VOL. 21 NO.

Electronic Design 14

FOR ENGINEERS AND ENGINEERING MANAGERS

JULY 5, 1973

IC voltage regulators abound, and they're getting cheaper to use. But with positive, negative and now dual-tracking devices, picking the right one isn't easy. On top of that, automated testing and a lack of standardization in specifications usually result in misleading data sheets. Get the facts. See Focus on page 46.

Fluke problem solvers

A new AC calibration system with wide range, superb stability, high accuracy and complete programmability.

Here's the best ac calibration system you've ever seen. It's designed to give you state-of-the-art performance in the cal lab, in the factory or in automatic test systems.

The new system consists of the Model 5200A AC Calibrator and the Model 5205A Precision Power Amplifier.

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The 5205A can also be used as a stand-alone amplifier providing programmable gains of X10 and X100 for frequencies from dc to 120 kHz. Output amplitudes from 1 millivolt to 1700 volts peak are offered for a wide variety of waveforms including pulses, sawtooths and triangles. All functions are remotely programmable with standard TTL logic levels. Uniquely, the 5205A can be programmed by both the 5200A and another control source so that it can be time-shared in an automatic system to perform a multitude of functions.

Price of the Model 5200A AC Calibrator is $3,995. The Model 5205A sells for $2,495.

To arrange a demonstration or get more details just dial 800-426-0361 for the location of your nearest Fluke sales office. Call it free anywhere in the contiguous United States.

For details call your local Fluke sales engineer. In the continental U.S., dial our toll free number, 800-426-0361 for his name and address. Abroad and in Canada, call or write the office nearest you listed below. John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Washington 98133. Phone (206) 774-2211. TWX: 910-449-2850. In Europe, address Fluke Nederland (B.V.), P.O. Box 5053, Tilburg, Nederland. Phone 13-673973. Telex: 844-52237. In the U.K. address Fluke International Corp., Garnett Close, Watford, WD2 4TT. Phone, Watford, 33066. Telex: 934583. In Canada, address ACA, Ltd., 6427 Northam Drive, Mississauga, Ontario. Phone 416-678-1500. TWX: 610-492-2119

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INFORMATION RETRIEVAL NUMBER 3

VOL. 21 NO.

Electronic Design 14

FOR ENGINEERS AND ENGINEERING MANAGERS

JULY 5, 1973

NEWS

TECHNOLOGY

PRODUCTS

Departments

Cover: Photo by Lennie Zbiegien, courtesy of Motorola Semiconductor

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across the desk

LED application note offered to designers

I would like to add another LED application note to the bibliography of the April 12 article "Shedding Light on LED Luminance" (ED No. 8, p. 92). Tektronix has an application note available on luminous intensity and visible LED measurements. This note is concerned primarily with the practical aspects of visible LED measurements.

It also might be advisable to mention the author's affiliation with California Optoelectronic Industries, since this company was mentioned twice in the article.

Pete Keller
Marketing, Analytical Instruments
Tektronix, Inc.
Delivery Station 48-188
P.O. Box 500
Beaverton, Ore. 97005

Ed Note: The author, Joe Horwath, is a principal of California Optoelectronic Industries. ELECTRONIC DESIGN *was unaware of this affiliation when the article was published; otherwise it would have been mentioned.*

Amsa: Here's what it means

Your item concerning the American Satellite Corp. in "Capital Capsules" (Washington Report, ED No. 8, April 12, 1973, p. 60) is producing confusion. The American Satellite Corp. is not abbreviated "Amsat," because of conflict and confusion with Amsat, trademark of the Radio Amateur Satellite Corp.

The Radio Amateur Satellite Corp. is a nonprofit, Washington-based organization created four years ago to provide communications satellites for amateur radio operators throughout the world. Six satellites, called Oscar's (for Orbiting Satellites Carrying Amateur Radio), have been launched since 1961. The first four were put into orbit by the Air Force as piggyback payloads, and the most recent two were launched by NASA on a similar basis through arrangements made by our organization. Oscar 6 is now in regular use by thousands of radio operators in over 50 countries, including the Soviet Union and East European nations.

Dr. Perry I. Klein
President
Radio Amateur Satellite Corp.
P.O. Box 27
Washington, D. C. 20044

