiconductor Corp., which has its sights set on a game market it estimates could reach $300 million in but a few years.

National, of Sunnyvale, Calif., is selling the MM57100, a p-channel MOS device measuring 175 by 200 mils, in a 24-pin package capable of providing all of the logic to generate in color, backgrounds, paddles, ball, and digital scoring for three games—tennis, hockey and handball.

Stephen W. Fields, National's manager for toys and games, describes the chip as a special-purpose logic processor consisting of flip-flops, NOR gates, read-only memory, and a digital-to-analog converter. And National is adopting the same strategy that has won the company a large market share in calculators and digital watches: the chip is being sold to other manufacturers while it is being used in National's own Novus line of games.

Most of the home video games and chips now available, Fields

News briefs

GE Schottky diode operates at 150 volts
A Schottky diode developed at General Electric Research Development Center, Schenectady, N.Y., operates at 150 volts—four times the usual potential. A new mesa structure boosts the voltage, according to GE. Other parameters include a forward drop of less than 0.7 V at 50 amperes and a reverse breakdown of more than 100 V.

Marisat malfunctions after orbit
Problems cropped up affecting signal strength on both the up and down links of the commercial C- and L-band channels of the first maritime communications satellite, launched Feb. 19 over the Atlantic Ocean. The problems are in 44 duplex teleprinter circuits and one two-way voice channel, approximately 25% of the satellite's capacity. The remaining 75% of Marisat's circuits dedicated to Navy use are working properly.

Hand-held wand reads hand-printed numerals, letters
Keytronic Corp., Spokane, Wash., claims it has the first commercially available hand-held "wand" for reading hand-printed and machine-printed alphanumerics. The wand recognizes several numeric fonts, the standard OCR-A font, and hand-printed numerals, as well as five hand-printed letters.

FAA picks TI over Hazeltine for DABS
Texas Instruments Inc. has won an $11.9 million Federal Aviation Administration development contract for three test ground stations and 30 airborne transponders to be used in a two-year test of the discrete address beacon system for air-traffic control. First delivery is planned for late next year. The TI hardware will be equipped to provide intermittent positive control for a later ground-based collision-avoidance service, the FAA said. Hazeltine Corp. was the other finalist for the award [*Electronics*, Feb. 5, p. 36].

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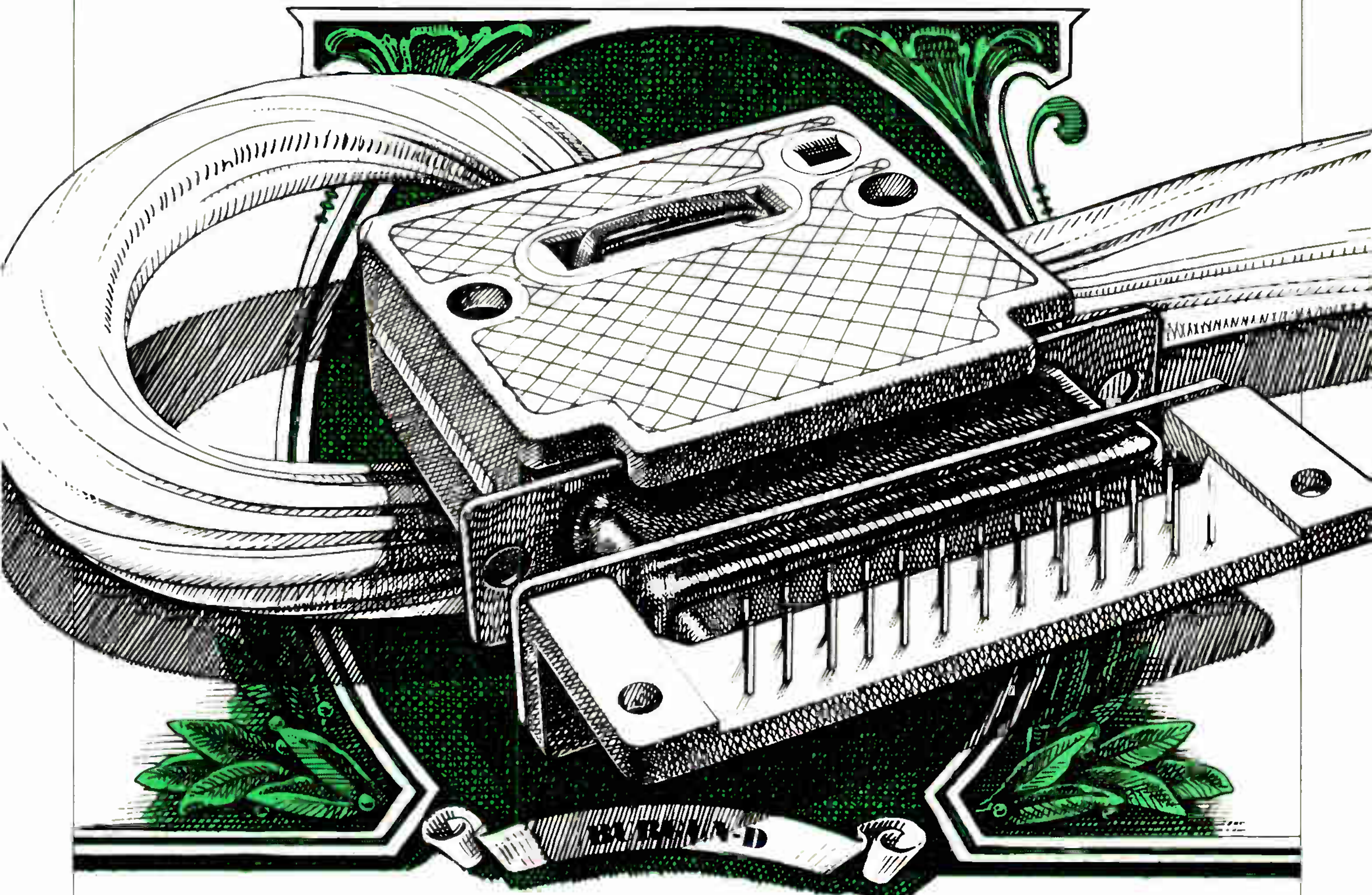

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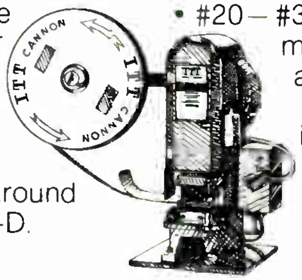

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points out, are in black and white. A few purport to be in color, but they are basically in black and white on a pseudo-color rainbow background. But the MM57100 chip, he says, modulates a 3.56-megahertz signal generated by an external crystal oscillator, onto a video carrier—a channel four 67-MHz signal, for example—to generate a sideband. "When this is fed into the 3.58-MHz demodulator in most standard color-TV sets, a beat-frequency range is generated to create a rainbow effect on the screen—green and blue on the left, yellow in the center, and red on the right," Fields says.

Richard Simone, consumer-MOS-design manager, explains that the $9 National chip generates specific color signals for each game. For example, tennis has a green court with a blue border, a yellow net, orange paddles, and a light green ball.

To generate the color information, the opening and closing of analog switches connected to a resistor string in the p-channel MOS d-a converter are controlled by digital information decoded from the logic portion of the chip. "When the beam sweeps across a portion of the TV screen that is supposed to be a green playing field," says Fields, "a series of bits is generated instructing the resistor-ladder network to put out an analog voltage representing that color. This information can then be fed to any standard chroma unit containing a set of balanced demodulators which then produces the proper color vectors."

The chroma unit needs a 3.58-MHz subcarrier signal, derived from a separate crystal. The same crystal provides true and complementary 1.022-MHz clock signals by dividing down the 3.58-MHz subcarrier.

Video output. The chip also generates video output signals containing horizontal and vertical blanking and synchronization, as well as the black-and-white information for generating a picture on a TV receiver. Chroma outputs provide the color and burst information properly timed with the video—the chroma leads the video by about 600 nanoseconds at the chip to allow for the delay of a low-pass filter.

If the chip is used in a unit that interfaces to the antenna, an external audio rf modulator is also needed, as well as crystal oscillators. Other external components are two RC networks to control the paddles and game-select and reset switches. The chip draws about 675 milliwatts and is powered by a line-voltage adapter that furnishes -9- and -15-volt inputs. □

Photovoltaics

Solar-cell effort pushed by Europeans

European researchers are excited over what they see as strong near-term potential for the application of photovoltaic solar cells. That was the drift of a conference on solar electricity held in early March in Toulouse, France.

Henry Durand, director general of the Laboratoires d'Electronique et de Physique Appliquée, a Philips group facility with a strong record in developing silicon cells, told the Toulouse meeting that he expects the production capacity for terrestrial-grade cells to increase substantially over the next few years.

Progress. Durand's estimate: a leap in production capacity worldwide from something like a 150-kilowatt peak yearly now to about 1-megawatt peak yearly by 1980. With that kind of impetus, there's plenty of incentive to edge up efficiencies of silicon cells percentage point by percentage point. And a lot of work is going into improving thin-film cells—most often cadmium sulfide—which may one day be better than silicon cells.

Durand's own outfit, in fact, had a much improved silicon-cell concept to talk about at Toulouse. Developed by a team led by Jacques Michel, the so-called black cell combines improvements on both the front and back that point to a gain in output of 10% or so above that of conventional silicon cells.

The cell has an n^+/p^+ structure;

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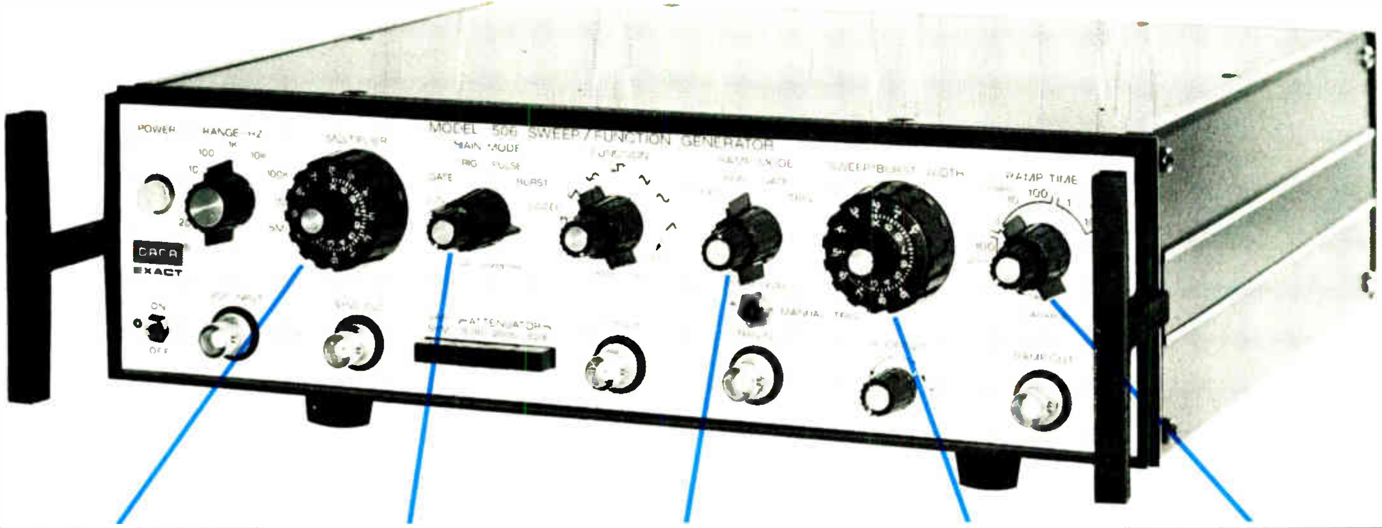

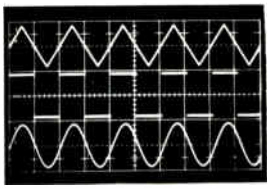

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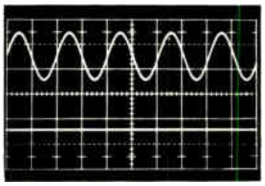

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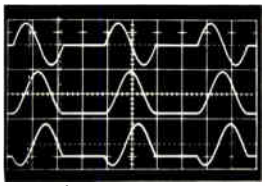
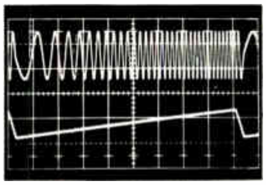
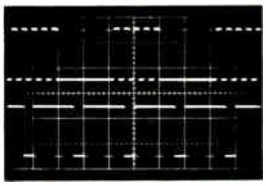


3. Variable Start/Stop control permits varying start/stop point 360 degrees in trigger, gate, pulse and burst modes.



4. Calibrated Sweep Width control uses Kelvin-Varley divider to set stop frequency to let you know precisely where you're sweeping without measuring with a counter.



5. Ramp Time sets the duration of the ramp and the sweep time in the sweep mode and also independently sets repetition rate and duty cycle in pulse mode.

more reasons the Exact Model 506 sweep function generator is the most waveform generator ever sold for $495:

TWO-IN-ONE. A main generator for sine, square, triangle, pulse and sync, *plus* a ramp generator for sweeping or triggering the main generator, or for use as an independent signal source.

WIDE BANDWIDTH. 0.1Hz to 5MHz frequency range, with ramp time of 10 μsec to 100 sec. (.01Hz available on the main generator.)

SWEEP. Ramp generator can sweep main generator over a 1000:1 range. Sweep width adjustable from zero to 3 full decades.

PULSE. Independently variable width and repetition rate.

TRIGGER/GATE. Both generators can be triggered (one shot) and gated (burst) independently.

SEARCH MODE. Main generator can be swept manually over 3 decades.

VERSATILE RAMP. Ramp available at main output and via its own connector. (Convenient for x-y and Bode plots.) Ramp gate output connector on rear panel can be used as a pen lifter or for blanking or unblanking.

COMPACT. Only 10cm high, 38.3cm wide, 30.7cm deep. Weighs only 4Kg. Simple maintenance because all components values, test points and calibration adjustments are printed on the P.C. card, identified and easily accessible.

LOW COST. Model 506 only $495. Model 507 with linear and logarithmic sweep, $595. Model 504 with trigger and gate, but without sweep, $450.

DANA® EXACT electronics, inc.

Subsidiary of Dana Electronics, Inc.

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(503) 648-6661 TWX 910-460-8811

the p^+ layer on the back is about 0.5 micrometer thick and sets up an electric field that inhibits recombination of photocarriers on the back contact, cutting losses there. But more important, the front has a textured surface that cuts reflection down to about 10% without any antireflective coating. This is done by etching the silicon surface with hydrazine pyrocathine, which produces tiny pyramids about 10 μm high; they reflect light back down into the cell. Just as important, the etching adds no process steps. "You just substitute one solution for another," Michel points out. RTC-La Radiotechnique-Compélec, the French semiconductor producer in the Philips group, has adopted the idea and has a one-year program under way to evaluate its potential.

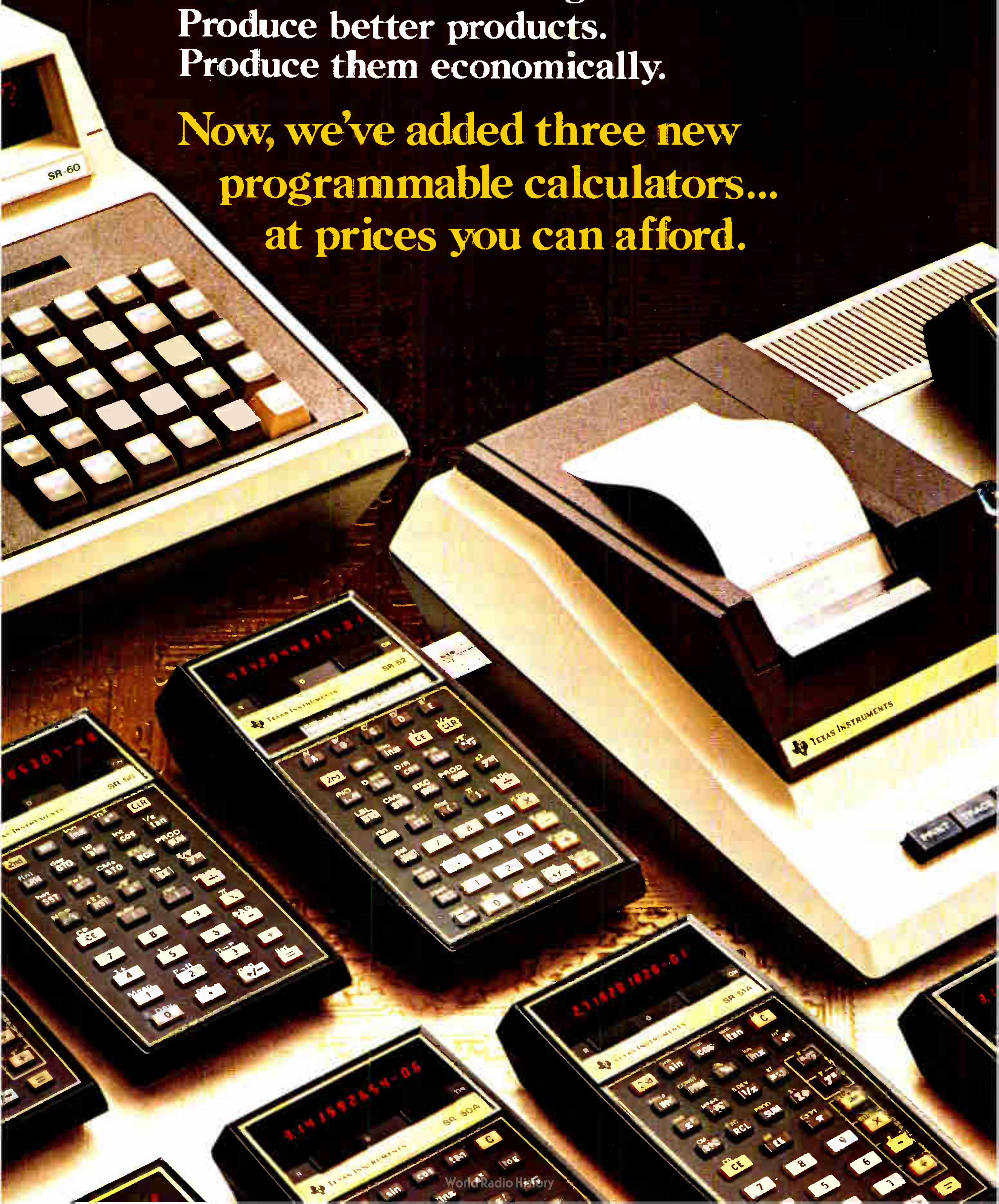
Technologies. The proponents of single-crystal silicon have perhaps another decade to keep edging up efficiency and whittling down prices of their solar cells. But around the mid-1980s, Durand predicts, polycrystaline silicon and other semiconductor materials like cadmium sulfide will start taking over because they're inherently cheaper. These are some of the more promising efforts reported at Toulouse:

- Cadmium sulfide films sprayed reactively onto glass substrates. This potentially low-cost technique is being worked out in France by the Société Anonyme de Télécommunications, among others.
- Doped tin-oxide films. They serve all the functions of a transparent contact layer, a protective layer, and an element in a heterojunction. The Laboratoires d'Electronique et de Physique Appliquée, Philips' Labs in Eindhoven, and a group at the Languedoc University of Science and Technology at Montpellier are among those exploring this line. The Montpellier people think efficiency of 8% is possible for this type of cell.
- Metal-insulation semiconductors. This effort is to find interface layers that will boost the low 2% to 3% efficiency of metal-semiconductor cells. Very thin ion-implanted layers and treatment by hydrogen fluoride show promise. ☐

Technology.

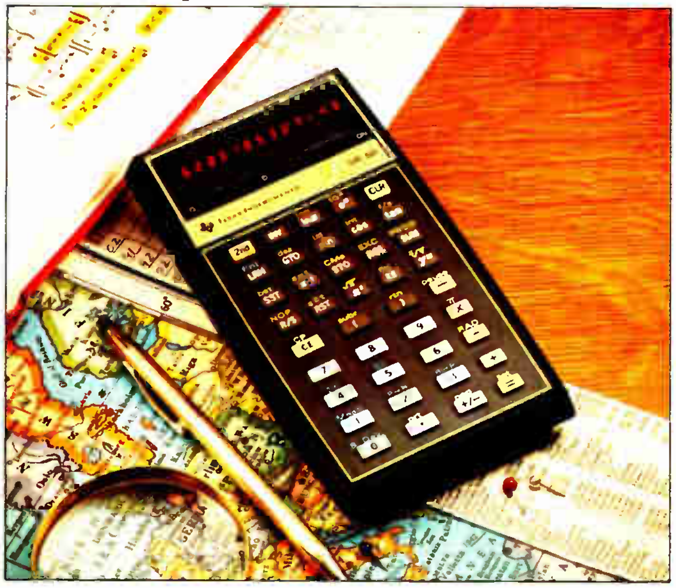
At Texas Instruments, it is the foundation of a double goal: Produce better products. Produce them economically.

Now, we've added three new programmable calculators... at prices you can afford.



Choose the right programmable ...and problems that once took hours can be solved in seconds.

SR-56 Key programmable. Full programming capability at an economical price.



SR-52 Pocket-card programmable. Records your programs for instant use. Anytime, anywhere.

SR-60 Prompting, printing, card programmable. Bridges the gap between calculators and computers.

SR-60

A prompting, programmable, printing calculator with an alphanumeric display that communicates with the user. $1695.00*

The SR-60 card-programmable, prompting, printing calculator is designed to bridge the gap between simple desktop calculators and computers. A powerful asset to business and technical operations alike. Delivering capability found only in programmable desktop calculators costing far more.†

Its business capability ranges from solving intricate financial analyses and long-range forecasting, to simpler operations like payroll and amortization.

For technology there are 46 scientific functions on the keyboard and 480 program steps for complex programming. This capacity can be expanded to 1,920 steps and 100 data memories with its optional module.

Prompting: The SR-60's unique 20-character display lets the user run alphanumeric programs which "ask" for information at successive stages of the problem. The SR-60 then waits for your response before continuing. This dialogue allows even a novice to work with complicated problems immediately.

Programming: Is easy and straightforward yet flexible for the user with: 78 labels, 10 flags, 10 branches, 4 levels of subroutines, and 2 modes of indirect operation. Plus, complete program editing capability. And, by using the printer you can list and trace the actual program execution.

Programs are easy to write and record on magnetic cards. With alphanumeric prompting, the cards can be used by assistants or secretaries. A person merely needs a minimum amount of instruction and a general concept of what's to be solved to have answers to you in seconds.

Ten prerecorded cards are included in the SR-60's Basic Library: Power transformer and filter design. Add-on rate installment loans and compound interest. Polynomial evaluation, cubic and quadratic equations. Basic statistics. Random number generator and diagnostics. Well over 100 optional additional programs are available, including many on business.

Printing: The SR-60's quiet printer provides a scaled replica of what appears on the alphanumeric display on 2½-inch thermal paper. You can get a hard copy of any keyboard calculation that appears on the display, a complete program list of the contents of the data registers, whether entered from the keyboard or run from a program card.

SR-52

An easy-to-use card programmable. Bringing you exceptional power wherever your work happens to be. At an exceptional price. $395.00*

The SR-52 is a card programmable calculator offering twice the capability of the only other programmable in its class – at half the price.† TI's advanced technology and start-to-finish quality control is the key to this exceptional value.

With an SR-52, complex repetitive problems or lengthy calculations that once took hours can now be solved in seconds. Chances for error are dramatically reduced.

The SR-52 allows you to record up to 224 keystrokes. Programming is simple and straightforward, even if you've never programmed before. Programming cards are available which can be integrated into your problem solving routines. Repeat your program as often as needed. Change values of known quantities. Explore "what-if" possibilities. Solve for different unknowns. Optimize designs.

Enter calculations exactly as you would state them – left-to-right. The SR-52's nine levels of parentheses, plus its 11-register stack, allow you to enter problems containing up to 10 pending operations.

Operating versatility: You literally teach the SR-52 your own calculating methods. Key in your program directly from the keyboard. If you wish, record your program on a magnetic card to use again and again.

Used manually, the SR-52 is one of the most powerful handheld, slide-rule calculators available today.

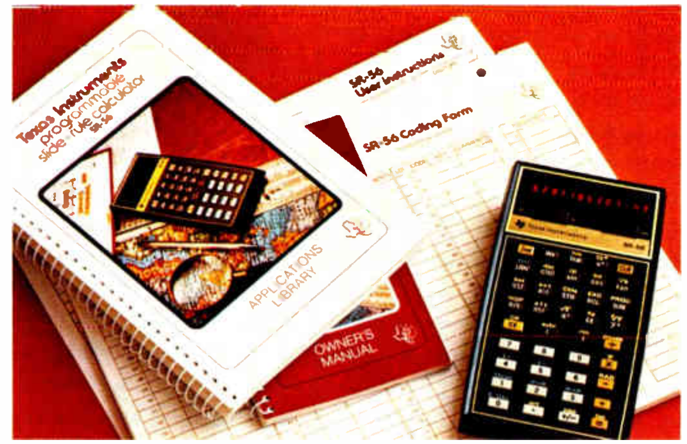
The Basic Library that comes with the SR-52 includes these prerecorded programs: Conversions. Solution of Quadratic Equations. Hyperbolic Functions. Prime Factor of an Integer. Complex Arithmetic. Checkbook Balancing. Compound Interest. Ordinary Annuity. Trend Line Analysis. Permutations and Combinations. Statistical Means and Moments. Random Number Generator. High and Low Pass Active Filter. Dead Reckoning. Lunar Landing Game. Diagnostics.

Optional libraries are also available: Statistics (with 25 different programs). Math (31 programs). Electrical Engineering (22 programs). And Finance (19 programs). And more are on the way.

*Suggested retail price
†Based on suggested retail prices of models available at the time of this printing

SR-56

A key programmable that provides tremendous mathematical power and value. And at an economical price. $179.95*



With TI's new SR-56, you get an easy-to-use, yet powerful state-of-the-art calculator that reflects Texas Instruments state-of-the-art technologies. It's able to handle extremely difficult computational problems with 100 programming steps and nine levels of parentheses that handle up to seven pending operations. Yet it is simplicity itself to key program.

With the SR-56's internal 8-memory stack, you can store and recall data. Add, subtract, multiply or divide within a register without affecting the calculation in progress. Now you can optimize mathematical matrices. Explore multiple "what-if" options. Solve lengthy iterative and repetitive problems with speed and efficiency. And much more.

Six logical decision functions and four levels of subroutine permit branching to appropriate program segments automatically – without interrupting the program. You may also write-over errors, erase unneeded keystrokes. Reviewing a program is easy with single and backstep capability.

Two unique features: A special test register permits comparison with the displayed value at any point in a calculation – without interfering with the calculation in progress. This means you can make quick checks of intermediate results for possible pass along to subroutine operations.

A pause key causes the display to be visible for a half-second during program execution. You may also use it to single step through your entire program.

Easy to use: Supply your input data then automatically execute the solution of your stored sequence with a single key. Get answers without the tedium of remembering and executing repetitive keystrokes.

Iterative and repetitive problems, statistical reduction, mathematical modeling, optimization, etc., are entered directly into the SR-56's program memory from the keyboard. Two looping control instructions give you single-key control. There are also four levels of subroutines. They execute instructions from the main program, or from another subroutine. On completion, control returns to the calling routine, automatically.

Operated manually, the SR-56 easily handles your day to day problems using the 27 arithmetic and transcendental functions including: Trig, logs, conversions and statistics.

PC-100: New optional printer turns an SR-52 or SR-56 into a quiet, high-speed printing calculator. $295.00*

The PC-100 operates with TI's handheld programmables – the SR-52 and SR-56. It delivers hard copy right on the spot. Perfect for printing out a businessman's long amortization schedule, or each step of a scientist's iterative problem.

Printing can be controlled by keys on the PC-100 or by keys on the calculator. Simply remove the calculator's battery pack. Then press the calculator firmly on the PC-100's connectors. Lock it in place and you're ready to print whatever appears in the SR-52 or SR-56 display register.

The PC-100 prints a "list" of your entire program step-by-step, including the program code. You may halt it whenever you wish, or begin printing from any point in the program. This makes the PC-100 invaluable for checking whether you have keyed-in the instructions correctly – match tape against your coding sequence. Edit and debug your program. Or, verify that your results are based on a correctly formulated program.

Using the PC-100's "trace" mode delivers a complete audit of every number and function you've used.

The quiet, reliable electronic printer uses thermal tape 2½-inches wide and prints out characters in a five by seven dot matrix.

The technological achievement beneath the keyboard is the reason TI's programmable calculators offer so much value for the price.

A programmable calculator is a state-of-the-art product reflecting state-of-the-art technologies. It's logical, then, to look first to the manufacturer known worldwide for both – Texas Instruments.

TI has long been a leader in solid-state technology and has pioneered a series of landmark developments relating directly to calculators: The original integrated circuit. Key patents in basic MOS/LSI technology. The "calculator-on-a-chip" integrated circuit which became the heart of miniature calculators. And the basic patent on the miniature calculator itself.

TI is steeped in calculator technologies from start to finish, making all critical parts and controlling quality every step of the way. And that's the key to the exceptional quality and value of TI programmable calculators.

The programmable calculator ...it can help you make the best choices, the right decisions...day after day.

Personal programming is here.

Economical programmable calculators may well be more significant to business and industry than were slide rule calculators introduced just a short time ago.

Why? Because the programmable calculator introduces a new dimension in problem solving. It decentralizes and personalizes the decision-enhancing power of the computer – bringing to the individual what before was only available to the organization.

Now you can cope with more data, explore with more insight, far more successfully than ever before. Right at the source. On the spot, and right at the moment it is most important. Immediately.

So you make better decisions. In the conference room. In the laboratory. In the field. Wherever decisions have to be made. Better decisions chosen from more options – better decisions founded on a broader data base. Better decisions from more fully optimized trade-offs. Better decisions in a profession where better decisions are the name of the game.

Indeed a programmable calculator is a powerful personal mathematical resource. And you don't need to know programming to put it to work. There's no special language to learn. The entry system is easy to use, and so flexible that you can apply it to your own personal problem-solving techniques and style.

Chances are, you already own a calculator – perhaps a sophisticated one. Chances are, too, that you found it exceeded your expectations right from the start...that you grew into it, and it magnified your professional capability far in excess of its cost.

Now personal programming is here. A step-function increase in capability over sophisticated slide-rule calculators. Capability you can put to work now to further strengthen your contribution. Capability you won't fully discover until you've owned one and explored its potential for yourself. Capability to enhance decisions of far greater importance than the cost of the model you choose. You will find your programmable is a high-leverage investment.

Most of the important functions found on computers are available to you on TI programmable calculators: Iterative and repetitive problem solving techniques. Looping. Conditional and unconditional branching. Flags. Subroutines.

Consider for a moment the advantages, in terms of increased productivity, achieved with this capability of: Developing broad what-if matrices. Optimizing mathematical models. Making trend and risk analyses. Projecting and forecasting more accurately. Performing statistical reductions. Automating time-consuming "number crunching". The list could go on and on.

The programmable calculator's capability is in the very mainstream of today's fast-paced, competitive world. A pivotal means of responding to the pressures of making accurate, objective, cost-effective decisions. Faster.

Texas Instruments offers three choices of programmable calculators. This allows you to more precisely match your programming requirements to capability and price.

Each is compact. Easy to use. And of great value for the price. The direct result of leading edge technology developed and practiced at Texas Instruments.

AOS...the new choice that makes it easy.

Most handheld professional calculators use either algebraic entry or Reverse Polish Notation (RPN). Texas Instruments chose algebraic because it is the most *natural* to use with easy left-to-right entry.

The user can put the calculator to work immediately...there's no new language to learn.

Now there's a new dimension: TI's *full* Algebraic Operating System – AOS. Whether you currently own a calculator with algebraic entry, or Reverse Polish Notation – or no calculator at all – you can move into programming smoothly and naturally with TI's full AOS. No system is easier to master.

The case for algebraic is straightforward: It lets you key the problem just as you would state it. TI programmables with full AOS combine full algebraic hierachy with nine levels of parentheses.

Full algebraic hierachy means that sequence of entry is left-to-right, while the sequence of operations is in the accepted convention of the way mathematical operations are ordered: Functions are performed first, then powers and roots, then multiplication or division, then addition or subtraction. For example, the SR-52's nine levels of parentheses, plus its 11-register stack, allow you to enter problems containing up to 10 pending operations. (That's more than three times the capability of its nearest competitor.)

With TI's Algebraic Operating System, you don't have to presolve a problem or search for the most appropriate, efficient order of execution.

The case for TI's Algebraic Operating System is strong – that's why Texas Instruments chose it. If you evaluate the alternatives, we think you'll agree you'll prefer AOS. But, even if you are conditioned to Reverse Polish Notation, the added value and power of TI's programmable calculators with full AOS is well worth the easy transition.

TI's high-capability slide rules and programmables.

Operating Characteristics	SR-50A	SR-51A	SR-56	SR-52	SR-60
Digits displayed (mantissa + exponent)	10 + 2	10 + 2	10 + 2	10 + 2	10 + 2
Calculating digits	13	13	12	12	12
Limited precision	—	—	—	—	•
Fixed decimal option	—	•	•	•	•
Roundoff (selectable)	—	—	—	—	•
Memories	1	3	10	20	40*
Store and Recall	•	•	•	•	•
Clear memory	—	•	•	•	•
Sum to memory	•	•	•	•	•
Subtract from memory	—	—	•	•	•
Multiply into memory	—	•	•	•	•
Divide into memory	—	—	•	•	•
Exchange display with memory	—	•	•	•	•
Indirect memory addressing	—	—	—	•	•
Exchange x with y	•	•	—	—	—
Exchange x with t	—	—	•	—	—
Parentheses levels	—	—	9	9	9
Maximum number of pending operations	—	—	7	10	10
Constant mode	—	Select	—	—	Select
Angular mode (deg/rad)	•	•	•**	•	•

*Optional add on for 100 memory **Also grads

Calculating Characteristics	SR-50A	SR-51A	SR-56	SR-52	SR-60
Log, lnx, e^x	•	•	•	•	•
10^x	—	•	•	•	•
x^2, $\sqrt{x}$, $\sqrt[x]{y}$, $1/x$, π	•	•	•	•	•
x!	•	•	•*	•	•
%, Δ%	—	•	•*	•*	•
Int x (integer part)	—	—	•	•*	•
2nd Int (fractional part)	—	—	•	•*	•
Trig functions & inverses	•	•	•	•	•
Hyperbolic functions & inverses	•	•	•*	•*	•
Deg/min/sec to decimal deg & inverse	—	•	•*	•	•
Deg to Rad conversion & inverse	•	•	•*	•	•
Polar to retangular conversion & inverse	—	•	•	•	•
Mean, variance and standard deviation	—	•	•	•*	•*
Linear regression	—	•	•*	•*	•*
Trend Line Analysis	—	•	•*	•*	•*
Slope and intercept	—	•	•*	•*	•*
Automatic permutation	—	•	•*	•*	•*
Random number generator	—	•	•*	•*	•*
Metric conversion constants	—	13	•*	•*	•*

*Programmable functions

Programming Capability	SR-56	SR-52	SR-60
Program steps	100	224	480*
Merged prefixes	•	•	—
Program read/write on magnetic cards	—	•	•
Data memory read/write on magnetic cards	—	—	•
Alphanumeric display	—	—	•
Program prompting (Que)	—	—	•
User defined keys	—	10	15
Possible labels	—	72	77
Absolute addressing	•	•	•
Subroutine levels	4	2	4
Program flags	—	5	10
Decrement & skip on zero (loop)	•	•	—
Conditional branching instructions	6	10	6
Unconditional branching	3	2	2
Indirect branching	—	•	•
Editing: Step, backstep	•	•	•
Insert, delete	—	•	•
NOP	•	—	—
Single step execution	•	•	•
Pause	•	—	•

*Optional add on for 1920 steps

SR-50A and SR-51A offer exceptional slide rule math power and value ...at $79.95 and $119.95, suggested retail prices.

SR-50A: Solves complex scientific calculations as easily as simple arithmetic. Full function, on-the-go portable featuring algebraic entry with sum-of-products capability. Performs trig and hyperbolic functions, logs, e to the x power, xth root of y and much more.

SR-51A: Exceptionally powerful. Performs all functions found on the SR-50A, and more: Mean, variance and standard deviation. Permutations. Slope and intercept. Trend line analysis and linear regression. Has 20 preprogrammed conversions and inverses.

Texas Instruments Incorporated
P.O. Box 5012 M/S 98
Dallas, Texas 75222

Please send me full information on:
☐ SR-60
☐ SR-52 ☐ SR-56 ☐ PC-100
☐ SR-51A, SR-50A

Name ____________
Title ____________
Company ____________
Address ____________
City ________ State ________ Zip ________

TI, IR, D, DN, MD, EF, FDN, SA, E

TEXAS INSTRUMENTS
INCORPORATED

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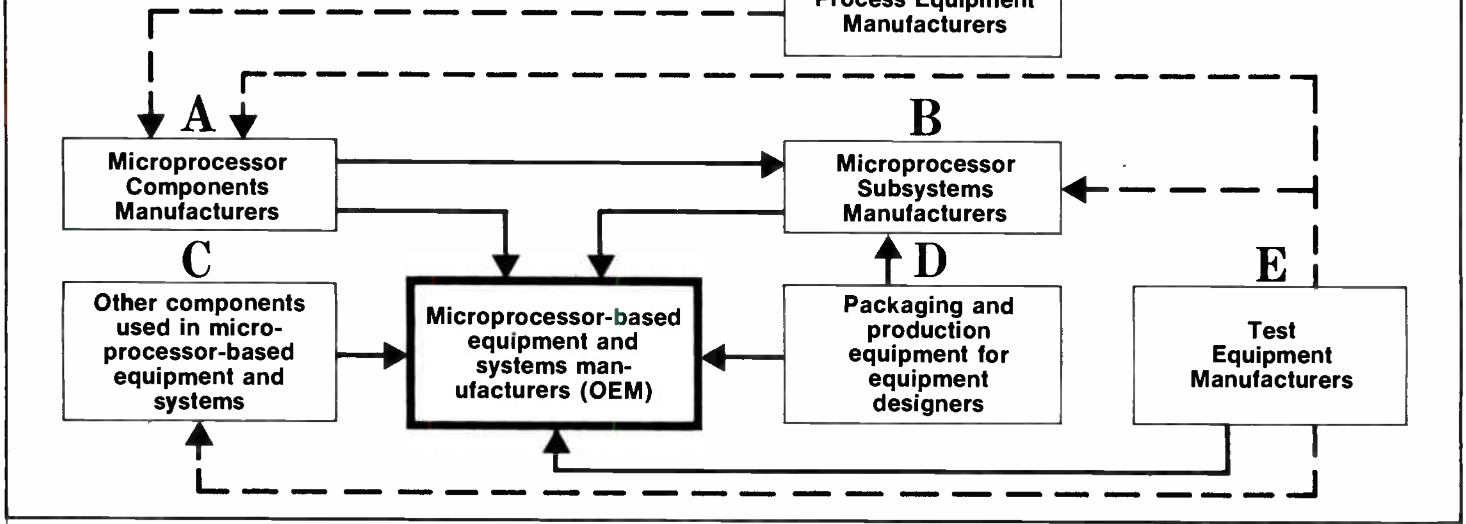
You are looking at our illustrated guide to the microprocessor explosion.



Who sells what to whom: Solid line indicates products specifically directed to companies identified in diagram. Dotted lines show other products used by the companies described.

This year, microprocessor companies alone will account for sales of $133.6 million, up from $67.7 million in 1975. Microcomputer sales contribute another $170 million. Plus the sales of equipment, instruments—all the products listed below:

A Microprocessor components
- ☐ chips
- ☐ random-access memories
- ☐ read-only memories
- ☐ programmed logic arrays
- ☐ I/O circuits

B Microprocessor Sub-systems
- ☐ microcomputers
- ☐ microcomputer boards
- ☐ application & system prototypes

C Other components used in microprocessor-based equipment and systems

Analog and linear circuit devices
- ☐ interface circuits
- ☐ analog-to-digital converters
- ☐ digital-to-analog converters
- ☐ operational amplifiers
- ☐ comparators
- ☐ voltage regulators
- ☐ sample and hold circuits
- ☐ modems
- ☐ multiplexers
- ☐ analog switches
- ☐ power supplies

Peripheral-devices
- ☐ terminals
- ☐ printers
- ☐ other input output devices

Miscellaneous components
- ☐ lamps
- ☐ switches
- ☐ potentiometers
- ☐ trimmers
- ☐ keyboards

Sensors
- ☐ temperature
- ☐ pressure
- ☐ flow
- ☐ strain

Displays
- ☐ incandescent
- ☐ LED
- ☐ fluorescent
- ☐ gas discharge

D Production & packaging products sold to micro-processor users and equipment manufacturers
- ☐ PC boards
- ☐ connectors
- ☐ wire and cable
- ☐ cabinets, chassis
- ☐ card files
- ☐ test fixtures
- ☐ breadboarding hardware
- ☐ IC socket panels
- ☐ IC sockets
- ☐ wire-wrapping equipment (machines, guns)
- ☐ fans & cooling equipment
- ☐ soldering equipment

E Test equipment
- ☐ logic analyzers
- ☐ logic probes
- ☐ oscilloscopes
- ☐ automatic board testers
- ☐ LSI device test equipment
- ☐ automatic test equipment
- ☐ pulse generators

F Products sold to micro-processor and IC manufacturers
- ☐ silicon
- ☐ chemicals
- ☐ computer-aided design and layout, hardware and software
- ☐ masking equipment—cameras, aligners & exposure
- ☐ diffusion furnaces
- ☐ ion-implanting equipment
- ☐ wafer scribers
- ☐ optical inspection equipment
- ☐ IC probes
- ☐ film carrier tapes and assembly equipment
- ☐ lead frames
- ☐ wire bonders
- ☐ plastic packaging equipment
- ☐ ceramic packages

Every major technical disclosure in micro-processors has been introduced in Electronics. If your company makes any of the products listed above, your best advertising opportunity to sell them is in the magazine that continually publishes the most current coverage of microprocessors—Electronics.

Intense reader interest is evidenced by the runaway success of our recent book of micro-processor articles from Electronics magazine. Over 7,700 copies have already been purchased by *our readers* for $6.95 (pre-pub) to $8.95.

The "big spenders" buy and read Electronics. 41.5 per cent of our subscribers who recommend, approve, or specify our advertisers' products are responsible for purchases between $50,000 and $1 million a year.

Coming April 15—an example of our continuing coverage—a 60-page special report: "Microprocessors Today."

Closing date: March 22.

Call your local Electronics salesman today.

Electronics' April 15 issue will contain the most complete and comprehensive report on microprocessors yet published.

Opening with a wide-ranging report based on interviews with industry leaders, the report will discuss the effects of microprocessors on equipment design, and will be a complete guide to what's available—from cpu's to memories, input-output devices and other components.

The report will also cover what engineers need to know about software, about starter kits, courses, and design costs. And, it will offer detailed examples of outstanding and innovative designs with microprocessors in actual applications.

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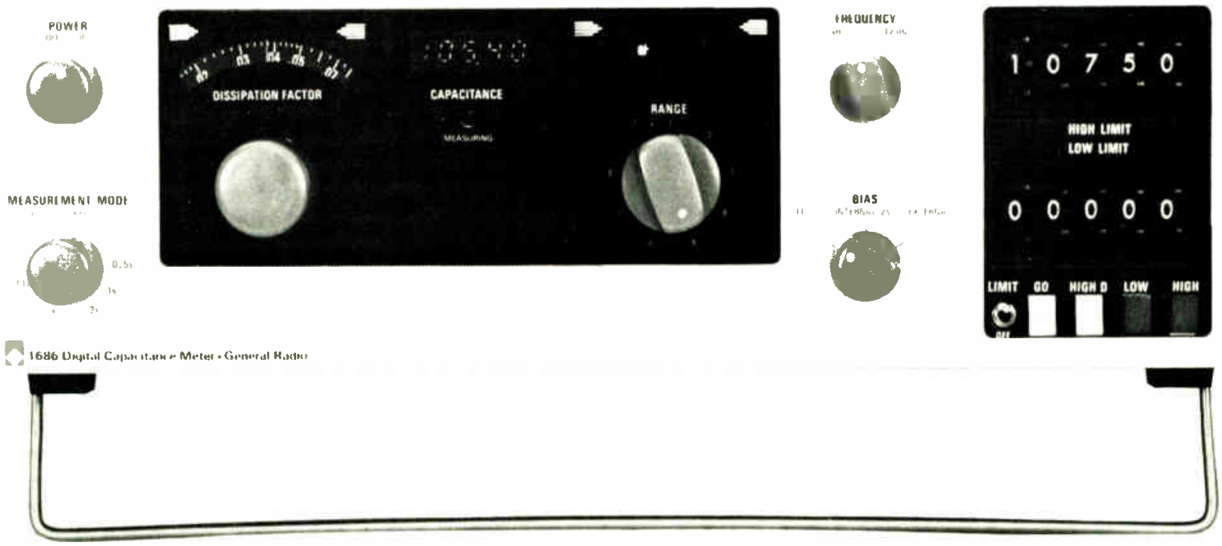
NEW

Digital Capacitance Meter permits High-Volume Testing with 0.1% Accuracy... for only $2785



• Automatic measurement • Automatic GO/NO-GO indications for C and D • C range is 0.01 pF to 20,000 μF • 120 Hz *and* 1 kHz test frequencies • Adjustable test voltage • 0.1% basic accuracy • Internal and external bias • Fast — 250 millisecond *unqualified measurement time* • Data output (BCD)

GR's new 1686 Digital Capacitance Meter provides the rapid throughput you need for high-volume testing **plus** the high accuracy you need for lab and QC work. Add to these two features wide measurement range, a built-in limit comparator, two test frequencies, and an attractive low price and you can easily get the idea that we have pulled off a performance/price breadthrough in measuring capacitance. Furthermore, no instrument is easier to operate. Anyone can master the 1686's operation in a matter of minutes, partly because of the Pass/Fail lights on both the insturment and on the optional test fixture.

To get the full story, request a copy of the Data Sheet on the GR 1686. Better still, ask for a demonstration.

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(formerly General Radio)

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FCC plans inquiry as AT&T protests Dataspeed rejection

A full-scale inquiry to determine where data communications ends and data processing begins is being readied by the Federal Communications Commission. The review is being set up as a result of American Telephone & Telegraph Co.'s strong protest of the Common Carriers Bureau's rejection of its plan to offer a new Dataspeed 40 service on the gounds that it is data processing, a business AT&T is barred from entering by the 1971 FCC computer-inquiry decision. AT&T contends that Dataspeed 40/4 is data communications and says it will "pursue all possible legal means to obtain a reversal of this decision."

The preliminary judgment represents a victory for International Business Machines Corp. and the computer industry, which opposed the AT&T plan [*Electronics*, Jan. 8, p. 34]. Dataspeed 404 would permit synchronous transmissions of data as well as private-line voice channels over AT&T's Dataphone digital channels at 2,400 and 4,800 bits per second.

Navstar award for user hardware models to Collins

The first two development models of military hardware for use with the Navstar Global Positioning System will be developed by Rockwell International's Collins Radio group, Cedar Rapids, Iowa. Being developed under a $3.4 million contract from the Air Force Avionics Laboratory, a complete system includes a phased-array antenna, receiver, data processor, inertial-measurement unit, and assemblies for control/display and interface. Employing 1,575- and 1,227-megahertz signals from as many as four of 24 Navstar satellites, **the navigator will be able to determine his position within 10 meters anywhere in the world in any of three dimensions.** The first two models will undergo flight tests for anti-jam performance during an eight-month period beginning in the summer of 1977.

Japan's share of color-TV imports climbs to 86%

Japan's share of the 1975 U.S. import market for color-television receivers jumped to 86% from 70% in 1974 after a sharp upturn in second-half shipments. A new Commerce Department analysis of last year's home entertainment electronics market says that Japan's first-half shipments fell 29% to 312,000 receivers, reflecting a downturn in the domestic-TV market, **but then climbed to 702,000 sets in the last six months.** As imports from Japan increased, those from Taiwan dropped to 138,000 from more than 200,000 the year before. The 1975 color-TV import market declined 8.2% to 1.18 million units from 1.28 million in 1974. Dollar value of imports of all home entertainment products fell $383 million to $1.52 billion—20% below the 1974 level.