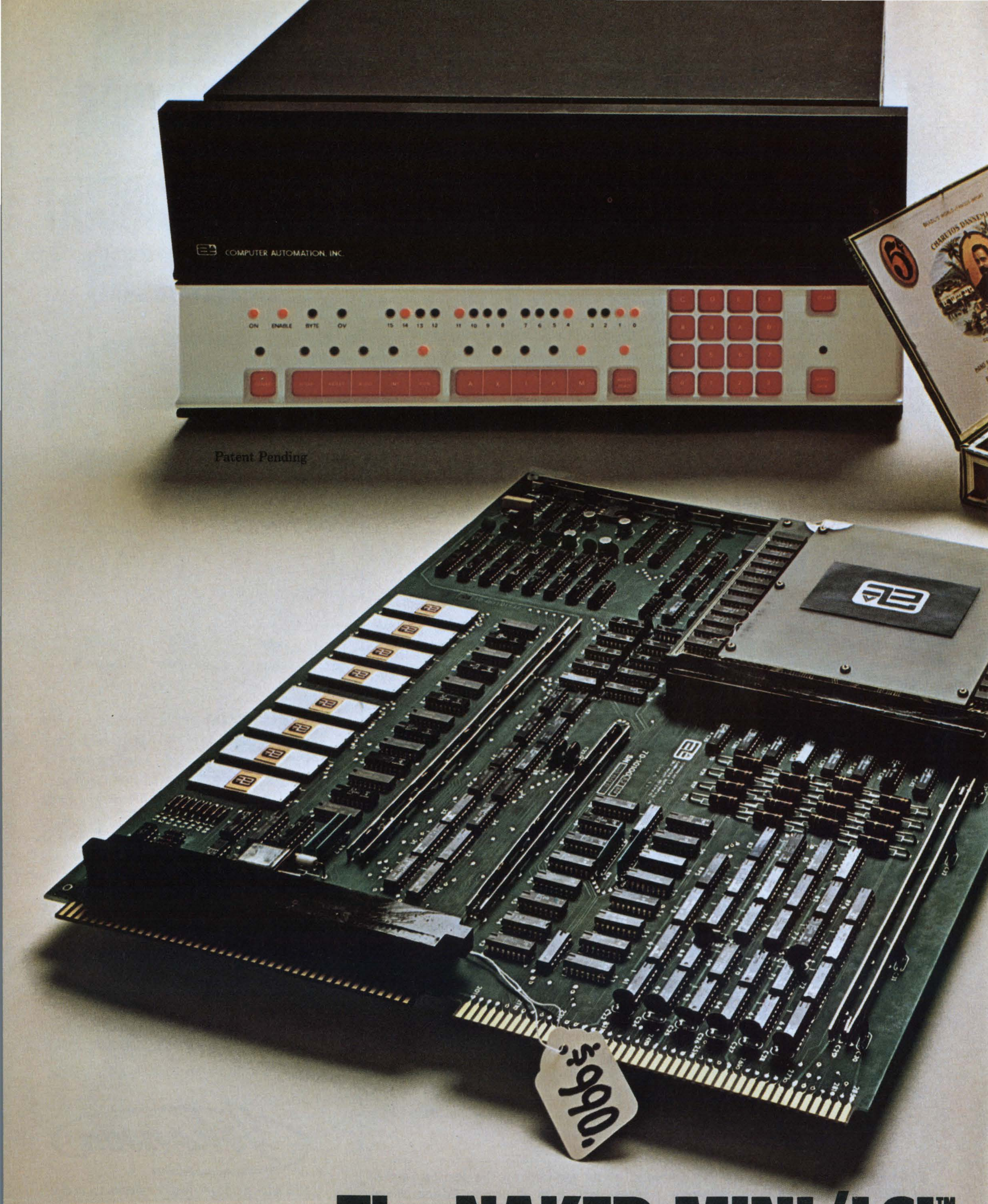
Correcting the score on sig-gen outputs

In "Focus on Signal Generators and Synthesizers" (ED No. 10, May 10, 1973, p. 62), I wish to suggest a correction to the statement that the HP-8660 synthesized signal generator offers "the highest frequency available in any synthesizer." Watkins-Johnson has three standard synthesizers with significantly higher frequency outputs. The multi-octave WJ-1154, WJ-1154-7 and WJ-1187 synthesizers provide frequencies of 1 to 12.4 GHz, 1 to 18 GHz and 0.5 to 18 GHz, respectively. W-J also offers a number of single-octave and narrow-band synthesizers within the frequency range of 500 MHz to 18 GHz.

Charles E. Foster 2d
Applications Engineer
Watkins-Johnson Co.
Systems Div.
3333 Hillview Ave.
Palo Alto, Calif. 94304

(continued on page 11)

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



The NAKED MINI/LSI™

What this country needs is a good $1,000 full-scale computer.

Introducing the computer for everybody. NAKED MINI/LSI.™

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It's also for people who have always been able to afford more, but have always gotten less computer than this.

NAKED MINI/LSI is the first OEM computer designed for widespread, multi-level use. The first computer able to do more jobs than any computer could ever do before.

Jobs that computers were too expensive to do. Jobs that were, consequently, always left to old-fashioned hardwired circuitry. Which meant that products weren't as flexible or immune to obsolescence as they could have been.

Or jobs that were done by more expensive computers. Which meant that products cost more and were less competitive than they should have been.

To make a computer capable of handling this kind of range, we had to give it an unheard of combination: extensive 16-bit computing power and a small price tag. Specifically, NAKED MINI/LSI is the first computer powered to satisfy 90% of all potential minicomputer applications — and yet be priced as low as $990 in OEM quantities of 200.

Imagine it. For a price less than most hardwired circuitry, your product can benefit from a computer having arithmetic capabilities, full byte and 16-bit word processing, and extremely flexible input/output. Without going into all the jazzy widget features, let's just say that the NAKED MINI/LSI gives your product all the intelligence it needs to monitor, sequence, and control effectively.

At this point, you may be wondering why a computer with all this clout was ever named the NAKED MINI/LSI. Actually, the name is very appropriate.

The NAKED MINI means that we designed it without all the over-design found on other minicomputers. All the extra, redundant features that make other minis too unwieldy and costly for OEM use have been purposely left off. (But everything you need has been deliberately built in.)

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from Computer Automation.

INFORMATION RETRIEVAL NUMBER 8

Within seconds after the match flame was applied to both the epoxy (left) and the silicone ICs (right), the epoxy burst into flame.

The hot issue in electronics today is flame retardancy. While epoxies and other plastics support combustion, silicone-packaged devices are virtually nonflammable. So, they don't need flame-retardant additives that alter the electrical and mechanical properties of epoxies and other materials.

And there are several other good reasons to specify silicone packaging compounds:

- excellent performance under thermal cycling
- low thermal expansion minimizes damage to components and lead wires
- basic electrical, physical, and chemical properties that remain constant over the widest temperature (—55 to 250 C), time, and frequency ranges
- uniform, lifetime electrical characteristics
- superior performance in 85 C/85% RH (biased) test
- total compatibility with *all* kinds of devices, including ICs, both digital and linear, MOS, CMOS, power transistors, SCRs, high-voltage rectifiers, etc.
- optimum reliability reduces manufacturing and repair/warranty costs
- safe, clean, inert, and require no special handling

Whether you are a device manufacturer or user, these advantages are important in semiconductor devices. Make the switch to nonburning silicone packaging compounds now. Write or call Jack Broser, Product Market Supervisor, Dow Corning Corporation, Department A-3312, Midland, Michigan 48640.

Silicones; simply the best way to protect electronic circuits

DOW CORNING

DOW CORNING

INFORMATION RETRIEVAL NUMBER 9

ACROSS THE DESK

(continued from page 7)

Outside testing backed for medical electronics

With reference to your timely article on medical electronic equipment in the March 1, 1973, issue, (ED No. 5, pp. 26-30), I would like to comment as follows:

A single group, such as the Emergency Care Research Institute, may not always be perfect and correct in its evaluation of equipment, but its findings are a lot better than none at all. If some companies keep on manufacturing unreliable and marginal equipment, we need someone to expose them. The user must be very careful of any company that objects to having its product evaluated and tested by someone else. Is such a company in a position to "know it all" and make perfect equipment? Most likely it doesn't want to expose its shortcomings.

Can the Government do a better evaluation job? I am very doubtful about this.

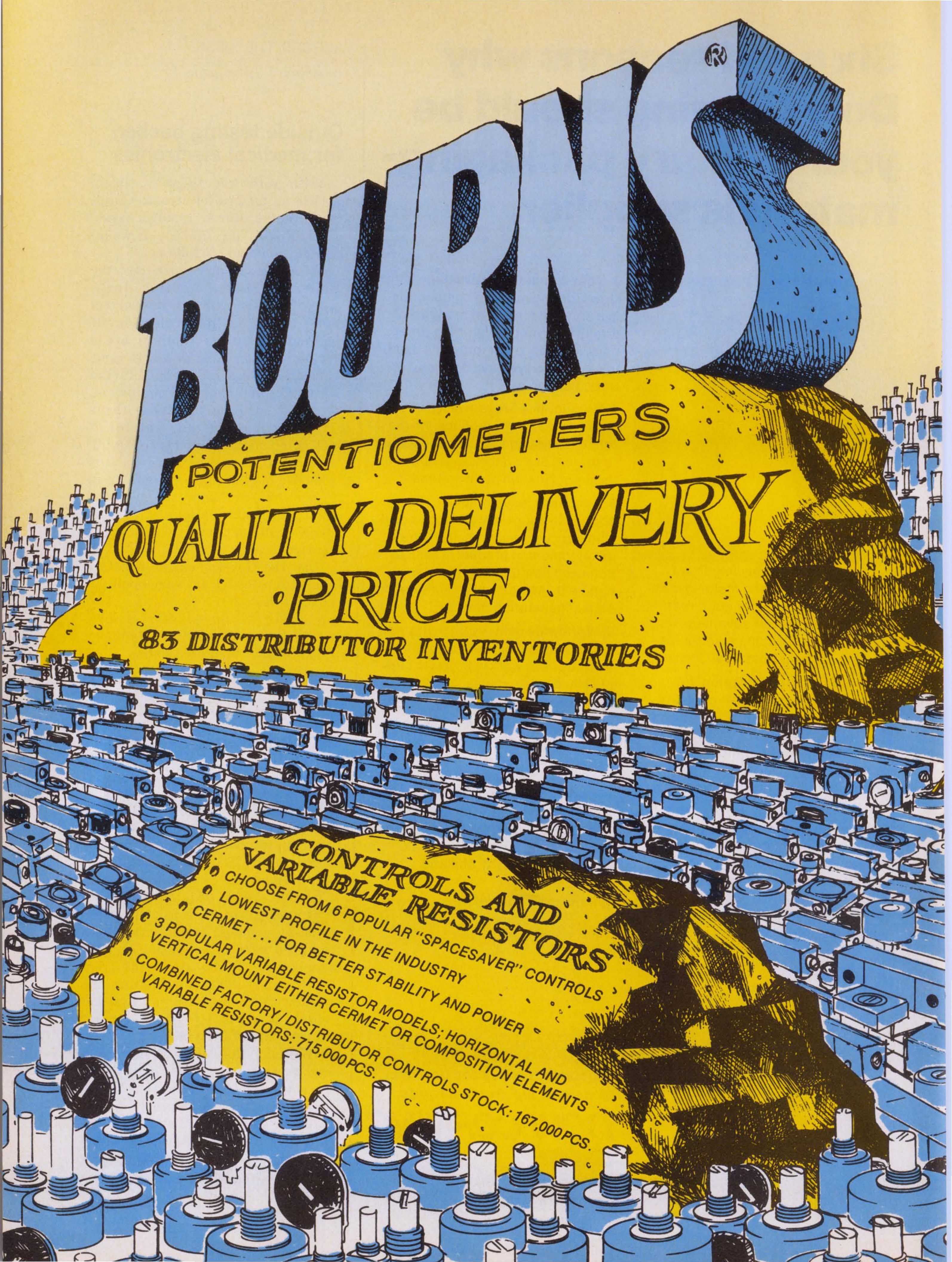
Mort Arditti
Senior Biomedical Engineer
Cedars-Sinai Medical Center
Los Angeles, Calif. 90029