Five get $990,000 from ERDA for 46 kW of solar cells

Contracts worth $990,000 have been signed with five companies by the Energy Research and Development Administration to produce 46 kilowatts of solar cells for terrestrial power generation [*Electronics*, Nov. 13, 1975, p. 40]. Pending an upcoming contract for another 130 kW of cells, the five contracts represent the largest single purchase of solar cells for power generation. The awards by NASA's Jet Propulsion Laboratory, ERDA's program manager, include: Solarex Corp., Rockville, Md., for 10 kW at $289,000; Spectrolab Inc., Sylmar, Calif., for 10 kW at $252,000; Solar Power Corp., Wakefield, Mass., for 15 kW at $205,000; Sensor Technology, Inc., Chatsworth, Calif., for 8 kW at $160,000, and M7 International, Arlington Heights, Ill., for 3 kW at $84,000.

Washington commentary

Bell's bill bombs with Congress

Motivating the Congress is somewhat different from leaning on a state regulatory commission, as American Telephone & Telegraph Co. chairman John deButts is beginning to find out. Under deButts' leadership, AT&T has been rounding up support of its Bell System affiliates, other telephone companies, and state regulators in a major political drive to get Congress to wipe out competition in telecommunications [*Electronics*, March 4, p. 34]. While AT&T got quick and near-unanimous support for its endeavor from the National Association of Regulatory Commissioners' executive committee at the end of February, the company's first attempts to find backers in the Congress have flopped.

Instead of lining up the hoped-for 50 members of Congress behind the introduction of what Capitol Hill now calls "the Bell bill," AT&T turned up only one, Wyoming Democrat Teno Roncalio. As his state's only House member, Roncalio dropped H.R. 12323 into the legislative mill early in March. He calls it "a bill to reaffirm the intent of Congress with respect to the structure of the common carrier telecommunications industry." Bell's name for it is "the consumer communications reform act," a euphemism that seems to have fooled no one.

Pastore's refusal

Though Roncalio is hardly a House heavyweight and not even a member of the Interstate and Foreign Commerce communications subcommittee that would have to clear the bill, AT&T has done better in the House than in the Senate. At mid-month, AT&T's batting average in the upper chamber was zero. Despite a personal visit by chairman deButts and a squad of senior AT&T executives to the offices of Sen. John O. Pastore, the Rhode Island Democrat turned the company down cold. Pastore, the chairman of the Commerce Committee's communications subcommittee, not only refused to introduce the bill, but also passed the word that his subcommittee would in effect scuttle legislation introduced by anyone else by simply refusing to schedule hearings on the bill.

Yet this combination of opposition and indifference to AT&T's initial lobbying efforts has not deterred chairman deButts. Long committed to restoring AT&T's autocracy in American telecommunications, he is intent on his program to set aside nine years of judgments in favor of competition by the Federal Communications Commission and the courts and turn the clock back to 1967. It is a program that FCC Common Carrier Bureau chief Walter Hinchman has aptly labeled "suicidal."

Experienced Washington lobbyists for high-technology electronics and aerospace clients are not in the least surprised by AT&T's initial failure. As one of them summarized it, "This is an election year, and 'big business' is not exactly a popular cause on Capitol Hill right now, especially after the embarrassments of Lockheed, Mobil and the rest," the payoffs on foreign sales, and the illegal corporate contributions to domestic political campaigns. Beyond that, Bell's timing is also bad. In the spring of an election year, congressional thoughts and energies invariably turn home and the challenge of reelection.

Why all the fuss?

Other reasons behind AT&T's failure to garner political support include some important economic issues. Colorado's freshman Democrat, Rep. Tim Wirth, went to the lion's lair to give his views on those issues to a Bell corporate policy seminar at Princeton, N.J., this month. A member of the House communications subcommittee, Wirth recalled that "none of the specialized carriers has yet broken even on its telecommunications operations. And none of the terminal manufacturers describes its business as being much advanced from a toehold. Given this state of affairs," he told the Bell executives, "it is difficult to understand the dimensions of your alarm."

Some in the telecommunications industry say Bell's alarm was set off by the long-term threat of International Business Machines Corp.'s proposed market entry via Satellite Business Systems Inc., a joint venture with money-laden Aetna Life & Casualty Co. and Comsat General Corp. as partners. "That plus AT&T's nightmares that you and I and the rest of their residential customers may one day be able to buy their handsets at Walgreen's are the principal reasons for Bell's concern," explains another industry executive.

Holding back the tide of technological advancement is virtually impossible, as Bell Laboratories demonstrates year after year with its myriad patents. Holding back the useful application of new technology, however, is something else. AT&T has demonstrated its ability to do this many times before the FCC. In a sense, the company has brought competition upon itself. And at the Federal level, at least, AT&T cannot legislate that away.

—Ray Connolly

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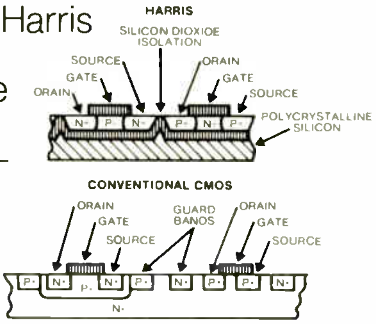
E 3/18/76

CAN THE ANALOG SWITCHES SYSTEM PASS THE HARRIS

The Harris Personality Test asks important questions about the behavior pattern of your system. In doing so, it'll help you determine whether your analog switches and multiplexers are as trouble-free as they should be. Of course, our own popular pin-for-pin compatible CMOS switches and multiplexers will be used as the standard of comparison. Why not see how your system measures up (Test results on opposite page).

1. Does your system have a latch-up problem that it can't cope with?

With the Harris devices, you have nothing to worry about. They're problem-free. That's because each MOS transistor on the chip is surrounded by an insulating layer, so no four-layer parasitic SCR's could ever be created.

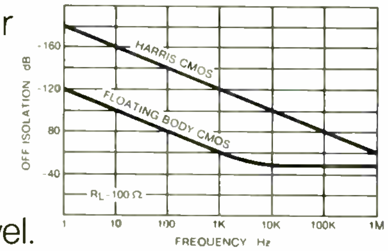


2. Does your system ever feel restricted on the sequence of power?

If it does, your system may have a slight disorder. The Harris analog switches and multiplexers never feel any restriction on sequence of power. And that goes for signal application or removal as well.

3. Does your system compromise its performance to achieve latch-free operation?

Harris has no such maladjustment. Leakage currents, capacitances, AC crosstalk are equal or better than the best of the other brands. And switch parameters are essentially independent of analog level.

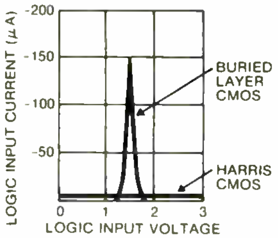


4. Does your system need extra support in order to give you on-board resistor-diode protection in all digital address inputs?

(In order to prevent failures during the handling of loose PC cards.) Harris doesn't need any. We have all the support we need on the same device.

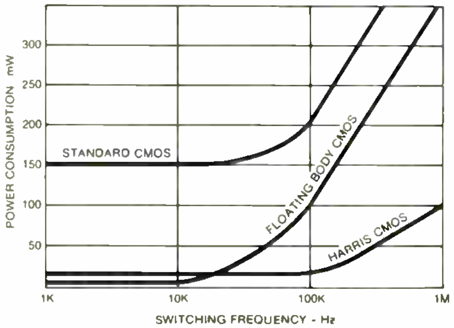
5. Do your systems' digital address inputs have severe negative resistance characteristics in their personality?

Many times this can cause double triggering or oscillations with TTL drive. Harris is free of this personality defect.



6. Do your systems' supply currents sometimes get very high when they shouldn't?

You can count on Harris supply currents to remain low, even when switching at 100 KHz rates!



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AND MULTIPLEXERS IN YOUR PERSONALITY TEST?

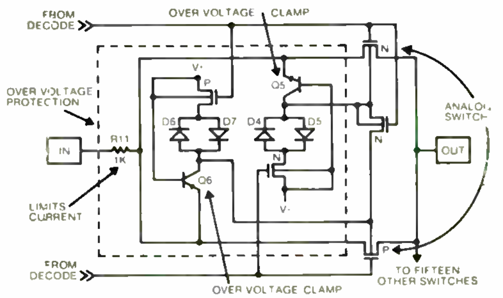
7. Do you find that your system has more burnouts from voltage transients than it should for its age?

Harris devices are much more immune to those kind of things. In fact, we invite you to test our devices side-by-side with yours in the usual bread-board environment, and you'll see what we mean.

8. Does your system feel insecure because it can't offer you extra protection in critical situations?

For example, in a system where multiplexer input signals come from outside the equipment and the signal lines could pick up induced voltage spikes, static electricity, or have signals present when the MUX power is off. Well Harris feels very secure with its HI-506A/507A/508A/509A Overvoltage Protected Multiplexers which can withstand up to ± 35 volts continuously or over 1000 volts momentarily on an analog input. The internal protection networks not only prevent system damage, but prevent the

PROTECTED MULTIPLEX SWITCH



overvoltage spikes from appearing at the MUX output. As a result, the only tradeoff is added ON resistance, which you'd have to create externally to protect any other MUX. So, if you need overvoltage protection, Harris can give it to you. On the chip, featuring the same low leakage currents with inherent low error, but without additional cost. If protection is not your problem, then you can choose from the industry's largest selection of switches and multiplexers, which retain all the other personality traits.

ANALOG CMOS DEVICES AND MULTIPLEXERS
Data based on information available 1/1/76

PRODUCT DESCRIPTION	HARRIS	SILICONIX	INTERSIL	ANALOG DEVICES	FOR MORE INFORMATION CIRCLE NO. ON REPLY CARD
MULTIPLEXERS:					
Over voltage protected					
16 Channel	HI-506A				226
8x2 "	HI-507A				227
8 "	HI-508A	DG-508			228
4x2	HI-509A	DG-509 non-protected			229
Non-protected, low ron					
16 Channel	HI-506	DG-506	IH-5060	AD 7506	230
8x2	HI-507	DG-507	IH-5070	AD 7507	231
8	HI-1818A			AD 7501* /7503	232
4x2	HI-1828A			AD 7502*	233
SWITCHES					
Dual DPST	HI-1800A				234
Quad – SPST – (600 Ω)				AD 7516 AD 7519	
75 Ω					
Dual SPST	HI-200	DG-200	DG-200	AD 7513	235
Quad SPST	HI-201	DG-201 (150 Ω)		AD 7501* /7511*	236
SPST	HI-5040		IH 5040		237
Dual SPST	HI-5041		IH 5041		238
SPDT	HI-5042		IH 5042		239
Dual SPDT	HI-5043		IH 5043	AD 7512*	240
DPST	HI-5044		IH 5044		241
Dual DPST	HI-5045		IH 5045		242
DPDT	HI-5046		IH 5046		243
4PST	HI-5047		IH 5047		244
30 Ω					
Dual SPST	HI-5048		IH 5048		245
Dual DPST	HI-5049		IH 5049		246
SPDT	HI-5050		IH 5050		247
Dual SPDT	HI-5051		IH 5051	*not pin for	248
DPDT	HI-5046A			pin inter-	249
4PST	HI-5047A			changeable	250

Test score results.

If you've answered "yes" to any of the Harris Personality Test questions about your system, then maybe it's time you talked to a Harris distributor or representative. We offer a complete line of analog multiplexers and CMOS switches. Available now. All with healthy, trouble-free constitutions.

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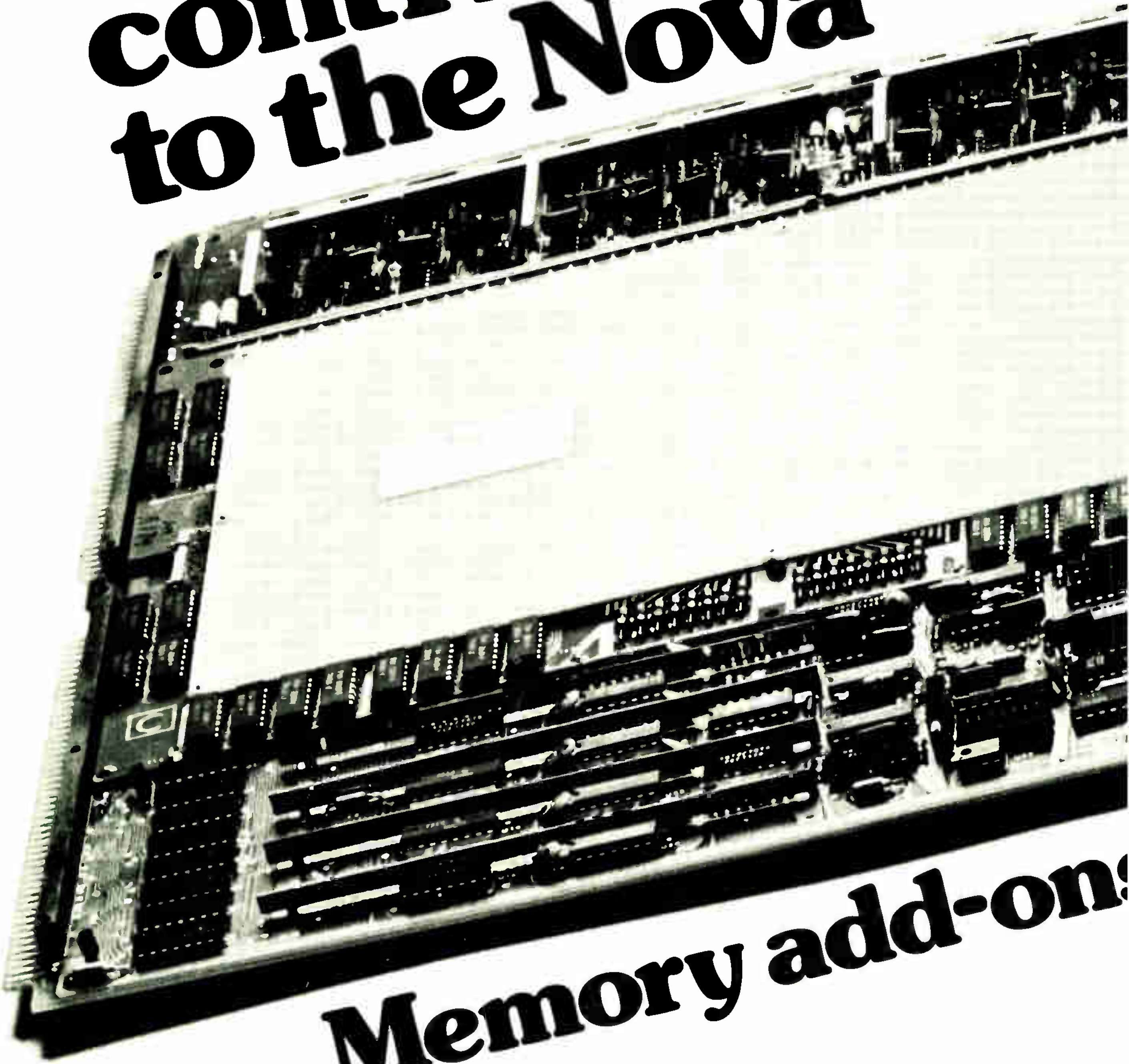
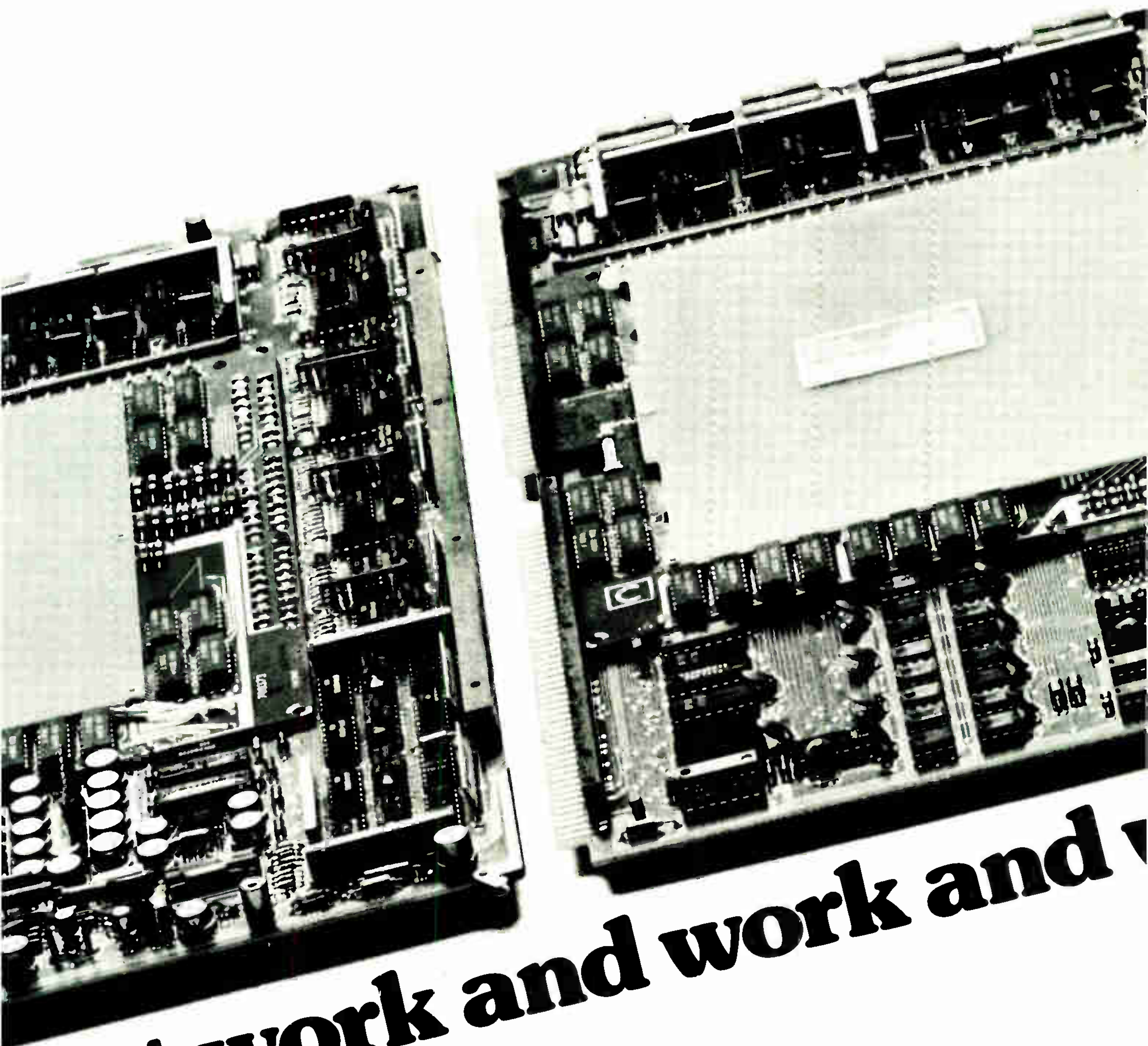
Plessey's contribution to the Nova



Memory add-ons



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If you've got a NOVA mini, Plessey Memories can save you more than money.

Our 16k PM-216 core memory module saves time on your NOVA 2/4 or 2/10, with a cycle time of just 800 nS.

Our PM-816 saves a slot in your NOVA 800, 820 and 840 cpu, with 16k words on a single plug-in card. It is also plug-compatible with the NOVA 830. And with the 800 nS Plessey PM-816 an expanded NOVA 840 costs less than a slower NOVA 830 with DGC memory.

There's just no reason to pay more for less.

So use the bingo card and get all the details on our NOVA (and DEC) add-ons—compatible memories, memory management and support equipment. They're all competitively-priced and available off-the-shelf.

Or if your problems won't wait, phone for a demo and get Plessey Memories working for you today.

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The mini expanders

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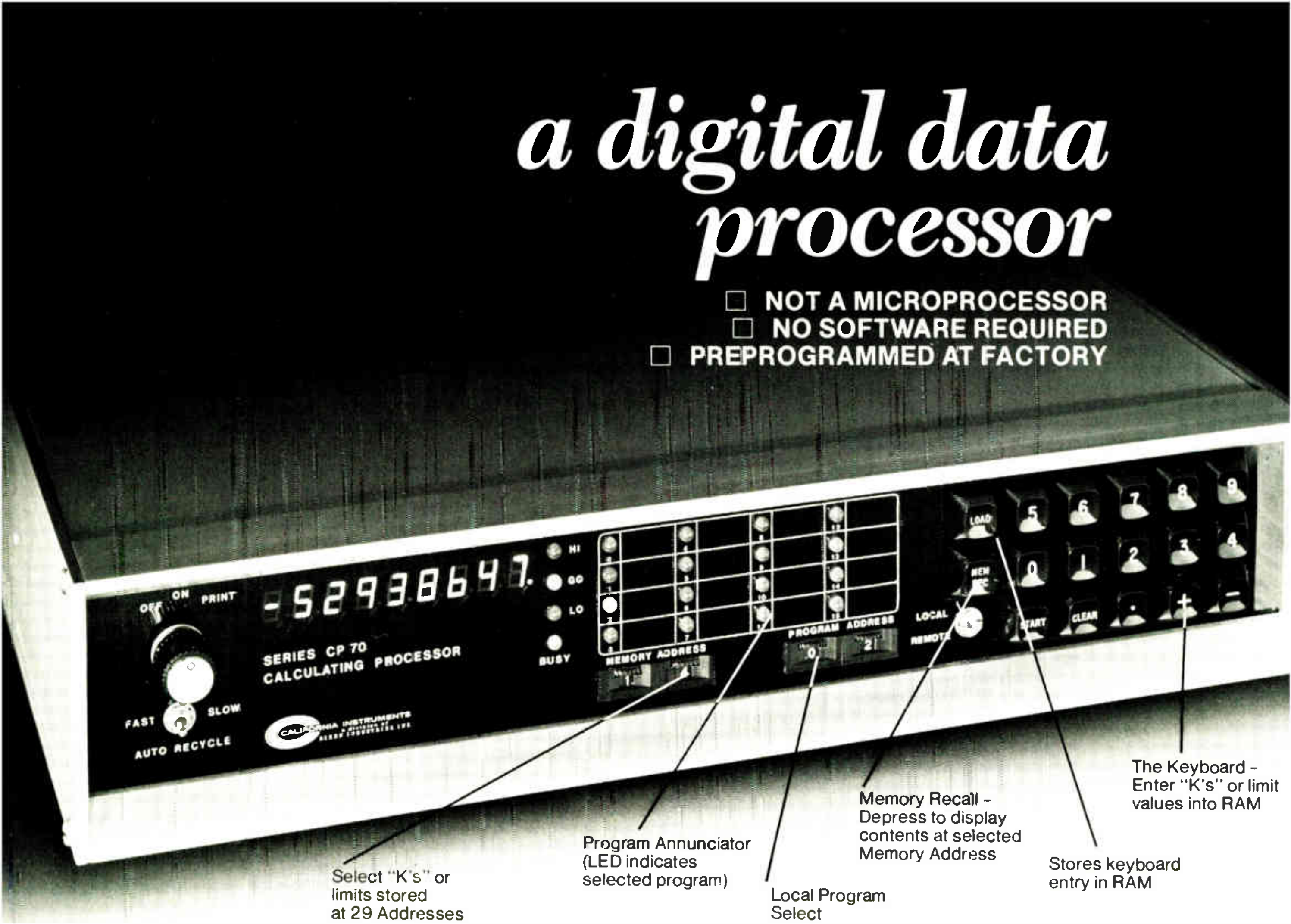
Circle 67 on reader service card



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The CP 70A closes the gap between individual digital measuring instruments and computer-based digital data acquisition systems. It accepts digital data from up to three separate sources and operates on these data according to equations stored in a plug-in Programmable Read-Only Memory. The basic CP 70A stores from one to eight equations in a single plug-in EPROM, but another may be added to double the equation storage capacity. The plug-in EPROM's let you keep an unlimited number of programs on hand, with a choice of equations ranging from two-term addition to third-order polynomials. If you need only measuring and calculating power don't buy mass memory or expensive software. Save time, trouble, and money with a CP 70A. Call or write for detailed information.

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Circle 68 on reader service card

Plessey and Ferranti aim at designers with several uncommitted logic arrays

The market in uncommitted logic arrays (ULAs) should expand after Plessey Semiconductors announces a 196-cell device early in April at the Paris components show. Like chief competitor Ferranti Semiconductors, Plessey will soon bring out several bigger and better ULAs.

Both manufacturers are aiming these versatile devices at the many designers who can profit from low-volume custom circuits that cost less for the combination of high speed and low power consumption than either complementary-MOS or transistor-transistor logic. To be sure, the logic arrays cannot compete with TTL or C-MOS circuits either in straight speed or low power demand, but the arrays are limited only by the upper speed requirements of TTL, Ferranti says.

Their versatility is what makes ULAs so attractive. Plessey's new device, for example, is a 14-by-14 matrix of unconnected cells on a diffused silicon chip of 147 by 154 mils in which the voltage rails come up through the substrate. Each cell consists of four resistors, one emitter-coupled pair of transistors, and a single transistor. As with Ferranti's method, it can be interconnected into custom logic patterns with only one row of metalization.

Next. Near year-end, Plessey will announce a 1,000-cell ULA made with integrated injection logic. Like the 196-cell device, it uses Plessey's Process Three planar-processing technology.

Ferranti plans to follow its three-year-old 187-cell ULA with three new ones made with its collector-diffusion-isolation technology. The new devices are: a low-power version that needs only 10% as much current as the 100 milliwatts at 5 volts of the present one; a high-speed 225-cell device due before year-end, and, soon thereafter, a 500-cell version optimized in speed and power for microprocessor applications.

A ULA now available is equivalent to about 60 gates and replaces some 40 TTL packages. Typical values are a gate delay of about 20 nanoseconds and clock rates of 10 megahertz for shift registers with speeds up to 30 megahertz.

A designer, by obeying process-design rules, can order a low volume of random-logic devices and get them into production within eight weeks. In terms of cost, a buyer would pay about $20,000 for the design, engineering, and production of 2,000 16-lead plastic-packaged ULA circuits or about 400 40-lead ULA circuits in ceramic packages. Conventional circuits would cost about $40,000 for the design plus a minimum order for 100,000 devices. □

Around the world

Sony memory tube has metalized target on glass

A memory tube being developed by Sony Corp. in Japan is expected to provide a better price-performance index than such memory devices as magnetic disks, semiconductor memories, and other tubes. The Sony tube, based on the vidicon, is likely to minimize production costs because the photoconductive target of the vidicon is replaced by a glass target with a metalized pattern. The tube is 26 millimeters in diameter by 200 mm long, with a socket at each end.

Made of the same materials and by the same method as masks for fabricating ICs, the tube's glass wafer is much less expensive than the silicon wafer of an earlier tube from RCA Corp., and precise dimensions are easily achieved. The Sony target has a glass substrate with a chromium layer about 0.1 micrometer thick. The pattern etched in chromium exposes memory-surface dots or stripes of the glass substrate. For the stripe pattern, alternating clear glass and chromium stripes are 5 μm wide.

The signal electrode for connection to the output is about 0.1 μm above the glass memory surface. The image is stored as charges on the dielectric of the memory surface. The glass wafer of an earlier Sony tube is about 2 mm thick, but an improved version has a wafer 40 μm thick. Erasure speed of the earlier tube is slow, but it has been cut to less than half the time—two or three TV frames—in the improved one, which also has better controls.

UK plasma etch system cuts costs, saves time

A plasma process developed by the Standard Telecommunication Laboratories in Harlow, Essex, and funded by the UK Ministry of Defence, overcomes several deficiencies in earlier plasma processes. What's more, the process is five times faster than chemical etching, and the plasma gas costs only 1% as much as the chemicals for wet etching.

The process, called Plasmatrode, not only etches silicon dioxide and aluminum, but can handle such materials as silicon nitride, polysilicon, tantalum, molybdenum, tungsten, and multimetal structures. Etching rates can be chosen precisely for the various materials and combinations. The system comes in a $30,000 manual system and a $36,000 automatic model—about 20% higher than comparable acid-chemical units.

The process will be introduced in early April at the Paris components show and in September at the Wescon show in Los Angeles by Electrotech of Abercarn, South Wales, which makes the equipment under license. Plasmatrode will be marketed in the U.S. by E.T. Equipments, Commack, N.Y., and E.T. Systems Inc., Santa Clara, Calif. Wafers are etched by a glow-discharge plasma between radio-frequency electrodes in a vacuum chamber.

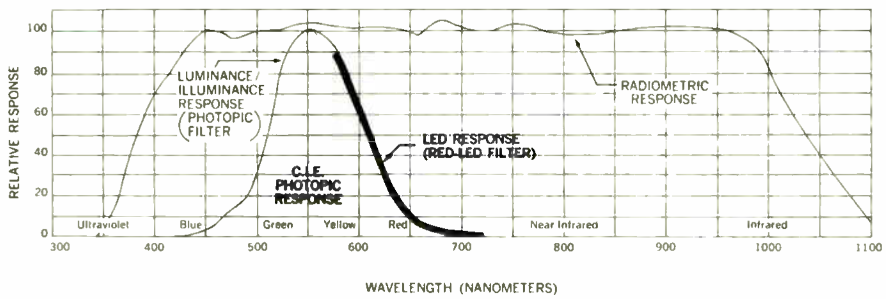
How to be sure what your display is really displaying.

As a sensor of light there's no substitute for the human eye. But when it comes to objective measurements of brightness level, color, uniformity or resolution of CRTs, alpha-numeric displays, LEDs, LCDs and light sources, it's another story. For that the eye needs help. And that's where our single-purpose, low cost light-measuring instrument comes in: The Spectra® SpotMeter™.

Look At It This Way

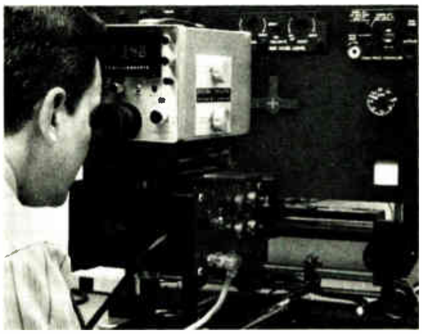
The Spectra SpotMeter is a self-contained, all-solid-state direct reading precision photometer specifically designed to accurately measure the brightness level of all types of light sources—at distances from 2½" to infinity—without any data correction or changing of lenses.

Models UBD and SPRD: CIE photopic eye response from 400 to 700 nanometers; model SPRD includes radiometric response from 375 to 1100 nanometers.



Two-In-One Lens

Behind it all is the Macro-Spectar™, a high-resolution, low flare, precision-ground lens that lets you use the photometer for telephoto or for micro measurements of light sources — as small as 0.010" in diameter—for brightness (luminance), contrast, uniformity and relative color coordinates.



High Sensitivity

The Model UBD SpotMeter features a built-in, highly sensitive photomultiplier tube, an eye-response filter, and advanced electronic circuitry for maximum stability and linearity.

Direct Readout

Direct readout of brightness (luminance) is in foot-Lamberts (fL), with full-scale sensitivity down to 0.01fL. And calibration of our UBD is traceable to NBS — your assurance of accurate, reliable data.

Simple Operation

We all know how to use a camera. And the SpotMeter is just as easy to operate. All you do is aim at the light source, focus, and read the output. It's that simple. What's more, its unique see-through optical system provides 100% alignment accuracy and zero polarization error.

More To Measure

Available for use with our UBD are optional interchangeable lenses and accessories for measuring illuminance, color temperature, MTF of displays, and more. For those who need the infrared response of a built-in silicon cell detector we offer our SPRD model — a budget-priced photometer/radiometer designed to measure both visible and infrared light sources from 375-1100 nanometers. And both the UBD and SPRD models use the same accessories.

But you don't have to know a lot about our accessories right now, as long as you know they're there when you need them. Meanwhile there may be a lot more about our Spectra photometers and radiometers you ought to know. For full technical data, write or call us, collect.

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The light measurement people

International newsletter

Microprocessors to control steel furnaces in Japan

A direct digital control system, built around 12-bit Toshiba microprocessors, has been ordered for autumn delivery to the Nippon Steel Corp., Japan's largest iron and steel manufacturer. **At $750,000, the system, which will have a supervisory Tosbac-40C minicomputer, about 130 loops, and a console with a picture-tube display in color,** is by far the largest microprocessor-based digital control system disclosed in Japan.

To be installed in a hot-strip mill in Nagoya, the Tosdic-200 system is expected to provide more accurate temperature control and better fuel economy in the five reheating furnaces than the present analog system. The control can be easily expanded, altered, or tied into a computer hierarchy. The microprocessor controls a maximum of eight loops.

Microprocessor sales predicted high in Europe . . .

Sales of microprocessors in Western Europe will increase more than 35-fold during the next decade, predicts West Germany's Siemens AG. From this year's level of around $21 million, sales will climb to $155 million in 1980 and then leap to nearly $800 million in 1985, forecasts the Munich firm. **West Germany is expected to gobble up about a third of total West European consumption:** $6.6 million this year, $55 million in 1980, and about $260 million in 1985.

Siemens, West Germany's largest electrical/electronics producer, is determined to cut itself in for a big share of the market. **The company is now marketing its own microcomputer circuits and others designed by Intel Corp. in the U.S.** It has established a microprocessor applications and software training school in Munich and plans to set up consulting offices throughout Europe and possibly overseas.

. . . as games boost UK microprocessors to vigorous sales

Games will boost the microprocessor market in the United Kingdom faster than had been expected, predicts National Semiconductors UK Ltd. The company, which now is marketing a complementary-MOS home-television game, will follow that with one based on its SC/MP microprocessor. In addition, amusement-parlor games similar to "one-armed bandits," also based on the 8-bit p-channel device, are slated to go into production this summer in a market forecast to be at least 2,500 units. The SC/MP also is scheduled for several other applications. The company is talking sales of the microprocessor with 16 manufacturers and giving design support to half of them. **Price of the SC/MP drops from $40 to $10 in volume.**

Italians double capacity of PCM speech links

Engineers of the Italian telecommunications-equipment producer Telettra have invented a way to double the transmission capacity of pulse-code-modulated speech links without any serious sacrifice in quality. **The Telettra team, headed by A. M. Molinari and F. C. Vagliani, can attain the quality of transmissions at 64 kilobits per second when transmitting at 32 kb/s.** This increase in capacity is achieved by transcoding the usual 8-bit PCM sample into samples of 3 to 7 bits, depending on the number of channels actually carrying speech information at the time.

A family of companding laws adapts the sampling to the transcoded word length and the "short-term power," which takes into account the different levels of voiced and unvoiced components of speech, for the best signal-to-noise ratio. The work was reported at the 1976 international Zurich seminar on digital communications early this month.

Swiss prepare digital watches for Basel fair

Watch for debuts of some new Swiss-made digital timepieces at the upcoming Basel Horological and Jewelry Fair, which starts late in April. Ebauches SA, which turns out some 85% of the parts used in Swiss jeweled watches, has put three digital electronic modules into production, and they'll turn up at Basel under several brand names. The Ebauches line includes men's and women's versions of a module with light-emitting-diode readout and a module with a liquid-crystal readout. **To get into production in a hurry, Ebauches has bought chip-production knowhow from Hughes in the U.S. for $1.3 million.**

At least one watchmaker plans to turn up at Basel with a watch that uses a circuit concept pioneered by the industry's Centre Electronique Horloger. This circuit uses a "loose" 500-kilohertz quartz crystal that is, in effect, "corrected" by a frequency divider adjusted by a memory to match the crystal output.

Germans establish plant in Bulgaria

A plant to produce high-voltage selenium rectifiers, mostly for black-and-white television sets, has been set up in Zepe, Bulgaria, by West German technicians of the ITT's Components group in Europe. **Bulgarian specialists have been trained at ITT's passive-components facilities in Nuremberg,** and a group of German selenium experts have been active in Bulgaria.

Japanese select civil servant to head VLSI research

With heavy government backing, Japanese computer companies are setting up an organization that for the next four years will oversee development of very-large-scale-integration technology for computers. Yssuo Tarui, a noted researcher in the Japanese government's Electrotechnical Laboratory, is expected to be appointed director of the organization. Other officials of the company, plus 40 to 50 researchers and operating personnel, are being selected from the country's five computer manufacturers and the two development groups they have formed [*Electronics*, Dec. 11, 1975, p. 56]. The laboratory will be situated in the new Central Research Laboratory recently opened on the outskirts of Tokyo by Nippon Electric Co.

The budget is expected to be about $233 million, of which about 40% will be government subsidy. Research is to begin early next year, and results are to be fed to member companies as and when they emerge. Two key research targets are growth of large-diameter crystals and development of high-resolution pattern technology.

UK company aims electronic cash register at U.S.

The U.S. market in electronic cash registers is about to be invaded by a $2,000 machine built by Gross Cash Registers Ltd., Brighton, England. The register is based on the CK114 microcomputer from American Microsystems Inc. The microcomputer consists of three p-channel MOS microprocessor chips, two 1,024-bit dynamic random-access memories, four 512-by-12-bit read-only memories, and a custom input/output chip for the character reader. **The register provides programable tables for local sales taxes and separates taxable and nontaxable items on sales checks.** Options include a tape cassette for inventory control, a light pen to read a patented bar code, and a conventional optical character reader.

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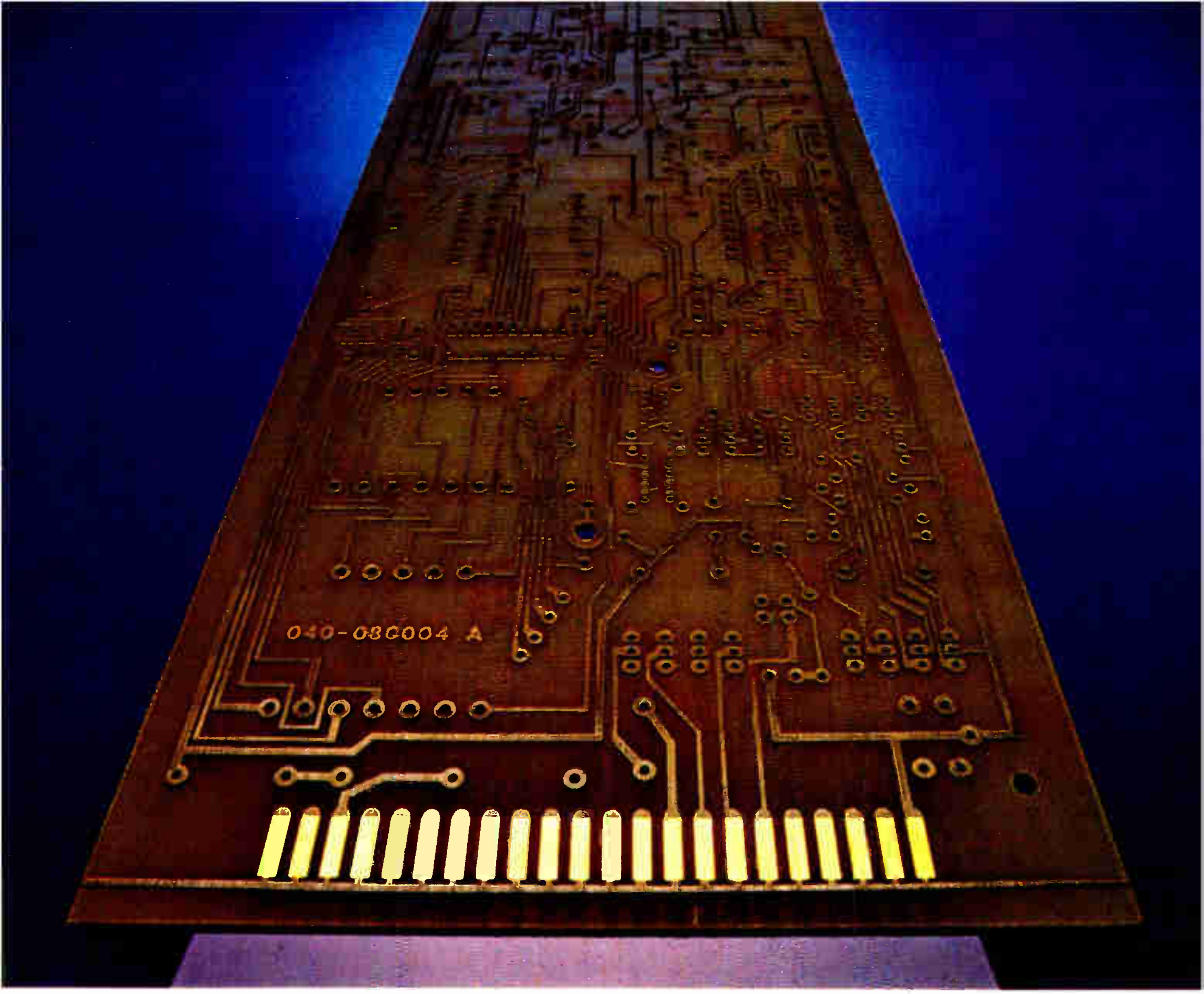
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Europeans nervous about F-16 shares

Belgium, Holland, Norway, Denmark see their $950 million worth of electronics contracts for craft being whittled away

by James Smith, McGraw-Hill World News

The arms deal of the century—the sale of $2.5 billion worth of F-16 lightweight fighters to Belgium, Holland, Denmark, and Norway—bids fair to turn into the arms squabble of the century. And a good part of the squabble centers on the electronics portion.

Contract negotiations between General Dynamics, prime contractor for the airplane; Pratt and Whitney, maker of the engines; their U.S. subcontractors, and European companies have been under way since January. Focus of the scramble is an estimated $950 million (in inflated dollars) of airborne electronic business. That's more than a third of the total co-production business that the four countries may eventually get.

Much of the noise is normal precontract bargaining. But European companies are also worried about the possible effects of runaway inflation both on their eventual share of the business and on their profits, especially if they make necessary capital tooling investments. These are thought to be particularly onerous in Norway, which has the largest single dollar share of the offset business.

The general view is that the problems will be ironed out in time for contracts to be signed as scheduled from April to July. Nevertheless, David Lewis, chairman of General Dynamics, recently called those problems "extremely difficult," and late last month the five-country steering committee, which sets policy for the program, agreed to spend most of March attempting to work toward solutions.

Belgian fears. A lot of the concern centers in Belgium. Industry there expected to receive some $680 million in total offset business, of which $205 million was estimated to be electronics, exclusively components for the F-16 radar. However, choice of the Westinghouse radar over the Hughes system in competitive bidding last November drastically reduced the anticipated per-unit cost of the system from about $270,000 in the U.S. to about $160,000, according to Belgian sources. The figures for Europe are higher because of higher production costs. As a result, the Belgian and Dutch industries, which sought out the radar in last year's co-production planning, claim their offset business on the radar is nearly halved.

What's more, say the Belgians, production of most of the radar must be divided among five companies. By agreement between the two Benelux countries, the remainder of the radar—the transmitter and antenna—is to be produced by a single Dutch firm, Hollandse Signalapparaten, a Philips subsidiary. This fragmentation of the business, the Belgians say, increases the risks of amortizing the investment needed to carry out production of the aircraft.

Meanwhile, the problem has become what one U.S. official connected with the program calls a hot potato for the steering committee. In the memo of understanding signed last summer U.S. commitments tie the total dollar amount of offset by fixed percentages to the eventual costs of the airplanes. Consequently, lower components costs reduce the total price of the aircraft to the purchasing governments but at the same time also reduce the dollar value of the offset. In other words, while Belgian taxpayers stand to get a break on the lower radar price, Belgium's electronics industry gets less business than it originally estimated.

The shortfall in radar offset is one of several delicate problems that the steering committee must resolve before contracts can be signed. The problem is complicated by the fact that total offset for the Scandinavian countries—mainly electronics—is comparatively low in percentage terms, partly because of the effort to pro-rate offset according to the size of each country's airplane purchase. This means that electronics involved in ground equipment (which still must be negotiated) may be used to balance out compensation due to the Norwegians and Danes and may not be easily available to help fill out business for the Belgian industry.

In addition, the co-production plan set up by the U.S. Air Force and the prime contractors with the Europeans has to apportion much of the work according to the various countries' industrial capabilities. The result is that most of the engine business has been concentrated in the sole engine assembler in the four countries: Belgium's Fabrique Nationale. This firm expects to get about $239 million worth of engine business, including assembly and testing of all engines for the European purchase.

Difficult search. Fokker of the Netherlands and Fairey and Sabca of Belgium will assemble respectively the Dutch-Norwegian aircraft and the Belgian-Danish planes. Thus, apart from the radar, most of the electronics work has been reserved for Danish and Norwegian industry. Finding electronics business to channel to the Benelux nations, should the steering committee decide to do so, won't be easy.

Also before the steering committee is a complicated problem of how to put cost differences between the U.S. and European companies on a comparable basis, to take account of factors like scale of production, transport costs, and government aids. This is yet another of the questions that has to be resolved in order to determine if European companies can meet contract requirements that they be resonably cost-competitive.

Such cost differences were taken into consideration in fixing the price of the European plane at a maximum of $6.09 million. The estimated cost of U.S. versions is $4.5 million apiece. The higher European price is attributed to development costs, the expense of setting up additional production lines, and other charges. However, there is some talk about dropping the European price about 7%, to around $5.7 million, once current bids have been reviewed.

That cost review is also of some concern to Belgian industry, which is trying to persuade its own government to help reduce the risk in capital investment and the threat to profits if options for some of the aircraft are not exercised during the 1979–1984 delivery period. For example, the Belgian companies argue that American companies might get the benefit of some nonspecific tooling and infrastructure that's owned by the Government but is made available to industry, items that could be used in other programs. This, argue the Belgian manufacturers, might weaken European competitiveness.

Agreeing on suitable inflation forecasts is also a problem. Inflation in practically all four countries is rampant compared to the U.S. and makes the Europeans distinctly nervous. For example, it may affect eventual sales to third countries.

Also, the U.S. requirement of dual sourcing means there will probably be an efficient U.S. producer available to take over any work that becomes uncompetitive. Once definite offset contracts are signed, however, any shifts in production must be approved unanimously by the steering committee, so that the affected government in fact would have a veto. But there is also a possibility that if costs get out of line, the number of units produced in the high-cost country may decline, reducing the job impact of the offset and squeezing producers' profits still further. □

Working out the offset

The memo of understanding signed last fall by the parties involved in the F-16 deal is a complicated one. European industry is participating, for the first time, right from the production development stage of a fighter craft. Also, in another first, the four European nations involved will produce parts of the planes ordered by the U.S. Air Force.

The memo is accompanied by a co-production plan based on 1,500 airplanes (650 for the U.S., 348 for the four European co-producers, the remainder to other countries). The guaranteed offset—that is, how much of each purchaser's cash outlay will be offset by subcontracts to that nation's manufacturers—is 58% of the 348 European planes based on a total American and European purchase of 1,000. The minimum offset target for 1,500 planes, assuming 500 sales to other nations, ranges to 80%.

The offset figure on F-16 work hasn't been worked out to the last penny. This can't be done until contracts are signed establishing costs and the price of the European airplane. However, General Dynamics, the F-16's prime contractor, has estimated total offset for the four countries involved at $2.1 billion. That sum would be broken down roughly this way:

	Total offset	Electronics portion	Planes ordered
	(in millions of dollars)		
Netherlands	700	181	102
Belgium	680	205	116
Norway	400	314	72
Denmark	300	250	58

In addition, the memo provides a flyaway cost per airplane of $6.09 million (on the basis of 1,000 airplanes in 1975 dollars) for the Europeans as compared with an estimated $4.5 million in the U.S. The higher European price is accounted for by development costs and the expense of setting up additional assembly lines.

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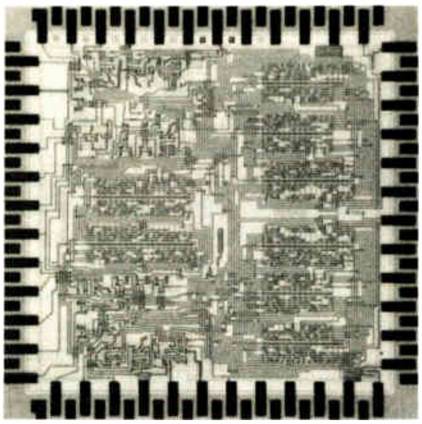
Solid state

I²L getting a second look

Bipolar technology encounters improving digital MOS but finds role in consumer, custom, military, analog jobs



Finding its spot. Top makers agree that I²L,—like this random logic array from Bell—must play its own role, not replace MOS.

After two years of intensive preproduct development, the semiconductor industry is beginning to understand integrated injection logic. Heralded in some quarters as the answer to everything and disparaged in others as practically worthless, I²L is staking out a position somewhere between those extremes. Indeed, I²L has entered that hard-engineering phase at several U.S. manufacturers—notably Texas Instruments, Fairchild Camera & Instrument, and Signetics—that will determine just how far and in what products it will go.