Round or flat symbol: Which for op amps?

In the words of Chris Columbus, "It's round, not flat!" And so it should be said of the flat-fronted op-amp symbol that appears once more in the May 10 article "Protect Op Amps From Overloads" (ED No. 10, p. 96). Although the flattened form is consistent with current symbol "slang," the well-rounded version is consistent with symbol standards. Standards from IEEE and others distinguish the op-amp symbol with a rounded front, as opposed to the flat front of the inverter symbol.

Without this distinction, it becomes difficult to distinguish an op-amp symbol from that of a logic inverter (differential input variety, of course). Let's put more into our op-amp symbols by using the rounded front (7% more area

(continued on page 16)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Raytheon Semiconductor announces two super products that just made us No.1 in voltage regulators.

No gimmicks. Just proof.

Here they are. Adjustable and fixed dual-tracking voltage regulators that are so simple to design into your system you can forget about your slide rule and calculator. They require fewer external components so they take up less space. Compared to other voltage regulators, they provide more than twice as much current. Which means you can supply a lot more systems for a lot less money in the long run. And they are the first voltage regulators to provide thermal shutdown protection for both outputs at a junction temperature of +175°C.

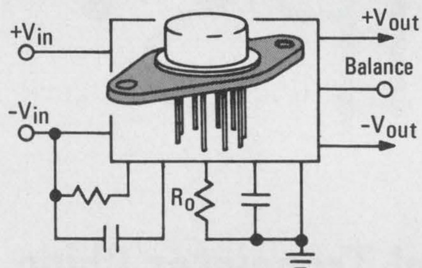
Adjustable 4194

With the 4194 you get both positive and negative outputs from 50mV to 42V — the widest range available today. All it takes is one external resistor (R_o) to ground for setting the desired output voltage. And to find out the value of R_o you just use this simple formula: $2.5 \times V_o = R_o\ (K\Omega)$.

Or if you want to program the outputs simultaneously, use one pot calibrated for 2500 ohms/volt.

Depending on the application, you'll only need from 4 to 6 external components — compared to 8 to 12 for other regulators.

The 4194 provides 200mA at both outputs simultaneously, with



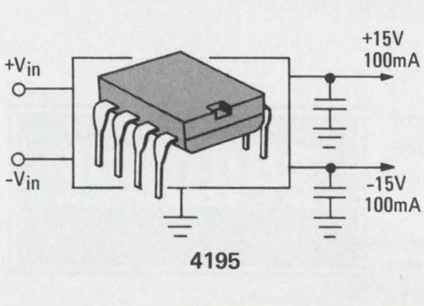
4194

0.2% load regulation over the entire voltage range. You need just one resistor to provide asymmetrical tracking voltages for the popular 710, 711, 702, 106 or the like. And with external pass transistors the 4194 can supply output currents to 10A.

Fixed 4195

Check these features against competition. The 4195 provides positive and negative 15V outputs at 100mA each. And it does it with only two bypass capacitors, compared to competition's six external components. That means you can power a lot more op amps for a lot less money.

The 4195 can be used as a single supply with an output of up to +50 volts. It comes in 3W and 900mW packages or — and this is another first — an 8-pin plastic mini-DIP!



4195

RAYTHEON

Raytheon Semiconductor
350 Ellis Street
Mountain View
California 94040
Phone (415) 968-9211.

Send me information right away on the voltage regulators checked below.

- ☐ LM104/204/304
- ☐ LM105/205/305
- ☐ LM109/209/309
- ☐ 723
- ☐ 4194
- ☐ 4195

NAME __________

TITLE __________

COMPANY __________

ADDRESS __________

CITY/STATE/ZIP __________ ED

ACROSS THE DESK

(continued from page 11)

and 4% more circumference)!

Another note on symbols in the article mentioned: The transistors of Fig. 4a are pointless, or arrowless, or of neuter "gender." While such neuter representations are socially nondiscriminative, distinctions of "gender" remain useful in schematics. The upper pair of transistors should be pnp's and the lower pair npn's. In each case the emitter terminal is that which connects to a resistor.

Jerald Graeme
Manager, Monolithic Engineering
Burr-Brown Research Corp.
Airport Industrial Park
Tucson, Ariz. 85706

Ed. Note: The flat-fronted symbol used by ELECTRONIC DESIGN *and other magazines is now almost universal throughout the industry. Among op-amp manufacturers, Burr-Brown is practically alone in clinging to the older, rounded-front symbol. Nevertheless Mr. Graeme makes a strong case for the rounded symbol. Which do readers prefer?*

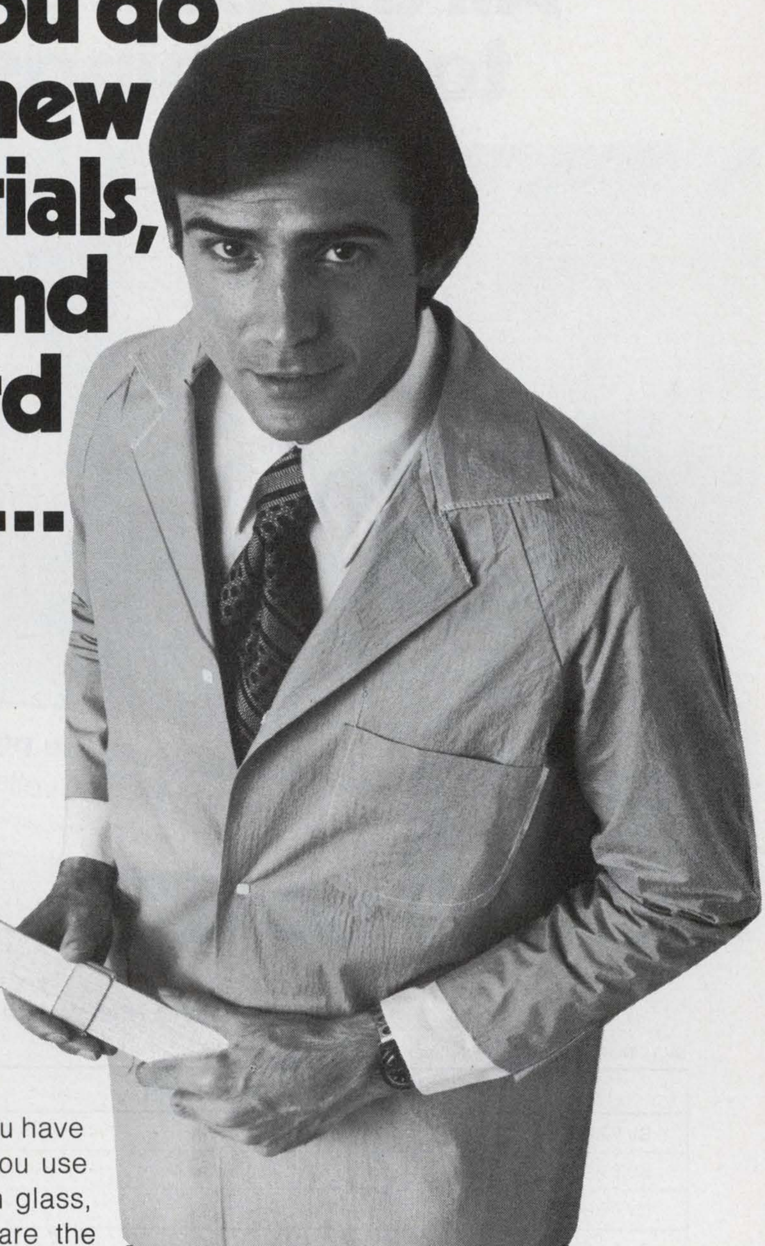
Caution on 'typical' seconded by user

This is a resounding second to the letter on "typical" specs by Michael I. Wier ("A Word of Caution on 'Typical' Designs," ED No. 10, May 10, 1973, p. 17). Considerable experience on the user side of the semiconductor manufacturer/user interface has taught many of us at HP that you do yourself a favor when you ignore what is adorned with the picturesque, but meaningless, adjective "typical."

This is especially true in the CMOS area, where marketing wordsmiths appear to have found it necessary to misrepresent rather more extensively than is customary the distinction between what's real and what's not real.

Lawrence W. Johnson
Manager, Materials Engineering
Hewlett-Packard
5301 Stevens Creek Blvd.
Santa Clara, Calif. 95050

Metal fastening is one thing, but what do you do about new materials, like plastics, and particleboard and...



It's a whole new bag of problems when you have to fasten different materials together. When you use plastic with wood, for example, or metal with glass, there are lots of things to consider. What are the physical properties of each? How will the fastener perform? What about cost?

Shakeproof has compiled a number of examples of how fasteners have been used to meet these new problems. They are contained in a folder called "BRINGING TOGETHER DISSIMILAR MATERIALS." It shows how Shakeproof can help solve your problems.

Send in the coupon today. Prepare to meet your next challenge successfully.