Here then is the new wisdom on I²L's future:

- For consumer products, I²L appears to be a solid large-scale-integration technique in watches, television circuits, organ chips, and timing controls—wherever low-cost digital functions are best combined with linear functions on the same chip. Already in production are watch chips, countdown and deflection circuits, frequency synthesizers, organ tone dividers, citizens' band radio circuits, telecommunications tone encoder and phase-locked-loop circuits.
- For custom circuits, I²L is getting into many applications ranging from the processor chip in Texas Instruments' Teletext home data system to timing and control systems for the auto industry.
- For military systems, I²L appears to be a perfect digital technique because it consumes little power and, unlike other forms of LSI, can operate over the entire military temperature range.
- For in-house system applications, I²L is providing dedicated logic and memory, such as the random-logic circuits being built by Bell Laboratories for equipment in data phone systems and the fast static memories being developed by International Business Machines Corp.
- For pure analog circuits, I²L appears to be a good alternative to the new complementary-MOS converter techniques.

Undoubtedly, for a mere three-year-old, the technology has made a dramatic impact. But the lingering question is whether I²L will make it as a main-line digital technology in the microprocessor and memory product area now dominated by metal-oxide-semiconductor devices. Here, considerable controversy still exists, chiefly because MOS performance keeps chasing that of standard bipolar devices. As examples, take the new two-level polysilicon MOS process, which begot the 16-k dynamic RAM, and the new depletion-mode logic techniques, which are spawning enhanced 8- and 16-bit microprocessors.

But I²L designers willingly cede this performance area to MOS products.

"We've never said that I²L will replace MOS," says H. Dean Toombs, the Texas Instruments assistant vice president who serves as engineering director for its Semiconductor group. "It does, however, meet C-MOS head on; and, as a bipolar technology, it has real potential in its marriage to conventional bipolar technology to implement functions where there's no other way."

That's why most of TI's I²L products in development and in production are either custom devices or dedicated to a particular high-volume application, such as TV circuits.

For instance, several camera control circuits, for several camera manufacturers, have been in production more than a year, and the I²L watch chip that the firm's Time Products division used in solid-state wrist watches now is being sold to other watchmakers.

An important consumer market for I²L will be in television receivers, Toombs says, "where many times the manufacturers would like some high-quality linear devices, like op amps and sample-and-hold circuits, right on the chip." TI has been shipping a digital-TV-tuner kit, with custom I²L and TTL parts, to a major TV manufacturer since last year, he adds. Also in development are standard TV circuits built in I²L [*Electronics*, Dec. 25, p. 26], including a horizontal processor/vertical countdown chip, which replaces multichip and discrete versions of those deflection functions, and a single-chip remote-control circuit that competes directly with C-MOS. "In remote control, power requirements can be bet-

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Others now ask you to compare them to us.

But they're sort of selective about what they ask you to compare.

Problem is that the average DVM lets you down in one performance area or another.

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It's got overload protection for all ranges. Twenty-six ranges of volts, amps and ohms. Normal mode rejection of 120 dB with an unbalance resistance of one kilohm. Auto zero. The best accuracy statement of any 3½-digit DVM—0.1% accuracy ± 1 digit.

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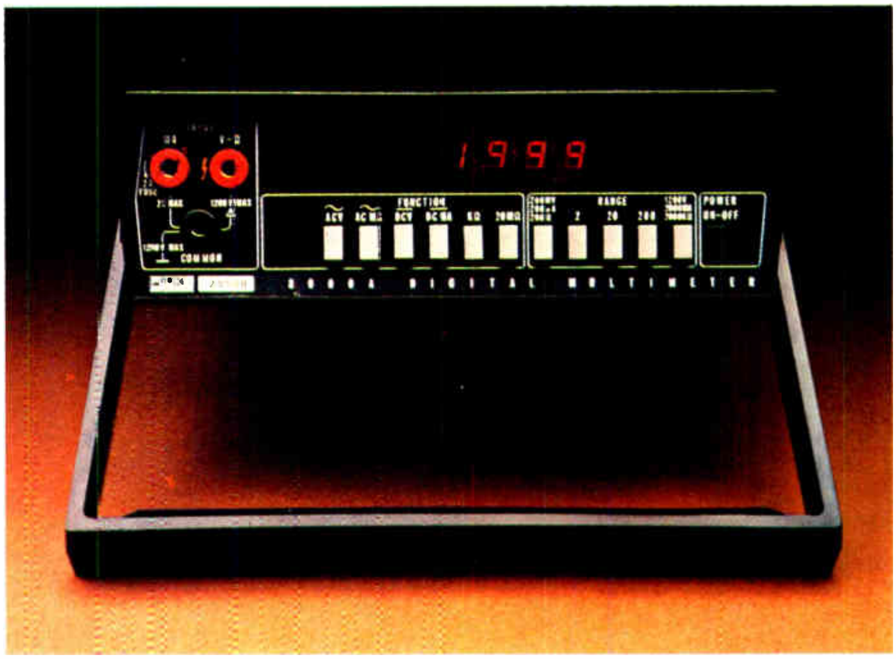

STILL THE LEADER. 8000A DVM. FLUKE

Probing the news

ter served by I^{2}L," Toombs points out. "It can operate off a 1.5-volt battery, instead of the 6 to 9 volts that C-MOS requires."

Also being developed are standard catalog linear parts, "mainly in the area of analog-to-digital converters," and an I^{2}L universal cathode-ray-tube controller that will replace the 100 to 150 transistor-transistor-logic packages now used.

As for main-line digital products, TI plans to have a family of standard logic and memory products. Indeed, TI has I^{2}L prototypes of a 4,096-bit static memory with a typical access time of 70 nanoseconds and is also working on a high-performance version of its 16-bit 9900 microprocessor. Although the company won't pin itself down to a marketing date, these devices will probably go into production this year.

TI also is working on an enhanced version of its 4-bit I^{2}L microprocessor slice—the only standard I^{2}L microprocessor that is on the market.

It has just put a second-generation I^{2}L process into production, but is unlikely to market it except possibly in the form of a few military products. "Optimistic vendors would say it's a 10-ns technology," Toombs says, "but in an actual circuit, with a fanout of four or five, it's more like 20 ns."

Instead, TI is cranking up its third-generation process, which Toombs dubs "advanced I^{2}L." It will go into production late this year.

To judge by devices in the laboratory, the average real propagation delay will be 5 to 10 ns, says Toombs. "We'll introduce a version of the 0400 4-bit microprocessor slice done in the advanced process," adds the TI official.

High performance only. At Fairchild, however, I^{2}L development under Thomas A. Longo, vice president and chief technical officer, was directed only into the high-performance area. "In my view," says Longo, "I^{2}L is the only really solid bipolar LSI technology. But being a bipolar technology, it should be used only where bipolar performance is required. That means memories operating under 100 nanoseconds and LSI logic with propagation delays of 10 ns or less. The worst thing you can do is to try to simplify injection logic to the point where it is competitive with MOS costs, because then you end up with MOS performance and we already have a very powerful MOS technology."

Fairchild is backing up its contention that I^{2}L is a high-performance technology with a 4,096-bit dynamic memory that it hopes will be in production this year. Aimed at the market in add-ons and very fast mainframes, the device has an access time of less than 100 ns that will make it the fastest 4-k dynamic RAM on the market.

Even though this type of device will cost somewhat more than 4-k MOS RAMs, "users who need this performance will be willing to pay a modest premium," says Longo. Other high-performance I^{2}L devices due from Fairchild are several LSI parts for its new Macrologic family, such as an I^{2}L program sequencer that the company described at last month's International Solid-State Circuit Conference.

On the other hand, Signetics hopes I^{2}L will enhance the performance of some of its existing products, such as the 2650 8-bit MOS microprocessor, as well as some high-performing MOS RAMs and ROMs. The firm's designers already have laid out an I^{2}L version of the 2650 processor.

In addition, Signetics has begun to introduce the first of what it hopes will grow into a full LSI family containing both I^{2}L and Schottky TTL devices. Already entering production are a character generator/checker, first-in/first-out shift register, a 16-by-16-bit multiplier, and several serial microprocessor-oriented memory chips [*Electronics*, Dec. 11, p. 29].

The latest in the Signetics large-function LSI family is a frequency synthesizer chip for telecommunications that operates in the 10-megahertz range. □

This article was prepared by Midwest bureau manager Larry Armstrong and Senior Editor Laurence Altman

HOW THE LEADER IN DIGITAL VOLTMETERS PLANS TO STAY THERE.

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Full line of accessories offering HI volts to 40 KV, RF to 500 MHz, current to 600A	only Fluke

There's not much competition.

Not just one feature that's unique or one lock-out spec, but an entire package that makes complete sense and offers you total value all the way around. Take specs, for example. We publish very conservative specifications. No one else does, but we think it's important that the instrument gives all the specs we've guaranteed. And then a little more. We feel that you ought to get better performance than you expected when you buy a Fluke instrument.

So what should you expect in a DVM?

First, an initial low cost. But also a low cost of ownership.

The Fluke 8600A sells for $549.*

But, even more important, the 8600A has a demonstrated 10,000 hours MTBF. We've fully defined and specified environmental capabilities. And the calibration cycle is 6 months.

That's going to save you a bundle in cost of operation.

Without any sacrifice in specs. Guaranteed six-month accuracy specs at 15°C to 35°C with an extremely low

A running start helps.

temperature coefficient. Five ranges each of ac and dc volts to 1200V with 0.02% dc and 0.2% ac accuracy. Five ranges each of ac and dc current to 2A with 0.1% dc and 0.3% ac accuracy. Six ranges of resistance to 20 megohms with 0.1% accuracy. AC bandwidth to 100 kHz.

Autoranging through all ranges plus individual range selection. Continuous overload specified for all ranges/functions with overload indication.

Features for flexible operation. Environmental capability specified and defined. Automatic zeroing. Low 7-watt power consumption for reliability. And a full line of accessories including 40 KV high voltage probe, 500 MHz RF probe and 600 A ac current probe. A self-contained rechargeable battery option.

And remember, those are conservative specs for the 8600A. At $549.

A genuine value from Fluke.

Which suggests we plan on being the leader in DVM's for a long time coming.

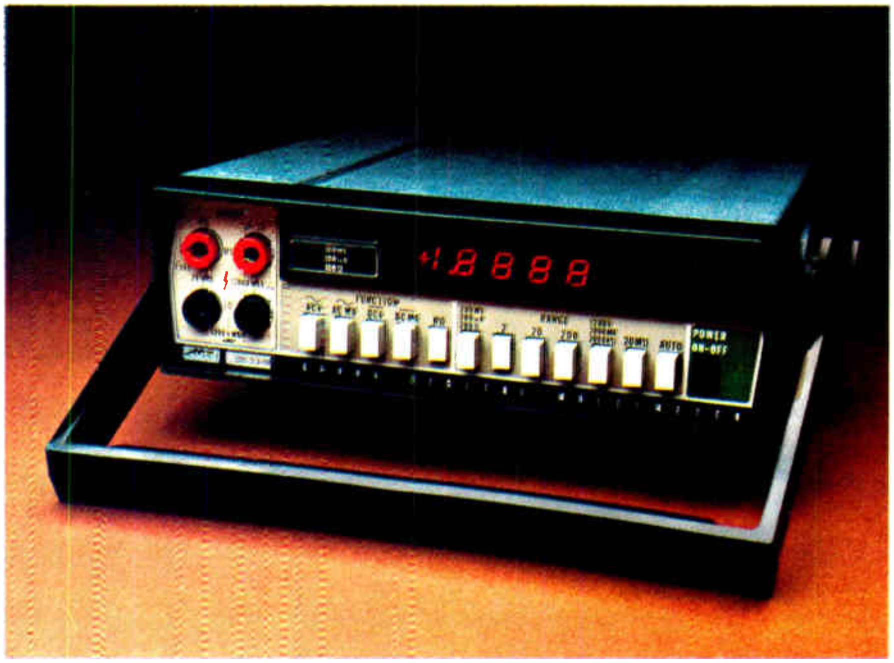
No matter how much it upsets our competitors.

For data out today, dial our toll-free hotline, 800-426-0361.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043

Fluke (Nederland) B.V., P.O. Box 5053, Zevenheuvelenweg 53, Tilburg, Netherlands.
Phone: (013) 673-973 Telex: 52237

*Domestic price only.



THE INDUSTRY STANDARD. 8600A DVM. FLUKE

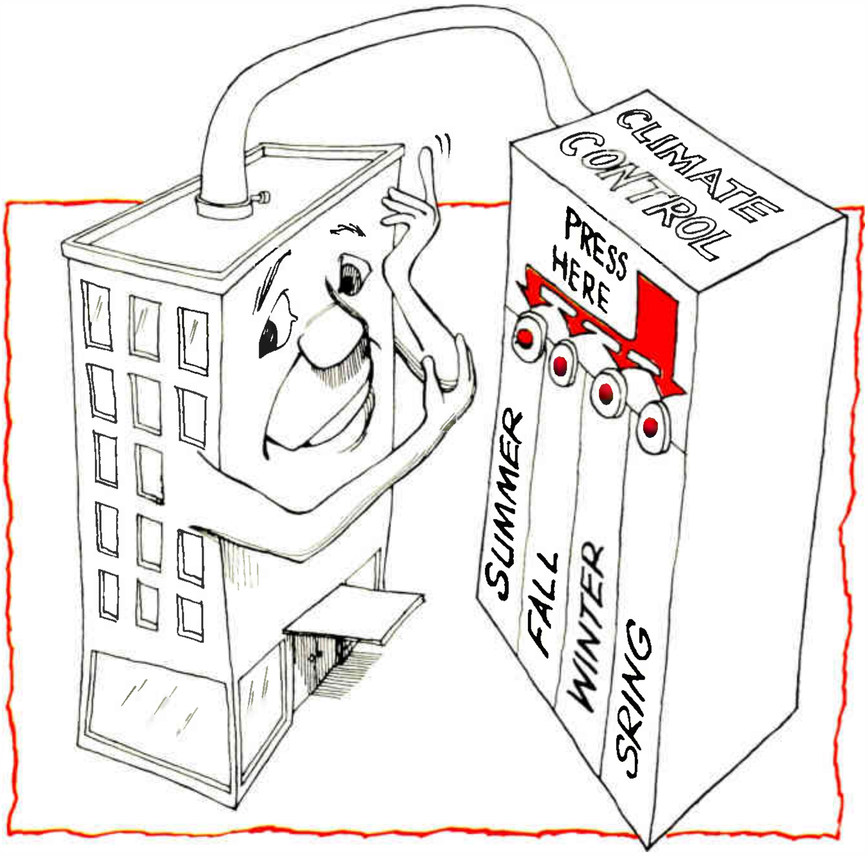
Circle 83 for demonstration, circle 175 for literature

Industrial electronics

Aerospace firms make living easier

Grumman, Lockheed, United marketing energy-control systems for buildings after doing the job in-house for their own facilities

by Ron Schneiderman, New York bureau manager



Cost-cutting energy-conservation programs instituted by nearly every major industrial complex in the country during the energy crunch have put at least two aerospace firms—Grumman Aerospace Corp. and Lockheed Electronics Co.—into the business of energy control in buildings. And a third one, United Technologies Corp.'s Hamilton Standard division in Windsor Locks, Conn., is about to announce its entry into the field.

They all started the same way: rising energy costs for their own massive facilities spurred them to initiate in-house energy conservation programs to cut heating, ventilating, and air-conditioning costs. Grumman used computer analysis to uncover excessive energy use in the more than 30 buildings in its Bethpage, N.Y., headquarters. When the first nine buildings were modified, the firm estimates, nearly a million gallons of fuel oil were saved each year. Coupled with a projected annual electricity reduction of 16 million kilowatt hours, the total energy savings represent enough oil to heat 1,200 single-family homes for a full year.

Armed with that data, Grumman Aerospace officials formed the Grumman Energy Program to provide a consulting service for outside clients, including state governments, private businesses, and public schools. Since it went public in 1973, says Tim Murphy, the operation's program manager, Grumman has completed over 50 major contracts, and has identified total savings of about $9 million at last year's energy rates.

Most of what Grumman does is fine tuning, says Murphy, usually involving more efficient use of the existing manufacturing and office space and heating, ventilating, and air-conditioning equipment. But there's more in the works.

In the past few weeks, Grumman began establishing a national network of distributors to market its line of Sunstream solar collectors, aimed at residential, commercial, and industrial markets.

Panels. Sunstream is designed to dump solar-heated water into the original hot water heater to keep it from drawing on public utility services. Basically, it consists of a series of 9-by-3-feet solar panels heating an antifreeze fluid that is circulated through the heater. Two panels can provide up to 80 gallons of 150° F water a day. They are produced by Grumman Houston Corp., a wholly-owned subsidiary of Grumman Aerospace.

"Essentially," says Murphy, "we're still a consulting service, but if someone uses a lot of process hot water in his plant and we think we can save him some money with our solar collector, we'll recommend its installation. If another system will

CAN THE LEADER IN DIGITAL VOLTMETERS TAKE OVER IN COUNTERS?

Well . . .

We've seen some surprising changes.

Last time we checked, for instance, we were sitting in the number two spot.* Not too bad for a company that didn't begin building counters until 1973.

But, then again, we had an advantage. We knew what to do. We knew what it would take to be a leader in counters.

Give the guy on the bench, or building a system, a top-performing, Fluke-quality counter at a price a few hundred bucks less than he expected to pay. An honest bargain is always a big seller.

Frequency Extension Options
520 MHz Prescaler
Covers frequency range of 50 to 520 MHz, using a scaling ratio of 4. Sensitivity is 15 mV rms (AGC). Maximum allowable input is 5 V rms (fuse protected). VSWR less than 2:1 into 50 ohms for levels less than 1 V rms.
1000 MHz Prescaler
Covers 50 to 1000 MHz using a scaling ratio of 8. Sensitivity is 15 mV rms, and maximum allowable input is 5 V rms (fuse protected). VSWR less than 2.5:1 50 ohms for levels less than 1 V rms.
1250 MHz Prescaler
Covers 50 to 1250 MHz using a scaling ratio of 8. Sensitivity is 20 mV to 1000 MHz, increasing to 40 mV rms at 1250 MHz. Maximum input 5 V rms (fuse protected), and VSWR less than 2.5:1 for levels less than 1 V rms.

We know frequency.

For example, a bench/systems box at $995** with the same programming potential of counters selling $130 to $305 and even $640 more.

That $995 bargain is our 1953A Programmable Universal Counter/Timer. What does $995 buy? Here's a good example of how we're changing the counter market. The 1953A is designed for both bench and systems use in frequency, ratio, period(s), time interval and gateable totals measurement. The basic box has a frequency range from DC to 125 MHz at sensitivities to 30 mV. Nine-digit LED display. Full triggering control.

Counters!

But you can see. Take a look at the unit pictured in this ad—you're going to see a lot more on the front panel.

And there are options. Time base options. Frequency extension options. System interface options. We're going to have to send you information for you to get a complete idea of what this counter can do.

But it all starts with the $995 unit.

An honest bargain from Fluke.

And, meanwhile, when someone asks if we're going to take over in counters, we just smile, shrug and keep on building those great Fluke counters.

After all, we've only been at it 3 years.

Time Base Options	TCXO	Oven-Stabilized
Frequency:	10.00 MHz	10.00 MHz
Aging Rate: (constant temperature)	<±3x10⁻⁷/mo.	<±1x10⁻⁷/mo.
Temperature Stability: 20°C-30°C	±2x10⁻⁷ typ.	±3x10⁻⁹ typ.
0°C-50°C	<±5x10⁻⁷	<±1x10⁻⁸
Line Voltage: (±10% change)	<±5x10⁻⁸	<±3x10⁻⁹

We know time.

For data out today, dial our toll-free hotline, 800-426-0361.

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*Source available upon request.
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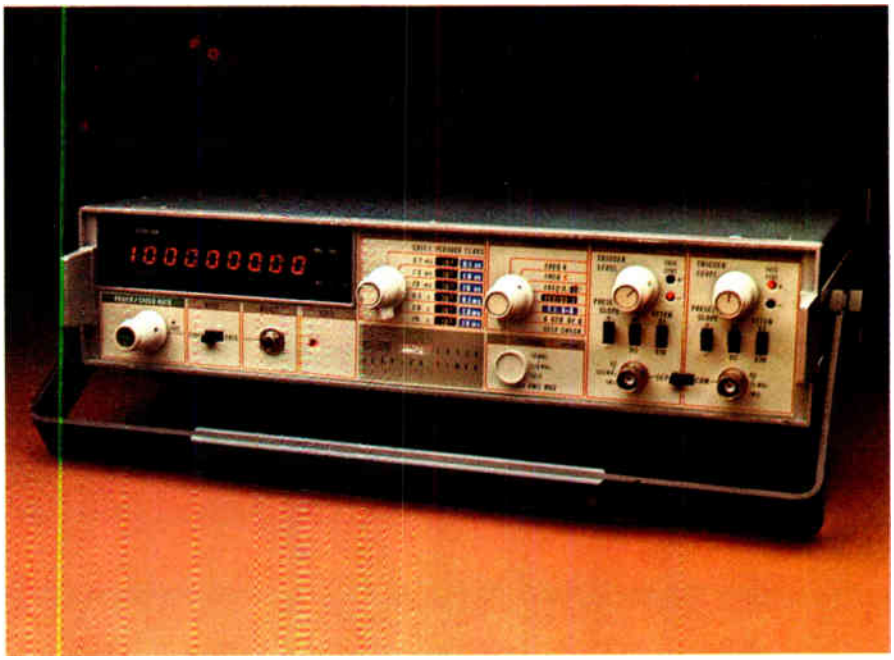

THE SURPRISING NEWCOMER. 1953A COUNTER. FLUKE do a better job, we'll recommend that."

The flat-plate Sunstream panels are priced at $995, but installation could take the price up to at least $1,400.

Grumman also has several devices under study by Underwriters' Laboratories, including a module that attaches to circuit breaker panels to switch lights or other electrical equipment.

Lockheed Electronics' approach to the energy conservation market is built around its MAC-16 minicomputer. About 3,000 MAC-16s have been sold by the Plainfield, N. J., Lockheed Aircraft subsidiary—mostly for air-traffic control and for control of power distribution.

Based on the savings on its installations in Plainfield and at the 3-million-square-foot Lockheed-Georgia plant in Marietta, Lockheed Electronics is setting up a national network to market and install its MAC-16 7600 computerized energy-conservation system along with an environmental-management software package.

However, the firm has decided to concentrate on the medium-sized commercial and industrial market. Kenneth Wetzel, one of three engineering/marketing specialists concentrating on the new venture, says typical customers will be a client that could save $15,000 or more on its monthly electric bill, or one whose energy-control system will pay for itself within two years. The basic Lockheed Electronics system is priced at about $40,000 without installation.

In use, it is part of a network of remote sensors and actuators that measure and control pressure, humidity, temperature, and other variables of the heating, ventilating, and air-conditioning equipment in a building. It can turn equipment on or off and change the set points.

Lockheed also plans to sell some systems directly. In fact, it recently beat out IBM Corp., Honeywell Inc., Johnson Control Co. of Milwaukee, and four other firms with its bid to install an environmental building-management system for $63,800 at a million-square-foot U. S. Postal Service bulk-mail facility in Kearney, N.J. The company also supplies the minicomputers with a private label to ADT Security Systems. The New York-based firm only recently began marketing an energy conservation service along with its long-time offerings of security and fire-control, all monitored from central stations.

United Technologies' plans aren't clear, but the company has developed a computer-controlled climate control system at its Windsor Locks facilities and is about to announce a major contract that will be its entrée into the business.

Although Honeywell leads the field, it is concentrating its Delta 2000 and recently-introduced Delta 1000 software-based system on commercial installations—for climate control and fire and security. □

WHAT WE DID FOR DIGITAL VOLTMETERS, WE'RE DOING FOR COUNTERS.

O.K. Wake up out there.

Fluke has got a frequency counter design specifically for communications —the 1920A. It sells for $860.*

We wouldn't bother you if it wasn't worthwhile.

Let's face it. We've had to forge some new ground to get a good footing in the counters marketplace. When you're coming up fast on the leaders, like we are, you can't afford any ho-hum instruments. Each counter gets a little better. And, of course, the guy at the bench benefits.

That's how it is with the 1920A counter.

Some advanced LSI/MOS circuitry gives the unit exceptional specifications. And makes it a little more portable. There's a 9-digit LED display, sensitivity to 15 mV, AGC standard, and a frequency range of 5 Hz to 520 MHz. Optional internal prescalers to 1000 MHz and 1250 MHz cover the UHF television, 900 MHz telecommunications, and beacon bands.

Frequency Extension Options
1000 MHz Prescaler
Covers 50 to 1000 MHz using a scaling ratio of 8. Sensitivity is 15 mV rms, and maximum allowable input is 5 V rms (fuse protected). VSWR less than 2.5:1 at 50 ohms for levels less than 1 V rms.
1250 MHz Prescaler
Covers 50 to 1250 MHz using a scaling ratio of 8. Sensitivity is 20 mV to 1000 MHz, decreasing to 40 mV rms at 1250 MHz. Maximum input 5 V rms (fuse protected), and VSWR less than 2.5:1 at 50 ohms for levels less than 1 V rms.

A few extras take you higher.

Direct and prescaled inputs are color-coded to match their corresponding function switches to facilitate operation. The display incorporates full leading zero suppression, automatic annunciation, overflow, and a self-check mode which lights all digit segments.

Then there are some features we're really proud of—exciting to find in an $860 unit.

But you knew that, anyway.

Measurement delays have been eliminated. A rapid-access gate free runs in the absence of input signals. It's in position to open the gate for the selected gate time as soon as a signal is sensed. An auto-reset circuit initiates a new measurement every time any front panel switch is activated. The first measurement obtained is always correct.

In addition to normal frequency measurements, there's a burst function. The unit measures RF bursts of greater duration than the selected gate time. To avoid erroneous reading, the display is automatically reset to zero if the burst width is less than the gate time selected.

An optional resolution multiplier coherently multiplies audio tone signals by 1000, providing a resolution of 0.001 Hz in 1 sec.

But now that we've got your attention, the 1920A really doesn't seem so surprising, does it? Really, it's something you sort of expect, when you come to think about it.

Another great instrument from Fluke.

As far as we can tell, it means two things. A promise to you that Fluke is giving their full attention to counters.

And a lot of worry for our competitors.

For data out today, dial our toll-free hotline, 800-426-0361.

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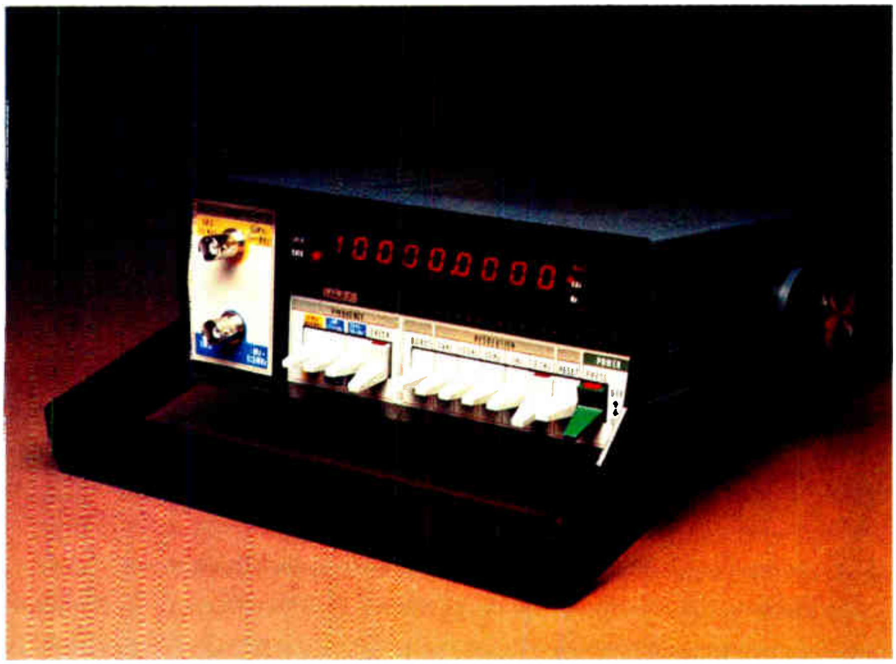


FOR COMMUNICATIONS. 1920A COUNTER. FLUKE

Circle 87 for demonstration, circle 177 for literature

BEFORE YOU GO BACK TO THE BENCH, TAKE A LOOK AT WHAT YOU SHOULD FIND THERE.

Fluke spends a lot of time paying attention at test and measurement benches across the industry.

Out of what we hear, we develop new products.

Not just DVM's. Not just counters. But also frequency synthesizers, automatic test systems, signal generators, calibrators, logic board testers, power supplies, data loggers, digital thermometers, ac and dc standards, and differential voltmeters.

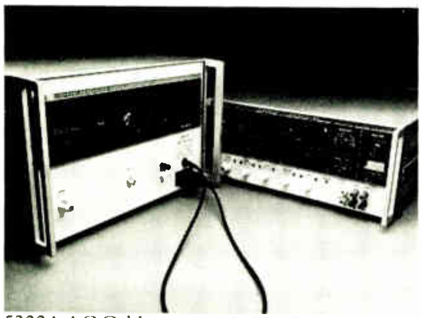
A company that listens so carefully, probably has what you've been looking for.

Smart, but friendly.

The Fluke 6010A Signal Generator incorporates a microprocessor for free-form entry of frequency in Hz, kHz, or MHz. The unit stores and recalls up to ten frequencies, modulation, and attenuator settings by pushing a single button—a feature unique in signal generation.

6010A Signal Generator

1900A Counter



5200A AC Calibrator and 5205A Power Amplifier

"I'll take one of those... no, that one! And one of those, too!"

The microprocessor plays a part in several other operations, including automatic range selection and automatic justification. You can automatically justify the frequency entry on the 7-digit LED readout to give the greatest possible resolution.

But for all its sophistication, the 6010A is friendly. It's easy to use. For example, you've got continuous tuning with the Frequency Edit control—the bright digit denotes the tuned decade. The bright digit can be incremented and decremented with complete carryover and borrow capability across a 10 Hz to 11 MHz coverage.

Put this intelligent, amiable fellow to work for you for only $2495*.

Keep up the standards on the bench.

From Fluke. A fully programmable ac cal setup with range, stability and accuracy that's hard to beat for the price.

Together, the 5200A Precision AC Calibrator and the 5205A Precision Power Amplifier can calibrate ac devices up to 1200 volts rms. The frequency range is dc to 1.2 MHz. DC output of ±1600 volts is available. Maximum output current is 200 mA. It will drive a 1500 pF capacitance load. Long-term stability is 200 ppm/ 6 months, midband accuracy is 0.02% overall, and response is a fast 0.5 sec.

Both instruments are short-circuit proof, fully guarded and interlocked. Phase lock availability and quadrature output are standard features.

The system interfaces easily with almost any system. Field installable serial and parallel isolated programming options are available. This unbeatable team goes to work for you for $8990*.

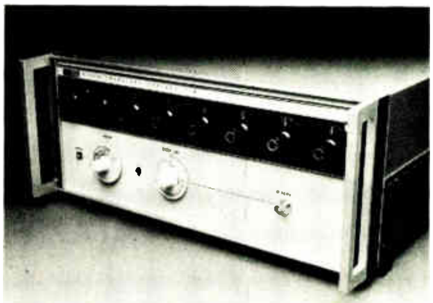
Basic counting.

A new Fluke multi-function counter, the 1900A features autoranging in both frequency and period modes, with 20% hysteresis to eliminate annoying range switching. There's leading zero suppression and autoreset in all functions for easy and correct readings every time. A large 6-digit LED display with automatic range of 5 Hz to 80 MHz. Exceptional sensitivity of 25 mV (typically 15 mV). Event counting to 10^6 counts. Signal input conditioning. Frequency. Period. Totalize.

At only $375*, you could say we've stayed close to the basics.

Shhhhhhhhhh.........

Are you doing NMR or microwave spectroscopy? Be quiet about it. Use the new Fluke 6160B Frequency Synthesizer with the best signal-to-noise ratio available and a guaranteed spurious spec of greater than −83 dB. A range of 1 to 160 MHz with 1 Hz resolution, and from 1 to 20 MHz the spur spec is −100 dB. BCD programmable frequency control. Switching speeds less than a millisecond. Modular construction for custom tailoring to your needs. And all of this quiet costs $5895*.



6160B Frequency Synthesizer

For information on the 6010A circle 701
For demonstration on the 6010A circle 702

For information on the 1900A circle 703
For demonstration on the 1900A circle 704

For information on the 5200A circle 705
For demonstration on the 5200A circle 706

For information on the 5205A circle 707
For demonstration on the 5205A circle 708

For information on the 6160B circle 709
For demonstration on the 6160B circle 710

8400A, 8375A, and 8800A Digital Voltmeters

5½-digit DVM extravaganza.

Whatever you need in a DVM—Fluke has it. We're the leader.

Let's say you need resolution to 5½ digits. Look at these three instruments.

The 8800A is a ± 0.005%, 200,000-count bench DVM with 1 μV sensitivity. It's light and small, has full guarding and autoranging, and sells for $985*. Accuracy is a guaranteed ±0.01% for 90 days over a temperature span of 18° to 28°C. Five ranges of dc volts from +200 mV to +1200V. Four ranges of ac volts from 2V to 1200V. True 4-wire resistance measurements on all ranges, 200 ohms to 20 megohms, with 3.3V maximum open post voltage. 10,000-hour MTBF. And overload protection of at least 1000V on any ac or dc range, 250 V rms or dc on any ohms range—the best in the industry. A wide range of accessories includes high-frequency probes, high-voltage probe and clamp-on ac current probe. An isolated printer output option is available.

For systems applications, Fluke offers the 8375A. Standard unit measures 5 ranges of dc volts and 4 ranges of true-rms ac volts. Basic dc accuracy is ±0.003%. Basic ac accuracy is ±0.1%. Resistance measurements are made in 7 ranges from 10 ohms to 12 megohms with 100 micro-ohms sensitivity. Fluke's patented Recirculating Remainder A-to-D conversion technique with autozero circuit provides reliable long-term accuracy and linearity. A quick check of all measurement functions is provided by the unique self-test feature. Field-installable systems options include remote control, data output and dc external reference.

The 8400A is the same basic box as the 8375A, with some different features. To the capabilities of the 8375A add ±0.002% basic dc accuracy, plug-in ac, resistance and ac or dc ratio options, switched filter for dc, ac resistance and ratio, automatic settling or time-out delays and serial or parallel data output.

Both instruments, the 8375A and 8400A, offer full autoranging, auto-polarity, 20% overranging, pushbutton selection and 10,000-hour MTBF.

Both sell for $2195*.

Got a fault in your logic?

Find it fast with the TRENDAR 200 IC TESTCLIP®. This complete pocket-size test set replaces the three commonly-used logic-checking devices—logic probe, logic status display clip, and hand-held IC comparator—for half the price. Using FAULTRACK©, a universal trouble-shooting procedure, board imperfections, solder defects and faulty IC's are easily found and displayed. Testclip automatically tests digital IC's in-circuit at megahertz rates. It automatically locates IC faults and board faults, and displays power status, logic states, toggling, and failures by pin number. Logic levels from 4.5V to 10V are tested automatically without adjustment. Waveform and timing integrity is insured by intimate contact of reference and test IC's. Minimized circuit load high-Z and low-C inputs insure

TESTCLIP

against upset circuit behavior. No calibration or routine maintenance. DTL, TTL, C-MOS, and HTL compatible versions available. Operates anywhere; portable case carries 36 reference IC's.

The TRENDAR 200 IC TESTCLIP, with carrying case, manual, Logic Probe Extension, 10 reference IC sockets and 40 programming pins is $395*.

Digital thermometers, with options.

Fluke's new series 2100A digital thermometers offer temperature range of −320°F to +3200°F with 0.1° resolution in three models.

And they've got options for maximum versatility.

Like an analog output in four offset ranges, both linearized and isolated. The linearized feature gives direct temperature readings on a strip chart recorder with no interpolation. And because it's isolated, there's no worry about ground loops.

2100A Digital Thermometer

The 2100A has a digital BCD output that monitors six thermocouple types (J, K, E, T, R and S) and two millivolt ranges: 40 and 400 mV. The unit operates from line, 12V dc or self-contained battery pack (7 hours off-line). And you can expand up to 100 points with the 2150A option.

In addition, these units are rated for a minimum 10,000-hour MTBF, have excellent noise rejection and come in tough, all-metal cases. Prices for the three basic models are $795* (2100A-03, single-point type), $995* (2100A-10, multi-point type), and $1095* (2100A-06, multi-thermocouple type).

*Domestic price only.

For data out today, dial our toll-free hotline, 800-426-0361.

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TEST AND MEASUREMENT INSTRUMENTATION. FLUKE

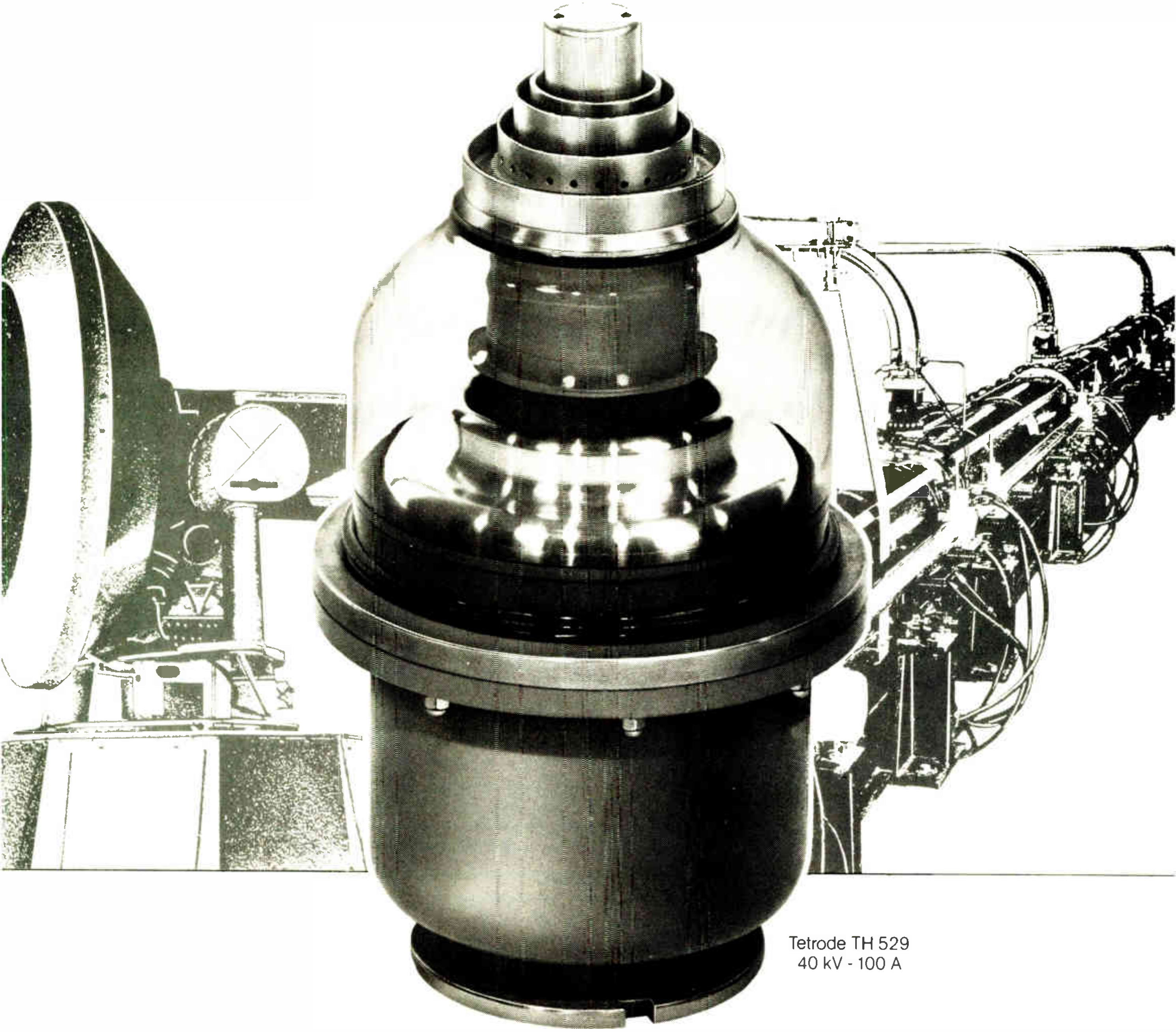
For information on the 8400A circle 711
For demonstration on the 8400A circle 712

For information on the 8375A circle 713
For demonstration on the 8375A circle 714

For information on the 8800A circle 715
For demonstration on the 8800A circle 716

For information on the test clip circle 717
For demonstration on the test clip circle 120

For information on the 2100A circle 121
For demonstration on the 2100A circle 122



Tetrode TH 529
40 kV - 100 A

THOMSON-CSF
vacuum modulator tubes

provide the punch you need
for your pulse-coded radar or particle accelerator
up to 15 Megawatts

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True rms measurements reveal the power behind the wave form

Specifications can be relaxed and designs made more economical now that engineers can afford rms meters than measure complex signals accurately

by Andy Santoni, *Instrumentation Editor*

☐ Accurate measurements are basic to successful design. In a well-designed system, no component is stressed beyond its limits, yet no component is sturdier—and more expensive—than its real situation demands. And only exact measurements can tell the engineer just what those limits and that real situation are.

But the measurement of some parameters is itself expensive to do well. Until recently, that has been the case with ac signals.

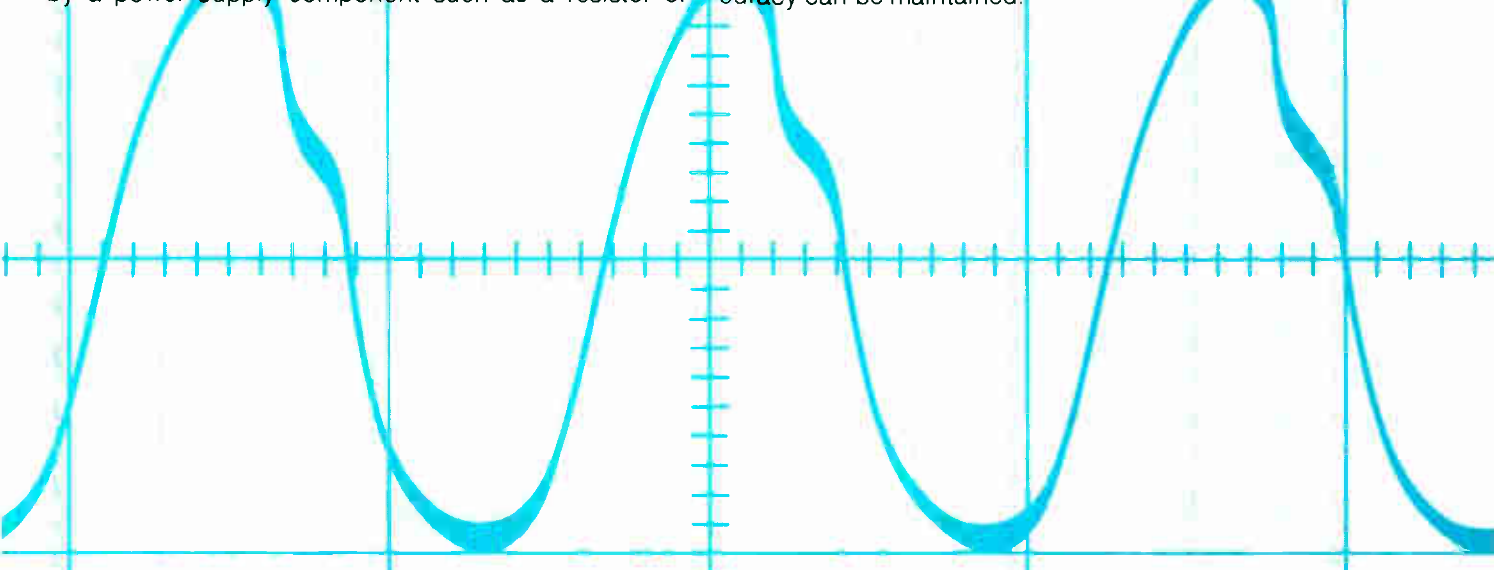
Only rarely do ac signals occur as pure sine waves. Highly accurate measurement of any more complex wave form can only be achieved with an instrument that responds to its root-mean-square value. But the high prices of rms-responding meters have more than offset the design economies they could make possible. While within the reach of the laboratory budget, they have been too expensive for use on a large scale in field service, say, or on the production line.

Today, however, the cost of these meters is declining rapidly, and the advantages that could accrue from using them to measure distorted sine waves and random signals—the commonest types of wave shapes—deserve further examination.

Power supply design is one area that could obviously benefit from their use. If the power dissipated by a power supply component such as a resistor or transistor or if the ripple current to be handled by a capacitor is measured by an rms-responding meter instead of being estimated, exaggerated and costly safety margins become unnecessary. Similarly, in frequency-division multiplex communications, the accurate measurement of line levels can cut network hardware costs. It permits the operator to set amplifier gains high enough to maximize signal-to-noise ratios and so to minimize the number of amplifiers needed without fear of overdriving the system and causing distortion and crosstalk.

It's worth emphasizing that the increase in accuracy to be obtained with rms measuring methods is quite large. Conventional instruments presume a sinusoidal wave form when converting average to rms values and therefore, in measuring nonsinusoidal signals like those found in digital logic and in power switching circuits, they can make errors that are often on the order of 10% and may go higher than 40%.

Of the two articles that follow, the first states the case for rms measurements and describes some of the circuits that can measure rms values. The second outlines some of the parameters that must be considered in choosing an rms meter and some of the precautions to be taken in applying rms meters so that high accuracy can be maintained.



How to measure ac signals accurately

M.H. van Erk and S. Rauch, *Philips Test and Measuring Instruments, Eindhoven, the Netherlands, and Woodbury, N.Y.*

The only true measure of the power capability or heating value of a wave form is its root-mean-square value. It is the only precise description of a signal's power and therefore the only quantity that permits a direct, accurate comparison between the effects of dc and ac signals, regardless of wave shape.

The ability to make rms measurements directly is becoming increasingly important because of the growing need to quantify nonsinusoidal wave shapes accurately. When a signal is a sine wave, or close enough to one, its peak or average value can be measured and its rms value extracted from that figure by a simple multiplication (Fig. 1). But often, the wave form is a chopped or otherwise distorted sine wave, a random, noise-like signal, or otherwise nonsinusoidal, such as a square, pulse, or triangular wave form. Consequently, in power measurements involving thyristor or other chopper-type controls, in telecommunications and audio noise testing, and in digital circuit measurements, actual rms values alone yield useful information.

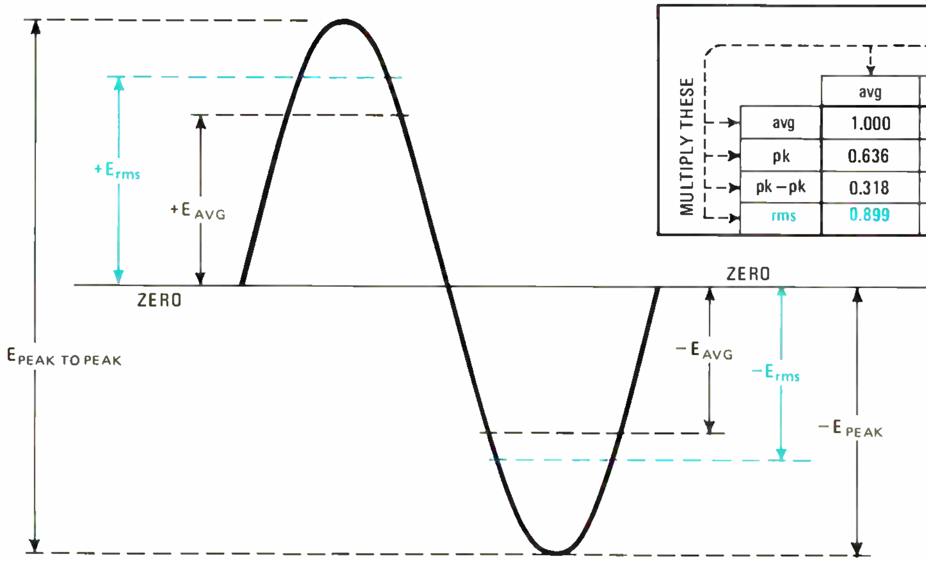
Such information can be translated into lower manufacturing costs. For example, assume that a piece of equipment must work properly even when the line voltage varies ±10% from nominal. In production testing of such equipment, an ac voltmeter usually measures the output of an autotransformer that can vary the power-line voltage seen by the unit under test. But the measurement itself suffers a degree of uncertainty from the combined effects of basic meter error and wave-form distortion, and this uncertainty may reasonably be estimated at 5%—half the allowable line-voltage variation. This means the equipment must be designed to withstand deviations of more than ±15%, to allow for a voltmeter reading that is 5% low when the real deviation is +10%. Such overdesign can be very expensive.

Sources of error

If the 5% uncertainty level seems high, consider how much error measuring distorted sine waves with an rms-calibrated average-responding voltmeter adds to basic meter error (Fig. 2). When only 5% of the signal is third-harmonic ($n = 3$ in Fig. 2), the additional error caused by harmonic distortion is already more than 1.5%, and this analysis doesn't take into account the effects of higher-order harmonics or variations in the phase angles between the different frequency components.

Every time power goes through an iron-core transformer or works into a nonideal inductive or capacitive load, some harmonics are generated. The total harmonic distortion on a power line may easily be more than 5% or 6%.

Another wave shape that can only be measured accurately by rms techniques is the kind of switched sine wave commonly seen in power-control circuits such as light dimmers. If the sine wave is switched off for 20% of each cycle ($\alpha = 0.2$ in Fig. 3), the average-responding meter will make a 10% error in its estimate of the rms value, and this 10% must again be added to any other sources of measurement error.



MULTIPLY THESE → TO OBTAIN THESE

	avg	pk	pk−pk	rms
avg	1.000	1.572	3.144	1.111
pk	0.636	1.000	2.000	0.707
pk−pk	0.318	0.500	1.000	0.353
rms	0.899	1.414	2.828	1.000

1. Perfect wave. The average, peak, and rms values of a pure sine wave are related by constants, so one can be calculated from another.

Except in special cases, such as insulation testing or certain magnetic measurements, where it really is essential to measure peak or average values, the most useful way to describe an ac signal is by means of its rms value—the amplitude that a dc voltage would need in order to transfer the same energy as the ac signal in a given period of time. The amount of energy, ΔE, dissipated in a resistor of value R when a voltage of value v is impressed upon it for a period of time Δt, is given by $\Delta E = (v^2/R)\,\Delta t$, a relationship first measured by Joule. For voltages that vary with time, $dE = (v^2/R)dt$.

The total amount of energy developed as heat in a resistor between t = 0 and t = T is then:

$$E = (1/R)\int_0^T v^2 dt$$

For a constant or dc voltage, V_{dc}:

$$(1/R)\int_0^T v^2 dt = (V_{dc}^2/R)T$$

If the effective or rms value of a voltage v is defined as the dc voltage that would produce the same amount of heat in a certain time, then $V_{dc} = v_{rms}$ and:

$$\int_0^T v^2 dt = v_{rms}^2 T \text{ or}$$

$$v_{rms} = [(1/T)\int_0^T v^2 dt]^{1/2}$$

For a sine wave in which $v = V_p \sin \omega t$ and $\omega T = 2\pi$, the rms value can be calculated thus:

$$v_{rms} = [(V_p^2/T)\int_0^T \sin^2 \omega t \, dt]^{1/2}$$
$$= V_p[(1/T)\int_0^T (½ - ½ \cos 2\omega t)dt]^{1/2}$$
$$= V_p[(1/T)([½t - ½(½\omega^{-1} \sin 2\omega t)]_0^T)]^{1/2}$$
$$= V_p[(1/T)(½T)]^{1/2}$$
$$= V_p[½]^{1/2} = 0.707\, V_p$$

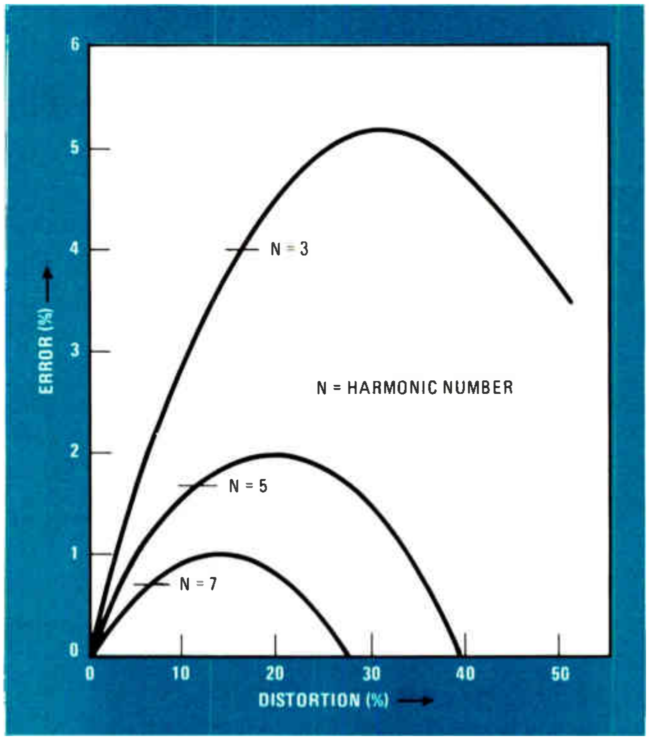
as shown in Fig. 1

Calculating the rms value of a wave form that is more complex than a sine wave is usually possible, but can be tedious. For electrical signals, it is much simpler to use one of the many rms-responding circuits available.

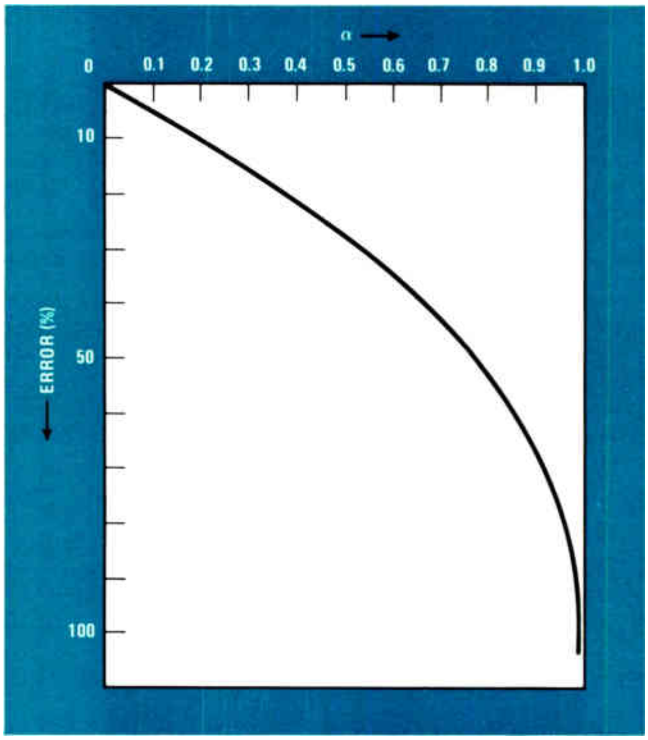
One method, called the analog computational approach, is to realize in circuit form the equation defining the rms value of a wave form. Such a circuit squares the input voltage, averages it, and extracts the square root (Fig. 4). The signal under test is fed into both inputs of an analog multiplier, M_1, the output of which is then the square of the input voltage. An operational amplifier, A_1, has a capacitor C in its feedback loop so it functions as an integrator. A second analog multiplier, M_2, is in the feedback loop of a second operational amplifier, A_2, so that the amplifier's output becomes the square root of its input.

Analog computational converters can function as fast-responding rms detectors, and the entire circuit can be integrated onto a single chip. In addition, the integrating time may be changed by connecting external capacitors in parallel with capacitor C.

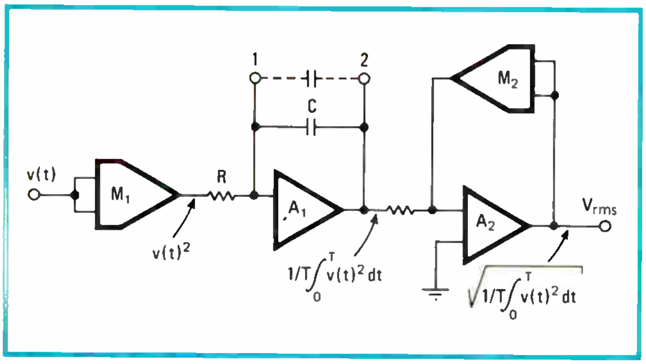
A similar rms-measurement technique requires that



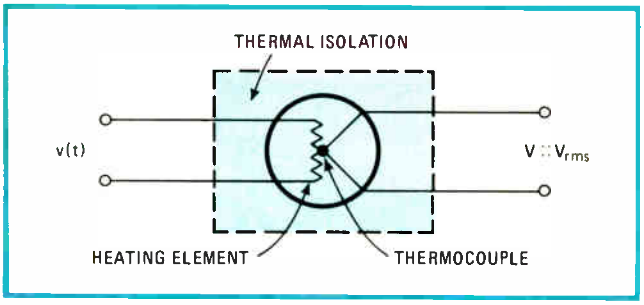
2. Distorted. Average-responding meters cannot accurately measure the rms value of a distorted sine wave. Here, the error is plotted as a function of increasing distortion for three odd-order harmonics.



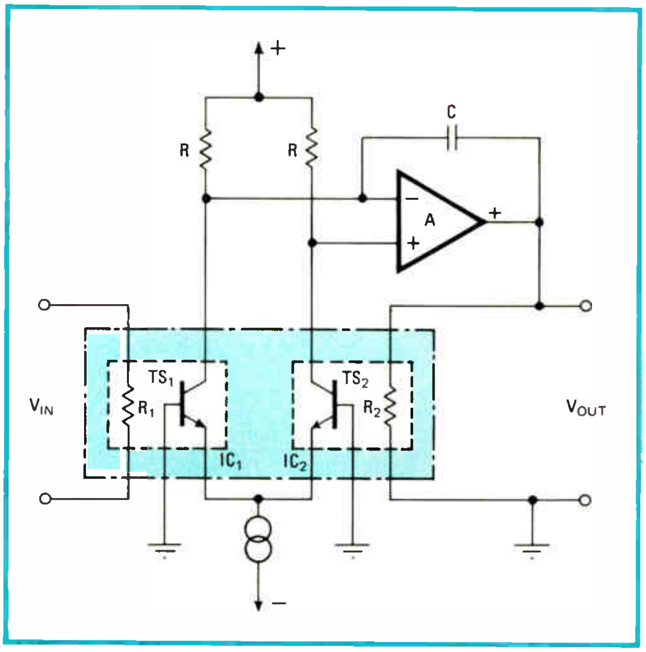
3. Chopped. When an average-responding meter is used to measure the rms value of a sine wave that is switched off for part of its cycle, the error made by the meter can be very high. If the signal is cut off only 20% of the time so that $\alpha = 0.2$, the error is 10%.



4. Calculated. An analog computational circuit like this one can determine the rms value of a wave form. Capacitors across terminals 1 and 2 change the integrating time constant of the network.



5. Thermal response. The traditional method for extracting rms values uses the definition that the rms value of a wave form is equal to its heating value. The input signal heats up an element, changing the output voltage of a thermocouple so that the dc value of the output is proportional to the rms value of the input.



6. Equally heated. This rms detector uses an inverting amplifier to control the temperature of resistor R_2 and set it equal to that of R_1. When equilibrium is reached, the dc voltage at the output is proportional in value to the rms voltage at the input.

the input signal first be converted to its digital equivalent. The rms value of the wave form is then calculated by digital techniques.

Two other methods apply the heating-value definition of rms. The traditional method for extracting rms values of a wave form is to amplify it, apply this signal to a resistance, and use a thermocouple to measure the temperature rise of the resistance (Fig. 5). The dc output is proportional to the rms value of the input. The problems inherent in this approach are many and well known. For instance, the thermocouple is sensitive to overloads and therefore frequently must be replaced. Thermocouples are also nonlinear, and the instrument's measuring circuits must compensate for this fact. The output voltage is also very low, on the order of tens of millivolts, so an accurate, high-resolution dc voltmeter is required to obtain high accuracies.

A hotter approach

A newer thermal method makes use of two resistors plus feedback (Fig. 6). The input voltage heats up one resistor, and a dc voltage brings the other to the same temperature. A pair of sensing transistors in a control loop equalizes the resistors' temperatures so that the dc control voltage is, by definition, equal to the rms value of the input voltage.

This type of rms detector can easily be assembled into a hybrid package. Here, the input resistor and transistor are put on one silicon chip and mounted in the same package as the resistor-transistor pair of the control circuit. To insure that the integrated circuits are as similar as possible, two adjacent circuits from the same silicon slice are selected during manufacture. They are not separated until they are mounted on a small glass plate that serves for thermal insulation. Their placement in a single housing helps cancel the effects of external temperatures.

Peak- or average-responding voltmeters that are calibrated to read the rms value of a sine wave have come into widespread use only because they are somewhat easier, and therefore less expensive, to design and build than are rms-responding meters. There are also some applications in which some value other than rms is desirable. For insulation testing, for example, special peak-detecting and -reading high-voltage meters are preferable, and in some magnetic measurements the average value of a wave form is more useful. Neither rms-responding nor average-responding meters have as yet been built that can match the frequency response of peak-detecting voltmeters designed for high-frequency measurements.

Meters that respond to the rms value of a wave form cost about 25% more than average-responding units. But the premium is down from about 100% a few years ago, so this factor is becoming less important. And the premium paid for the benefits of rms capabilities is soon returned by tighter and more economical designs resulting from more accurate measurements.

How to choose and use an rms meter correctly

by Fred L. Katzmann
Ballantine Laboratories Inc., Boonton, N.J.

It isn't enough to appreciate the need for precision root-mean-square measurements and understand how to make them. To make sure that a measurement is, in fact, as accurate as possible, an engineer must choose the best rms-responding meter for a particular task and use the instrument so that the its inherent accuracy is not diminished by such extraneous factors as ground currents, circuit loading, noise, and hum in the measurement setup.

The basic selection criteria—resolution, ranges, and accuracy, for example—are the same for voltmeters that respond to rms as for those that measure peaks or averages. But since higher accuracies are the reason for making measurements with rms meters, the engineer must also avoid some of the more subtle pitfalls—crest factor, bandwidth, and dc-coupling limitations—that can cause errors that are meaningful in such cases.

The measurement of pulse trains or other asymmetrical wave forms with short duty cycles or duty factors—the ratio of one pulse width to the period of repetition—often presents signals to the voltmeter that have peak values many times higher than their rms values. If the peak of the signal overdrives the instrument, distortion will be produced, and accuracy will consequently be lost.

Considering the crest factor

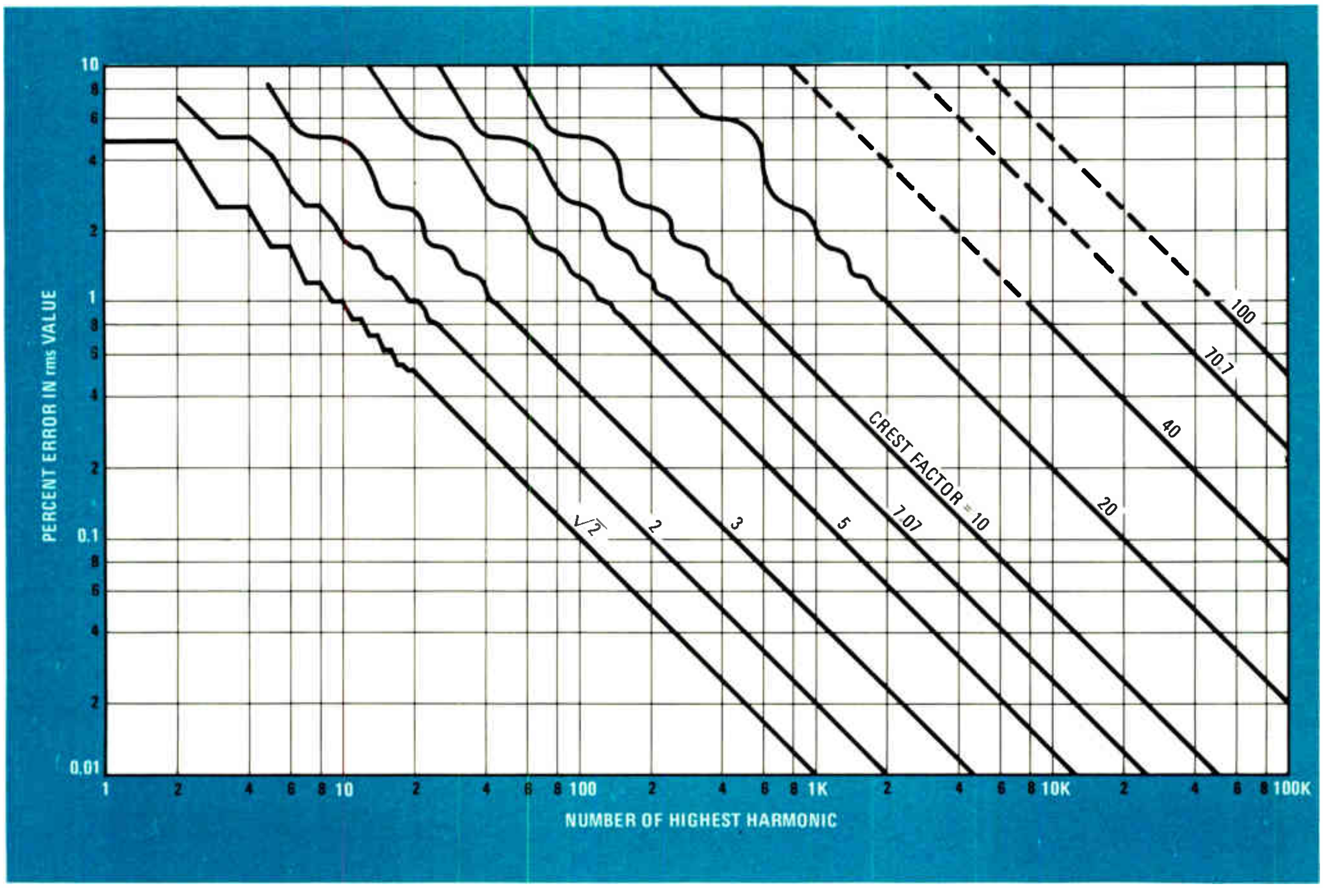
Crest factor is defined as the peak value of a signal divided by the signal's rms value, and the capability of an instrument to handle the crest factor is a measure of its dynamic range. For a pulse train, the crest factor is equal to

$$[(1/\text{duty cycle}) - 1]^{1/2}$$

For example, a pulse train with a duty cycle of 0.02 has a crest factor of 7.

Any rms-responding voltmeter can handle a signal with a crest factor of 7, but it cannot always do so at full scale. As the input-signal level increases, the crest-factor

1. Error sources. Bandwidth and crest-factor limitations in a measuring instrument may cause error. The uncertainty of the measurement can be determined from these curves when the number of harmonics passed by the instrument and the crest factor of the signal are known.



limit of the instrument decreases. If reading the rms voltage of a pulse train with a crest factor of 7 at full scale would overload the instrument and yield a faulty reading, it would then become necessary to switch to the next higher range and read down the scale—10% of full scale of the original range. In that situation, the capability of the instrument to handle the crest-factor is adequate.

Since the highest crest factors are allowable at low percentages of full-scale readings, measurements with rms-responding meters should be started at the least sensitive range. Then, the sensitivity can be increased to obtain greater resolution until the rms-value reading changes when the instrument overloads. This procedure reduces the possibility that input signal peaks will at any point overload the instrument's amplifiers or rms converter.

External attenuators may also be used to match the crest factor of the input signal to a specific point on a given range of the instrument. The indicated value is then multiplied by the division ratio of the external attenuator to determine the actual rms value of the applied signal.

A cause of error related to crest-factor limitations is the bandwidth of the instrument. If an ideal pulse train having a 0.01 duty cycle and a 10-kilohertz repetition frequency is applied to an instrument that has a bandwith of 3 megahertz, the uncertainty in the indicated rms value resulting from bandwidth limitations can be calculated.

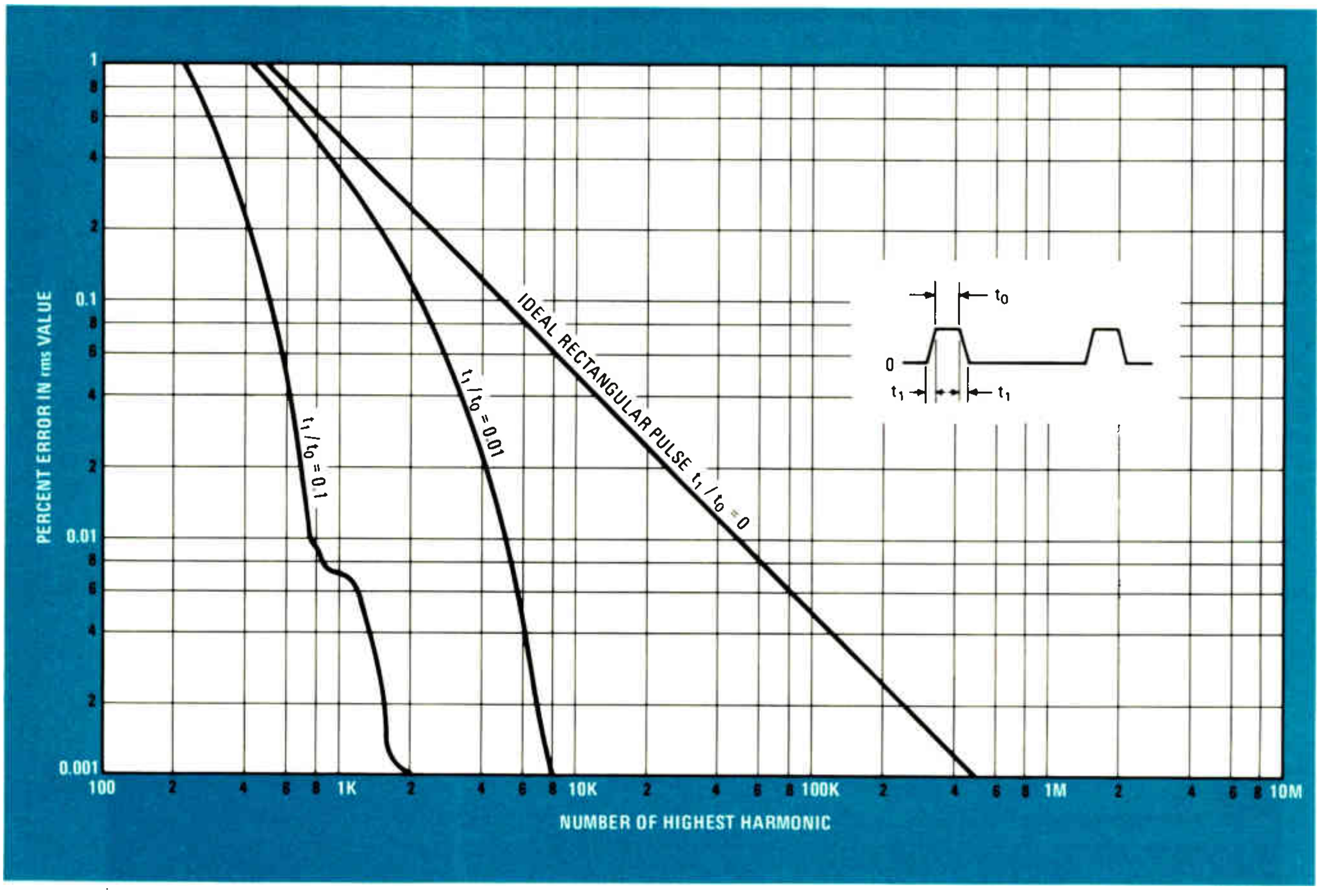
The crest factor—10—can be calculated from the equation above. The number of the highest harmonic passed by the voltmeter is the bandwidth divided by the signal's repetition frequency—the 300th harmonic. As shown in Fig. 1, the uncertainty under these conditions is 1.7%, and this percentage has, of course, to be added to basic meter uncertainties.

Either by reducing the repetition frequency to 1 kHz or by increasing the instrument's bandwidth to 30 MHz, the rms-reading error can be reduced to 0.17%. Increasing the duty cycle of the 10-kHz pulse train to 10% for a crest factor of 3 would reduce the uncertainty of measurement to about the same level, 0.15%.

Bandwidth must be large

Large bandwidth is required to make precision measurements even when the pulse shape is not rectangular and the transition time is an appreciable percentage of

2. Shape dependence. When the shape of pulses in a train is not rectangular and the transition times are an appreciable percentage of the pulse width, the measurement error is less than it would be for ideal pulses. The curves here are for signals with crest factors of 10.



the pulse width. For example, if a pulse train has a repetition rate of 3 kHz, a duty cycle of 0.01 (crest factor = 10), and a trapezoidal form in which the flat top is 10 times longer than the transition time, the uncertainty is less than 0.1% only if the measuring instrument's bandwidth is greater than 1.5 MHz, as determined from Fig. 2. If the same pulse-train-transition time had been zero, the uncertainty would have been 1%.

A selection factor that is appreciated even less is the input-coupling of the instrument. An rms-responding meter can be ac-coupled, but since the dc component of a signal also contributes to the rms value, only those instruments that have direct coupling can measure the true rms value of the complete signal. An rms voltmeter that has only an ac-coupled input is not a true rms meter, since it can never determine the total (ac+dc) rms value of the waveform nor even whether or not the input signal has a dc component.

Dc components show up more often than is commonly realized. Often they are small, so unless they are of special interest, they can be overlooked. But for ac measurements with less than 1% error, dc levels cannot be ignored.

Dc levels are commonly found in power-control circuits that chop away part of a sine wave to control motor speeds or perform similar functions. They are also to be found in speech wave forms, digital-logic signals, strain-gage signals and switching power supplies, as well as in most pulsed signals ranging in applications from electromechanical controls to such exotica as lighting studies.

The error caused by ac coupling in measuring a common signal such as an asymmetrical square wave can be calculated. The true-rms value of an asymmetrical square wave is given by:

$$(1/2)^{1/2} \times (Y^2+Z^2)^{1/2}$$

where Y is the positive-going amplitude and Z is the negative-going amplitude. If, for example, Y = 8 and Z = 5, the wave form can be thought of as a pure ac square wave with an amplitude of 6.5 volts superimposed on a dc level of 1.5 V. An ac-coupled rms meter would read 6.5 V, but the value measured by a dc-coupled instrument—the correct value—is 6.67 V. The error, then, is approximately 2.5%.

The right answer could be calculated from the measured dc and ac components by adding their squares and extracting the square root. The problem is that this approach is not only time-consuming but also assumes that the existence of a dc component is known in advance and that the voltmeter can extract the dc value without error.

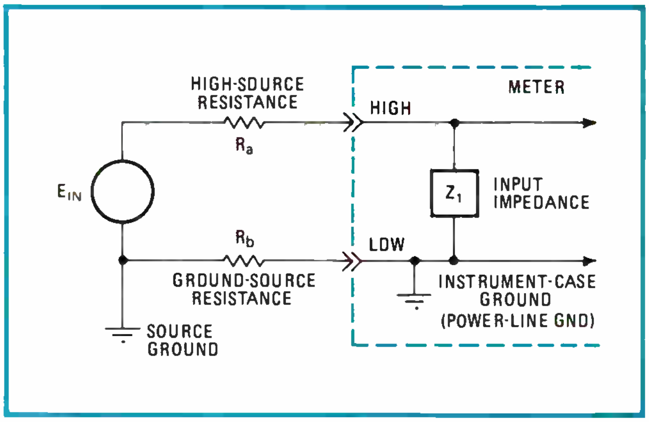
Beware of extraneous signals

After a high-accuracy true-rms voltmeter has been purchased, its precision should not be wasted by sloppy use. Especially when measuring signals with low-level or high-frequency components, a true-rms voltmeter will read unwanted dc voltages, noise, and hum in addition to the desired wave form as part of the input signal. Most techniques intended to eliminate such extraneous signals are not new, but they are still worth mentioning here.

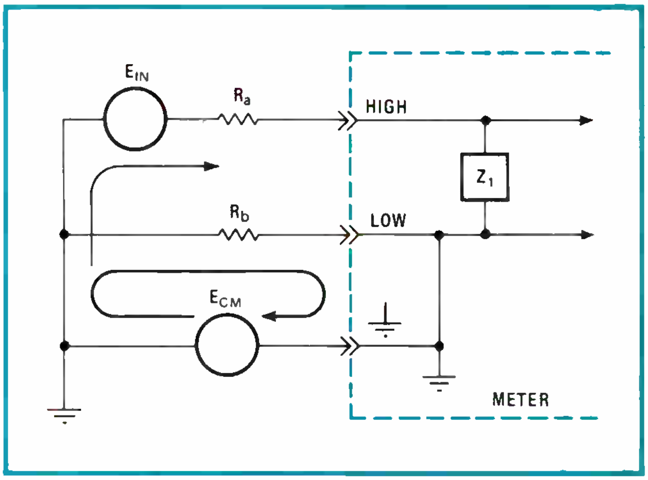
For example, input test-lead capacity must be minimized to reduce loading of the circuit under test. Open-wire test leads may add an input capacitance of 25 to 50 picofarads or more if the leads are twisted to minimize stray pickup or are strung over a ground plane. The loading factor of the total shunt capacitance may be determined from the relationship:

$$X_c = 1/2\pi f_c F$$

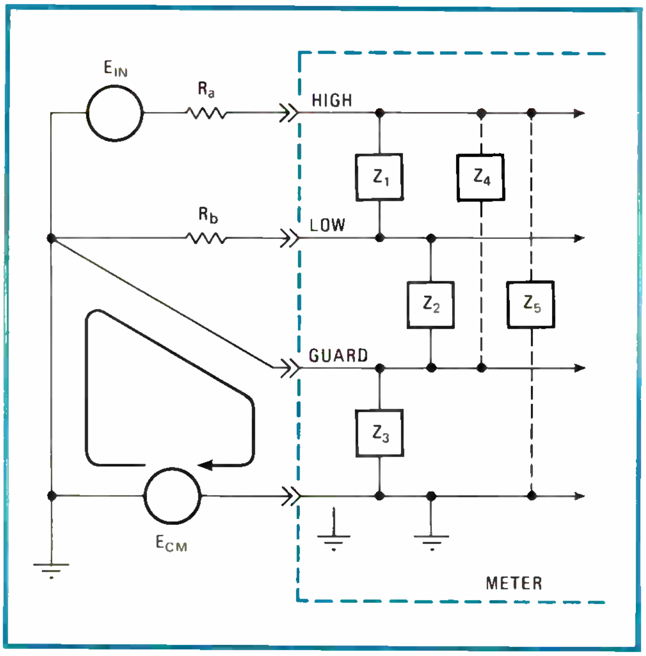
where f_c is the frequency in hertz and F is the capacitance in farads. For example, a 50-picofarad shunt capacitance at 1 MHz has a reactive loading of 3,180 ohms,



3. Two-terminal measurements. When the source-ground and instrument-low potentials are the same, the resistance of the low test lead is effectively canceled, and no unwanted ground-related voltages appear at the meter's input terminals.



4. Ground loop. When ground potentials are not equal, noise may appear as a voltage across the ground-lead resistance. If the measurement-low terminal is connected to earth ground, then most of this current will flow through the low terminal to ground, changing the reference-voltage level and causing measurement errors.



5. Guarding against errors. A metal shield around an instrument's measuring circuits increases its common-mode rejection by shunting ground current away from the measuring terminals and increasing the impedance between the measuring terminals and ground.

a very low figure when compared to the input impedance of the voltmeter itself.

To achieve less than 1% error from capacitive loading, the test-point source impedance should be less than 1/100 of the combined capacitive-loading impedance of the voltmeter and test leads. The use of a high-impedance divider probe is recommended to minimize capacitive loading and to provide shielding of the input-signal test leads.

At higher frequencies and when using long lengths of cable, errors may be caused by time delays and standing waves in unmatched and unterminated lines. These errors can be minimized by using a matched and terminated coaxial connecting system.

Allowing for ground current

Another common source of measurement error in low-signal-level measurements is extraneous ground current. This ground current is normally a power-line or other frequency signal that is not part of the signal to be measured, but flows in the ground-lead impedance. This causes an unwanted voltage to appear along with the signal at the input connector.

The effects of such ground currents may be reduced or eliminated by a number of techniques. One common method is to employ twisted or coaxial signal leads that are as short as possible or to use only one power-line earth return for all the equipment related to a single measurement setup. When connected in power lines, isolation transformers with low interwinding capacitance, high series resistance, and shielding can break power-line and other low-frequency ground loops. In another approach, operating the voltmeter or the rms converter from an isolated and floating external supply such as a battery can also help reduce unwanted signals.

Measurement errors related to grounding problems can also be caused by common-mode signals. Such signals are unwanted voltages common to the high and low input terminals. A floating input signal may have a common-mode component relative to earth ground. Often this unwanted component, caused by grounding differences between the voltmeter and the voltage source, is picked up from the ac power line.

The magnitude of common-mode voltages may range from a few millivolts to hundreds of volts. Such voltages cannot be eliminated by the instrument, but it is possible to make them flow around the measuring circuit without appearing across the measuring terminals.

When a signal input is connected to a simple grounded instrument, as long as the source ground potential equals the meter ground potential, no current will flow other than that caused by the voltage to be measured, and the instrument will measure this voltage less any voltage drops across the input lead resistances (Fig. 3). But when the ground potentials are not equal, unwanted power-line-related noise signals may appear as a voltage across the ground-lead resistance (Fig. 4). If the signal-measurement low is connected to earth ground in the instrument, most of this common-mode current will flow through the low terminal to ground because of the high impedance from the high measuring terminal to the low measuring terminal.

Measuring low signal levels

For accurate measurements at very low signal levels, a floating input does not always yield enough common-mode rejection, and other techniques are needed for optimum precision. The guard terminal and its connection with the instrument's circuits can provide such rejection.

The guard, a metal shield around an instrument's measuring circuits, reduces common-mode currents. This reduction, in turn, increases the common-mode rejection of the instrument by increasing the impedance between the low-measuring terminal and case ground. When the guard is connected to the reference low of the circuit under test, common-mode currents are shunted away at the source (Fig. 5).

With four input terminals (high, low, guard, and ground), the ideal input cable would be a double-shielded, two-conductor cable with the outer shield connected to case ground and the inner shield connected to the guard. The inner conductors should have low-noise insulation and capacitances lower than 20 pF per foot to the inner shield and to each other. In addition, the inner conductors should be twisted to phase out any difference signals from external magnetic fields, which would not be attenuated by the double shield. Such precautions may seem excessive, but they are necessary to obtain the savings attainable by true-rms measurements.□

Part 2

Designing reliability into power circuits

Component selection and protection for critical solid-state devices pay off in heavy-duty service

by Alexander Kusko, Thorleif Knutrud, and John J. Cain,
Alexander Kusko Inc., Needham Heights, Mass.

☐ Reliability problems in power-semiconductor equipment are tackled in the same manner as any good circuit design—select optimum components based on worst-case conditions, then back off to a cost-versus-performance selection with which you can live. With power equipment, this process must be carried out once for the control and logic and again for the power circuit.

Part 1 [*Electronics*, March 4, p. 111] of this two-part series discussed control and logic design, with emphasis on noise, the biggest culprit undermining its reliability. Now we move on to the rectifiers, inverters, and choppers that make up the bulk of power-semiconductor equipment.

Phase-controlled rectifiers are found in lasers, research magnets, battery chargers, equipment for electrochemical processing, power supplies for computers or mass-transit traction substations, and other types of power-generation equipment. Rectifiers are available in various combinations of dc voltage- and current-control and polarity. Capacities range from a few watts to over 100 megawatts. When matched with dc motors, they can be found in drive packages of up to 500 horsepower (or more, in special applications).

Single-phase, two-pulse rectifier circuits can handle loads up to about 5 kilowatts; three-phase, six-pulse circuits up to 500 kW, and six-phase, 12-pulse circuits, about 500 kW. The higher the pulse number of the circuit—the number of pulses present in the dc output voltage for each cycle of ac supply voltage—the lower the harmonic feedback. In handling megawatts, harmonic feedback to the utility can become a problem.

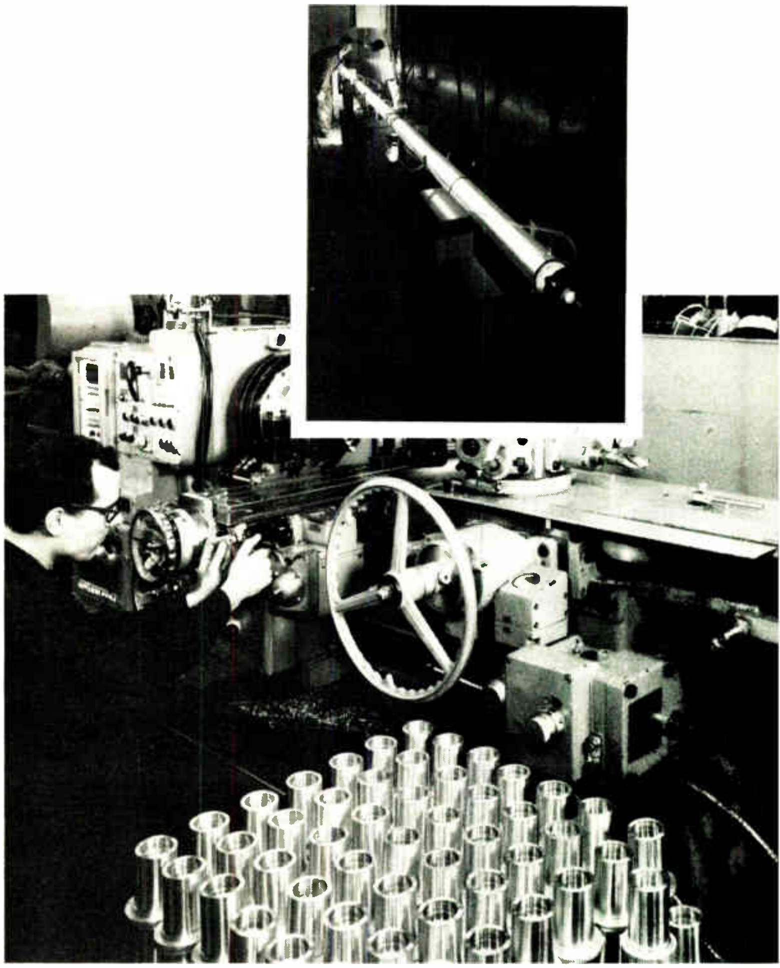
Figure 1 shows a typical three-phase bridge circuit used as a dc motor-drive. Six thyristors control voltage down to zero, minimize ripple, and permit regenerative braking (where the motor, with the field reversed, acts as a generator). Substituting three diodes for thyristors 2, 4, and 6 reduces costs. But there is no regenerative braking, and, as the motor voltage drops, the ripple pulse becomes larger in relation to the average motor voltage. If there is no need for voltage control, diodes can replace all six thyristors.

The voltage and current requirements for each arm of the bridge in Fig. 1 can be met with a single thyristor and diode or with multiple devices connected in series or parallel. Of course, a series connection may degrade reliability, while a parallel connection may improve it.

In a dc motor drive, the transformer delivers the proper ac voltage for rectification, isolates the dc terminals from the ac line, provides high impedance to limit current surges, and attenuates harmonic feedback and certain types of line-voltage transients. But the transformer is an expensive, heavy device. If possible, eliminate it. There are two sets available, in which the motor operates directly on rectified three-phase power: 250- and 500-volt dc motors operating from 230- and 460-v ac sources, respectively.

Rating the devices

To design highly reliable rectifiers (or any power-semiconductor equipment), select power semiconductors rated to withstand the worst-case voltage, current, and temperature conditions. Typically the initial selec-



Power semiconductors in action. Two typical applications are ac or dc motor-drive packages for machine tools and solid-state power supplies for regulating low-to-medium-power lasers.

tion is subject to cost tradeoffs, resulting in a combination of lesser-rated power semiconductors and added suppression devices that will handle abnormalities.

Worst-case voltage conditions for thyristors are the peak forward and reverse voltages, and for diodes, the peak reverse voltage. These peaks are equal to the sum of the highest steady-state peak voltage and the transient voltages passed by the suppression devices (metal-oxide varistors or capacitors). Rather than using handbook formulas for peak voltages, sketch the worst-case waveforms across the circuit and calculate the peak. The formulas apply to specific sample configurations from which the actual circuit may vary significantly.

Thyristors and diodes must withstand both the worst-case steady-state load current and the worst-case surge current. Worst-case surge current results from a dc side fault. If parallel, individually fused diodes and thyristors are used, the worst surge current occurs when fuses blow. The rest of the circuit has to carry the total surge.

To account for abnormal conditions, a safety factor often is added to the worst-case steady-state voltage and current. This factor will vary with the type of equipment. A typical rectifier circuit with transient voltage suppressors that has no unusual overload requirement will carry safety factors on its maximum ratings of 2.5 for voltage and 3.0 for current. These ratings should be enough to handle all transients, but, as a precaution, calculate the actual peak values and compare them with the values based on the safety factors.

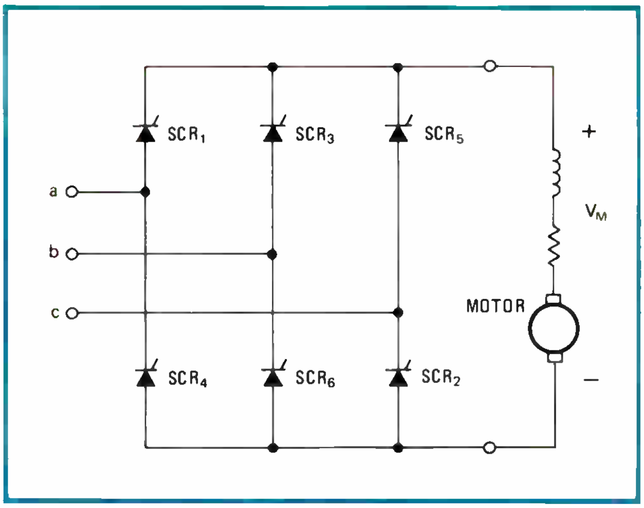
Introducing voltage suppressors and current protectors requires some thought, for they must be matched carefully to the characteristics of the rectifying circuit.

With surge current, the designer must keep in mind its duration as well as its magnitude, because the ratings of diodes and thyristors are based on both factors. Duration depends on how the surge is interrupted. There are three techniques, with all of them incorporated into a well-designed circuit.

The fastest response is through suppression of the thyristor firing signal, which prevents any further gate pulses from getting through after the first half cycle. Fuses may take longer to respond: for fast fuses, the peak amplitude and duration of the surge can be calculated as if they resulted from a line-to-line ac fault at the terminals of a bridge. An ac line breaker may permit a surge as long as 50 milliseconds, but the actual calculations are beyond the scope of this article.

For suppressing transient voltages, resistor-capacitor snubbers, varistors, or both are connected to the transformer's secondary terminals or to the supply line when there is no transformer. Each of these devices provides a lower impedance path for the transient than the source impedance, and each of them works equally well. In general, selection depends on the specified safe voltage for the semiconductor, the surge energy that must be discharged, and cost.

The use of the transformer means the suppression circuit must be designed to handle the voltage transient caused by switching the transformer on and off. Without a transformer, the protection must be designed to handle voltage transients caused by lightning and by switching in the distribution system that supplies the



1. Motor drive. In this typical power-semiconductor bridge, six thyristors convert three-phase power into a dc voltage across the motor.

equipment. The design for the transformer circuit also will take care of these two additional kinds of transients.

In order of decreasing severity, the three types of transient voltages produced by transformer switching are:

- Interruption of the magnetizing current and discharge of the core energy.
- Interruption or application of the load current, causing ringing between the leakage inductance and any secondary capacitance.
- Application of primary voltage with direct transfer to the secondary through the interwinding capacitance of the transformer.

A varistor or the capacitor of a snubber will limit the first type. Varistors, which should be connected line to line across the transformer's secondary terminals, are selected to limit the peak secondary voltage for a peak pulse of magnetizing current and to absorb at least the core energy. The peak core energy expressed in joules is $W_m = I_e \times VA \times 1/377$ where I_e is the per-unit exciting current and VA is the volt-ampere rating.

The key to selecting a varistor for a given secondary voltage is to choose the one with the highest average energy dissipation that the budget will permit. The higher the dissipation rating, the greater the suppression of the varistors and the lower the output voltage for a given peak current.

A resistance-capacitance snubber also would be connected to the line-to-line voltage V_o (rms). The capacitance will absorb the core energy W_m in cases when $C = W_m/V_o^2(k - 1)$, where k is the safety factor applied to the normal peak voltage of 1.4 v.

To damp ringing between this capacitor and the leakage inductance L, and to limit the discharge current when the rectifier diodes and thyristors commutate, the resistor in the snubber is necessary. For a damping ratio of 1, choose a resistance approximately equal to $(L/C)^{1/2}$.

Transient voltages transferred through the interwinding capacitance, the final kind of transformer transient, can be suppressed typically with 0.01-microfarad capacitors. These capacitors would be connected from

TABLE: STRESS LIMITS FOR INVERTER THYRISTORS	
Each of these calculated or measured parameters shall not exceed the stress factor multiplied by the thyristor rating for that parameter	
Quantity	Stress Factor
Working voltage peak forward and reverse	0.5 max
Repetitive peak voltage, forward and reverse	0.7 max
Non-repetitive peak voltage, forward and reverse	0.9 max
Rate of reapplied forward blocking voltage	0.5 max
Average forward current*	0.7 max
Repetitive peak current	0.7 max
RMS current	0.7 max
Rate of current rise during turn-on	0.5 max
Gate current	2 min, 0.7 max
Gate power	0.7 max
Junction Temperature, Calculated	$[(T_j)max-40]$°C avg $[(T_j)max-25]$°C peak

*For guidance only. Actual current depends on junction temperatures.

the plus and minus sides of the rectifier to ground.

When there is no transformer, varistors and snubbers can limit transient voltage in bridges and control circuits. Choose a varistor that will limit the peak surge voltage at the peak discharge current. This current is approximately equal to the peak surge voltage divided by the peak surge impedance. Again, the higher the average dissipation rating of the varistor, the lower the peak voltage that will pass through it. Experience has shown that, at higher line voltages, the snubber is a more cost-effective voltage suppressor than a varistor.

On to inverters

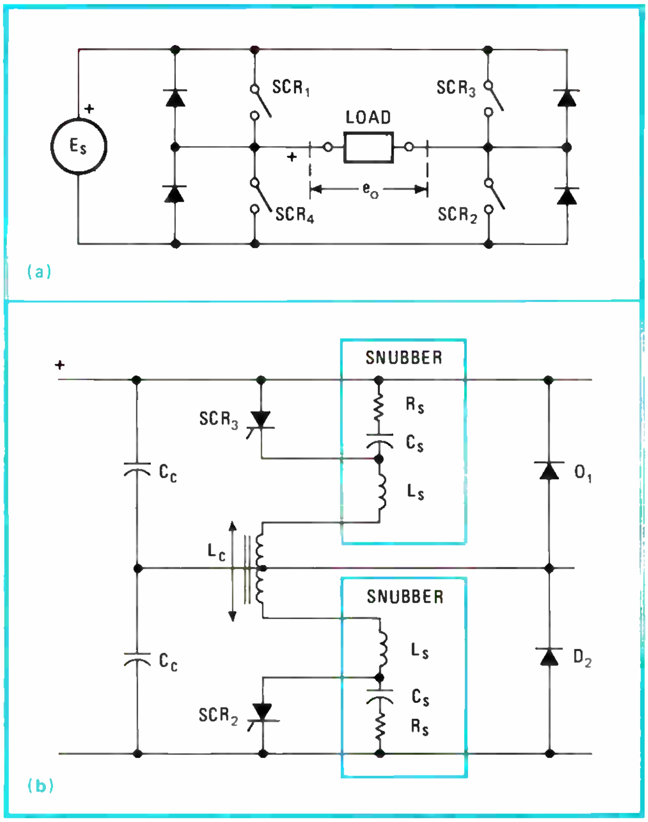
Low-power portable fluorescent lights, megawatt-size uninterruptible power supplies, and metal-processing equipment all use inverters operating at frequencies spanning a range of 50 hertz to over 100 kHz.

Inverters require commutation circuits, which are susceptible to noise problems and transitional logic states that can cause firing failures. If the commutation circuit fails, it may result in a blown fuse or, even worse, a wrecked inverter.

The important specifications for thyristors used in inverters are minimum turnoff and recovery time, di/dt, dynamic thermal impedance, peak current levels, and peak forward and reverse voltages.

Generally, thyristor turnoff times fit within a range of from 8–10 microseconds for top-quality examples to about 400 μs for slower units. The reverse pulse voltage applied during commutation must last at least the minimum turnoff time.