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INFORMATION RETRIEVAL NUMBER 15

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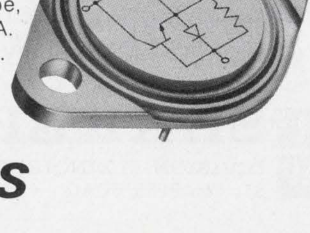
SVT 6060	300 Volts	20 Amps	2.0 Volts (I_c=20A, I_b=2A)
SVT 6061	350 Volts	20 Amps	2.0 Volts (I_c=20A, I_b=2A)
SVT 6062	400 Volts	20 Amps	2.0 Volts (I_c=20A, I_b=2A)
SVT 6000	300 Volts	10 Amps	1.4 Volts (I_c=10A, I_b=500$_m$A)
SVT 6001	350 Volts	10 Amps	1.4 Volts (I_c=10A, I_b=500$_m$A)
SVT 6002	400 Volts	10 Amps	1.4 Volts (I_c=10A, I_b=500$_m$A)
SVT 6251	350 Volts	5 Amps	1.4 Volts (I_c=5A, I_b=500$_m$A)
SVT 6252	400 Volts	5 Amps	1.4 Volts (I_c=5A, I_b=500$_m$A)

Available in quantity—now, from your local distributor. For additional information, call Pete Wood, collect, at (213) 679-4561; or write TRW Semiconductors, an Electronic Component Division of TRW Inc., 14520 Aviation Blvd., Lawndale, California 90260. In Europe, contact Mr. C. Thompson, TRW Composants, Electroniques, S.A. Rue René-Magne, Zone d'Entrepôts, 33 Bordeaux-Nord, France. Telephone (56) 297870. Telex: 842-57179.



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INFORMATION RETRIEVAL NUMBER 16

Navy to try fiber optics instead of wiring

The Navy has taken the first steps toward replacing conventional electrical wires for carrying data with fiber-optic cables.

The small glass, light-transmitting cables weigh less and need less space than electrical wires. They are free from electromagnetic interference, producing no cross talk. They are more neutrally buoyant than electrical wires—an advantage for underwater work—and silica cables are temperature-resistant up to 1200 C.

The first major rewiring will be in an A-7 attack aircraft. Eventually the Navy plans to install fiber optics in ships and underwater vehicles and installations.

A total of 302 wires in the A-7 will be replaced by 52 fiber-optic cables. The electric wires are 4832 feet long; the fiber-optic cables, 832. The electric wires weigh 82 pounds; the fiber-optic cable, 13. The electric wires cost $7900, while the cables will cost $2100.

IBM in Owego, N.Y., has successfully bench-tested a portion of an A-7 installation for the Naval Electronics Laboratory Center, San Diego, and expects to install it in the plane soon.

The break in fiber optics came when attenuation losses were cut from 1000 dB per kilometer to 20 dB, according to Don Albares, a research physicist and head of the Command Control Branch of the Navy center's Electro-Optics Technology Div.

Attenuation losses as low as 4 dB per kilometer have been reported, Albares says, but the Navy is testing systems with attenuation losses of 100 dB and lower.

A second experiment the Navy plans—to be carried out before September—is to replace a closed-circuit television cable on board a ship with a fiber-optic cable.

Also within the next three months, the Navy will install a six-terminal telephone system on a ship.

Other applications that Albares foresees are fiber-optic cables for telemetry systems to towed television cameras or hydrophones. And the Marine Corps plans to use them for carrying signals to and from computers in its tactical data links.

"With a 4-dB-per-kilometer system we could comfortably transmit for distances up to 25,000 feet without a repeater," Albares says.

The bandwidth of a multimode fiber bundle is 50 MHz over a distance of one kilometer with use of an incoherent light source, such as a LED. Under development at the Navy center, as well as at Bell Laboratories in New Jersey and at various universities, are single-mode, fiber-optic channels with much smaller cores—a few wavelengths in diameter. "These will provide a broader bandwidth—something in the neighborhood of 10 GHz over a distance of one kilometer," Albares says.

$13-billion spending by Pentagon forecast

The Pentagon will spend approximately $13-billion between now and fiscal 1978 for command, control and communications systems, according to a Frost & Sullivan market research study.

The peak in annual expenditures should occur next year, the report says, when an estimated $2.691-billion will be requested. This total is expected to drop to $1.17-billion by 1978.

The Air Force, which is the biggest spender for command, control and communication systems, will ask for $869-million for such equipment in 1973, according to the report, and $237-million of this will go for surveillance and warning systems. The Awac (airborne warning and control) aircraft system is expected to receive $310-million in 1974 and $771-million in 1976.

The second largest spender in the field, the Navy, has about 40% of its budget going into equipment for the S3A ship-based antisubmarine aircraft, the land-based P3C sub chaser and the electronic-warfare aircraft, the E2C, which is also used for command and control of air operations. All these systems use sensors, computers, displays and communications gear to serve as extensions of ship and shore-based systems.

Other key Navy programs include the ULMS/Trident submarine for launching ballistic missiles, work on a new submarine-launched ballistic missile and modifications on the Poseidon missile.

Much of the Army's funding in this category goes to the Safeguard antiballistic missile system, site defense of Minuteman, the SAM-D surface-to-air missile, the improved ground-to-air Hawk missile and STANO, a surveillance target-acquisition and night-operations system.

Seminar to consider electronic thievery

As the use of commercial computer systems rises in the country, a new type of crime is spreading with it: electronic theft. To bring manufacturers and users together to discuss problems and solutions, the IEEE has organized an Electronic Security Systems Seminar, to be held Sept. 25 and 26 at the Statler Hilton Hotel in New York City.

J. Howard Schumacher, organizer of the seminar, says there will be eight technical sessions and a small display area for about 30 exhibitors.

Of the eight sessions, one of the more popular is expected to be an all-day meeting on data-center security. Organized by Robert Wilk, security manager for Grumman Data Systems Corp., the session will consist of two panels, one composed of manufacturers, the other of users.

Members of the panels, which

will include representatives from such companies as Honeywell, IBM, Motorola, Radio Frequency Laboratories, Grumman Data Systems, Chase Manhattan Bank and Merrill Lynch, Pierce Fenner & Smith, will discuss the shortcomings of present security systems and offer suggestions for new devices to overcome the problems.

"We'd like to bring to the attention of manufacturers, areas where security people need help," Wilk explains. The biggest problem, he says, is data-center access control. One reason for this is that all current control systems are transferable. They all use some sort of device—such as a card, key or combination—that can be stolen or given to an unauthorized person to gain entrance.

A nontransferable means of identification is needed, Wilk notes, and researchers are looking into palm identification and voice identification, but neither has reached the point where it is accurate enough for use.

Accessing data from a remote terminal is also a big problem. Unless some sort of data scrambler is used, there isn't much a company can do to protect data being transmitted by phone, Wilk points out. And there isn't much hardware around that will stop unauthorized remote use of the computer. Here again, voice identification is being considered, as is closed-circuit television.

Alarm devices and systems will be discussed in a half-day session that will include presentations on the growing problem of false alarms, the proper place of closed circuit television in alarm systems, and a review of electronic innovations in central station alarm systems.

Other sessions at the seminar will focus on security requirements for the financial, industrial, retail and transportation industries, and auto theft and credit and banking-card fraud.

European data traffic headed for huge rise

The use of data communications in Europe is expected to increase tenfold by 1985, according to a joint study completed by Quantum Science Corp. of New York City and P.A. International Management Consultants, London.

The survey, which was commissioned by 17 West European national telecommunications authorities and which reportedly querried over 4000 European companies, forecast that there would be more than 1.4 million data terminals in Europe by 1985—about three times the number in the U.S. last year.

The study indicated that by 1985 data-comunication terminals would exceed the number of Telex stations in use.

Quadrasonic systems getting better pickups

A major problem with discrete quadrasonic recording and playback systems—the making of pickups that can respond to 20-to-50-kHz grooves—appears well on the way to solution. More than half a dozen manufacturers demonstrated improved pickups at the Consumer Electronics Show in Chicago.

When quadronics equipment was introduced about three years ago manufacturers faced a perplexing problem: whether to go to discrete four-channel systems or to use the matrix approach. In the discrete setup, four channels of recorded music feed four amplifiers and loudspeakers. In the matrix, portions of the sound are electronically mixed and fed to the four speakers in the proper magnitudes, with speaker signals at the proper phase angles.

There has been a universal agreement that discrete systems give the best quadrasonic performance, but so far only one company—JVC America, Inc., of Maspeth, N.Y.—has manufactured four-channel discrete recording systems. It is recording two additional channels on a 33-1/3-rpm stereo record.

JVC's playback system—called the CD-4—requires a bandwidth of 45 kHz, which poses technical problems in playback-cartridge development. The original JVC pickups are made by Shibata of Japan and use a difficult-to-manufacture stylus that has severely limited the supply but a number of firms in the past two years have started making these pickups using their own approach.

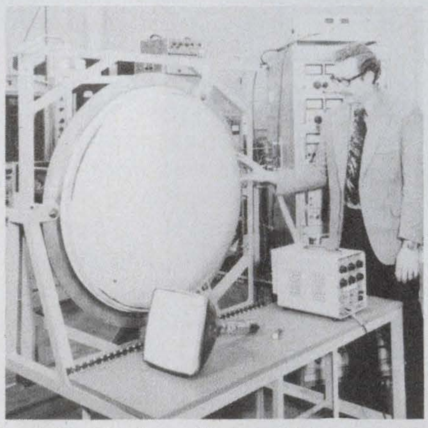
Manufacturers displaying improved CD-4 cartridges—magnetic, semiconductor and ceramic—at the consumer show included Stanton Magnetics, Shure Bros., Inc., Micro/Acoustics Corp., Pickering, Pioneer, Audio Technica, Empire, Panasonic, JVC and Glenburn/McDonald.

Micro/Acoustics displayed a semiconductor IC pickup that, it said, has superior characteristics over the magnetic type, including separation between the 20-to-45-kHz channels. The solid-state pickup requires no voltage supply; it operates on the "electret principle," according to Sandy Drellinger, vice president of the Elmsford, N.Y., company.

"Our QC-1 tranducer," Drellinger explains, "puts out a linear signal from 5 Hz to 50 kHz without the phase shift normally encountered with inductive pickups."

The high cost of the CD-4 reproducers—$75 to $150—has been another barrier to wide acceptance.

'Largest' TV tube developed by AF



What is described as "the world's largest TV tube"—a 226-pound, 36-inch CRT—has been developed by the Air Force Human Resources Laboratory at Wright-Patterson Air Force Base, Ohio. It will be used to train Air Force pilots in a new type of advanced simulator. Seven of these giant CRTs will be combined to provide a panoramic field of view.

The CRT is said to deliver more light output than any previously manufactured tube with an output exceeding 5000 lumens. By contrast, the typical 60-W bulb used in normal house lighting produces 870 lumens.