A thyristor usually is turned on by a transistor switch and pulse transformer whose secondary is connected to the thyristor's gate. As the thyristor is turned on, circuits with low series inductance—as is often the case in inverters—experience an initial high rate of current change. So di/dt must be limited. And the resulting voltage transient seen by other thyristors in the circuit must be damped. Also, severe thermal fluctuations affect thyristors when they are subject to a combination of high di/dt and high current levels.



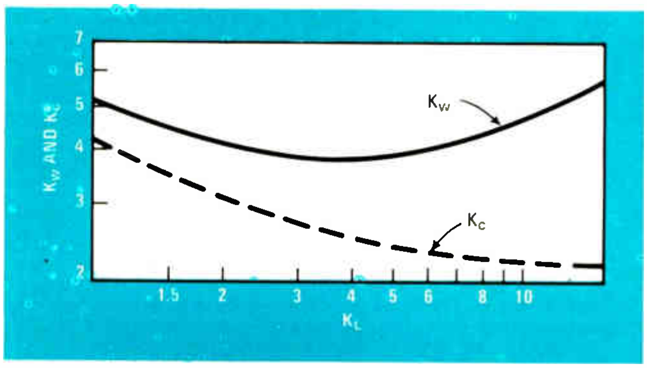
2. Switching output. Thyristors SCR_1 and SCR_2 close simultaneously for the positive half-cycle output. Then they open, and SCR_3 and SCR_4 will close and conduct for the negative half cycle. The diodes provide regeneration paths for the inductive load current. Only half the circuit is shown in (b), the other half is symmetrical with the load connected between the two diode midpoints.

For high reliability, the thyristors must operate well within their specified limits. Too often the stress margins have been reduced or neglected in favor of short-term economy. The table lists a set of suggested stress limits for good reliability. If the inverter is essential to safe operation, a doubling of these factors may be appropriate.

Other components in the inverter circuit can affect thyristor stress significantly. For example, in high-power inverters, it's common for a pair of thyristors to switch an output terminal between the positive and negative sides of a dc source (Fig. 2). This variation of a circuit known as the McMurray-Bedford inverter commutates one current-carrying thyristor by gating the other (In Fig. 2a thyristors are depicted as switches.)

To optimize weight, size, and cost, the designer tries to pick values of commutating capacitors and inductors that will minimize the energy in the commutation process. This is particularly important in the circuit in Fig. 2, because most of the energy in the inductor is dissipated by the current circulating through the diodes. (There are additional circuits for partial recovery of the commutating energy, but they aren't shown.)

For any given value of the commutating capacitor C_C, there is a minimum commutating inductance L_C



3. Sufficient time. Commutation time depends on the proper selection of the commutating capacitance and inductance, which are a function of K_C and K_L. Ideally, these two constants should be selected from values somewhat to the left of minimum K_W.

that will yield enough commutation time for the thyristor:

$$C_C = K_C \times I_L \times t_0 / E_S$$
$$L_C = K_L \times E_S \times t_0 / I_L$$

where L_L is the maximum load current that must be commutated, t_0 is the turnoff time, and E_S is the minimum dc source voltage. K_C and K_L are constants selected from the graph in Fig. 3. Although the basic equations for these constants are relatively simple, they are transcendental. The graph has been plotted from values calculated with the aid of a computer.

For the inductor, the constant K_W in Fig. 3 can help figure peak energy, $W = K_W \times E_S \times I_L \times t_0$. Peak energy will be least when K_W is minimum.

Since K_W changes little over a rather wide range of K_L, L_C can have a fairly broad range for near minimum values of W. The same rule holds true for C_C, because K_C also changes little over the same range of K_L.

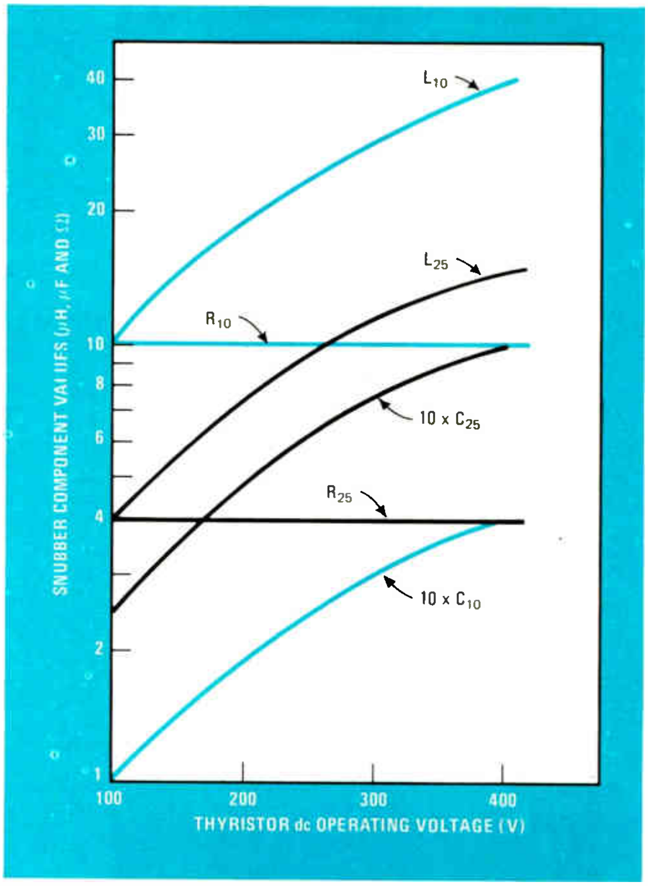
But minimum peak energy is not the only criterion for inductor and capacitor selection. The inductor must carry the load current at all times; therefore it will dissipate significant I^2R losses. And the thyristors require an initial reverse turnoff current, which decreases commutation time and requires added capacitance.

So pick an inductor with a constant somewhat to the left of the minimum K_W in Fig. 3 and a capacitor that has somewhat greater capacitance than indicated by the K_C curve. Because the peak thyristor current goes up as the inductance goes down, the capacitor must allow enough margin for the peak thyristor current.

Snubbing the problem

The primary purpose of a snubber is to prevent the rate of rise of forward voltage through a thyristor from exceeding a specified limit. The most severe voltage transients through a thyristor occur when other thyristors in the circuit switch, creating a step change in voltage. Often the thyristor manufacturer will recommend a specific RC snubber circuit (such as the one in Fig. 2b) without mentioning series inductance, which must be included for the snubber circuit to work.

This inductance L_S may be an inherent part of the inverter circuit, as with the leakage reactance of the commutating inductor L_C in Fig. 2b. In any case, make sure



4. Snubber variations. As the maximum operating voltage increases, the resistance, inductance and capacitance values required for adequate suppression will increase. Subscript numbers refer to the di/dt design valves.

that it is included, and choose the resistors and capacitors in the following manner.

The required inductance can be calculated from the equation $L_S = E \times (di/dt)_{max}$ where E is the step change in voltage and $(di/dt)_{max}$ is the maximum tolerable di/dt. In Fig. 2, $E = E_S$, the source voltage.

Once L_S has been figured, the designer can calculate the capacitance C_S required to limit the dv/dt across the thyristor and the resistance R_S necessary for good damping of the circuit:

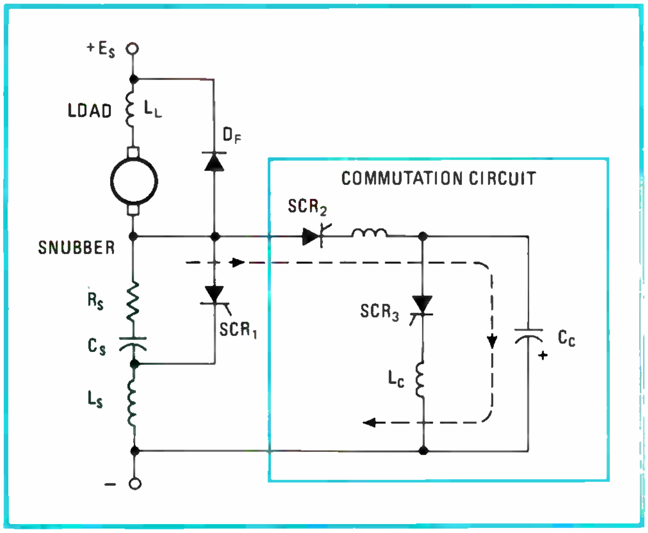
$$(dv/dt)_{max} = E/(L_S/C_S)^{1/2}$$
$$\text{Therefore } C_S = E^2/L_S \times (dv/dt)_{max}^2$$

The damping ratio equals $(R/2)\,(C/L)^{1/2}$. Picking a damping ratio of 0.5, a good compromise value:

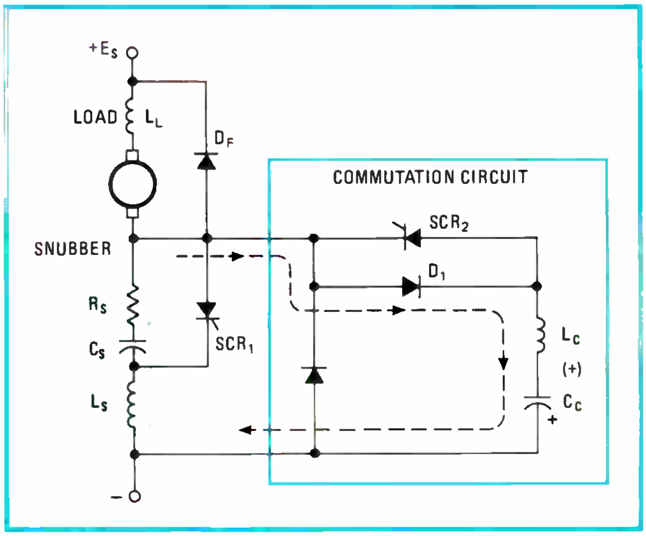
$$R_S = (L_S/C_S)^{1/2}$$

Note that a 0.5 damping ratio will result in a 30% overshoot after a step change in input and the thyristor rating must be compared against this peak voltage.

A word of caution also is necessary about the snubber circuit in Fig. 2. When the thyristor is gated on, C_S will discharge through it with a high di/dt. The designer must insure that the thyristor can operate with a good safety margin over the calculated values of R_S, C_S, and voltage. If not, he must consider alternate snubber designs that will limit the capacitor discharge current.



5. Self-commutating. When SCR_3 is fired, the charge builds up in L_C, reversing polarity of C_C and causing SCR_3 to turn itself off. For clarity, snubbers are omitted from SCR_2 and SCR_3.



6. Help from a diode. When SCR_1 fires, the load current travels in the direction indicated. After SCR_2 fires, the current reverses and commutates SCR_1. For clarity, snubber is omitted from SCR_2.

Figure 4 shows the variation of snubber component values with operating voltage E for two typical di/dt design values.

Chopping the power

Chopper circuits control loads supplied from fixed dc sources such as the batteries of fork-lift trucks and the third rails of rapid-transit cars. Two such circuits in common use are shown in Figs. 5 and 6. In both, the main load-carrying thyristor SCR_1 connects the bottom end of the load to the negative side of the dc source.

The average dc voltage across the load is controlled by adjusting the on-off ratio of SCR_1. When the thyristor is commutated, there is no longer a path through it. The voltage across the load will reverse, and the current will continue to flow through the load around a circular path through diode D_F as long as it is supported by the load inductance L_L.

In both choppers, the discharge of capacitor C_C commutates SCR_1. The capacitor polarity and the load-current direction are shown for the start of the discharge. Then the voltage across SCR_1 reverses, commutating the thyristor. The load current continues to flow through C_C until the polarity across it has reversed.

The main difference between the two circuits is the method used to reverse the C_C charge before the next commutation. In the circuit in Fig. 5, the commutation cycle is started by firing SCR_2, allowing the current to flow as indicated. After commutation, SCR_3 is fired, and current builds up through L_C, reversing the polarity of C_C. (Losses in this resonant type of circuit usually are low, so the final voltage of C_C is very nearly equal to the voltage before reversal.) SCR_3 then self-commutates as the current tries to flow back through L_C. The chopper now is ready for a new conduction period, starting with the firing of SCR_1.

The chopper in Fig. 6 also begins commutation by firing SCR_2, with a buildup of current through L_C, SCR_2, and SCR_1 back to C_C. After reversal is complete, the current flows as indicated, commutating SCR_1.

The circuit in Fig. 5 has a wider voltage range because there is no minimum on-time for charge reversal of the capacitor. Also, because there is no need for the same current pulse through SCR_1 and SCR_2 to reverse the capacitor, the peak current is significantly lower.

However, since the circuit in Fig. 6 has one fewer thyristor, it offers potentially higher reliability. Also the commutation cycle is considerably shorter.

Many other chopper-circuit variations are used, some of which can yield outputs from zero to the full supply voltage. Considerations of peak voltage, peak current, high di/dt, and high dv/dt are common to all.

The problem of peak voltage has been particularly hard to solve in mass-transit propulsion, because of high operating voltages (up to 3 kilovolts) and high peak voltage transients.

To meet high voltage requirements, designers have used two or more thyristors in series with a resistor-capacitor snubber across each to obtain the proper off-state voltage. However, when series thyristors are gated on, significant differences in turn-on time can prevent the RC snubbers from providing adequate protection. During commutation, the reverse current-pulses, which may differ considerably among the thyristors, can give rise to an uneven division of thyristor voltages.

With the following equations, the designer can approximate the peak voltage unbalances ΔV_P, caused by turn-on time differences ΔT and storage differences ΔQ:

$$\Delta V_P (R_S \times \Delta t/L)(E_S \times [n-1]/n)$$

for turn-on differences,

$$\Delta V_P = (2 \times \Delta Q \times di/dt)^{1/2} R_S + \Delta Q/C_S$$

for storage differences, where L is the total series inductance and n is the number of thyristors in series.

These voltage transients force a well-designed thyristor string to have individual voltage ratings significantly above those for single thyristors. High failure rates have occurred when designers neglected to provide individual thyristors with adequate voltage ratings. □

Dual-555-timer circuit restarts microprocessor

by James R. Bainter
Motorola Semiconductor Products, Phoenix, Ariz.

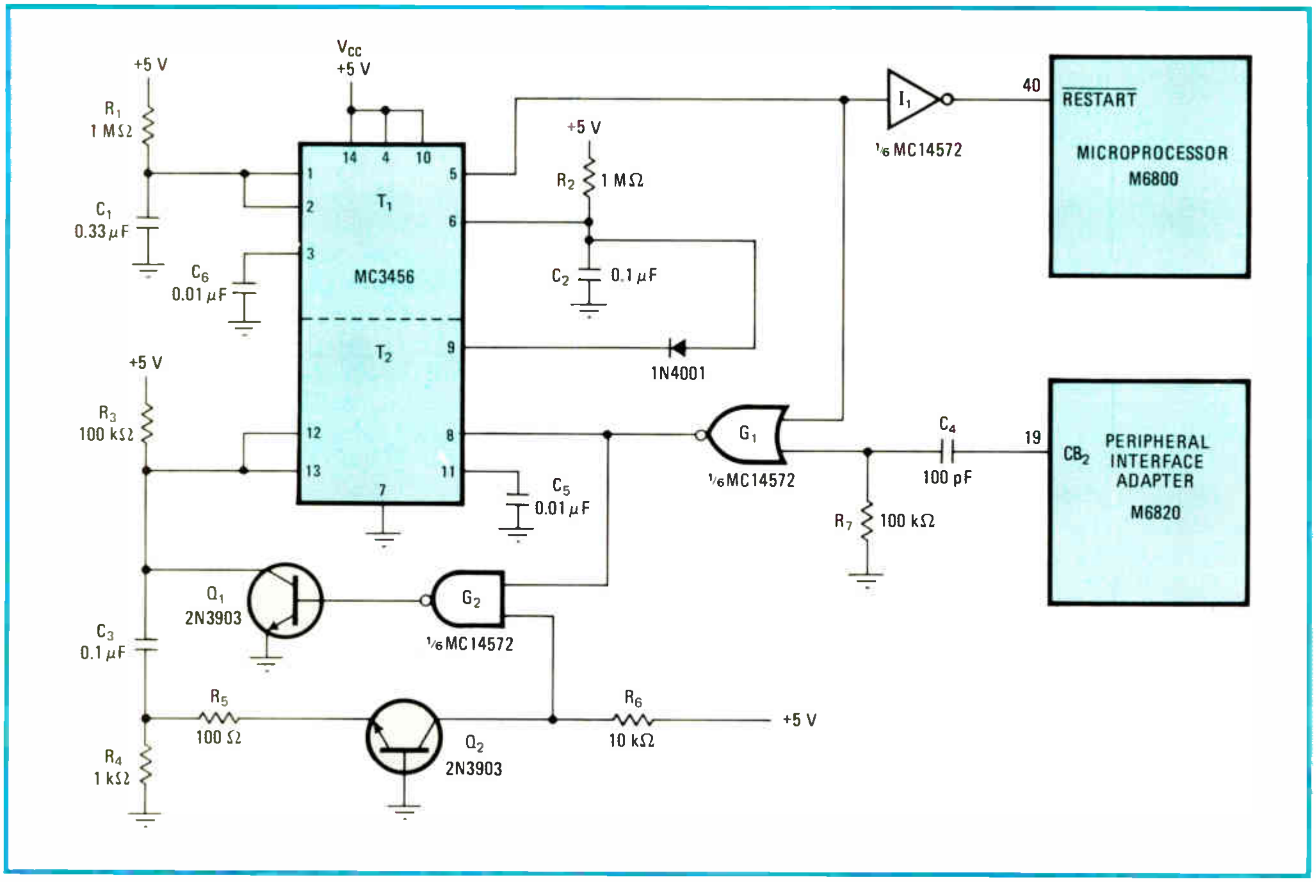
If noise on one of its bus lines garbles an instruction sequence, a microprocessor system will operate incorrectly—unless monitored by a timing circuit such as the one described here. When the circuit detects a garble, it generates a restart signal that causes the microprocessor to start its program all over again. The circuit also generates the power-on starting signal for the system.

Take the case of the M6800 microprocessor, which employs instructions composed of three 8-bit binary numbers, or bytes. The first byte is the operation code—describing the task to be accomplished—and the second and third bytes, if required, contain either data or address information. Now, suppose the hexadecimal number 20FE is to be loaded into the index register of the M6800. The instruction in machine code (hex representation) is CE,20,FE, and the three bytes reside in three consecutive memory locations. If noise from one of the data, address, or control buses were to make the processor skip the CE, the next byte, 20, would be interpreted as the operation code for "branch always," and then the byte FE would cause the processor to branch always on itself—in effect locking itself up in a loop with no exit.

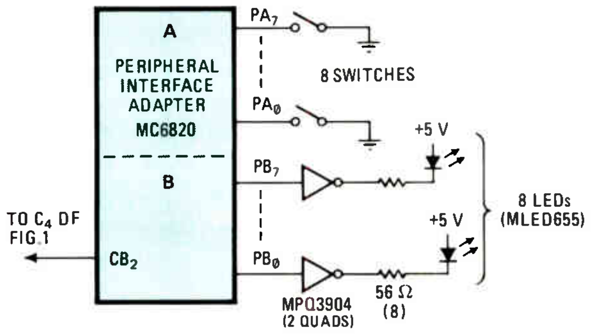
One way of restoring proper operation is to restart the system by pulling down the restart pin. In the case of the MC6800, this means driving pin 40 of its low-voltage condition—a job done by the circuit in Fig. 1.

The circuit is implemented with an MC3456 dual-555-type timer. Timing portion T_1 and timing networks R_1, C_1 and R_2, C_2 generate a 400-ms restart signal when power is applied. During normal program execution a signal lead applies a periodic pulse to T_2. In Fig. 1 this pulse comes from CB_2, the number 2 control lead from section B of a peripheral interface adapter. But if the processor goes off into never-never land or gets stuck in a loop with no exit, timer T_2 causes T_1 to generate a restart signal.

The circuit operates as follows. Assume pin 5, the output of T_1, is in the logic 0 (low-level) state. The pulses



1. Generates a fresh start. Dual-timer circuit applies starting pulse to microprocessor and also restarts it if noise bursts or other troubles cause it to get off program or stuck in a loop. Improper operation is indicated by absence of timing pulse to T_2 from a adapter program.



PIA LABELS	MEMORY ADDRESS
PIA1AD	\$4004
PIA1AC	\$4005
PIA1BD	\$4006
PIA1BC	\$4007

TEST PROGRAM

Machine Code (HEX)	Assembly Listing		
CE 00 34		LDX #\$0034	00→DDRA; \$34→PIA1AC
FF 40 04		STX PIA1AD	
CE FF 34		LDX #\$FF34	\$FF→DDRB; \$34→PIA1BC
FF 40 06		STX PIA1BD	CB 2 LOW
FE 40 04	START	LDX PIA1AD	SWITCH DATA TO X(HIGH)
09	D1	DEX	
26 FD		BNE D1	X=0 ??
86 34		LDA A #\$34	
C6 3C		LDA B #\$3C	
F7 40 07		STA B PIA1BC	CB2 HIGH
B7 40 07		STA A PIA1BC	CB2 LOW
7C 40 06		INC PIA1BD	INC LEDS AT PIA1BD
20 EB		BRA START	GO TO START ALWAYS

2. Program listings. Automatic restart test program, stored in RAM, generates the pulse from the interface adapter. Switches connected to PA_7—PA_0 are read into the index register (X), which then decrements down to zero. Control lead CB_2 pulses, and then LEDs blink on in sequence if the microprocessor system is functioning properly. START follows four instructions programing interface adapter.

occurring on CB_2 will be coupled via capacitor C_4 to NOR gate G_1. Each pulse will appear inverted at the output of G_1, retriggering T_2 and discharging C_3 via transistor Q_1 and G_2. The transistor-gate combination of Q_2 and G_2 insures the discharge of C_3 is complete. The pulse is 5 microseconds long if the system clock frequency is 1 megahertz.

When the C_3 discharge current drops below 0.7 milliampere, Q_2 turns off, turning off Q_1 and allowing C_3 to recharge. If no input pulse arrives within 10 ms, C_3 will charge up to 0.67 V_{CC} level, and output pin 9 of T_2 will go low, discharging C_2. When C_2 discharges to 0.33 V_{CC}, T_1 output pin 5 will go high, generating a restart signal.

A high-level signal on pin 5 will also be presented to NOR gate G_1, causing T_2 pin 8 to go low. This resets T_2 pin 9 high, allowing C_2 to recharge. When C_2 recharges to 0.33 V_{CC}, C_1 will then recharge to 0.67 V_{CC}. T_1 output pin 5 will remain high until C_1 reaches the 0.67-V_{CC} level. Thus the restart (no pulse) signal will have a duration of R_1C_1 or 300 ms. This long restart signal is needed to turn on the power in a processor system that uses crystal-controlled clocks.

The test program in Fig. 2 is stored in the system's random-access memory. It generates the pulse on CB_2 and tests out the circuit shown in Fig. 1. It reads the switches at the A side of the interface adapter and places the switch data in the upper half of the index register, which it then decrements down to zero. Next, it stores a hex 30 in the B side control register, causing CB_2 to go high, followed by a hex 34, causing CB_2 to go low. The combination of these two instructions has thus caused a positive pulse on CB_2 that lasts for five machine cycles (5 μs for a 1-MHz clock).

The program then increments light-emitting diodes at the A side of the interface adapter, to give a visual indication of proper program execution. Then it branches back to where the switch data is loaded into the upper half of the index register.

As the higher-order switches are placed in the open (logic 1) position, the index register will be loaded with a larger number, and the program will take a longer time to decrement the index register down to zero. Thus the frequency of the pulses on CB_2 will be lower. With the values of R_3, C_3 in Fig. 1, timer T_2 will time out if a pulse does not occur on CB_2 at least once every 10 ms.

A real-life operating system would not use the test program of Fig. 2 to generate timing pulses to T_2. Instead the regular program residing in the system memory would include the two steps that drive CB_2 high and then low again. These would provide the pulse that indicates proper operation of the program; if the pulse failed to appear periodically, the T_1 timer would restart the program.

During system development, the output of T_2 pin 9 can be used to generate other signals, such as interrupts to print stack contents. This printout would be useful in pinpointing the cause of system problems. The signal could also be connected to a counter to record the number of system "hiccups" over a given time period. □

Timer IC stabilizes sawtooth generator

by Frank N. Cicchiello
Geometric Data Corp., Wayne, Pa.

A temperature-independent audio-frequency sawtooth generator that uses a 555 integrated-circuit time is shown on page 109. Its sawtooth output maintains linearity within 1%, and its output is available from a low-impedance source that is fully buffered from the timing circuitry.

The circuit is superior to the more conventional approach that develops a linear sawtooth by adding a con-

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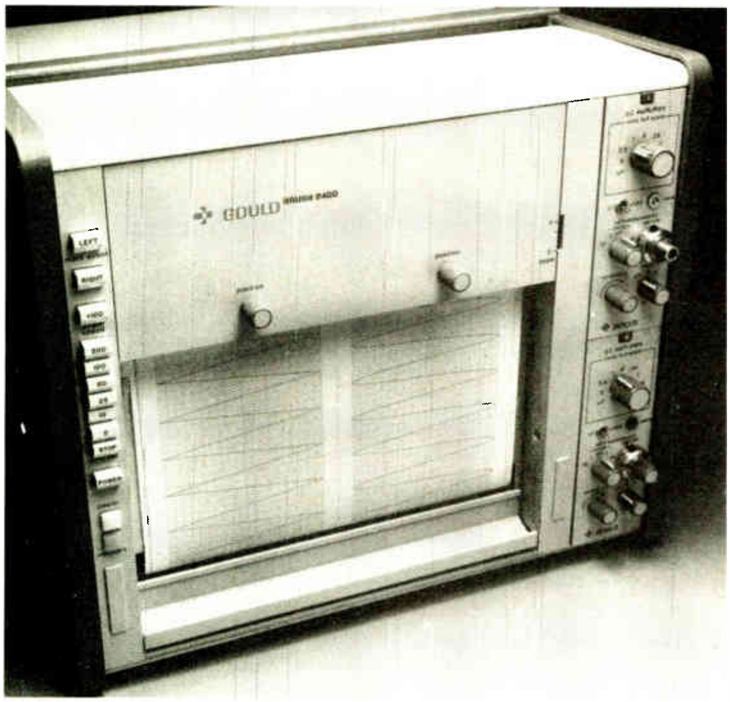

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stant-current pump to charge the sawtooth-forming capacitor. Since V_{BE} of the constant-current transistor changes with temperature in a conventional circuit, a corresponding change in its current would cause a variation in frequency of the output sawtooth. No such change occurs in this 555 circuit.

Connecting pin 2 to pin 6 (trigger and threshold inputs respectively) of the 555 causes it to trigger itself and free-run as an astable multivibrator. Consider the circuit action after the IC's internal discharge transistor (pin 7), having dumped the charge on the sawtooth-forming capacitor C_1 via R_3, has become an open circuit and allows C_1 to recharge.

C_1 begins to charge through R_1, R_2, and R_3 toward the supply voltage V_{CC}. For all practical purposes, the change in voltage at the junction of R_2 and R_3 is equal to that at the top side of C_1. This voltage change is applied to the base of a Darlington-type emitter follower, Q_1. Since Q_1 has virtually unity gain, it couples this same change in voltage back to the top side of R_2. As a result, the voltage across R_2 remains essentially constant during C_1's charging cycle and so produces the same effect (linear-ramping) as a constant-current source feeding C_1.

Once the linear sawtooth signal at pin 6 reaches a value of ⅔ V, the IC's internal comparator resets its flip-flops. The reset again activates the discharge transistor (pin 7), causing C_1 to dump through R_3; this action causes a new trigger wave to be applied to pin 2, thus repeating the circuit operational cycle.

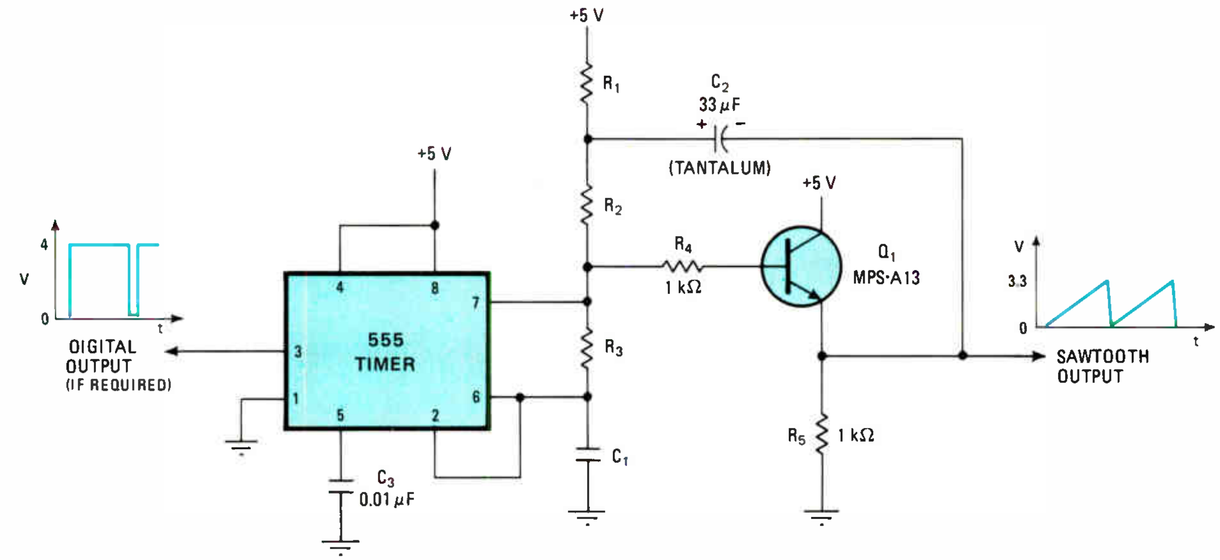
Resistor R_3 is required to slow down the negative-discharge slope of the sawtooth wave form. Resistor R_4 is a parasite suppression resistor for Q_1. C_3 is a bypass capacitor on the voltage-control (pin 5) input of the IC, which is unused in this circuit.

The component and frequency relationships can be simply stated and easily implemented:

$R_1 = R_2$
R_2 *is equal to or greater than 10* R_5
R_3C_1 *is equal to or greater than* 5×10^{-6} *s*
R_4 = *1 kilohm*
R_5 *is equal to or greater than 100 ohms*
R_1C_2 *is greater than 10* R_2C_1
$f = 1/C_1[0.75(R_1 + R_2) + 0.693\, R_3]$

As in the conventional exponential sawtooth generator circuit, the output frequency is independent of variations in supply voltage. Typical performance data is shown in the table. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.



±5% TOLERANCE ON ALL COMPONENTS

FREQUENCY		R_3	R_1 & R_2	C_1
Computed	Measured			
54.2 kHz	50 kHz	5.1 kΩ	10 kΩ	1,000 pF
665 Hz	667 Hz	510 Ω	100 kΩ	0.01 µF
6.7 Hz	6.9 Hz	51 Ω	1 MΩ	0.1 µF

Linear, buffered, and stable. Sawtooth voltage generator, developed for CRT sweep deflection, uses 555 astable multivibrator. Emitter-follower arrangement of the transistor maintains charging current to C_1 constant for linear ramps and provides buffered low-impedance output. Temperature-induced changes of V_{BE} do not affect frequency. Table shows typical frequency characteristics; supply voltage can be raised for greater output without changing frequency. In addition to the sawtooth wave form, a digital output is also available from 555 as shown; this signal may be useful for triggering a scope, for example, but it is not necessary for generating the sawtooth.

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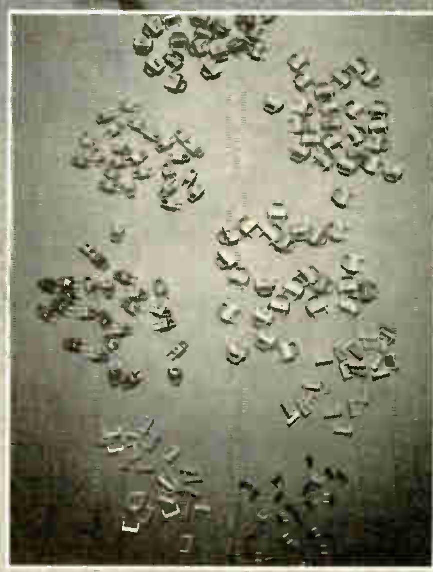

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Resistive insulated gates produce novel a-d converters, light scanners

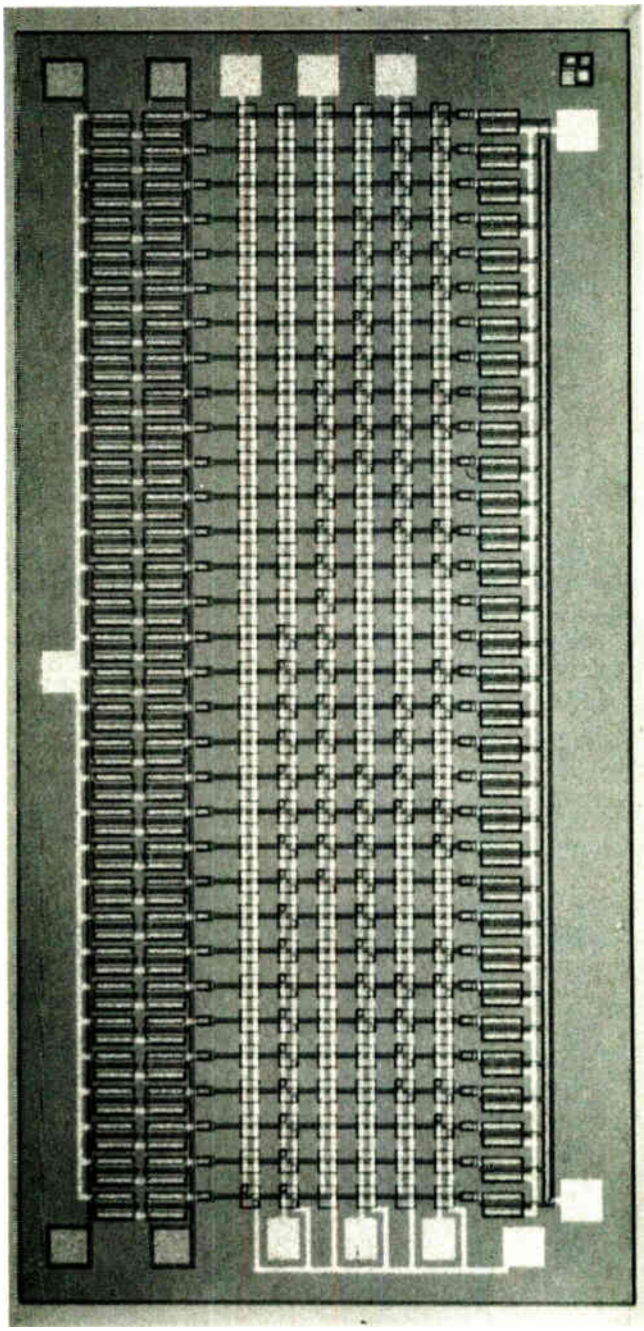
by Maurice V. Whelan, L.A. Daverveld, and J.G. deGroot,
Philips Research Laboratories, Eindhoven, the Netherlands

☐ A simple variation of standard silicon-gate technology has produced extremely versatile arrays that make novel analog-to-digital converters, analog type displays, and light-pattern scanners. The arrays consist of devices similar to standard metal-oxide-semiconductor elements, except that a resistive electrode structure replaces the normal metal insulated gate. This structure permits a voltage gradient to be set up across the ends of the gate and then manipulated to control the transistors either singly or in groups.

One type of array, for instance, allows an analog voltage to regulate the length of a column of light-emitting diodes. It can serve as a relatively cheap but reliable remote-controlled indicator of volume, tone and balance in radio and television equipment. Extensions of the arrays have been used to produce sophisticated types of analog-to-digital converters, which even at this early stage offer 5-bit resolution, as well as light-pattern scanners up to 100 elements long, which are simple to operate and require no complicated clocking system.

In the conventional insulated-gate field-effect transistor, the normally metallic gate has an extremely low resistance. The resistive insulated gate, on the other hand, develops a relatively large potential gradient between its ends when a small current passes through it. Polycrystalline silicon has proved admirable as a gate material. If the gate is of uniform resistivity and if it has a constant width and thickness, the voltage variation along the gate will be linear.

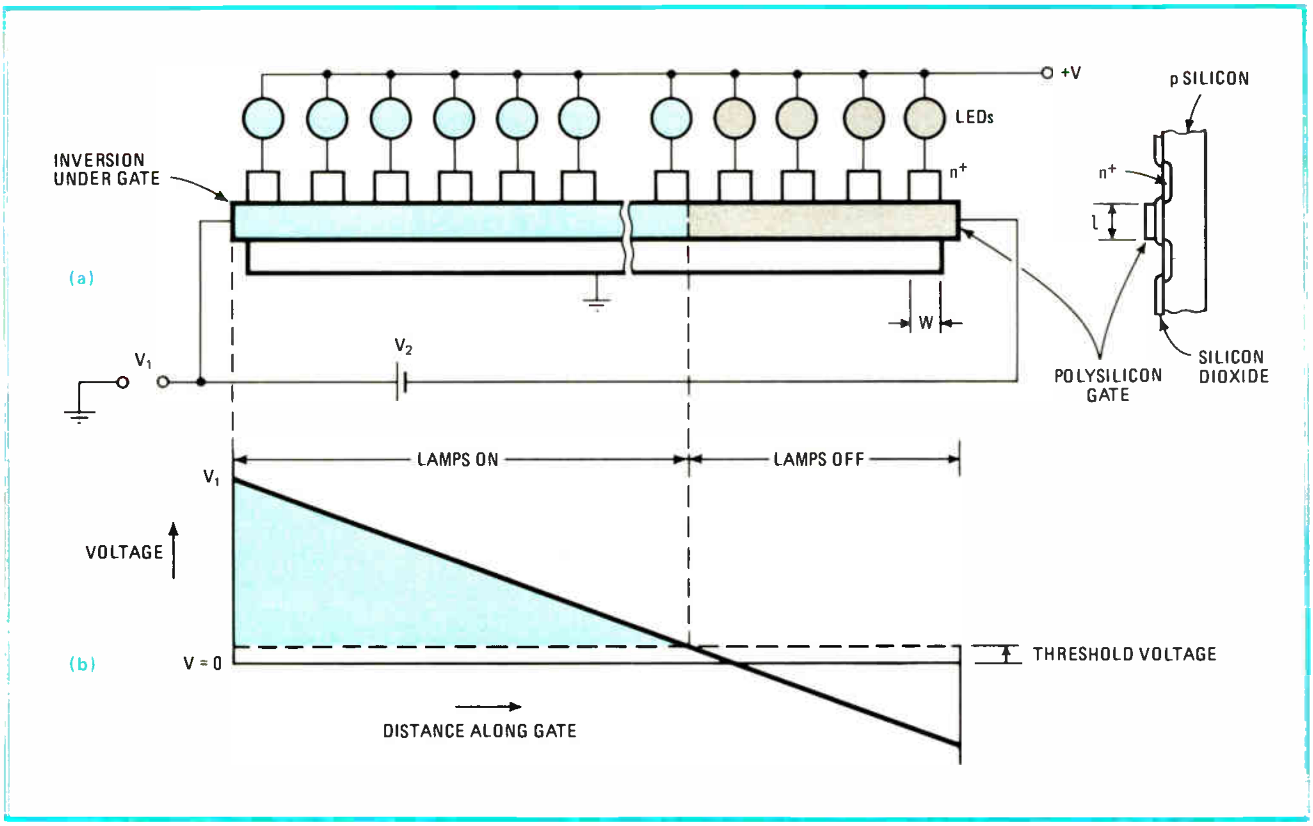
The large potential difference between the gate ends produces a corresponding variation in the surface potential along the silicon-insulator interface under the gate (Fig. 1). What's more, if the voltage gradient along the gate is kept constant and the potential of the whole gate is varied with respect to the silicon substrate, then an inversion layer of electrons can be made to grow and collapse along the surface of the p-type silicon under the gate, effectively turning built-in IGFETs on. This action is the basic control mechanism that results in a number of useful applications.



Five bits. This chip implements a ROM-type a-d converter. At the left are twin gates with 32 levels. The center part of the chip bears the random-access memory, and the sampling gate is at the right. The device achieves a high, 5-bit resolution.

Light-bar indicator control

One simple but potentially useful application of a resistive gate is in regulating the length of a bar-type indicator composed of LEDs (Fig. 1a). The control element is a row of IGFETs with a common polysilicon resistive-



1. Light bar. A row of insulated-gate FETs with a common resistive gate controls the length of a column of light-emitting diodes. The number of energized LEDs is controlled by analog voltage V_1, which varies the length of the inversion layer under the gate.

gate electrode. Depending on the application, the sheet resistivity can be chosen to lie between 15 and 8,000 ohms per square or more.

The operation of the array can be understood from Fig. 1b, which shows the variation of the voltage across a resistive gate for one value of V_1. Inversion exists under the gate so long as the voltage exceeds the threshold value, V_T. In the arrangement of Fig. 1a each n^+ region in turn links up to the common n^+ region (shown grounded) as V_1 forces the inversion layer to advance under the gate. This gradual turning-on is caused by the voltage drop along the resistive gate and therefore across the width of each n^+ region.

In practice it would be better to avoid this gradual turning on and off, particularly when a large width-to-length ratio for each IGFET is desired. The solution is the meander arrangement of Fig. 2, since the voltage drop over each IGFET's active region now occurs across only the relatively small distance between source and drain.

The chip in Fig. 2 is 2 millimeters square and contains a row of 12 IGFETs, each with a width-to-length ratio of 1,000. The meandering polysilicon gate is 5 millimeters wide, and its underlying oxide is 1,000 angstroms deep. Its transconductance is 15 milliamperes per volt, and its threshold voltage is 0.3 V. A resistance between the gate ends of 10 kilohms distributes V_2 among the IGFETs.

The spread in threshold voltage for the row of 12 IGFETs across a 2-inch slice is less than ±15 millivolts, and the variation in the 10-kΩ resistance less than 6%. A voltage of 9 V across the gate is enough to operate a display of a dozen 20-mA LEDs, and 3 V is enough for the same number of 5-mA LEDs.

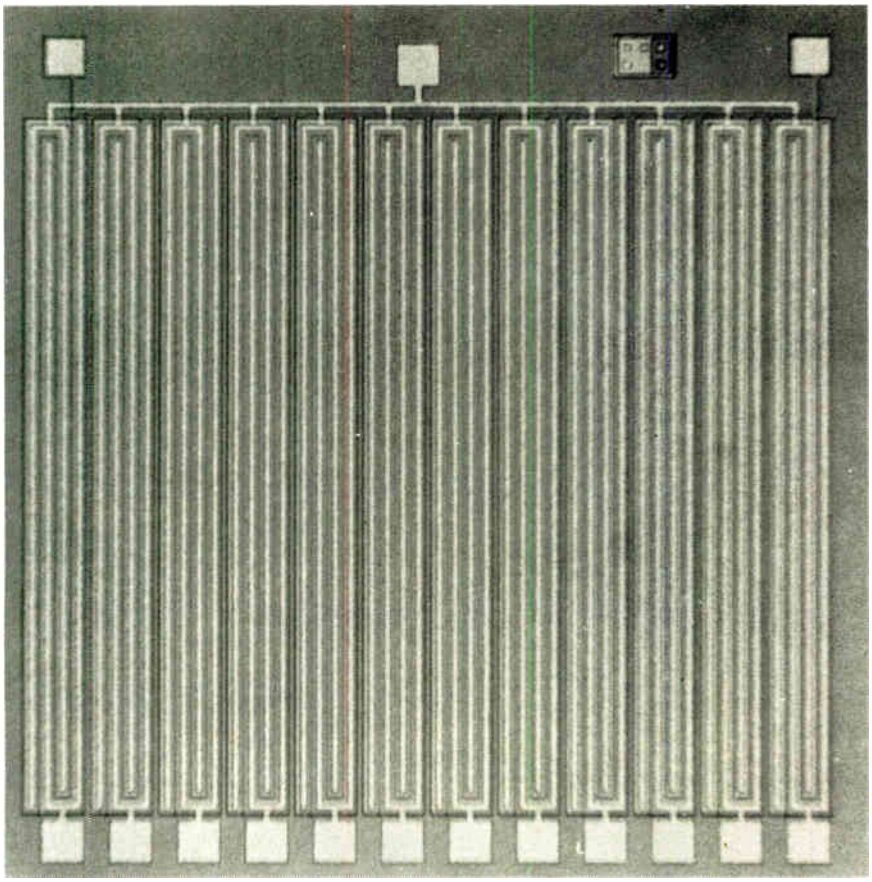
Lighting one lamp only

In some display applications, such as channel selection in receivers, a circuit must activate only one of several lamps in a row. Lamp choice depends on the value of the analog signal applied to the selection circuit.

The twin-gate arrangement of Fig. 3a yields a circuit of this type. Figure 3b shows the voltage across both resistive gates for a particular value of input voltage. V_3 regulates the overlap of the inversion layers under the resistive gates. For the case shown, only one lamp at a time is allowed to light up. When the analog voltage changes, so does the position of the overlap and hence the lamp which lights.

One interesting aspect of the twin resistive gate is its selectivity and dependence on V_3. Selectivity is defined to be high when the ratio of current at a given terminal to that of the adjacent terminals is large. This ratio was measured for values of V_3 from 2 to 4 V. For each value of V_3, the input voltage V_1 was adjusted to center the overlap region at terminal C in Fig. 3, a bias was next applied to terminals B, C and D, and the current from each terminal to the grounded common source was measured.

It was found that the ratio of the currents can be as large as 4×10^3 at the optimum setting of $V_3 = 3$ V. In general, a very large value of V_3 gives a large overlap and relatively large equal currents through the three



2. Wanderer. The light-bar control chip uses a meandering pattern for its IGFETs to make them as wide as possible. Each, in fact, achieves a width-to-length ratio of 1,000.

terminals, while a very low value of V_3 gives no overlap and no current flow through C.

The device described was developed to investigate the feasibility of the twin-gate arrangement for selection, and all results are preliminary. The technique can be applied to select one out of as many as 32 levels.

A ROM-type a-d converter

An analog-to-digital converter can be built around a twin resistive-insulated gate similar to the unit used in the pointer circuit. The schematic is shown in Fig. 4.

A twin resistive-insulated gate, which is shared by a row of IGFETs, selects an address line in a read-only memory. The value of an analog input to the twin gate determines which line it selects. The address lines are perpendicular to the output lines of the ROM. If a 1 is desired on an output line, this line is allowed to contact the drain of an IGFET. The source of any such IGFET is grounded.

Also shown in Fig. 4 is a sampling gate. This is an insulated gate (not resistive) that is common to a row of IGFETs. These have a common source, which is tied to ground, but separate drains.

When the sampling gate is turned on, the address lines are connected to the common source of the sampling gate and are shorted to ground. This prevents any address line from being turned on by the twin gate so that only when the sampling-gate is turned off will an output be obtained from the ROM.

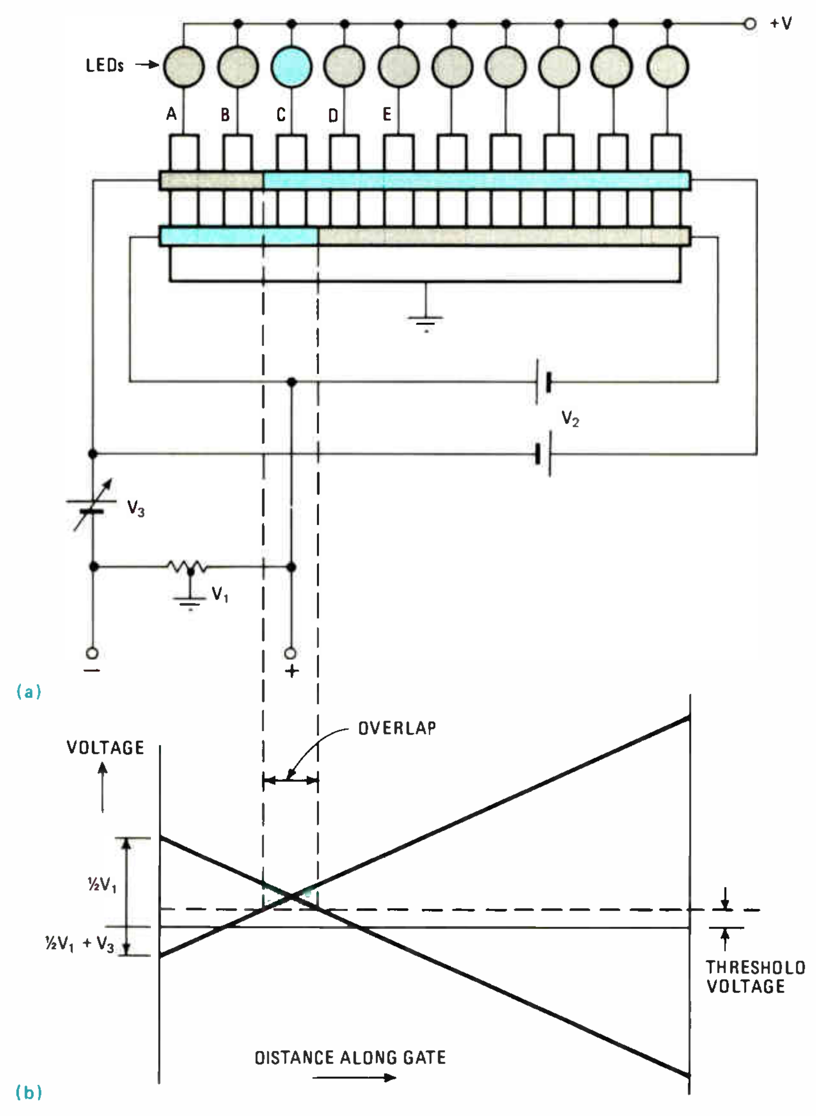
Overlap of the inversion layers in the twin-gate arrangement is adjusted so that at least one, but never more than two, lines of the ROM can be addressed at any instant. Otherwise, no output will be obtained from the ROM for those values of the analog input voltages that fall between two address lines—an unallowable state of affairs, since it implies zero-digital output for a finite analog input.

On the other hand, some analog voltages correspond to two address lines. Now if the ROM is programed in binary code, the digital output from the two lines addressed will not correspond to the analog voltage. But when a Gray code is used to program the ROM instead, only one bit changes for each increment, and no false intermediate codes will occur.

The photograph on page 111 shows a 5-bit a-d converter based on this principle. At the left are the twin gates with 32 levels; the resistance between the ends of each gate is 6 kΩ. A voltage of 12 to 15 V across each gate is enough to select any one of the 32 levels. Smaller voltages are possible with thinner gate oxides and shorter source-to-drain distances. This device uses a gate oxide of 1,100 angstroms and a source-to-drain distance of 8 micrometers.

There are two possible limits to the speed of operation of the ROM-type a-d converter. For one thing, the resistive gates and the associated capacitances from gate to oxide form a distributed RC network with its associated frequency limitations. For another, it takes time to charge a ROM address line to a voltage large enough to turn on its associated IGFETs. The second factor turns out to be the decisive one in limiting device speed.

Although the twin-gate system discussed has the ad-



3. Singular selection. Twin resistive-insulated gate and multiple supplies allow the selection of one lamp out of a row. Varying V_1 determines where the two inversion layers of each gate will overlap, and varying V_3 determines the size of the overlap.

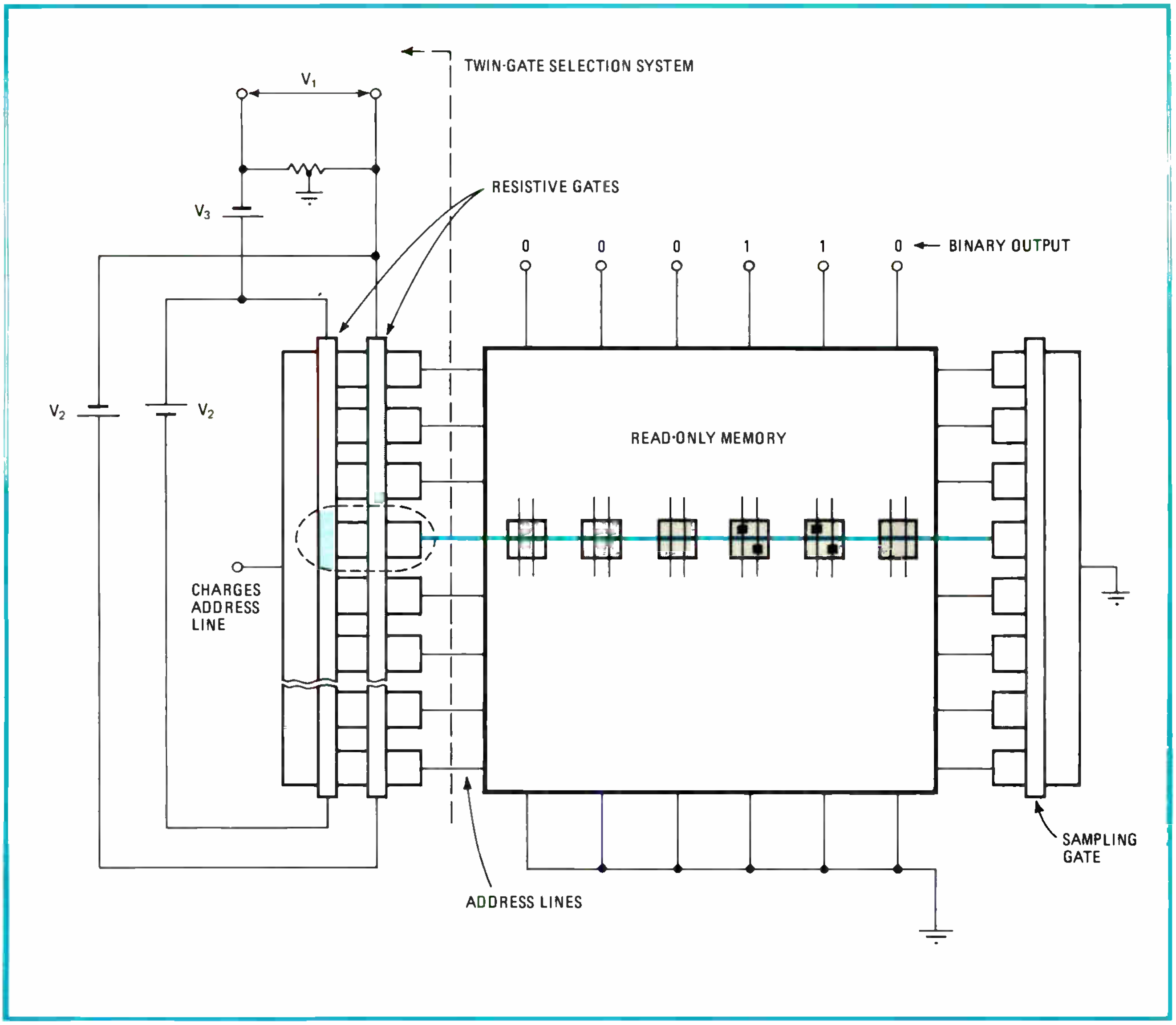
vantages of simplicity of construction, flexibility in adjusting the overlap between the inversion layers, and a simple selectivity control by an external voltage, it does suffer from some drawbacks. Two resistive gates are required with their associated driving voltages, some of which must float with respect to ground. The extra voltage needed for selectivity control, particularly when one ROM line is being selected at a time, is undesirable. The input signal has to be split, half being applied to one gate and half to the other gate. Furthermore, the variation of the input signal needed to scan the whole ROM is directly related to the voltages applied across the gates, so that an increase of selectivity and speed necessitates a corresponding increase in input signal. Further work is required to overcome these problems.

A pulse-train a-d

Another type of a-d converter combines an array of single resistive gates with a binary counter (Fig. 5). To summarize its mode of operation, a voltage is applied across a resistive gate along with a triangular wave between the gate and the substrate. During each period of the wave, a chain of pulses appears at the output of the resistive-gate array across resistance R. The number can be regulated by an analog signal in series with the triangular wave. If the pulse chain is fed to the counter, its output is a binary equivalent of the analog signal. The counter is automatically reset to 0 after each cycle of the triangular wave.

The compensation gate in Fig. 5 serves to suppress an undesirable capacitive signal contained in the output pulse train and caused by the flow of holes needed to supply the inversion layer. A 5-bit a-d converter has been successfully breadboarded that uses this circuitry plus a resistive-gate array to produce 32 pulses.

A more detailed examination of Fig. 5 reveals that the array consists of a row of p^+ regions that are covered by a resistive-gate electrode but insulated from it by a relatively thin oxide layer. A single p^+ readout region lies parallel to the row and extends just under the



4. Analog-to-digital. The twin-resistive-gate selection method can be combined with an IGFET ROM and an IGFET sampling gate to create the 5-bit analog-to-digital converter shown in the photograph on page 111. V_1 and V_3 select the address line of the ROM.

gate, from which it also is insulated by an oxide layer.

V_2 applies a voltage gradient of approximately 30V per centimeter across the gate. Simultaneously, the triangular wave is applied between gate and n substrate (other waveforms can also be used). The wave causes the whole of the gate to become positive with respect to the bulk and subsequently sufficiently negative to invert the n silicon substrate.

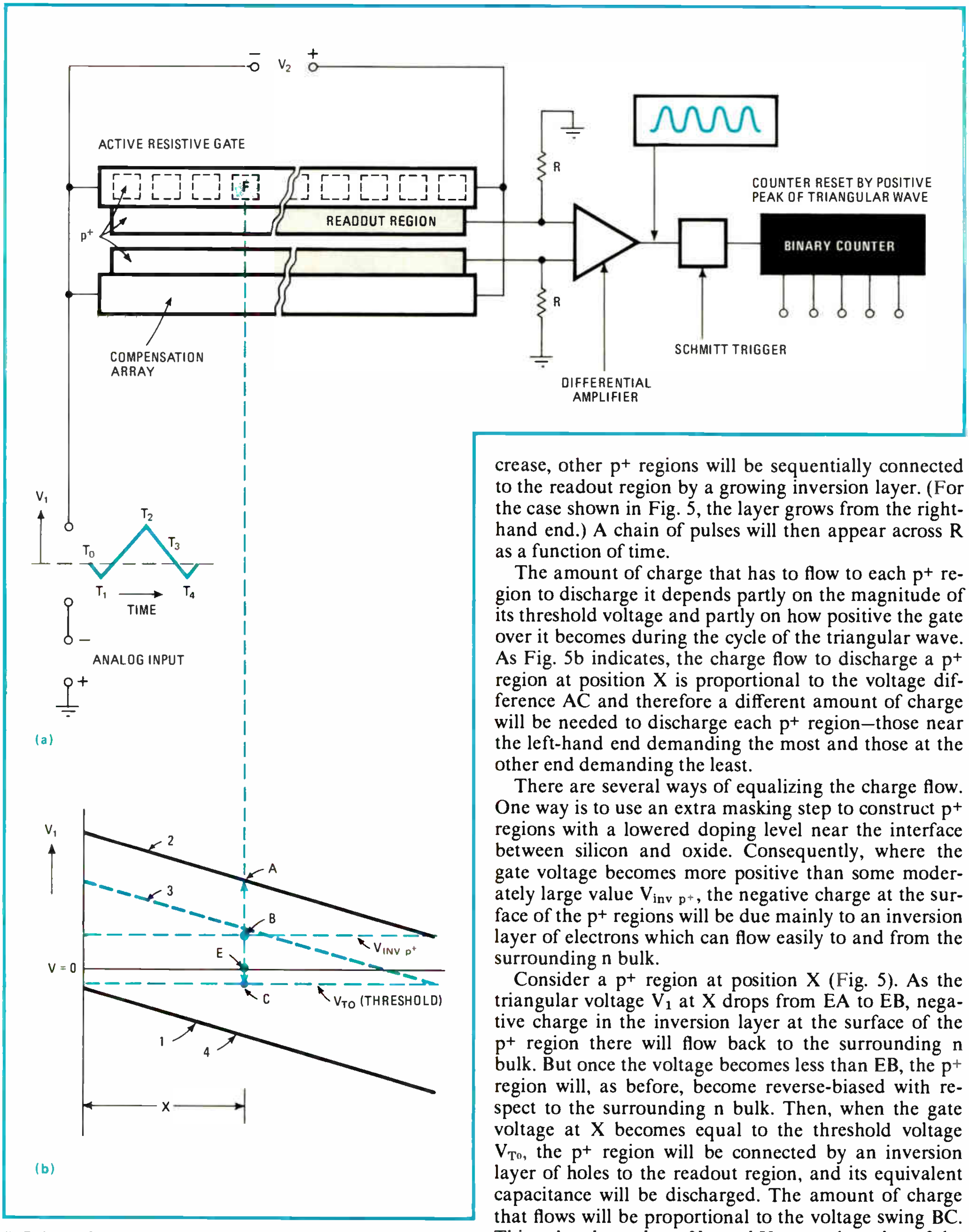
Figure 5b shows the voltage distribution (in the absence of an analog signal) across the gate at various times during the triangular wave's period. The gate becomes positive with respect to the underlying silicon between times T_0 and T_2 of the triangular wave's period. As this happens, the p^+n junctions become forward-biased, and the oxide capacitance between the gate and each p^+ region becomes charged to more or less the full voltage between that gate and the n substrate. (Of course the oxide capacitance between the gate and the n substrate will also be charged.)

When the triangular wave begins to decrease (time T_2 to T_4), the p^+n diodes are in their blocking condition. Each p^+ region can now be represented by two capacitances in series with the voltage between the gate and the n substrate. One capacitance is formed by the oxide, the gate, and the p^+ region, and the other is due to the junction between the p^+ region and the n bulk.

As the gate voltage continues to decrease, condition 3 in Fig. 5b is reached. At this voltage, inversion is about to occur under the right-hand end of the gate since the gate-to-substrate voltage there has reached V_{T_0} (the threshold voltage).

When inversion occurs, holes will be able to flow to a p^+ region from the readout region (grounded via R). The effect is to short-circuit the p^+n junction capacitance by means of R and to allow the capacitance of the oxide between the p^+ region and the gate to be charged to the voltage that exists between the gate and the substrate where the p^+ region is discharged.

The hole flow to the p^+ region causes a signal to appear across R. As the triangular voltage continues to de-



5. Pulse train. Active resistive-gate array, driven from gate to substrate by the triangular voltage plus the analog voltage, produces a train of pulses proportional to the analog voltage. This in turn is converted into a binary form by the counter. The compensation array counteracts undesirable capacitive current.

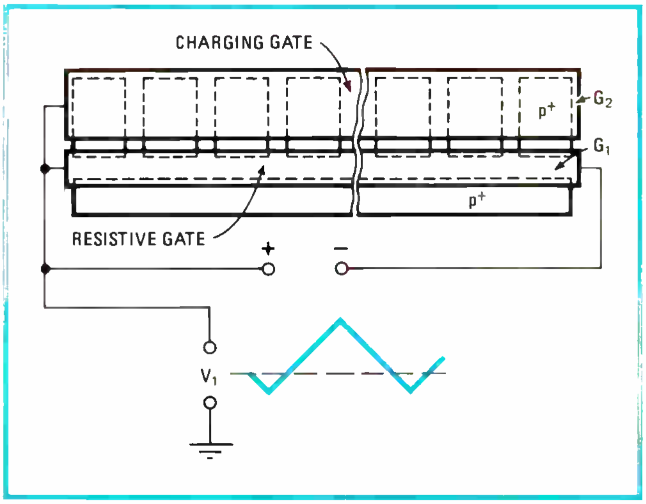
crease, other p+ regions will be sequentially connected to the readout region by a growing inversion layer. (For the case shown in Fig. 5, the layer grows from the right-hand end.) A chain of pulses will then appear across R as a function of time.

The amount of charge that has to flow to each p+ region to discharge it depends partly on the magnitude of its threshold voltage and partly on how positive the gate over it becomes during the cycle of the triangular wave. As Fig. 5b indicates, the charge flow to discharge a p+ region at position X is proportional to the voltage difference AC and therefore a different amount of charge will be needed to discharge each p+ region—those near the left-hand end demanding the most and those at the other end demanding the least.

There are several ways of equalizing the charge flow. One way is to use an extra masking step to construct p+ regions with a lowered doping level near the interface between silicon and oxide. Consequently, where the gate voltage becomes more positive than some moderately large value $V_{inv\ p+}$, the negative charge at the surface of the p+ regions will be due mainly to an inversion layer of electrons which can flow easily to and from the surrounding n bulk.

Consider a p+ region at position X (Fig. 5). As the triangular voltage V_1 at X drops from EA to EB, negative charge in the inversion layer at the surface of the p+ region there will flow back to the surrounding n bulk. But once the voltage becomes less than EB, the p+ region will, as before, become reverse-biased with respect to the surrounding n bulk. Then, when the gate voltage at X becomes equal to the threshold voltage V_{T0}, the p+ region will be connected by an inversion layer of holes to the readout region, and its equivalent capacitance will be discharged. The amount of charge that flows will be proportional to the voltage swing BC. This value depends on V_{T0} and $V_{inv\ p+}$—the value of the gate voltage at which the p+ region begins to become reverse-biased.

Voltage swing BC in Fig. 5 is now independent of the position of the inversion layer and alike for all the p+



6. Double gates. A twin-gate structure is another method of obtaining output pulses that are equal. G_1 discharges the p+ regions and G_2 reverse-biases the p+ regions.

regions under the gates. As a result, a chain of pulses of equal magnitude will be obtained across resistance R as the row of p+ regions is discharged.

Another method of obtaining equal output pulses is to add a second gate, this time a charging gate that practically covers the p+ regions (Fig. 6). The resistive gate now overlaps only one edge of each of the p+ regions of the array and one edge of the readout region. The array of p+ regions is simultaneously charged by momentarily making the charging gate positive, then is sequentially discharged by the resistive gate. A disadvantage of this special structure is that a separate signal is needed to operate the charging gate.

The same factors could limit the maximum scan rate of pulsed-mode resistive-gate arrays as could limit the speed of ROM-type a-d converters—the formation of a distributed RC network by the resistive gate and the underlying oxide capacitance, and the time needed to discharge the regions under the resistive gate. As before, the second factor is actually the dominant one.

Light scanners

A very simple type of resistive-insulated-gate device designed for use in a light scanner is shown in Fig. 7. V_2 creates a voltage gradient along a transparent resistive electrode, so that an inversion layer will advance or retreat along the surface as V_1 goes respectively negative and positive. The electrode is made of 2-μm-thick polysilicon.

Assume a light pattern is incident on the gate electrode and changing at a rate that is slow compared to the scanning rate of the inversion layer. The part of the pattern that falls on the inversion layer causes a photocurrent to flow through the resistor R, which connects the p+ region to the n bulk. This photocurrent is proportional to the total amount of light incident on the inversion layer. If the inversion layer is made to vary in length with time, the differentiated output signal across R will be proportional to the light intensity at the extremity of the advancing or retreating inversion layer.

Unfortunately, a capacitive current also flows into R because of the charge flowing to or from the expanding or contracting inversion layer. The current increases with increasing scan frequency and even at relatively low frequencies can swamp the photo signal. This undesirable signal can be eliminated from the output by using two resistive gates and utilizing the differential signal when light falls on only one of the gates. Such a technique extends the useful scan frequency up to hundreds of hertz.

Because this device operates in a photocurrent mode, it is inherently insensitive. To improve sensitivity, devices may be operated in an integration mode.

The array of Fig. 5, for instance, can also be used to scan a light pattern if operated in an integration mode. Here, a row of p+ regions sits under a resistive gate electrode but is insulated from it by an oxide layer plus a common readout region. As the voltage on the gate is increasing, holes are injected from the p+ regions under the gate and are lost by recombination with electrons in the n bulk.

When V_1 begins to decrease from its maximum value (condition 2 in Fig. 5), the p+ regions begin to demand holes and to become reverse-biased with respect to the surrounding n bulk. The demand for holes is not satisfied until the gate voltage equals the threshold value V_{T0} or unless light is incident on the array. The voltage AC is proportional to the time-integration period during which the region F is demanding holes and is sensitive to light.

When a pulse-output resistive gate similar to the 32-element p+ array already considered is used as a light scanner, its action is unlike most other light scanners whose outputs increase with incident light. With a resistive gate scanner, incident light causes a decrease in output pulse magnitude.

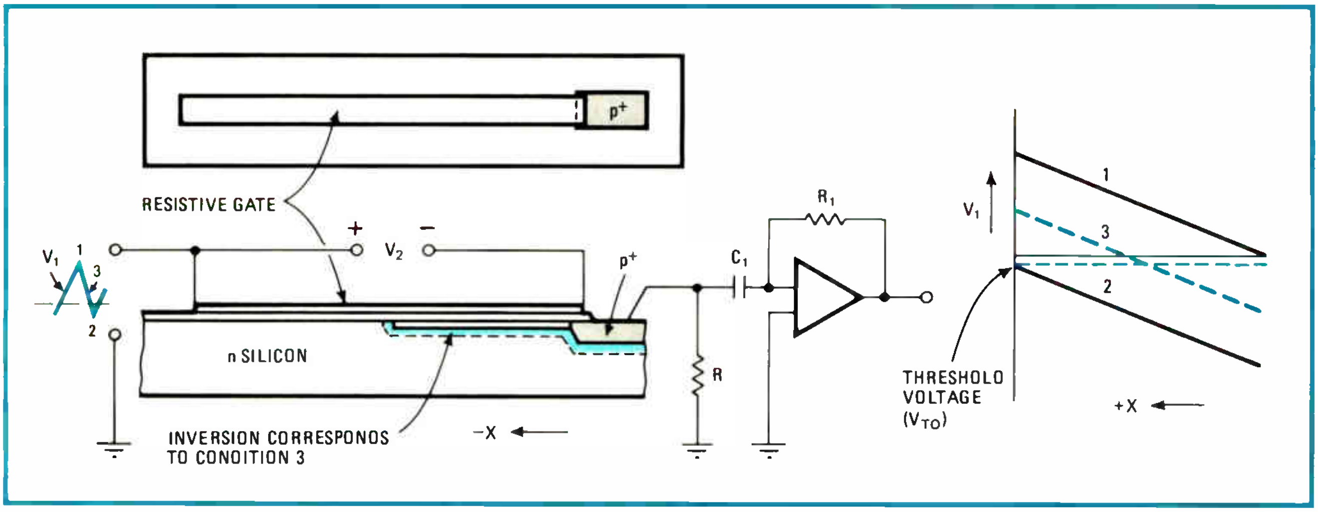
However, the output pulses for the p+ regions are not alike, and neither are the integration periods. To overcome these drawbacks, the surface doping level of the p+ regions under the resistive gate is lowered sufficiently to allow an n-type inversion layer to be induced there when the gate voltage exceeds a relatively low value. This, of course, was also to be the cure to the unequal output pulses of the serial-pulse a-d converter.

Uncoupling integration time

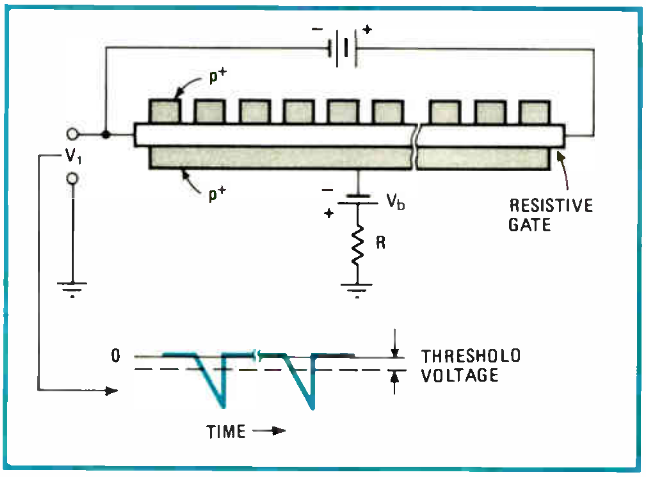
In both of the previous devices, integration time (the period during which a p+ region is sensitive to light) is coupled to the rate of change of the driving voltage V_1. Total integration time for all p+ regions is related to the time it takes the voltage V_1 to change from value T_1 to T_4 (Fig. 5). But it is possible to uncouple the integration time from the scanning time.

In the device shown in Fig. 8, the voltage gradient along the gate allows each p+ region in the row to be sequentially connected to the p+ readout region when V_1 becomes sufficiently negative. As each p+ region is connected to the readout region, it becomes charged to the potential V_B. After scanning the row, the voltage V_1 decreases quickly to zero and the row of p+ regions is left reverse-biased and isolated from the readout region.

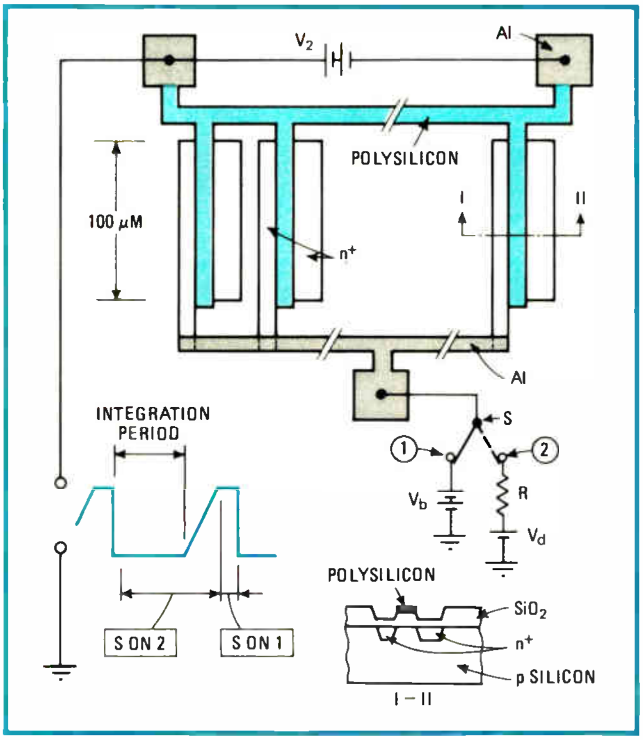
If light is allowed to fall on the row for a period assumed long compared with the time needed to scan the



7. Photocurrent. In this scanner V_2 creates the voltage gradient along the gate, and V_1 causes the inversion layer to expand or contract. Any light pattern that falls on the gate and hence affects the inversion layer causes a photocurrent to flow through R.



8. Light scanner. In this gated-array scanner, the common p+ region serves as both the charging and the readout region. A specially shaped voltage is used to sweep the inversion layer.



9. Dual-mode. This special 100-element scanner operates in two modes. When the switch is in the S_1 position, the n+ regions are reverse-biased; when it is in the S_2 position, integration takes place.

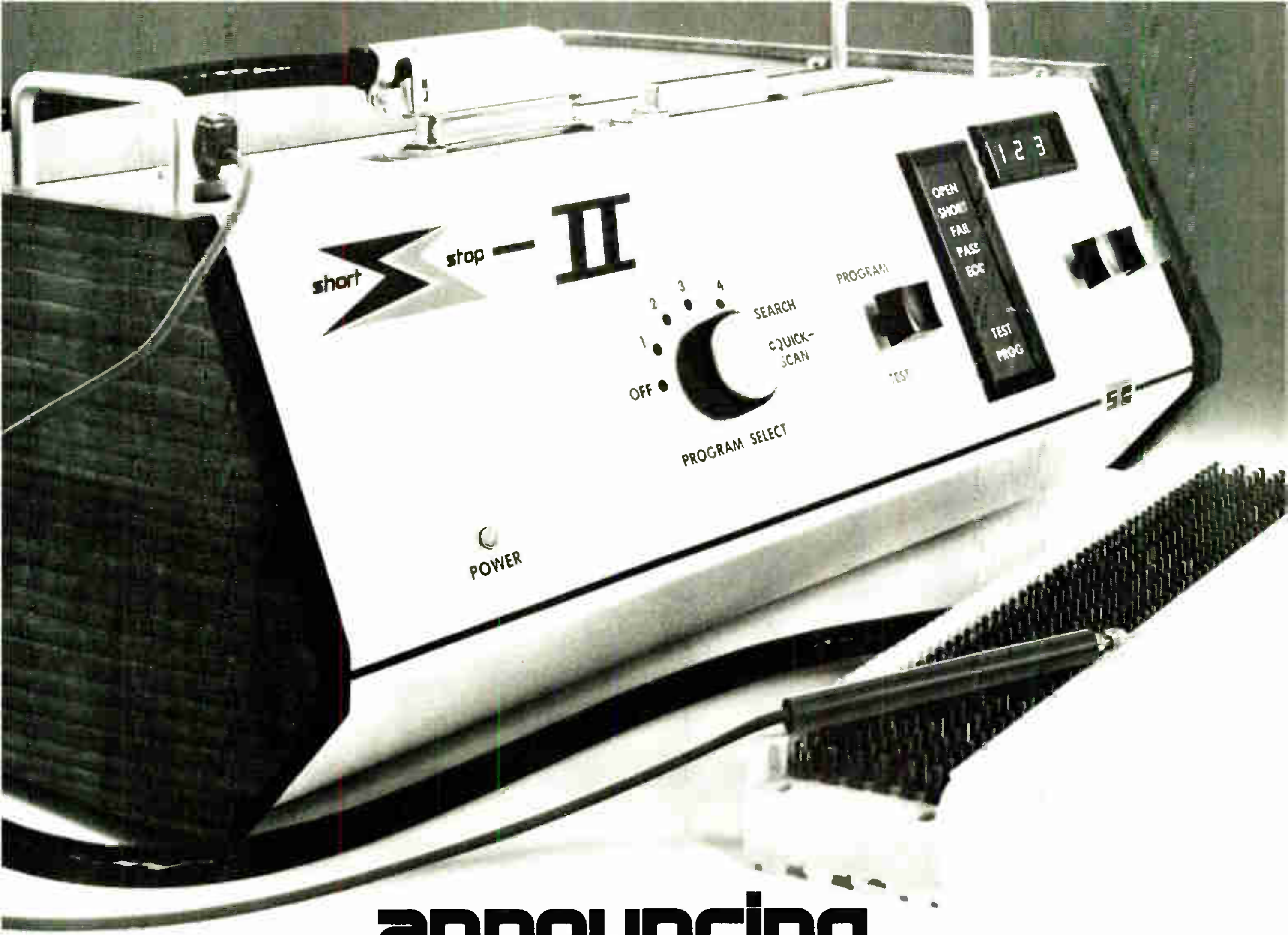
p+ regions), the p+ regions will be discharged somewhat. Now when the row is next scanned, charge will flow to each p+ region in an amount proportional to the intensity of the incident light and the integration period. The output chain of pulses that appears across the resistance should thus be related to the variation of the intensity of the light along the row of p+ regions.

Although simple, this scanner has a drawback. As the potential of the p+ regions varies with the variations in light intensity, so also does the threshold voltage. This could give rise to nonsequential scanning and a time separation between output pulses that is no longer proportional to the spatial variation of the light intensity along the array.

A redesigned array avoids this problem with a better-defined current flow path from the readout region to the p+ regions so that they discharge more rapidly. The new unit was built during a feasibility study of the resistive-gage scanning technique for relatively long arrays containing 100 or more elements.

The array is n-channel and operates in two modes (Fig. 9). With switch S in position 1, the n+ regions are reverse-biased via an inversion layer. The inversion layer is next allowed to decay. With switch S set to position 2, integration begins, and the n+ regions are scanned by applying the same signal as before to the gate. The n+ regions are now sequentially discharged. The greater the light intensity, the smaller the output pulse for an n+ region.

Nonsequential scanning has been avoided in this array by ensuring that, during scanning, the n+ readout regions are at the same potential as each other and in effect act as IGFET sources by being at a lower potential than the light-detecting n+ regions. □



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Computer program reduces fusible-PROM errors

by Shlomo Waser
Monolithic Memories Inc., Sunnyvale, Calif.

A brief computer program written in Basic saves time and minimizes errors in the fuse-blowing process used to store information in a programable read-only memory. The procedure for programing a PROM employs momentary current pulses to selectively open fusible links between diodes and the internal memory array. Thereafter, whenever an input address selects a bit with an open fuse, the output voltage is low (0 to 0.4 volt). When a bit with an unblown fuse is selected, the voltage is high (2.4 V).

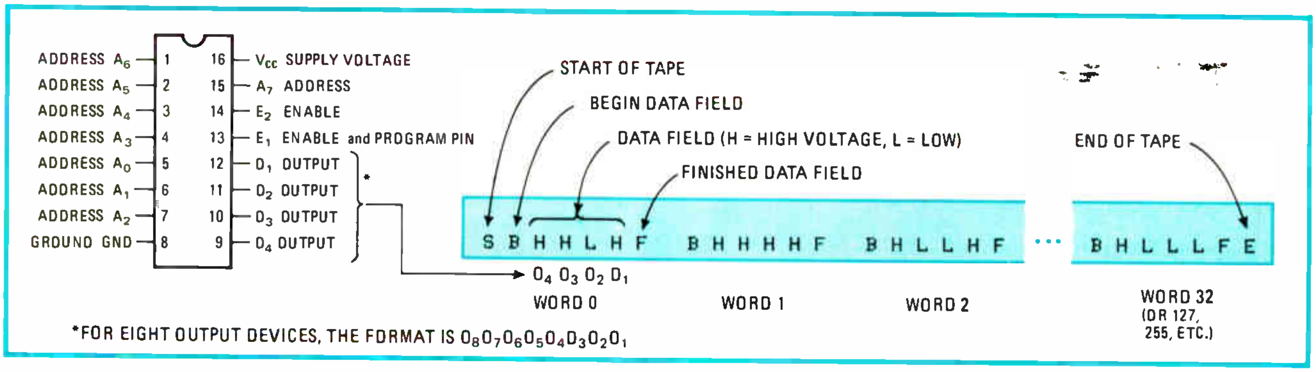
The machine used to blow these fuses selectively is called a PROM programer, which usually has two operating modes—manual and automatic. Using the manual mode entails a three-step operation after the machine has been attached to the PROM:

- The address word is set on the address-line dials.
- The output word to be stored at that address is set on the output-line dials.
- A button is pushed to make the machine blow the fuses that store the output word in memory.

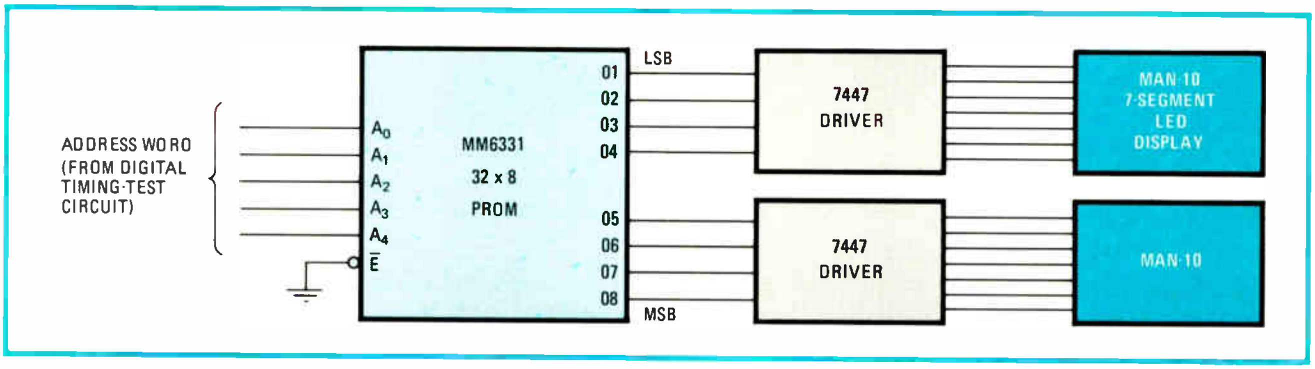
For example, if the PROM is required to have an output of 0110 when location 8 is addressed, the operator sets the address dial to 1000, sets the output dials to 0110, and pushes the "blow fuses" button. Then he repeats the three steps to store the next memory word in location 9, and so forth.

Because use of the manual mode for PROMs containing more than 21,048 bits is tedious and highly susceptible to human errors, it is desirable to use the automatic mode whenever possible. The automatic mode is typically interfaced to a paper-tape reader, which reads in the tape containing the information to be stored. The paper tape, which goes through all of the addresses in order, applies the output word and blows the fuse for each, at high speed.

Manufacturers who provide PROMs that are programed from input information on a paper tape specify the format to be used. Monolithic Memories specifies the tape format shown in Fig. 1. The letter S indicates the start of the storage-instruction data, and the letter E indicates the end of the whole procedure. The data is divided into fields (the output words). Each output word is preceded by the letter B for begin and is followed by the letter F for finish. The actual data to be programed is either H for high voltage or L for low voltage. The use



1. Tape format. Automatic Monolithic Memories PROM programer is fed by a punched paper tape that gives the desired output word for each input address in sequence. In this tape format, H and L are used instead of 1 and 0 to avoid ambiguity of positive or negative logic.



2. PROM at work. The PROM converts the output from the digital tester into a form suitable for input to the display driver. Text describes how to generate a tape for programing the PROM automatically. Note that output is in BCD to drive the two seven-segment displays.

```
100 !/PROM-PROG/
110 INTEGER T,B,K
120 OPEN /FILE/,OUTPUT,1
130 J='' 'B' 8W 'F'/''! OUTPUT FORMAT
140 WRITE ON 1:''S''!START OF DATA
150 FOR I=0 TO 31!START OF LOOP CALCULATIONS
160 T=5+(I*3)  !CALCULATE DECIMAL VALUE
170 K=T/10
180 B=T+(K*6)!  CONVERT IT TO BCD
190 WRITE ON 1 IN FORM J:B!OUTPUT TO A FILE
200 NEXT I
210 WRITE ON 1:''E''!END OF DATA
220 CLOSE 1
230 END
```

3. Basic program. This little computer program, written in Basic, calculates the output data to be stored in the memory, which is given by the equation T = 5 + (3 × I), where I is the address location. Results are converted into the format required by the automatic PROM programing machine. Line 180 converts the representation to BCD code; thus, 98 is 1001 1000 (i.e., the first 4 bits are the 9, and the second 4 bits are the 8).

```
S                  S
B00000101F         BLLLLLHLHF
B00001000F         BLLLLHLLLF
B00010001F         BLLLHLLLHF
B00010100F         BLLLHLHLLF
.                  .
.                  .
.                  .
.                  .
B10001001F         BHLLLHLLHF
B10010010F         BHLLHLLHLF
B10010101F         BHLLHLHLHF
B10011000F         BHLLHHLLLF
E                  E

    (a)                (b)
```

4. Output. The output file, (a) above, is from the Basic program, while (b) in the format of Fig. 1 is obtained from (a) by use of the text editor. Each of the 32 data words represents two binary-code-decimal digits: the first word is 05, and the last word is 98.

of H and L avoids the possibility of confusion resulting from using 1 and 0, which have different meanings in positive and negative logic.

The program is punched on the paper tape by the teletypewriter interface from the computer that prepares the program for the PROM. The complete procedure for generating the program and tape is illustrated by the following example:

Figure 2 shows a PROM used to translate timing information from a digital testing circuit into a 2-digit binary-coded-decimal output to drive a display. The parameter measured by the tester is a time, which is quantized in 3-nanosecond steps from 5 to 98 ns. Therefore, the 32 possible outputs from the PROM are BCD codes for 5, 8, 11 . . . 95, 98. The outputs for successive inputs (addresses) 0, 1, . . . 31 are:

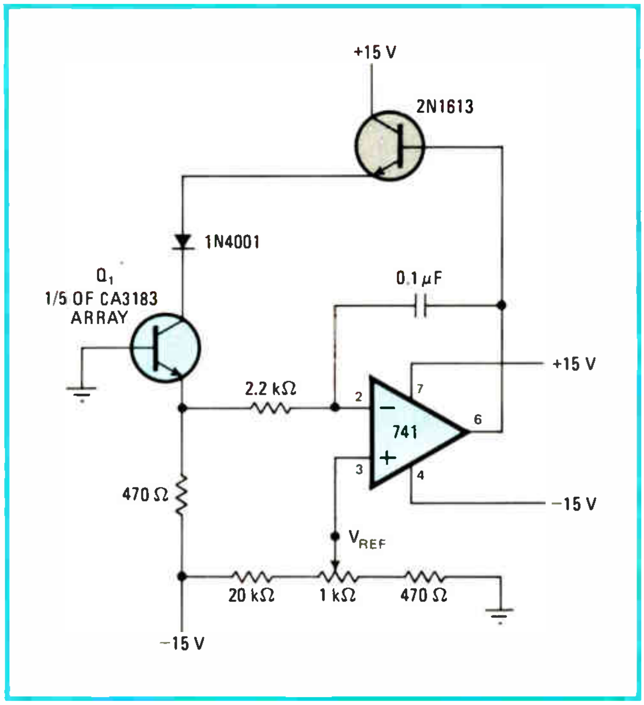
$$T = 5 + (3 \times I) \quad I = 0, 1, 2 \ldots 31$$

Once a functional relationship like this is established, it is an easy matter to convert it to a program. The Basic program in Fig. 3 executes the above equation in a loop controlled by I, the address; it converts the results into BCD form, and it files the conversion in a binary format with control characters S, B, F, and E as shown in Fig. 4a. This file is then edited by a text-edit routine to substitute H for 1 and L for 0. The edited file, shown in Fig. 4b, is punched on the paper tape, which then is used to control the PROM programing machine. □

One transistor senses, heats in temperature regulator

by Neil Dvorak
Technical Equipment Corp., Denver, Colo.

Most circuits for regulating the temperature of a substrate employ at least two transistors—one for sensing the temperature, and another for generating heat. But the designer can make a single transistor serve as a combination sensor and heater by exploiting the fact that the voltage drop across a silicon junction changes by −2 millivolts per °C change of temperature. As a result, he is free to use, for example, a matched dual transistor



Double duty. Transistor Q_1 serves as both temperature sensor and heater element in this circuit for regulating substrate temperature. Reference voltage is set to the value that a base-emitter junction has at the desired substrate temperature. The op amp senses the difference between the reference level and the actual V_{BE} of Q_1, and it drives current through the transistor to bring it to that temperature.

as a temperature-independent logging element or to use all but one of the transistors in an array for purposes other than temperature regulation.

In the accompanying circuit diagram, transistor Q_1 is connected as a current source. The grounded-base configuration permits the base-to-emitter junction voltage V_{BE} to be easily monitored by the operational amplifier. The op amp compares V_{BE} to a preset reference voltage, V_{ref}, that is equal to the junction voltage at the desired substrate temperature. Unbalanced voltage at the op-amp inputs causes it to drive more current through Q_1, thus changing the junction temperature and voltage.

To calibrate the regulator, the collector of Q_1 is initially grounded so that the emitter-to-collector voltage is essentially zero, and, therefore, power dissipation in the transistor is zero. The base-to-emitter voltage is then measured, preferably to the nearest millivolt. This reading, V_O, is the junction voltage at ambient temperature. If the ambient temperature is, for example, 23°C and the desired junction (substrate) temperature is 63°C, the V_{ref} must be set to V_O - [2 mv × (63 - 23)]. When the op amp is then reconnected to the collector of Q_1, the servo action will maintain enough collector dissipation in Q_1 to keep its junction at 63°C.

Although a small-signal transistor in an array is shown as Q_1 here, this same principle can of course be applied to larger transistors, such as the 2N3055. To enable the op amp to source more current, an emitter follower can be added to the circuit, in the line connecting the emitter of the 2N1613 to the anode of the 1N4001 diode. □

Voltage-regulator IC biases expanded scale meter

by Alan D. Wilcox
University of Virginia, Charlottesville, Va.

To monitor the state of charge of a standby storage-battery system, only voltages between 12 and 15 volts need to be read. A conventional test meter reading 0 to 15 v full scale will suffice, but readings can more easily be observed when the voltmeter has an expanded scale that reads from a minimum of 10 v to a maximum of 15 v.

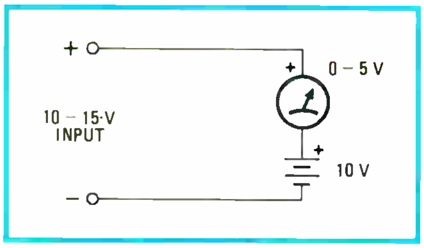
One such expanded-scale circuit is shown in the figure. The battery provides a 10-v bias to the meter so that when a voltage source of 10 to 15 v is applied to the combination, the meter shows the difference of 0 to 5 v. But this arrangement is unsatisfactory, both because it must have a battery for operation and because its accuracy depends on the battery having a potential of exactly 10 v.

There is a better way. Since the voltage to be monitored will be above 12 v, a National Semiconductor LM723 voltage regulator can be used as shown in the figure to provide a stable 10-v bias. A 500-microampere meter and series resistor R_2 constitute the 0-to-5-v voltmeter. If the battery voltage should drop below about 11.7 v, regulation falls off, but this inaccuracy can be corrected by using a 1.5-v dry cell if readings below 12 v are necessary. The dry cell does not affect the accuracy of the meter calibration—it simply extends the reading range down to about 10.2 v.

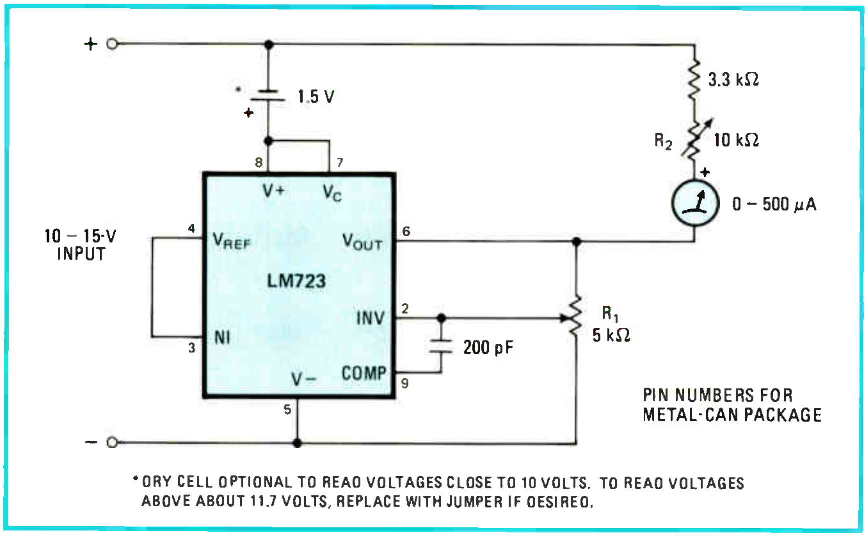
The unit draws about 3 milliamperes and can be used continuously across the storage-battery system. The entire circuit can be constructed on a small circuit board and mounted on the terminal posts of the 500-μA meter.

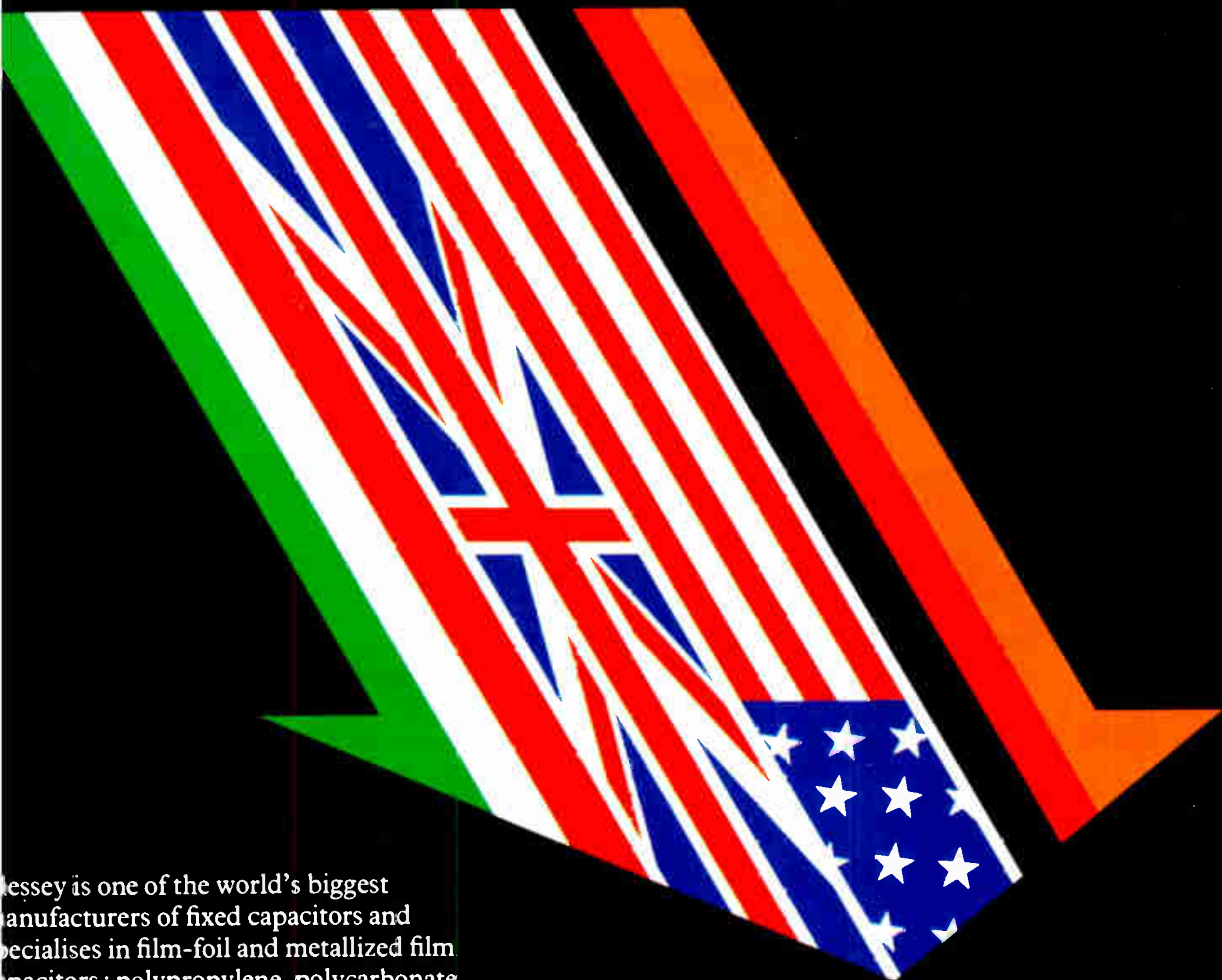
The circuit is calibrated by applying 15 v to the input and adjusting R_1 for 10 v at the output of the 723. Then, R_2 is set for a full-scale reading on the meter. For the 500-μA meter, 200 μA corresponds to 12 v, 300 μA to 13 v, etc. Normal battery voltage reads near center scale, and small deviations can be seen at a glance. □

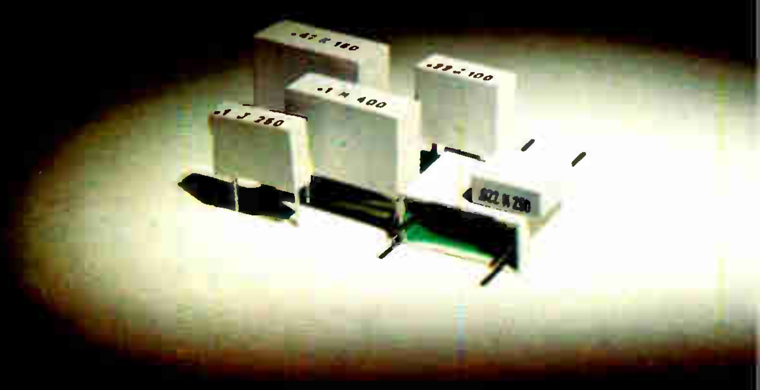
Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.



The right idea. This circuit displays very precise readings of 0 for 10-v input, 100 for 11-v input, and so on up to 500 for 15-v input. Adjustment of R_1 and R_2 calibrates it accurately. Circuit shown in inset also displays voltage in the 10–15-v range but requires a battery of exactly 10 v for accurate reading. Note that the 1.5-v dry cell used in the main circuit does not affect its calibration and is not necessary for readings above 11.7 v.







Silicon rectifiers can be good solar cells

Although manufacturers of diffused-junction silicon rectifiers seldom characterize their product's sensitivity to light, many such devices **can also function as photovoltaic cells,** states Ivan Garshelis of Research Associates Inc., Linden, N.J. For example, under a microscope illuminator, GE's IN5059 rectifier generates a sizable open-circuit voltage of about 0.5 volt at 20°C. Maximum current is 187 microamperes into 1,000 ohms, and peak power is 68 microwatts into 2,400 ohms.

The diode responds to most kinds of visible light, hitting its junction from most angles. It will react even to the trace on a cathode-ray tube with a P31 phosphor and to the xenon flash of a stroboscope.

Similar characteristics, says Garshelis, can be found in the GE A14 series (IN5059–5062), the General Instruments Glass-Amp II types (IN4245–4299 and others), and Trans-Tek IN4001–4007. Interestingly enough, he points out, **manufacturers' ads sometimes consider this photosensitivity an undesirable property—yet some of these rectifiers are the most economical "solar cells" presently available.**

Scope for more study

Most engineers use one nearly every day, but chances are they could still brush up on their use of the oscilloscope. "Oscilloscopes—Dual Channel and Delayed Sweep" consists of an 18-page booklet and 37 slides describing dual-beam and dual-trace scopes, **the principles of chopped and alternate time-base modes, and how delayed time bases are derived and used.** It costs $25 from Philips Test & Measuring Instruments Inc., 400 Crossways Park Drive, Woodbury, N.Y. 11797.

MOS takes on power applications

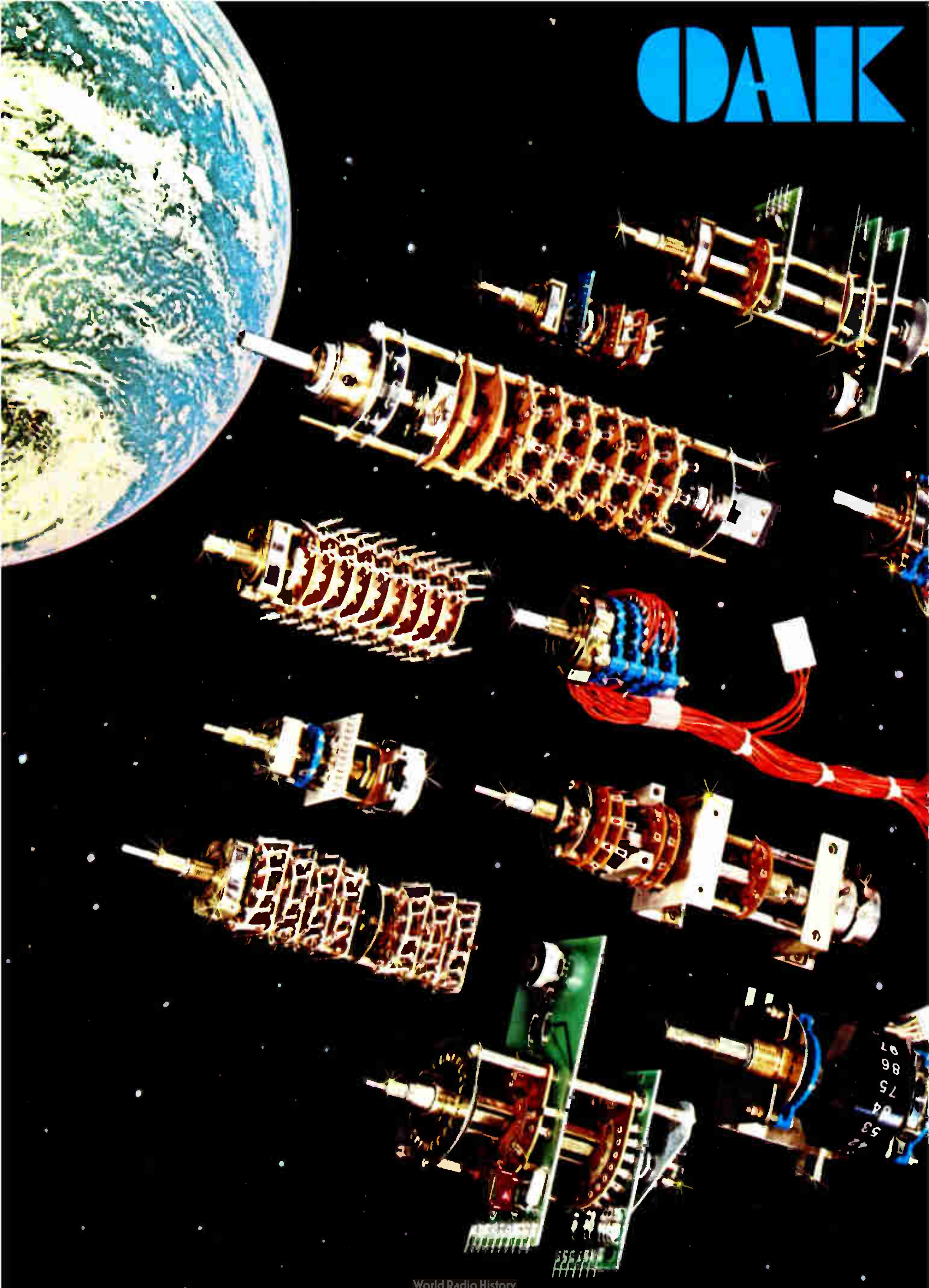
With the emergence of the new MOS processing techniques—double diffusion and vertical device structures, for instance—look for MOS devices to make a strong bid for the power jobs traditionally held down by bipolar transistors. Operating voltages for C-MOS analog switches recently soared to 200 volts [*Electronics*, Feb. 19, p. 110], and now power MOSFETs are becoming commercially available.

For instance, within the last month or so, Siliconix Inc. of Santa Clara, Calif., introduced what is **probably the first commercial MOS power transistor—an n-channel enhancement-mode MOSFET that can switch 1 ampere in 5 nanoseconds.** Minimum drain-source breakdown voltage is 60 V, maximum gate threshold voltage is 2 V, and maximum drain current is 2 A. It's directly compatible with C-MOS logic and can be used as an analog switch, a microprocessor interface driver, or even as a lamp or speaker driver.

Thin copper creates fewer printed-circuit processing problems

Thin copper foil, 0.31 mil thick, has some very practical advantages as a printed-circuit-board laminate. In report IPC-TR-482 from the Institute of Printed Circuits, Kenneth Hafften of the Bureau of Engraving Inc. in Minneapolis points out that **drilling is faster with thin-foil than with 1-ounce-copper-plated laminates, and drills also last longer.** Then, too, etching takes less time, pollution problems are fewer, lines can be made finer, and there's no undercut. The report contains other papers on thin copper foils and costs $10 from the institute (address: 1717 Howard St., Evanston, Ill. 60202).

—Stephen E. Scrupski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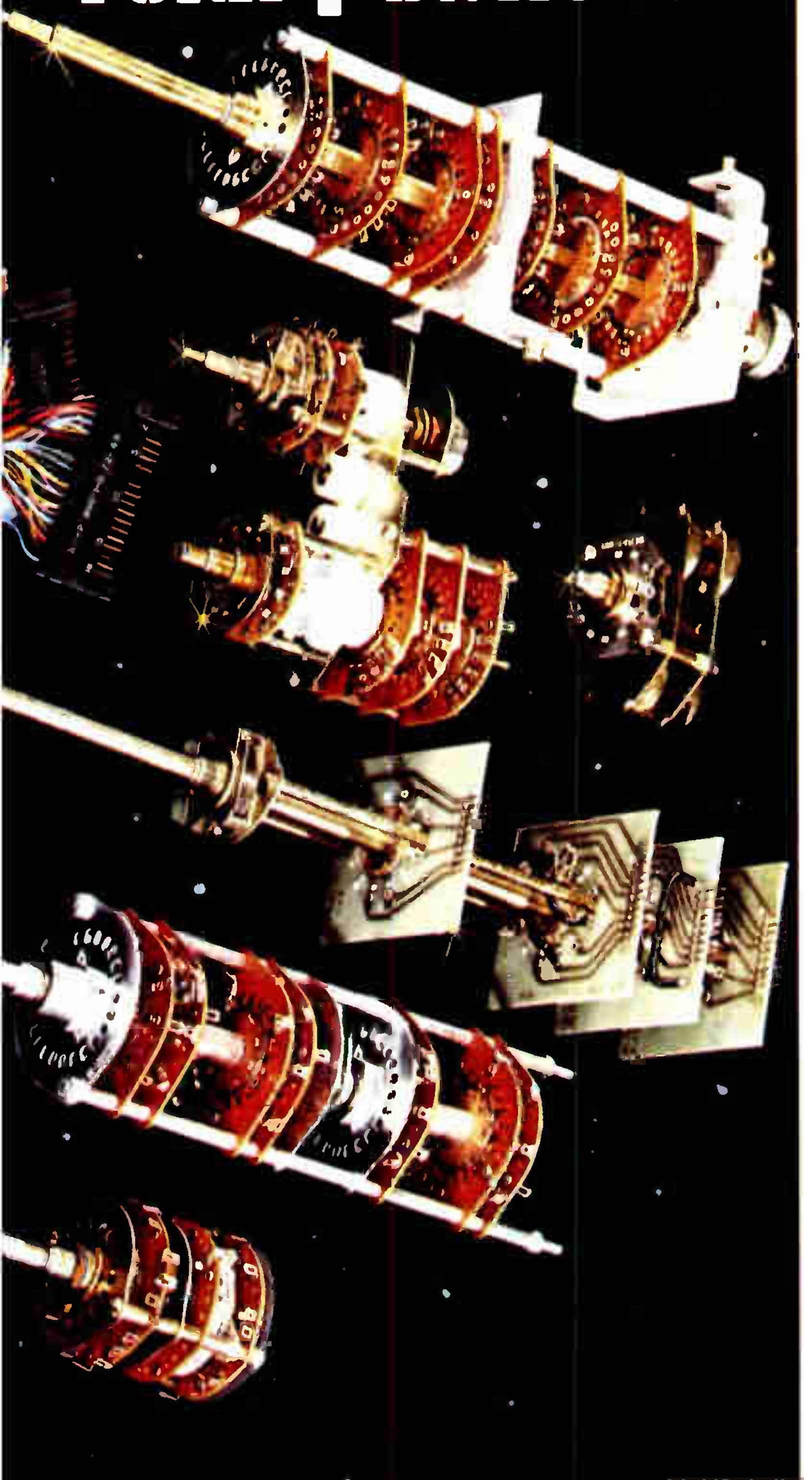

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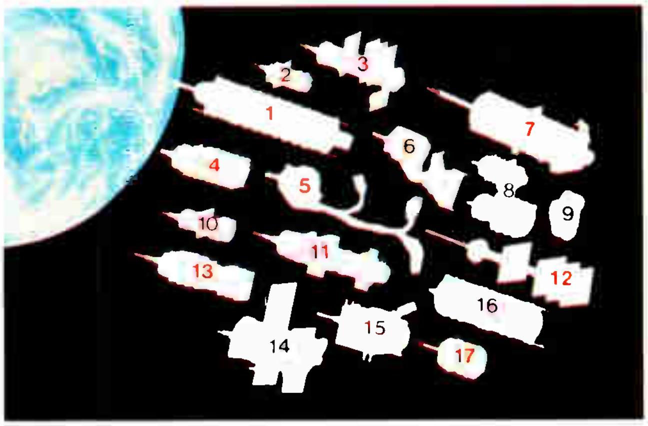

1. Combination push-button/rotary switch. Rotation can occur only after shaft is pushed in to activate push-button. Special hardware designed and built by Oak.

2. PC Board assembly with Unidex detent concentric shaft and PC switch section, with two variable resistors controlled from center shaft.

3. Test equipment assembly, combining phenolic switch sections, resistors and capacitors attached to PC boards, with concentric shafts, brackets and potentiometer.

4. Nine section Unidex switch with PC terminals at opposite sides for attachment to parallel PC boards.

5. Connector and harness assembly attached to four section, 24 position Multidex switch.

6. Five section Multidex switch wired and terminated with customer supplied connectors.

7. Triple concentric shaft with dual detent, with potentiometer on inner shaft, rear bank of 3 sections on center shaft and 4 front sections on outer shaft.

8. Switch assembly for electronic test equipment assembled by Oak. Includes six switch sections, gear system, potentiometer and special brackets.

9. Compact assembly controlling four 7.5A, 32V snap switches.

10. For PC board insertion, this Unidex dual concentric switch combines a PC board switch section, standard switch section and shielded variable resistor.

11. Stamped and machined mounting brackets and shielding hardware on multi-section switch with variable resistors controlled by center shaft.

12. Glass epoxy PC board switch sections with added components, solder terminals, special brackets and shielding for hi-fi equipment.

13. Seven section dual concentric Unidex switch with PC board terminals and shielding between sections.

14. Printed circuit section switch with additional wiring and components; for attachment to PC mother board.

15. Dual concentric switch with bracket and special counting dials, wired sections and attached connector.

16. Dual-concentric, 7 section switch, with shielding and special locking mechanism for use in test equipment.

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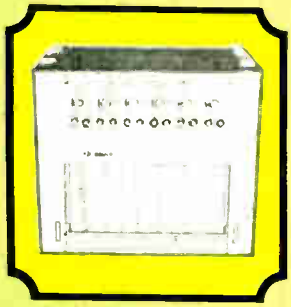
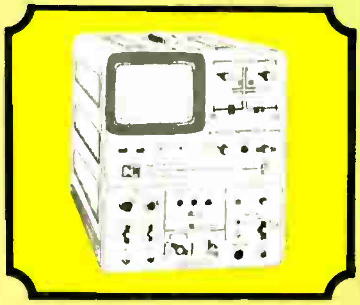
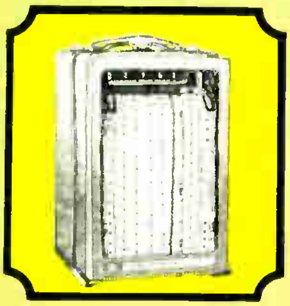
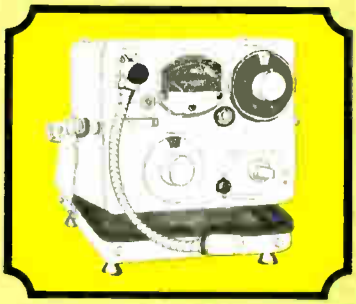

Brush Oscillograph 260

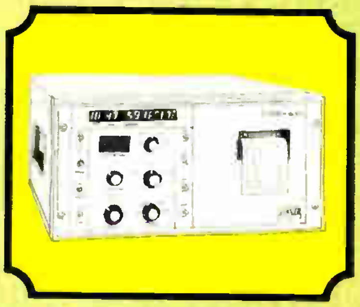

Nicolet
Digital Storage Oscilloscope


Hewlett-Packard 5302 A


Data Research
Transient Voltage Recorder


Esterline Angus Chart Recorder


General Radio
Sound Level Analyzer


Kaye Data Acquisition System


Tektronix Oscilloscope


GE Chart Recorder

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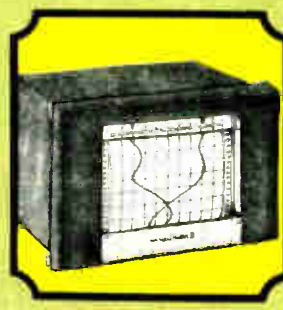
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Microprocessor: 1 chip outdoes 2

In speed, cost, power, RCA's single-chip device leapfrogs over original; 8-bit software-compatible C-MOS unit has 91 instructions, 1.25-μs cycle

by Laurence Altman, Solid State Editor

In the semiconductor industry, almost as much effort goes into lowering the cost and increasing the performance of a product after introduction as goes into developing the product. RCA's new one-chip 8-bit microprocessor is a striking example. Not only does the CDP 1802 complementary metal-oxide-semiconductor microprocessor cost one third less than the two-chip 1801 metal-gate version, but it's almost three times faster and has considerably more powerful branch and arithmetic/logic-unit instructions.

The 1802 has a cycle time of 1.25 microseconds. Since it takes only one or two cycles (plus, of course, one fetch cycle) to perform any of 91 instructions, the instruction time is either 2.5 or 3.75 μs. That makes it as good as any n-channel microprocessor now available, such as the 8080A or the 6800D.

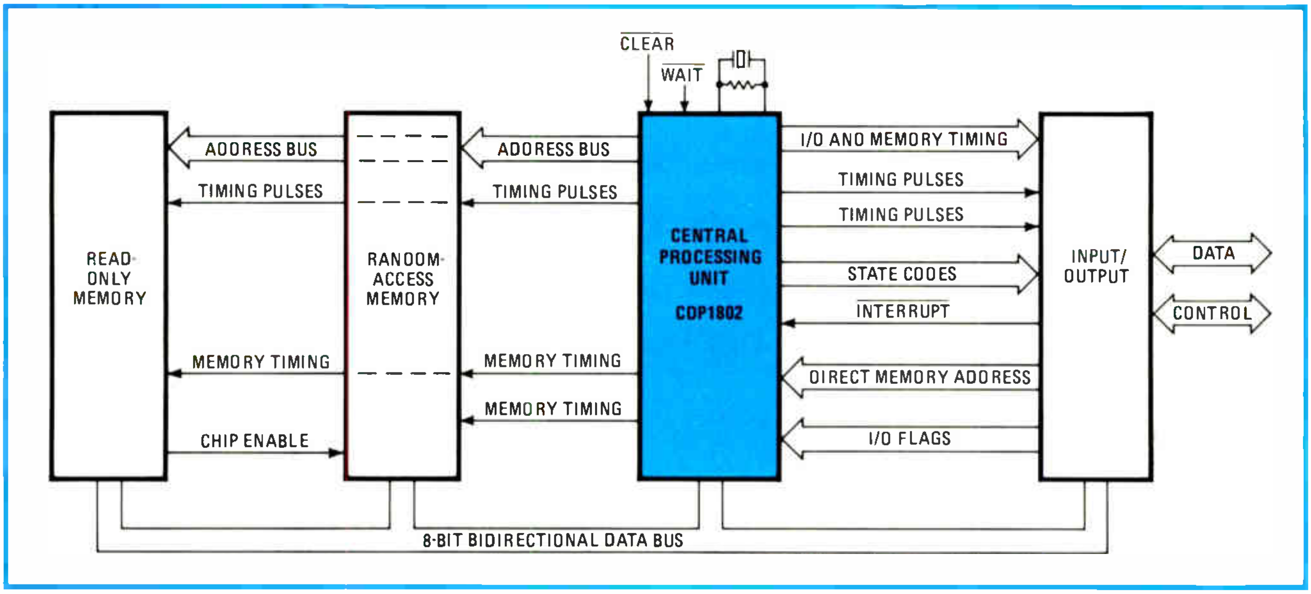
Engineers at RCA's Solid State division, Somerville, N.J., turned the trick with a newly developed silicon-gate process. It enables them to pack register and control functions, which took two chips in the old design, onto a single chip housed in a 40-pin dual-in-line package. Yet they were careful to keep the architecture of the original Cosmac design intact, so that the new chip runs off the same software program as the 1801. This permits present users to upgrade their designs easily with the cheaper part and to add new instruction capability and speed at no additional development costs.

Besides the new 1802 chip, RCA is expanding the 8-bit family to include more than a dozen peripheral circuits designed for the Cosmac system. Available now are four silicon-gate parts: two 512-by-8-bit C-MOS read-only memories (CDP 1831 and 1832), a 256-bit C-MOS random-access memory (1824), and an 8-bit input/output latch (1852).

By flexing its muscles in silicon-on-sapphire processing, RCA also is making available from stock two system-compatible SOS static 1,024-bit C-MOS RAMs—a 1,024-by-1-bit configuration sporting a typical access time of 90 nanoseconds and an equally fast 256-by-4-bit version.

Other family members coming during the second quarter include a universal asynchronous receiver/transmitter, a multiply/divide unit, 8-bit latch-decode circuits, a bus separator/driver, and a 256-by-4-bit C-MOS RAM. A 128-by-8-bit C-MOS RAM, a 1,024-by-8-bit ROM, a programable-bit I/O bus interface, and

Heart of the matter. Many controller functions can be accomplished by a typical system such as this, built around the CDP1802.



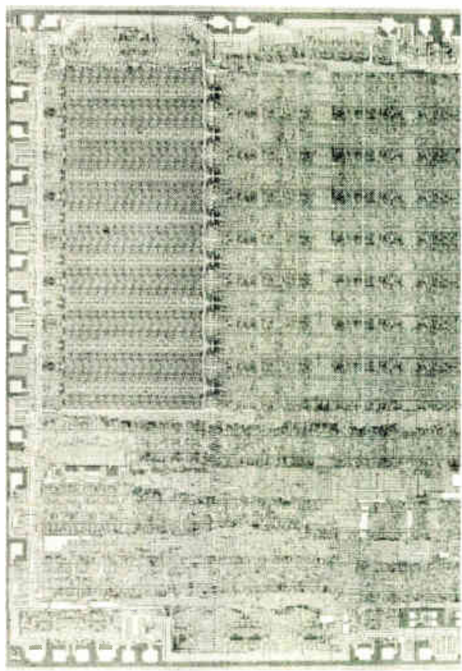
an analog-to-digital converter, are scheduled for introduction later in the year.

Since the 1802 retains the Cosmac architecture, the addresses are separated from the instruction registers and placed in an array of 16 internal registers. These serve as address pointers, so that the unit doesn't force the user to provide an address with each memory reference instruction, unlike other processors. Moreover, each register can point to either data or program area.

It is these easily accessible address registers that allow the 1802 to perform many one-byte instructions that with other 8-bit microprocessors require two or three bytes. Yet the 1802 has the same powerful general-purpose processing capability that characterizes the best of the others: multiflag interrupts, programed input and output ports, a programable-bit output port, on-chip direct memory access that speeds up data transfer, and so on.

Two versions of the 1802, as well as the other peripheral chips, are available. A 4–6-volt version is priced at $23.50 and a 3–15-v (the full C-MOS voltage range) version costs $36.50.

RCA Solid State Division, Somerville, N.J. 08876 [338]



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Georgia

Opto-isolators get better, cheaper

Fairchild expands its line from four to 50 device types; introduces DIP units with minimum isolation-voltage ratings of 5,000 V

by Bernard Cole, San Francisco bureau manager

In a move calculated to turn the growing opto-isolator market upside down, Fairchild Camera & Instrument Corp. is expanding its coupler family from four to 50 device types and reducing prices as much as 6% to 30% below the competition's.

In addition, many of the new device types will set new standards for both phototransistors and photo-Darlingtons in dual in-line plastic packages. Some examples are: isolation of 5,000 volts guaranteed minimum versus the usual 2,500 V maximum; current transfer ratio, 450% as against 200%; sensitivity, 0.5 milliampere in, and 2 mA out, and response time, 2 microseconds vs 2.4 to 4 μs typically.

Integral to the design of many of the devices is a "glassolated" coupler. Steve Carmichael, optoelectronics product manager, says this technique guarantees not just the 5,000-V minimum standard isolation but also continuous isolation at 6,000 V and peak isolation at 7,000 V. Unlike present optocouplers with isolation ranging anywhere from 500 to 2,500 V, Fairchild's new devices use a 6-mil-thick piece of glass to separate the light-emitting input diode from the output npn phototransistor or photo-Darlington pair (see diagram).

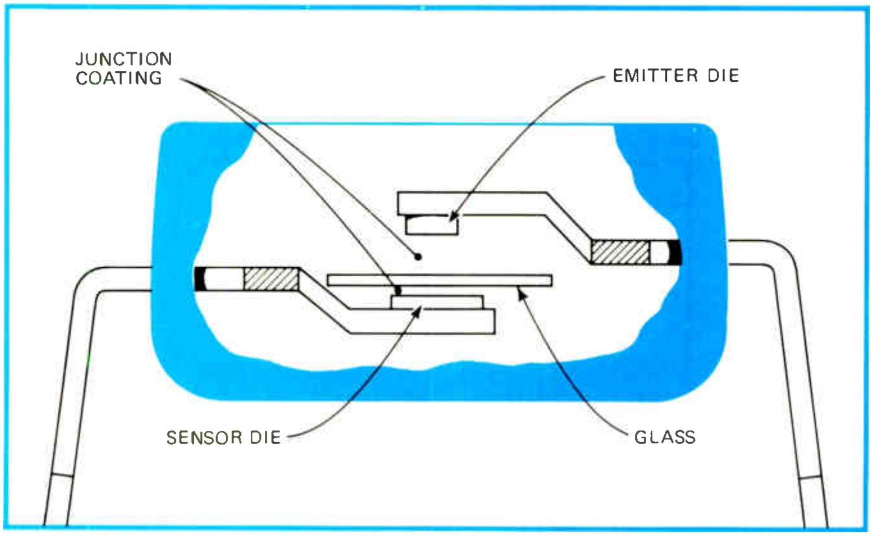
Using the technique, Fairchild is introducing 19 devices, including the FCD 810C,D; 820C,D; 825C,D; 830C,D; 831C,D; and 836C phototransistor isolators and the 850/855C,D and 860/865C,D photo-Darlington isolators. All are in six-pin dual in-line packages with 5,000-V minimum isolations and have current-transfer ratios of 10%, 20%, 50%, 75%, 20%, 10%, 6%, 150%, and 400% respectively, as well as 10^{11} ohms isolation resistance, 1-to-1.5-picofarad coupling capacitance, and 250-milliwatt total package power dissipation at 25°C.

High-sensitivity series. The FCD 860/865C,D series, says Carmichael, was designed specifically as high-sensitivity Darlington components in the 0.5-mA input region and features a current-transfer ratio of 400% with 2-mA output for 0.5-mA input. The output has a collector-emitter breakdown of 30 V, a collector-to-emitter leakage current of 100 nanoamperes, and a dc forward current gain of 30,000 at a collector-emitter voltage of 1 V and a base current of 1 microampere. The input diode has a reverse voltage of 3 V, a continuous forward dc current of 80 mA, and a peak forward current of 3 A (1 μs pulse, 300 pulses per second). In quantities of at least 1,000 the 860C costs 85 cents each, the 860D costs $1.15, the 865C costs $1, and the 865D costs $1.35.

The FCD 830C,D; 831C,D; and 836C phototransistors feature a response time (that is, a collector rise or fall time) of about 2 μs. The prices in quantities of 1,000 are 75 cents each for the 830C, 95 cents for the 830D, 65 cents for the 831C, 85 cents for the 831D, and 55 cents for the 836C.

Unit prices in lots of 1,000 and up for the rest of the 5,000-to-7,000-V isolation series range from 45 cents to 95 cents for the phototransistors and from 85 cents to $1.15 for the photo-Darlingtons. In packages specified at 2,500-V minimum isolation the phototransistors are available in lots of 1,000 for 40 to 60 cents. These have the same features as the higher-voltage parts, including fast response time, low coupling capacitance, and current-transfer ratios up to 150%.

Fairchild Camera & Instrument Corp., Consumer Products group, Optoelectronics Division, 4006 Miranda Ave., Palo Alto, Calif. 94303 [339]



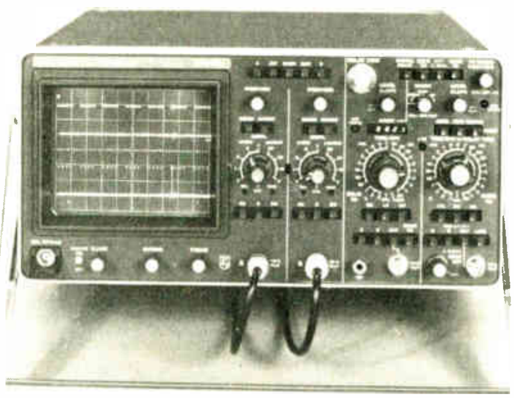
Scopes zero in on digital faults

Two additions to Philips portable line offer either 120-MHz bandwidth and delay-by-events triggering or 50-MHz bandwidth and four traces

by John Gosch, Frankfurt bureau manager

When Philips introduced its PM 3260 dual-channel, 120-megahertz oscilloscope two years ago [*Electronics*, Feb. 21, 1974, p. 120], the Dutch company promised the unit would be the first in a new range of lightweight, low-cost portable scopes.

Now Philips is augmenting this portable-scope series, which has grown to six units, with another two models. One is the PM3244, a 50-megahertz instrument billed as the first portable scope with four-channel operation. The other, designated the PM3261 (see photo), is a lightweight scope with a digitally delayed time base. This capability, claimed to be a novelty in a compact and portable instrument, enables the user to pick out a particular pulse or bit from a stream of up to 100,000 bits.



"Both instruments will be launched by May and will sell for about $2,500 on the American market," says Jacques Wouters, a product manager at Philips' Eindhoven-based Industrial Equipment division. "It's likely that the U.S. will be one of the major markets for the new instruments."

The PM3261 has the same basic characteristics as the two-year-old 3260 model: a 120-MHz bandwidth, a 3-nanosecond rise time for the vertical amplifiers, an 8-by-10-centimeter display screen, a 5-nanosecond-per-division maximum sweep speed for both the main and delayed time bases, plus a low weight of 20 pounds. "But with at least three out of ten 3260 users clamoring for a digital delay, we have added that facility to the standard delayed time base on the 3261," Wouters points out.

The digital delay makes it possible to locate pulses even with jitter from disk memories, tapes or other electromechanical devices. This is because pulse location is based solely on the number of pulses counted and not on the time difference between the trigger point and the desired pulse, Wouters adds.

With digital delay as provided in the PM3261, the operator need merely set the number of the pulse he wants to investigate on a five-digit display consisting of seven-segment light-emitting diodes. Then, when there's coincidence between that number and the actual number of pulses counted by a signal counter, the delayed time base is triggered and the pulse being looked for is intensified.

One refinement is in the method for controlling the pulse setting. Instead of using thumbwheels as scopes with plug-in units do, the 3261 has an electronic control. This control is adjustable by the same knob that sets the number of the pulse to be investigated. With this knob, the instrument can also be put in the automatic search mode, in which the display moves up or down the data stream thereby allowing pulse-by-pulse checking. Both the speed and the direction of movement are controllable by the same knob. Counting is possible at rates as low as one step every two seconds.

Still another specialty is an extra trigger lamp, also a LED indicator, which lights up when the delayed time base loses triggering. It can be used as a selective logic probe in combination with the digital delay function to indicate whether the selected bit was present.

Like the other members of the Philips portable-scope series, the PM3261 can be operated off a supply from 90 to 260 V at 46 to 440 hertz and off any dc power source from 100 to 200 V [*Electronics*, Oct. 2, 1975, p. 109]. Battery operation is also possible, and this too makes the new scope attractive for field use.

Application in the field is what Philips engineers had in mind also when designing the PM3244, the company's second entry in the scope market this spring. With four identical 50-megahertz channels at his disposal, the 3244 user can follow several ongoing events at a glance, and this "results in a dramatic reduction of measuring time," points

and do it with standard modules Powercube's MIL-Standard "gold line" Cirkitblock® modules enable you to breadboard custom power supply systems in minutes with AC or DC input switching preregulators, EMI terminal modules, high-frequency generators and transformer isolated output modules - all encapsulated in tiny, lightweight packages and most available right off the shelf. (Powercube can also assemble your power supply systems for you.)

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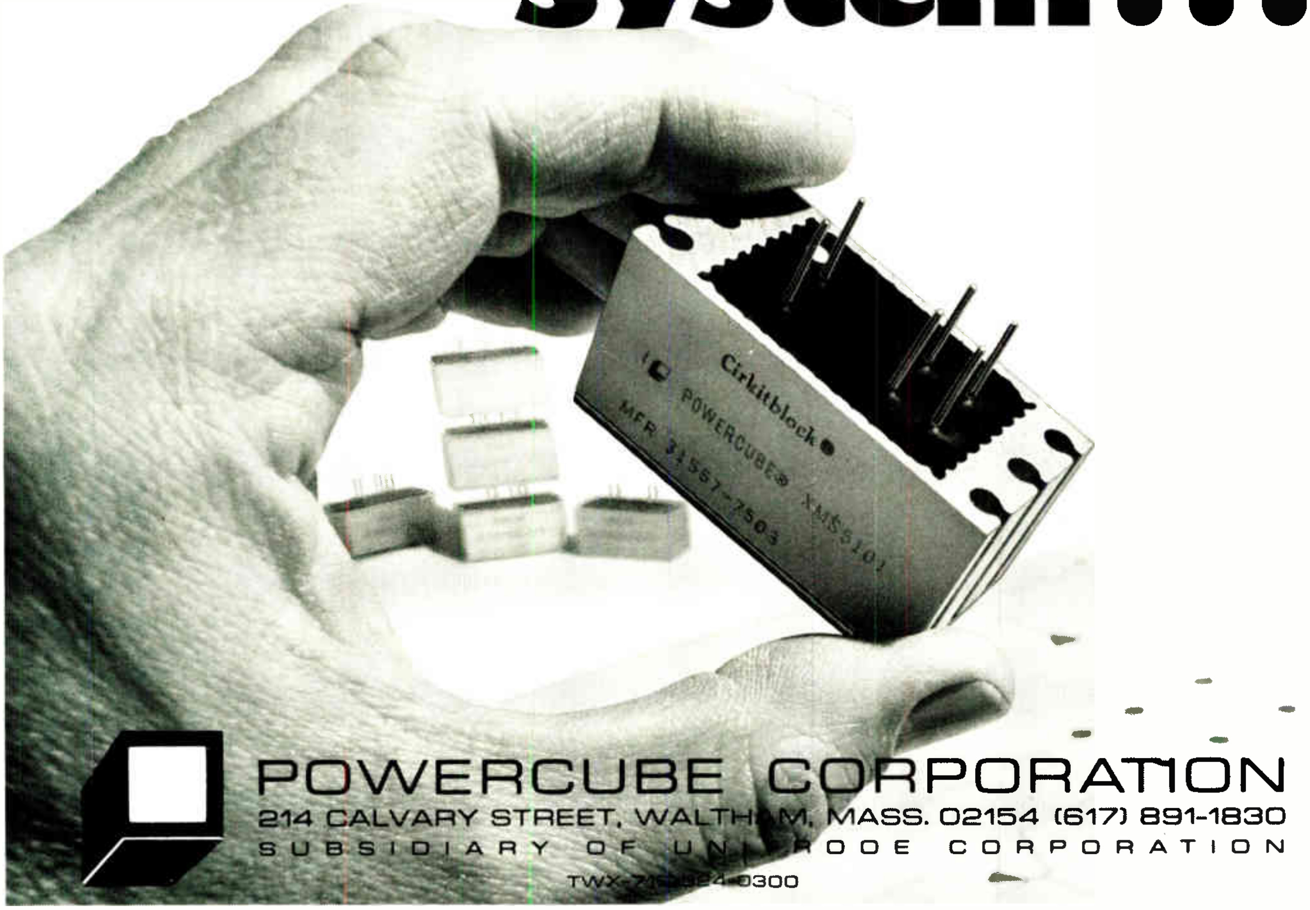

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TWX-710-324-0300

out Hans Toorens, product manager for scopes up to 50 MHz.

A typical application for the PM3244 is in inspecting simultaneously what is happening on, say, address lines, input and output lines, and on timing pulse lines. For differential measurements, it's possible to display two differential signals—those resulting from adding or subtracting the signals on channels A and B, and C and D so that a total of six signals can be displayed on the instrument's 8-by-10-cm screen.

Four-channel operation as such is not a new feature, Toorens says. "But so far, it has been possible only with bulky instruments with plug-in systems." Now it's available in a portable and compact instrument weighing less than 20 pounds and using no plug-ins, he adds. The reason is a space-saving power supply and "cold switching," two features common to all models in the Philips portable-scope series.

Triggering. To enhance operation, the PM3244 has a wide range of triggering possibilities. Triggering can be from any of the input channels, any composite signal, from an external source or from the line voltage. Except for the latter case, triggering from the various sources applies not only to the main time base but to the delayed time base.

Cold-switching, also called dc switching, is essentially internal remote control, Toorens says. Instead of the front panel controls being connected directly and mechanically to the instrument functions, they switch only low-power dc commands that drive solid-state and reed-relay switches mounted on the instrument boards. This allows the controls to be conveniently placed. And since these controls are compact, further space is gained for other electronic functions. Simple rotary switches with only one or two decks suffice.

Philips Test & Measuring Instruments Inc., 400 Crossways Park Dr., Woodbury, N.Y. 11797 Phone (516) 921-8880 [340]

N.V. Philips Gloeilampenfabrieken, Industrial and Scientific Equipment Division, Eindhoven, The Netherlands [371]

Instruments

CB testers have extended ranges

Production-line instruments anticipate expansion to 50 or more frequencies

As the demand for citizens' band radios has increased, so has the demand for instruments that can quickly test CB radios on the production line. At the same time, the proposed increase in channels from 23 to 50 or more means new testers need some provision for the increase, to guard against obsolescence.

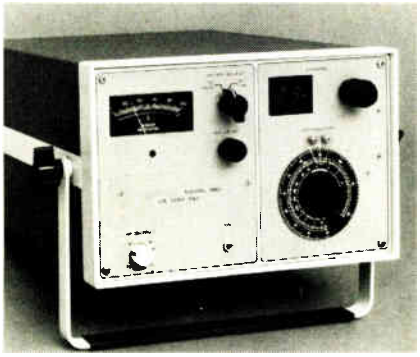
Two new instruments, one from Matsushita and one from LogiMetrics, aim to meet these needs. Each uses a phased-locked-loop synthesizer to generate switch-selectable frequencies in the 27-megahertz citizens' band, and each offers a simple means for updating to whatever number and frequencies of channels may be added.

The model VP-8260 from Matsushita Communication Industrial Co. (below) has switch-selectable upper and lower sideband frequencies that either are 1 kilohertz above or below the channel frequency or are adjustable to within ±5 kHz of the channel frequency.

The 50-channel model VP-8260B

is priced at $1,660. The 25-channel, $1,600 model VP-8260A, introduced last September, can be upgraded.

A temperature-compensated 1-MHz crystal oscillator module is the primary frequency-determining element. The high stability of this oscillator provides the 4 × 10^{-7} parts per week stability of the instrument. A 10.004-MHz voltage-controlled crystal oscillator is the offset oscillator in the channel-frequency generation loop. It is controlled by the 1-MHz reference oscillator when the channel frequency is selected by the front-panel switch, but operates with normal crystal stability in the variable-frequency mode.



The built-in attenuator permits adjustment of output level between -20 decibels and +100 dB above 1 microvolt in 1-dB steps. The attenuator is protected from damage even if the transmitter of the unit under test is energized.

Leakage is low enough to permit testing receiver sensitivities as low as -10 dB (0.3 μV). Nonharmonically related spurious signals are down by at least 60 dB from the signal, and harmonically related spurious signals are down 30 dB.

The LogiMetrics model 980 CB test set (above) is a $1,195 23-channel unit. The rf output level is continuously adjustable from 0.1 μV (-127 dBm) to 10 mV rms (-25 dBm) into a 50-ohm resistive load. The attenuator of the waveguide-beyond-cutoff type is protected against overloads as high as 5 watts.

The model 980 is designed for production-line testing by semi-skilled persons. Output channels are selected with a single rotary switch in conjunction with a read-only memory that can be programed for the 23 present channels or, when needed, up to 37 more. The selected channel is displayed on seven-segment light-emitting-diode readouts.

Amplitude modulation is provided at a standard 1-kHz rate, with distortion less than 1% for 30% modulation and less than 3% for 70% modulation.

Leakage is less than 0.1 μV one inch from the unit—low enough to permit testing with the top covers off the tester and the receiver under test.

Matsushita Communication Industrial Co. Ltd., 4-3-1 Tsunashima-Higashi, Kohoku-ku, Yokohama 223, Japan [351]

LogiMetrics Inc., 121-03 Dupont St., Plainview, N.Y. 11803. Telephone: (516)681-4700 [352]

DPM can drive printer while making measurements

When the user of a digital panel meter wants to link it to a digital printer, he often doesn't want it to stop doing analog-to-digital conversion during the printout. His wish is now met by the AD2016—a line-powered 3½-digit panel meter from Analog Devices Inc. It is one of three additions to a series introduced last year. The others are 4¾-digit units: the AD2025 and AD2028.

The AD2016, an improved version of the company's AD2009, uses MOS LSI components and a half-inch-high LED display that improves its reliability and lowers its cost because of lower parts count and power consumption. Unit price is $129.

A novel feature of the AD2016, says James Hayes, marketing manager for DPMs, is availability of two hold options, one to stop the instrument's conversion and hold the display, the other to stop the data outputs from changing independently of the display. The latter allows interfacing to digital printers, BCD comparators or computers without interrupting the conversion func-

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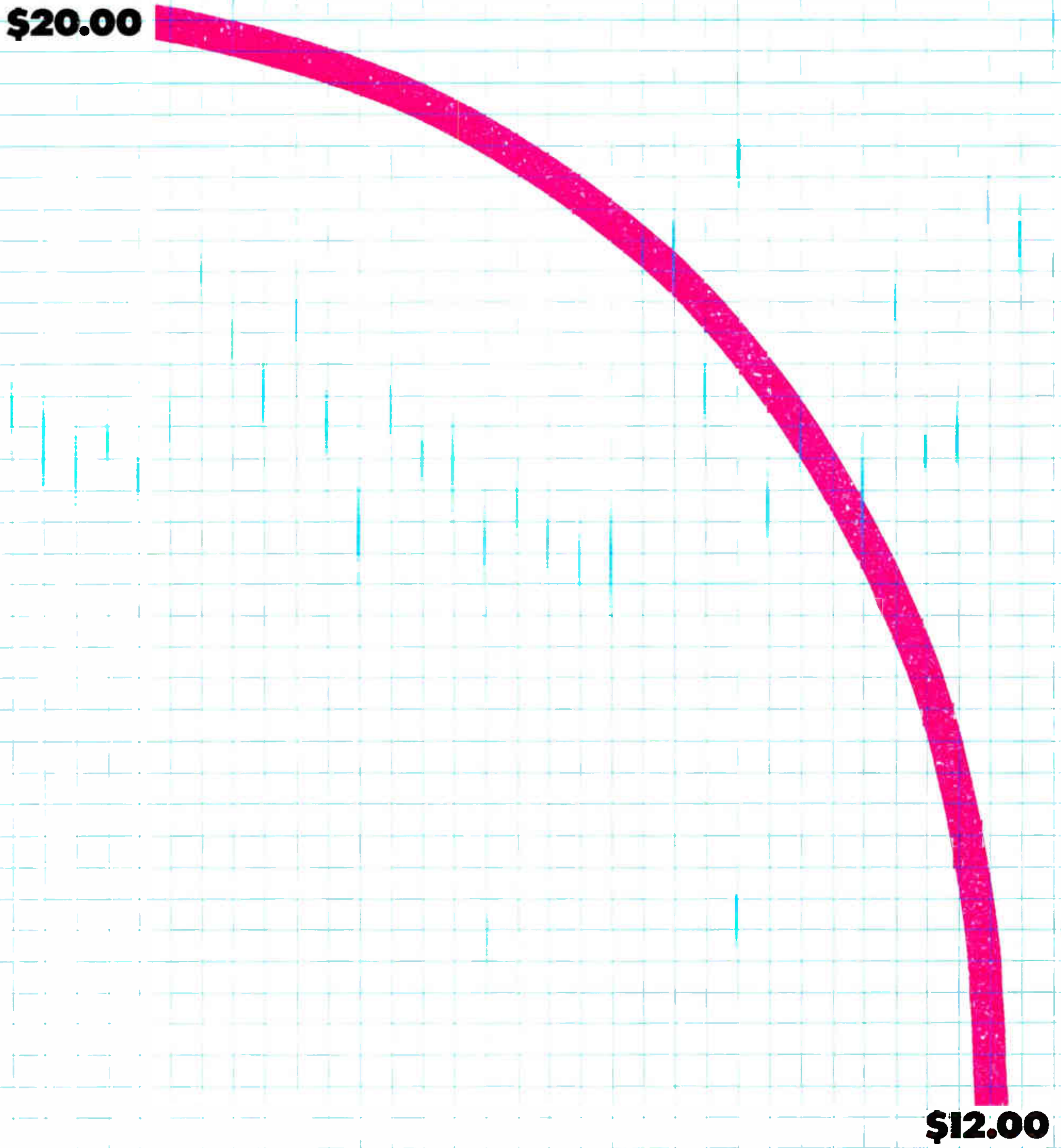

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National Semiconductor

2900 Semiconductor Drive, Santa Clara, CA 95051, (408) 732-5000

Circle 139 on reader service card

tion. The parallel BCD option costs an additional $10.

The AD2016 measures bipolar input voltages over full-scale ranges of ±199.9 millivolts, ±1.999 V, or ±19.99 V with an accuracy to within ±0.1% of reading ±1 digit.

The line-powered AD2025 and logic-powered AD2028 offer 4¾-digit resolution to ±3.9999 V or ±39.999 V with an accuracy to within ±0.005% of reading, ±0.005% full scale, ±1 digit. Both have LED displays that are 0.43 inch high. Unit prices for the AD2025 begin at $259; for the AD2028, at $249. Parallel BCD outputs are $27 more.

Analog Devices Inc., P.O. Box 280, Route 1 Industrial Park, Norwood, Mass. 02062. Phone Lowell Wickersham at (617) 329-4700 [352]

Pocket-sized digital multimeter sells for $124

The pocket portable DVM35 is a three-digit multimeter with an input impedance of 15 megohms, a basic dc-voltage accuracy of within 1%, and a price tag of $124. Able to measure ac and dc voltages from 1 volt full scale to 1,000 V, ac and dc current from 1 milliampere full scale to 1 ampere, and resistance from 100 ohms full scale to 10 megohms, the DVM35 obtains long battery life by means of a push button, located on its probe, which allows the user to turn on the meter only when he actually is making a measurement. A protective fuse is located in the probe for convenience of replacement in the field.

Sencore Inc., 3200 Sencore Dr., Sioux Falls, S. D. 57107. Phone Bob Bowden at (605) 339-0100 [354]

Signal-seeking WWV receiver employs double conversion

Dedicated to the National Bureau of Standards radio stations WWV and WWVH, the model TF-4 WWV receiver uses frequency scanning to allow unattended reception of NBS time information. This signal-seeking unit, which has been designed using the upshift, double-conversion principle, includes an active filter for selecting any of the six tones broadcast by the NBS. The tones

may be gated or ungated at the user's option. In its standard form, the receiver can receive four carriers—5, 10, 15, and 20 megahertz—but any four frequencies between 2.5 and 30 MHz can be provided. Price of the TF-4 is $990; delivery time is 30 days.

True Time Instrument Co., 429 Olive St., Santa Rosa, Calif. 95401. Phone (707) 528-1230 [353]

Computing radiometer needs no dark-current control

The model CR-1 computing radiometer has no need for zero or dark-current controls because its internal microprocessor automatically subtracts these components when computing a reading. Autoranging, signal averaging, and signal-rate sensing are also provided by the microprocessor. Able to work with any of the company's photomultiplier detector assemblies, the CR-1 has a 16-key keyboard that, among other things, can apply correction factors,

store readings, and perform log conversions. Price is $3,900.

Gamma Scientific Inc., 3777 Ruffin Rd., San Diego, Calif. 92123. [355]

TOPICS

Instruments

Honeywell Test Instruments Div., Denver, Colo., has developed a dry processor for use with two series of its Visicorders. The model 1219 processor, which sells for $2,450, is designed for use with the model 1806A recording oscilloscope and the 1856A line-scan recorder. . . . **Clemens Manufacturing Co., St. Louis, Mo.,** intends its model FA-20 fused attenuator to protect signal generators and other test equipment when transceivers are being serviced. If the transceiver is accidentally keyed, the fuse opens. . . . **Yokogawa Corp. of America, Elmsford, N. Y.,** has added temperature-measurement and electrostatic-writing capabilities to its YEW 3050 line of strip chart recorders. . . . **Bertan Associates Inc., Hicksville, N. Y.,** has announced a high-current version of its line of high-voltage laboratory power supplies. The model 210-03R can provide up to 50 milliamperes at ±3,000 V dc. . . . **Keithley Instruments Inc., Cleveland, Ohio,** has introduced a clamp-on current probe—the model 1685—that allows multimeters to measure currents up to 200 A ac. . . . **RFL Industries Inc., Boonton, N. J.,** has introduced an automatic-control module for its model 990 Magnetreater.

The real test for a display's readability is direct sunlight. Most of them are washouts.

By comparison, Beckman displays stand out. With wider viewing angles and more brightness by the foot. Important factors when you're looking at critical readouts in the air or on the ground.

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To top it all, Beckman displays can give you a visible edge in your market – a simple case of product differentiation.

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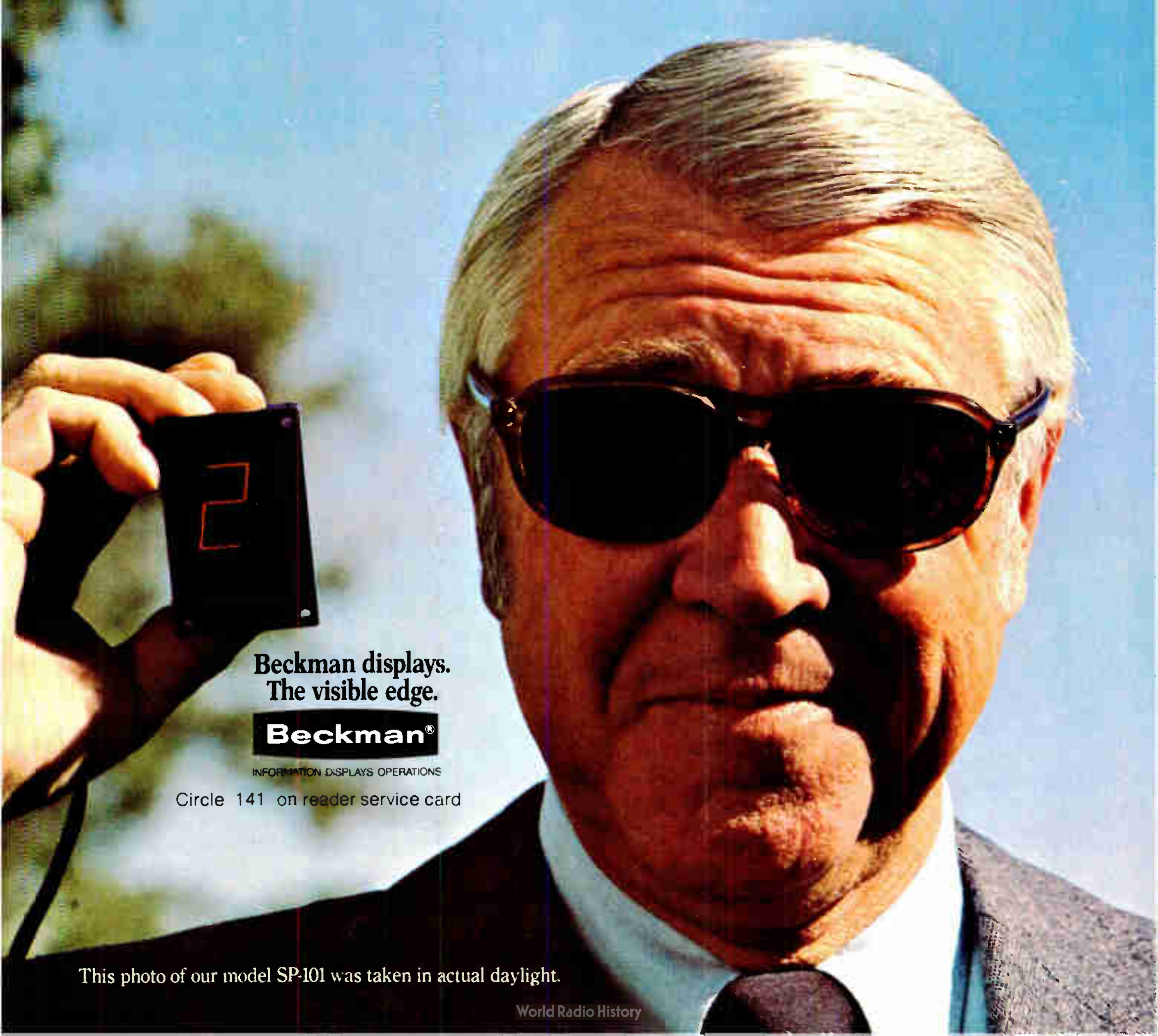
For complete details, write: Beckman Information Displays Operations, P.O. Box 3579, Scottsdale, AZ 85257; or, call (602) 947-8371.

Beckman beats the daylights out of all other displays.



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Circle 141 on reader service card

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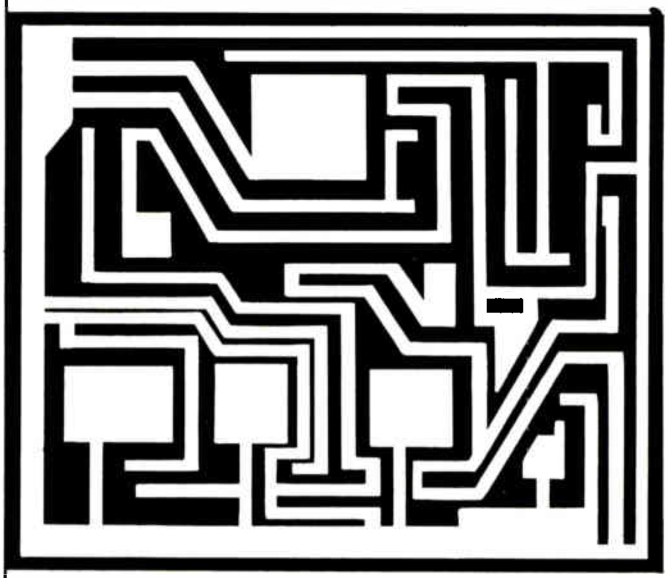

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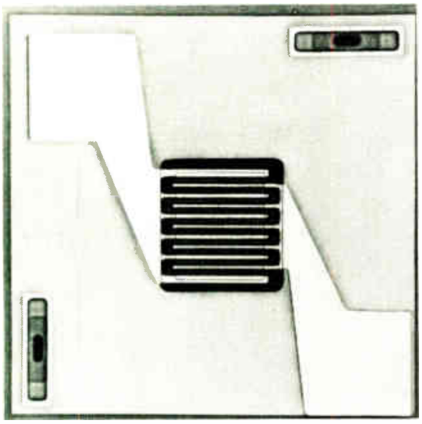
Microwave

4-GHz transistor has low noise

At top frequency, gain is at least 8 dB, and noise figure is, at most, 3 dB

In the microwave-transistor business, it's one thing to have a relatively high-performance part and quite another to get high yields of consistently good devices. For example, some 4-gigahertz bipolar



transistors on the market achieve 3- to 3.3-decibel noise-figure levels, but the yield is low.

Now, however, Hewlett-Packard's newly formed Microwave Semiconductor division is introducing the first in a series of parts that combines low noise and high gain with consistently high yields and, ultimately, lower costs. The HXTR 6101 microwave transistor, rated at 4 gigahertz, has a guaranteed noise figure of 3.0 dB maximum and 2.7 dB typical. Associated gain at that frequency is 8 dB minimum and 9 dB typical. When the transistor is operating at 1.5 GHz, the noise figure is 1.5 dB, and the associated gain is specified at 15 dB.

Product-marketing engineer Len Lea says the 13-square-mil device uses several methods to achieve the high yields, low noise, and high performance—among them are ion implantation, local oxidation, and proprietary self-aligning techniques.

For conventional devices, a combination of diffusion and ion implantation is used in the fabrication of the emitter and base fingers, but HP uses a fully ion-implanted process. "What this does," says Lea, "is give the device much clearer, more uniformly sharp emitter and base-finger outlines, resulting in low noise. It also allows placement of the interdigitated fingers closer together—under 1 micrometer—leading to better gain characteristics at high frequency."

The combination of implantation and a new self-aligning-mask technique, in which all the necessary patterns are generated on the same mask, ensures uniformity of performance from batch to batch while easing registration problems, he says.

Using ion implantation and a local-oxidation technique has allowed HP engineers to fabricate 1-square-mil gold-bonding pads directly on the interdigitated fingers with less collector-base parasitic capacitance than on other pads of half the size, the company says.

Other key specifications of the 6101 are a collector-base breakdown voltage at 100 microamperes of 30 volts, a collector-emitter leakage current at 1 V of 5,000 nanoamperes, a collector-cutoff current of 100 mA at a collector base voltage of 15 V, and a forward-current transfer ratio of 50 minimum, 150 typical, and 250 maximum at a collector-emitter voltage of 10 V, and an input current of 4 milliamperes. Maximum dc collector current is 10 mA, and total device dissipation is 180 milliwatts.

Available now in the HPAC-70GT metal/ceramic hermetic package that meets the environmental requirements of MIL-S-19500 and the test requirements of MIL-STD-750/883, the HXTR 6101 is priced at $150 each in quantities of one to nine; for 10 to 24, $130 each; and for 25 to 49, $115 each.

Hewlett-Packard Co., Microwave Semiconductor division, 3172 Porter Dr., Palo Alto, Calif. 94304 [341]

Connector provides phase adjustment

Combining a variable-length section of transmission line with an SMA connector produces a microwave

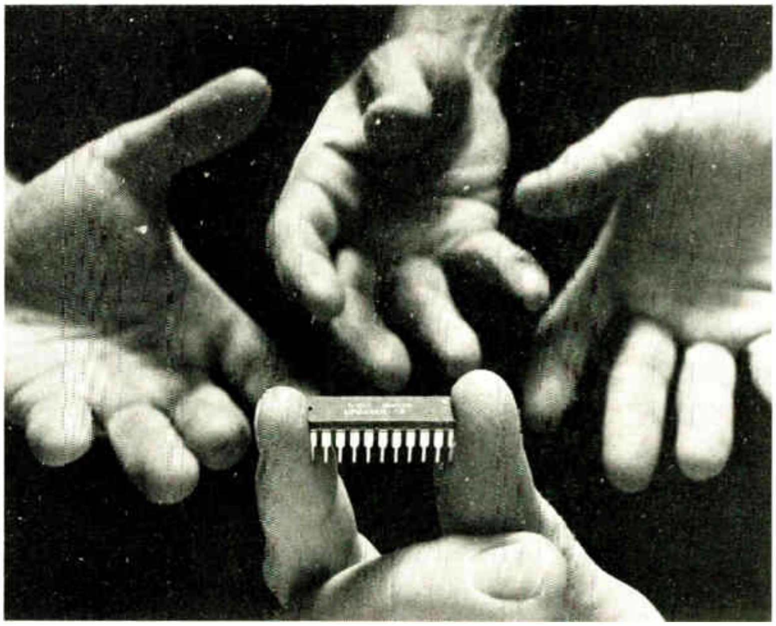
connector that can be used to trim phase angles in such systems as phased-array radars, instrument landing systems, and test equipment. The phase-adjustable SMA connectors cover the range from dc to 18 gigahertz and are rated at 500 V rms. Nominal impedance is 50 ohms. Phase is adjusted by rotating one nut and then locking it in place with another nut. Maximum phase adjustment is 180° at 18 GHz. An adapter version of the connector is available for in-line use. The connectors sell for $31.40 each for one to four pieces, while the adapters are priced at $33. Delivery of production quantities takes from 8 to 10 weeks.

Amphenol RF Division, 33 East Franklin St., Danbury, Conn. 06810. Phone (203) 743-9272 [343]

Subminiature attenuators handle more than 5 watts

Two coaxial attenuators—the models 21 and 21A—are subminiature units that can handle input powers of at least 5 watts. The model 21 spans the frequency range from dc to 18 gigahertz, while the 21A goes only to 12.4 GHz. Measuring 1.52 inches long by 0.64 in. in diameter, both models are offered in four

OUR 4K RAMS ARE SO GOOD, EVEN THE COMPETITION CAN'T RESIST.



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Third, delivery. We can deliver this state-of-the-art technology and incredible reliability right now. In whatever volume you want.

So if you need 4K RAMs, take a look at our μPD411 series – the best 4K RAMs you can buy.

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NEC Microcomputers, Inc., Five Militia Drive, Lexington, Massachusetts 02173. 617/862-6410.

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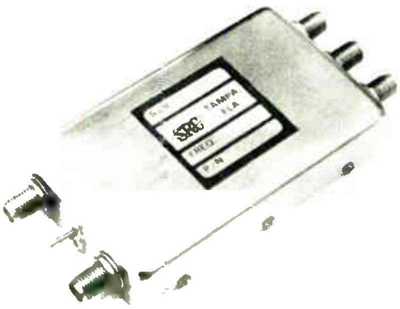
New products

standard attenuation values: 3, 6, 10, and 20 decibels. The 3-dB units can take an average input power of 8.75 W; the 6-dB devices are rated at 6.25 W; and the remaining two are 5-W attenuators. The 50-ohm units can handle peak powers as high as 1 kilowatt. The price of the model 21 is $100, and the model 21A sells for $85. Both are available from stock.
Weinschel Engineering, Gaithersburg, Md. Phone (301) 948-3434 [344]

Frequency multiplier provides three outputs

When the model 3850-1610 multiplier is supplied with a 25-megahertz input, it puts out 5 dBm at 100 MHz, 17 dBm at 300 MHz, 10 dBm at 500 MHz, and −25 dBm over a 4-to-8 gigahertz comb-line spectrum. The active unit requires 200 milliamperes maximum at +15 V dc. Its thin-film hybrid construction allows



it to combine high reliability with dimensions of only 3 by 1.75 by 0.6 inches, nominal. The multiplier sells for $2,700 and has a delivery time of 90 to 120 days.
Trak Microwave Corp., 4726 Eisenhower Blvd., Tampa, Fla. 33614. Phone Tom Roberts at (813) 884-1411 [345]

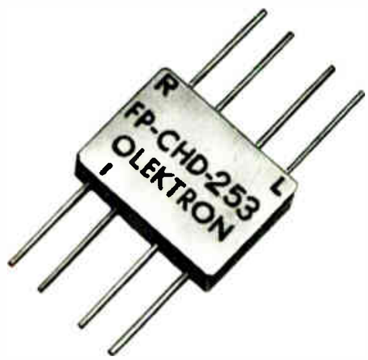
Synthesizer phase-locks sources from 0.5 to 18 GHz

Designed for telecommunications applications, the series DS miniature frequency synthesizers are capable of digitally programing phase-locked signal sources in al-

most any band from 0.5 to 18 gigahertz. Providing frequency steps as small as 50 kilohertz at 5 GHz, the series DS is housed in a 2.5-by-4-by-1.5-inch package. Standard programing is by four-digit binary-coded-decimal inputs.
Communication Techniques Inc., 1279 Route 46, Parsippany, N. J. 07054. Phone Dr. John Payne at (201) 263-7200 [346]

High-power mixer spans 10 MHz to 3 GHz

Able to handle, when necessary, local-oscillator power levels as high as 26 dBm, the model FP-CHD-253 double balanced mixer has a frequency range of 10 megahertz to 3 gigahertz. The unit has a conversion loss of 6 decibels at 1 GHz and 10 dB



at 3 GHz. At its normal operating LO power of 23 dBm, the mixer has a typical third-order intercept of 25 dBm, a 1-dB compression point above 18 dBm, and a 1-dB desensitization level of about 12 dBm. The mixer sells for $65 in small quantities. Delivery time is two weeks.

Olektron Corp., 6 Chase Ave., Dudley, Mass. 01570. Phone J. Oleksiak at (617) 943-7440 [347]

Sensitive detector covers 18 to 40 GHz

The model CDV-31840 is a point-contact detector that covers the frequency range from 18 to 40 gigahertz and features a voltage sensitivity of 1.5 millivolts per microwatt, average, at a bias current of 100 microamperes. It has a minimum tangential sensitivity of –42 dBm and a typical sensitivity of –48 dBm. Unit price is $300; delivery time is four to six weeks.

Microphase Corp., 35 River Rd., Cos Cob, Conn. 06807. Phone George P. Vrattos at (203) 661-6200 [348]

Microwaves

Microwave Associates Inc., Burlington, Mass., has announced a line of X- and Ku-band mixer and detector diodes. The MA-41220 series devices are noteworthy for their extremely low package parasitics. . . . **Alpha Industries Inc., Woburn, Mass.,** has introduced a line of limiter chips that can handle incident pulses of up to 4 kilowatts and reduce leakage power to as little as 10 milliwatts for the protection of sensitive receivers. . . . **EM Systems Inc., Sunnyvale, Calif.,** is offering a cavity-backed spiral antenna for the 18-to-40-GHz range. The model A4400 has a nominal 3-dB beam width of 70°. . . . **Omni Spectra Inc., Merrimack, N. H.,** has announced its model 20751 zero-bias Schottky detector for use up to 18 GHz.

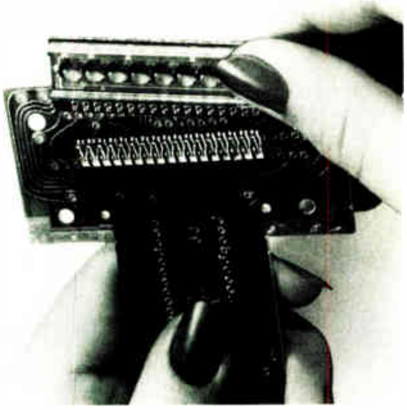
Packaging & production

Connector holds LED displays

Low-cost finger strips allow assemblies simply to snap in

A low-cost, pluggable metal strip that acts as a display connector for light-emitting-diode displays already has found an application in a hand-held calculator.

Many hand-held calculators use



nine-digit magnified LED displays, which are mounted on their own small printed-circuit cards. These displays usually are soldered to the calculator's pc board with a special external set of pins (the display board having no pins of its own) or are plugged into a relatively expensive connector on the calculator circuitry board. Soldering doesn't allow replacement of the display, but it is much less expensive than using a connector.

An almost brand-new company specializing in metal stamping, Precision Concepts, has developed the new unit that allows a customer to snap in a display or pc board and remove it at will. One side of the all-metal strip is soldered into a calculator board, and the other side accepts the LED display in a special row of solderless contacts.

The strips are stamped out of tinned, spring-tempered phosphorous bronze by high-speed machinery and can be furnished with any number of contacts. A 17-pin version designed for a nine-digit readout sells for 9.5 cents in large quantities.

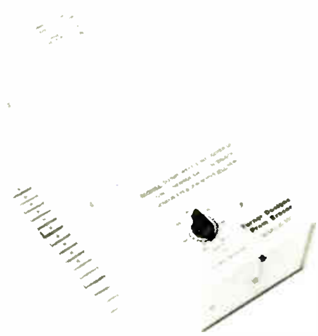
One end of the strip consists of a row of fingers, similar to those of a dual in-line package, spaced on 0.1-inch centers and bent up at an angle of 30°, 45°, or 90°. The opposite end of the strip (photo) consists of three-finger bifurcated springs on 0.1-in. centers. These spring fingers accept 1/32- or 1/16-in. pc boards, which are snapped in.

Display connectors of this type are being supplied to General Instrument Corp., Hicksville, N.Y., for a calculator for the Soviet Union. Other calculator manufacturers are considering use of these units. Possible other applications are as a calculator keyboard connector and as a motherboard connector to accept smaller pc cards.

Precision Concepts Inc., 1595 B Ocean Ave., Bohemia, N.Y. 11716. Phone (516) 567-0995 [391]

Ultraviolet device erases up to 60 PROMs at once

Able to hold as many as 60 erasable programable read-only memories, the model 30-000 delivers ultraviolet radiation at a density of 7 milliwatts per square centimeter. The wavelength (2,537 angstroms) is optimal for erasing such widely used memories as the MM5203Q, the 1702A, and the 2708. To minimize handling, the memories are loaded

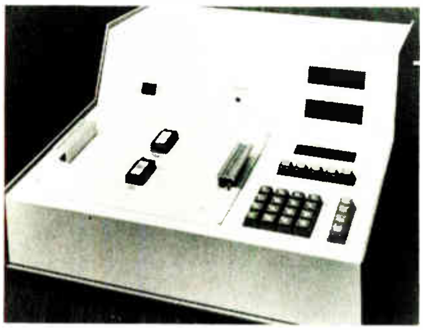


on removable metal trays, which also protect the PROMs against electrostatic damage. Ultraviolet dosage is controlled by an adjustable timer, calibrated in minutes, with a maximum setting of one hour. A hold feature permits both very short exposures and very long ones. The operator of the model 30-000 is protected from exposure to the intense ultraviolet radiation by a door interlock, and from ozone by the specially designed envelope of the ultraviolet lamp. The eraser sells for $295.

Turner Designs, 2247A Old Middlefield Way, Mountain View, Calif. 94043. Phone John E. Griffin at (415) 965-9800 [393]

ROM programer's display, keyboard are hexadecimal

The model 501 PROM programer has a hexadecimal keyboard and a complete set of hexadecimal displays to eliminate the need to translate addresses and data from binary form.



The unit, which contains an 8-bit microprocessor, has two sockets, one for a master PROM and one for a copy PROM. Among the functions it can perform are straight duplication of the master PROM, duplication with change in section of copy PROM, zero field test, verification, and step-by-step reading of PROM contents.

The 501 is a plug-in instrument consisting of a mainframe and a variety of personality modules for a wide range of memories. The mainframe sells for $2,150, and the personality modules are priced from $300 to $600. Available options include a paper-tape reader, a teletypewriter interface, and a general-purpose interface. Delivery time is four weeks.

Technitrol Inc., 1952 E. Allegheny Ave., Philadelphia, Pa. 19134 [395]

Self-taught analyzer finds shorts and opens

Designed to be quick and easy to set up, the model TA-4 trace analyzer system detects shorted and open circuits in single- and multilayer printed-circuit boards, cable harnesses, and back planes. The system, which programs itself from a known-good board, comes in versions that can handle as many as 10,000 test points. It includes a pneumatic indexing fixture, control logic, memory, and measurement circuitry. A variety of configurations with prices ranging from $13,000 to $32,000 is available.

PWR Inc., 9334 Mason Ave., Chatsworth, Calif. 91311. Phone Andrew Gourley at (213) 886-5030 [394]

Hand-held wire stripper can't damage wire

Because its blades are made of Stilan plastic, which is harder than insulation but softer than copper, the Alpha plastic-blade stripper cannot nick, cut, or otherwise damage the wire being stripped. Unlike strippers with steel blades, which have holes into which the wire must be carefully positioned, the new stripper's plastic blades have no holes. The wire is positioned anywhere along the blade; then, when pressure is applied, the blades cut through the insulation and deform around the conductor.

Because of this operating principle, the stripper can handle more than one wire at a time. It can also strip twisted pairs, ribbon cable, twin-lead antenna wire, lamp cord, and telephone wires as easily as a single wire, all without separating the conductors.

The tool strips any size wire from AWG 12 through AWG 28 with just about any insulation in common use today—polyvinylchloride, rubber,

neoprene, cross-linked polyethylene, etc. Two important exceptions, insulations that the stripper cannot handle, are Teflon and Kynar, the company says.

The stripper, which is supplied with three sets of blades, sells for $39.95. The blades, which last up to 50,000 strips on simple hook-up wire, can be replaced without tools.

Alpha Wire Corp., 711 Lidgerwood Ave., Elizabeth, N. J. 07207. Phone (201) 925-8000 [396]

Components can be placed on either side of breadboard

A versatile Klip-Blok breadboard, mounted on an aluminum chassis, allows components to be mounted and interconnections to be made from both sides to increase wiring convenience and reduce clutter. Signal and power bus connections can be made on the bottom, if desired, leaving the top clear for wiring that may be altered. The model 51X is an unclad board that allows solderless interconnections to be made with 22-gauge wire. Dual in-line packages and most semiconductor devices simply plug into the board. The 51X sells for $25.50 while the 51X-GP is priced at $29.95.

Vector Electronic Co. Inc., 12460 Gladstone Ave., Sylmar, Calif. 91342. Phone (213) 365-9661 [397]

TOPICS

Production

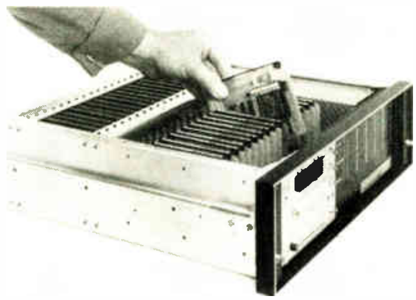
Technical Wire Products Inc., Cranford, N. J., is now offering its Celci connectors with silver-filled silicone conductive buttons as well as with nonmetallic-filled silicone. . . . **EECO, Santa Ana, Calif.,** has developed a line of fast-mount hardware that allows its thumbwheel switches to be mounted without tools, mounting holes, screws, nuts, bolts, or washers. . . . **Thomas & Betts, Elizabeth, N.J.,** has announced a hinged corner post that makes removal of a wiring harness from the fabrication board very easy. . . . **Minitool, San Jose, Calif.,** is selling a line of 32 gold-plated Micro-tools with tip sizes from 0.005 inch to 0.02 in. for use in any kind of delicate work done under a microscope.

Data handling

Single-chassis data gathering

Acquisition system with room for microprocessor aimed at control tasks

To process both multiple analog signals and digital inputs and outputs, users of industrial process-control systems have till now needed more than a single-chassis data-acquisition system. But Analogic Corp. has produced a single-chassis system, the AN5400, complete with provision for a microprocessor. The company has drawn on its expertise in analog-to-digital and digital-to-analog converters to come up with what it calls the most versatile data-acquisition system on the market.



Clark F. Crocker, manager of advanced instrumentation development engineering for data-conversion systems, says one of Analogic's chief goals was to design a system that would serve many different kinds of customers yet be a relatively standard product. "Some requirements for high speed are quite dramatic," he says, "calling for high accuracy as well. But there are also low-end needs, and we wanted to cover any signal level required in a system with a highly flexible control organization."

To that end, the AN5400 will accommodate signals ranging from 5 to 10 millivolts full scale at 100 to 200 samples per second on the low end all the way up to 10-v signals at 200,000 samples a second. Crocker stresses, however, that 200,000 samples per second is only a figure of merit and would have to be derated depending on the kind of computer linked to the AN5400.

The system is based on a master chassis that holds a variety of up to 16 Analogic data-acquisition modules, depending on the user's needs. A chassis will accommodate up to 512 channels of single-ended or 256 channels of differential multiplexing. The system can be expanded to eight chassis holding 4,096 single-ended channels.

The single chassis can also contain up to 64 simultaneous sample-and-holds and the same number of digital-to-analog converter outputs. Twelve different d-a converter modules provide resolution of 8 to 16 bits, moderate to very high speeds, moderate to very high stabilities, and bipolar and unipolar ranges, all with selectable output codes.

Some key numbers for analog output performance for a system with 12-bit resolution are a maximum settling time of 2.5 microseconds and relative accuracy full-scale of 0.015%. Comparable figures for a 16-bit system are 20 μs and 0.001%.

Provision for the Intel 8080 microprocessor allows the user to have a stand-alone data-acquisition system, with storage in the form of both programable read-only memory and random-access memory for data-logging applications, for instance. Alternatively, the microprocessor permits the AN5400 to be remotely located and operated through a communications link. Crocker points out that the user can have the microprocessor and minicomputer operating together, with the 8080 addressing 32,000 words of computer memory through direct memory access. In this manner, the minicomputer can be directed to store the data-acquisition system program.

Yet again, the program can be transferred from the minicomputer to the microprocessor, so that the 5400 then executes the program and the minicomputer is free to run

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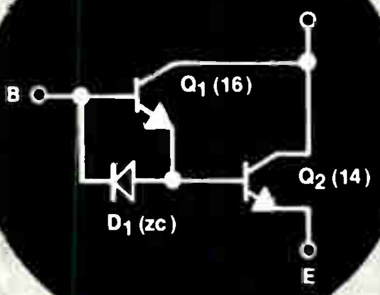

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Analogic Corp., Audubon Road, Wakefield, Mass. Phone (617) 246-3000 [361]

Software-design system handles both 8080 and 6800

Nearly every semiconductor manufacturer making a microprocessor also is offering its customers a software development system. But what about the engineer who is designing different systems using different manufacturers' processor chips? If the two of those chips happen to be Intel's 8080 and Motorola's 6800 eight-bit processors, he can now do the software development on just one instrument, according to Microkit, Inc., Santa Monica, Calif. Microkit's new model 8/16 handles both the Intel and the Motorola chips and, according to Microkit's Bruce Gladstone, future plans include the new 16-bit Texas Instruments 9900.

The Microkit 8/16 Mod 6800

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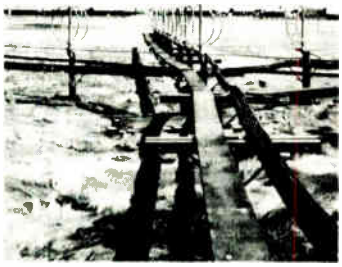

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consists of the computing system, a 960-character cathode-ray-tube display, a keyboard, and two tape-cassette units that transfer data at 2,000 bits per second. Options include a 65-line-per-minute printer, dual floppy disks, and a programable ROM programer.

The 6800 also can do in-circuit emulation, adds Gladstone, using a 40-pin plug that can be inserted in the microprocessor socket on the engineer's prototype board. For software-development purposes, the system has an editor, assembler, and monitor/debugger.

The user can set software breakpoints, which cause interrupts during program execution. His microcomputer can then be interrogated for register, flag, and memory contents. Cycle-stealing is used to read and modify the user memory without halting the real-time process of the system.

With the optional hardware breakpoint/trace module:

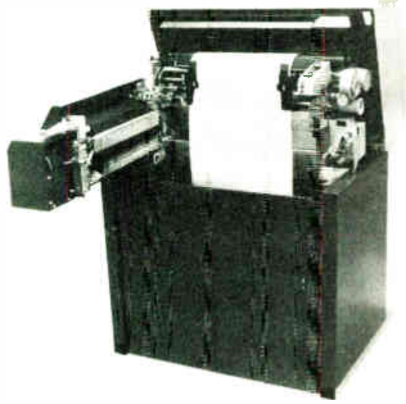
- The user can set breakpoints that cause his microcomputer to halt, trace the last 32 steps of operation, and display the values of the processor registers.
- The user can set address traps that provide a snapshot of the 15 steps prior to and the 16 steps subsequent to the trap address. The use of the trap does not interrupt or halt the processor, so that real time systems can be monitored while they run.

The price of the Microkit-8/16 MOD 6800 is $4,950 including peripherals and a 6800 in-circuit emulator. The price of the Microkit-8/16 MOD 8080 is $3,850 including peripherals; with an 8080 in-circuit emulator, it is $4,950. Delivery time is 45 days.

Microkit Inc., 2180 Colorado Ave., Santa Monica, Calif. 90404 [362]

900-line/minute printer has 200-ns microprocessor

A new 900-line-per-minute printer for minicomputer-based systems contains a fast, homegrown micro-



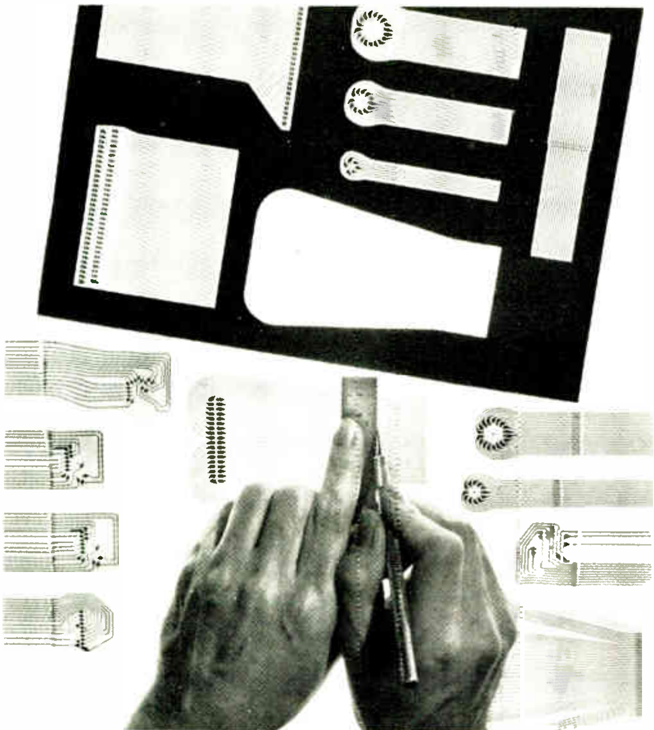
processor. The engineers at Dataproducts Corp. knew they had to use a microprocessor for the sake of its simplicity, cost savings, and ability to adapt to different end users' needs without hardware modification.

But no commercially available microprocessor had the 200-nanosecond speed that is necessary to scan lines, generate characters, and control the print head at that line rate. "To get the 200-nanosecond execution time, we had to build our own microprocessor, with off-the-shelf medium-scale integration," explains George Ismael, project engineer on the model 2290 printer.

The result was an 8-bit transistor-transistor-logic device that proved capable of achieving the desired speed. Also, the number of random-logic chips was reduced from 100 in earlier printers to 65, and the number of discrete components was cut in half, from 300 to 150. The 2290 is the first in the Dataproducts line to incorporate a microprocessor.

The 900-line-per-minute model uses a 64-character set. A 660-line-per-minute version has a 96-character set. Each line contains 136 characters, and the speed accommodates 960-baud communication rates. An optional 12-channel direct-access vertical-format unit eliminates the need for paper tape for defining forms, allowing software to control the handling of forms completely, without any aid from an operator.

The 2290, which is designed for lower-end data-processing applications, sells to original-equipment



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Dataproducts Corp., 6219 De Soto Ave., Woodland Hills, Calif., 91364. Phone (213) 887-8000 [363]

Microcomputer helps evaluate microprocessors

A self-contained microcomputer, believed to be one of the first to use RCA's Cosmac central processing unit (see p. 129), is available in assembled or kit form. Designated the UT 1800, it is suitable as a training device in the use of computers and for evaluating the application of microprocessors. Access to an external bus allows connection to a variety of peripheral devices, including an add-on memory. Keyboard programing is built in, and there is a digital display for address, memory contents, and input/output port. The 1800 offers front-panel control of interrupt, direct memory address, and I/O flag. Its 256-byte random-access memory is expandable to a 4,096-byte RAM or ROM on board.
Infinite Inc., P.O. 906, 151 Center St., Cape Canaveral, Fla. 32920 [364]

Diskette drive handles up to 6.4 million bits

Offered in standard or double density with up to 6.4 million bits, the model 76 diskette drive is designed for OEM applications, including data entry, remote terminals, data communications, word processing, and minicomputer systems. Features include a transfer rate of 250,000 bits per second and an access time of 6 milliseconds track to track. A door interlock is designed to eliminate operator error and prevent media damage and data corruption. No job restarts are required, the company says. Also featured is a self-centering lotus-petal clutch that eases the diskette into registration position. Price is $528.
Orbis Systems Inc., 14251 Franklin Ave., Tustin, Calif., 92680 [366]

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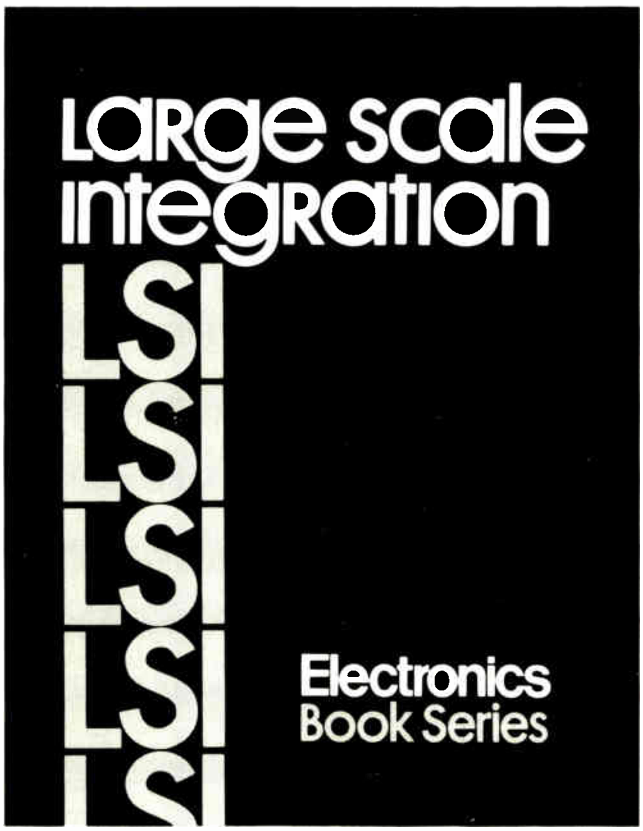

Large scale integration

Like the well-received "Microprocessors"—the first book offered in the Electronics Book Series, also edited by Laurence Altman—"Large Scale Integration" is a compendium of recent articles published in Electronics. Although in some ways it is a companion piece to "Microprocessors" because it explains the new circuits that play in mp systems, it is much more. "Large Scale Integration" deals with the entire range of design applications: main memory systems, peripheral memories, memory controllers, on-line industrial controllers, data acquisition boards, communication systems, calculators, watches, etc.

The content: six general areas

1. LSI technology: the latest MOS and bipolar techniques.
2. LSI devices and performance: memory, logic and interface.
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4. LSI circuit modeling: hands-on design techniques using computer-aided design.
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☐ C-MOS—the road to low-power LSI designs.
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Circuit Designers, Engineering Managers

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☐ Taking a look at the big 16-k RAM—its impact on memory design through the seventies.
☐ What good are the new C-MOS static RAMs.
☐ How to get the CCD advantage now for the next generation of mass storage systems.
☐ Merging software and hardware for the optimum balance.
☐ Analyzing the LSI digital domain—packing the most punch onto a pc board.
☐ The new breed of LSI in circuit testers—troubleshooting your LSI prototypes pays off in performance.
☐ CAD for LSI—takes the guesswork out of today's logic design.

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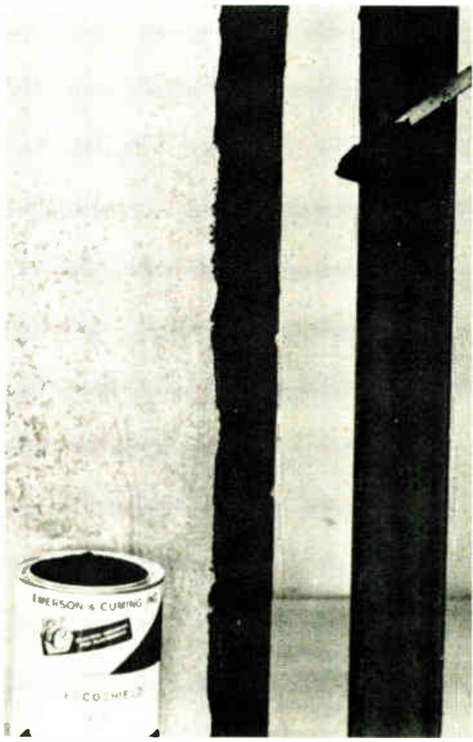


A conductive grease with a volume resistivity of less than 100 ohm-centimeters is effective as a lubricant for large metal-to-metal sliding contact areas which require continuous conductive paths. It is also useful as an rf caulking compound in metal-to-metal joints. Called Eccoshield CO, the material will not enter into electrolytic corrosion reactions and will protect the surfaces to which it is applied from corrosion. It sells for $4.70 per pound in lots of more than 5 lb. Delivery is from stock.

Emerson & Cuming Inc., Canton, Mass. 02021. Phone (617) 828-3300 [476]

An extremely tough plastic resin, which the Du Pont Co. believes is the most rugged engineering plastic ever developed, is the first of a complete line of super tough materials. Called Zytel ST-801 nylon resin, the new material combines the chemical resistance of other nylon resins with an impact strength greater than that of polycarbonate. It also outperforms die-cast aluminum and die-cast zinc in the tensile-impact and Charpy tests. The material is expected to compete with polycarbonate and metals in applications where transparency is not required.

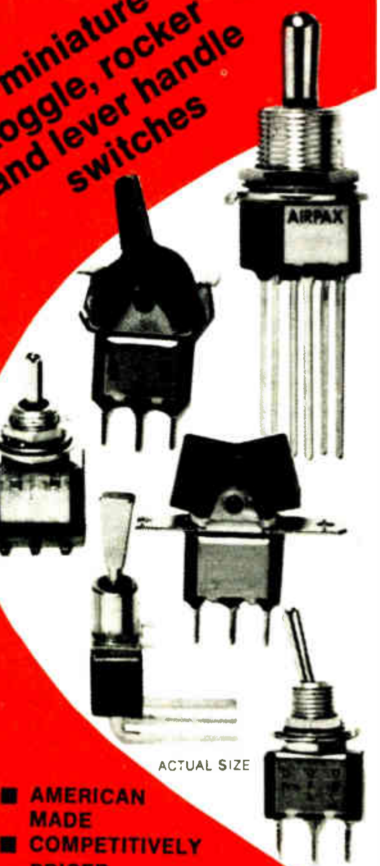
Zytel ST-801 has an introductory price of $1.45 per pound for quantities of at least 40,000 lb.
Du Pont Co., Room N-24911, Wilmington, Del. 19898 [477]

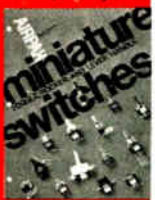
Silicone resin SR-262 is a heat-resistant material especially developed as a coating for resistors, capacitors, and other electronic components. The resin has excellent thermal-shock resistance, being able to withstand cycling between -40°C and 250°C with no degradation of its electrical and physical properties.
Silicone Products Dept., General Electric Co., Waterford, N. Y. 12188 [478]

Removing electroless nickel coatings from copper, brass, and copper alloys has been made safer by the introduction of Fidelex #227—a free-flowing alkaline powder that contains no cyanide. A solution of 2 pounds of #227 for each gallon of stripper will remove about 1 mil of electroless nickel per hour at 160°F. The stripper should be used with steel or stainless steel tanks, baskets, heaters, and racks. Samples of parts to be stripped may be submitted to the manufacturer's laboratory for test purposes at no charge.
Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark, N. J. 07114. Phone (201) 242-4110 [479]

An acrylic adhesive for flexible laminates is noteworthy for its high-temperature characteristics, high peel strength, and high resistivity. The 410 series adhesive, which is supplied in both roll and sheet form, is intended for use in flexible printed circuits, multilayer boards, and other electronic applications.
Fortin Laminating Corp., 1323 Truman St., San Fernando, Calif. 91340. Phone (213) 365-9651 [480]

Ultrafine magnet wire ranging from 0.010 to 0.063 millimeter in diameter (AWG 60 to 45) is available in both single-insulated and double-insulated forms. The wire is easy to wind into formerless coils.
Englehard Industries, Manufacturing/Customer Service, 2655 U.S. 22, Union, N.J. 07083 [379]





New literature

Suppressing transients. A 108-page publication entitled "Transient Voltage Suppression Manual" includes 80 pages of text on the causes, detection, and suppression of voltage transients. The rest of the book is essentially catalog data on GE-MOV varistors. Copies are available from GE distributors, or they may be ordered from GE Semiconductor, Electronics Park, Bldg. 7-49, Syracuse, N.Y. 13201. The price is $2.50 plus local tax.

Hybrid combiners. A four-page brochure describes how hybrid junctions operate as combiners for making high-power amplifiers. It discusses all important specifications of hybrid junctions and includes four curves that may help in predicting their efficiency and isolation under various conditions. Called "Predicting Performance in Hybrid Combined Amplifiers," Technical Note 601 may be obtained from Werlatone Inc., P.O. Box 258, Brewster, N.Y. 10509. Circle reader service number 422.

Undersea cables. Written under a contract awarded by the White House Office of Telecommunications Policy, "The World's Submarine Telephone Cable Systems" lists all commercial undersea telephone cable systems that contained at least one submerged electronic amplifier (repeater) and were in operation at the end of 1974. The 291-page publication also includes some historical background material, a glossary, a list of abbreviations, and a list of all sea cable systems known to be under construction, under international tender, or in the planning

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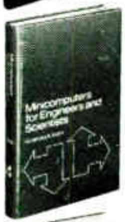

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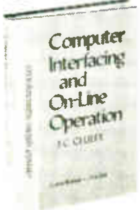

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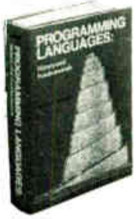

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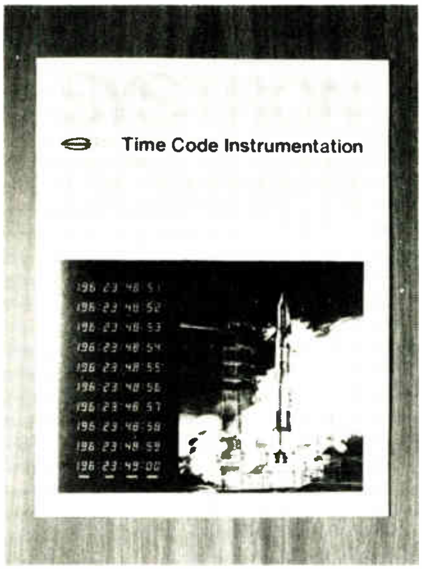
Relays. A 24-page short-form catalog describes 28 series of relays including general-purpose, reed, sensitive, power, hybrid, and solid-state types. In addition, the document lists Sigma's line of opto-isolators and photoelectric control components. A second brochure tells about the company's new low-cost series 226 solid-state relay and includes specifications and applications information. Both of these relay catalogs are available from Marketing Services Dept., Sigma Instruments Inc., 170 Pearl St., Braintree, Mass. 02184. [425]

Keeping time. A broad line of precision time-code and time-keeping instrumentation, such as time-code generators, readers, and digital clocks, is presented in a 22-page



catalog that has been released by Systron-Donner Corp., 935 Detroit Ave., Concord, Calif. 94518. The catalog includes applications information on serial time codes, slow codes, and other typical time codes used for time-indexing recorded data for playback at a later time. [426]

Semiconductor screening results. A computer-printed summary of test results on more than five million parts, the annual screening summary report on electronic components for 1975, is now available. For information on how to obtain a copy, write or call Continental Testing Laboratories Inc., 763 U.S. Highway 17-92, Fern Park, Fla. 32730. Phone (305) 831-2700 [427]

Switches. Rocker, rotary, rotary slide, toggle, lever, push-button, push-button slide, and multi push-button switches in a wide variety of configurations are described in a 36-page catalog offered by Shigoto Industries Ltd., 350 Fifth Ave., New York, N.Y. 10001. [428]

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