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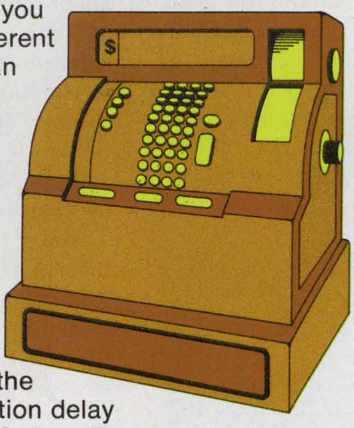
							Typical	Maximum
	NE521	±5	10	5.0	20.0	7.5	8	12
	NE522	±5	10	5.0	20.0	7.5	10	15
	NE526	±5	10	5.0	35.0	5.0	40	48
	NE527	±5 to ±12	10	0.75	2.0	6.0	16	26
	NE529	±5 to ±12	10	5.0	20.0	6.0	12	22
	μA710	+12, −6	1	5.0	25.0	5.0	40	—
	μA711	+12, −6	1	15.0	100.0	5.0	40	—
	LM311	+5, GND to ±15	5	0.05	0.250	7.5	200	—

Life sweetens a little. When you can get everything in comparators, from the fastest TTL to the finest precision with one call, you save a lot of migraine and a lot of bucks.

The chart also tells you something else. You can choose exactly the device you want for each of many different requirements. So you can optimize your systems, which gives you one kind of economy. And you can combine your comparator orders to get more economy. Known as smart-money thinking.



Say one of your interests is speed. You look at the four listed comparators that go from the NE527 with 16nS propagation delay down to the NE521, an 8nS dual. That's a spectrum you'd be looking in if you're building MOS memory sense amps, or maybe a Schottky line receiver.

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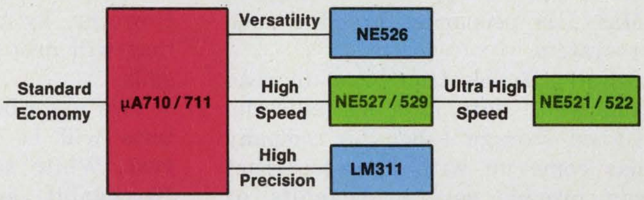

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Two offbeat technologies invade the burgeoning field of memories

Two unusual memory technologies are pushing hard to replace present technology in memory applications.

In the area of rotating memories, discs and drums are being challenged by a new electron-beam memory, while semiconductor ROMs and pROMs are being threatened by the CROM, a capacitive read-only memory.

Although they have been talked about for years, beam-addressable memories have, until now, not become commercially viable. Now the Micro-Bit Corp. of Lexington, Mass., is preparing to offer such a system.

Using an electron beam to read and write data in a specially designed storage tube, the company has come up with a system that can provide several megabits of storage—depending on configuration—with an access time of between 5 and 10 μs at a cost of 0.01 cent/bit.

Jules H. Gilder
Associate Editor

Early deliveries due

According to Robert White, one of the system's designers, the first system will be delivered in August or September to Control Data Corp. It will contain nine storage tubes, each capable of storing one million bits of data. Since it is the first system, White notes, it will be more expensive—0.1 cent/bit. However, by the end of the year that will drop to 0.01 cent/bit, he adds.

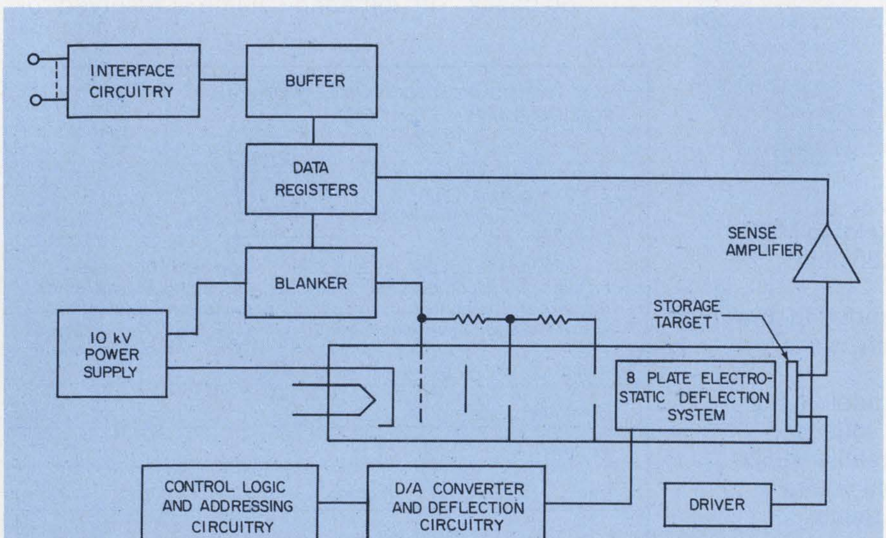
Two more beam-addressable systems will be delivered later this year, White says. The second, an 18-megabit system, will go to Honeywell and the third to Univac.

In describing how the new electron-beam memory works. White notes that, at the start, all the locations in the memory contain a logical ONE. Information is entered in blocks by scanning the memory target with an electron beam and selectively erasing the ONEs by blanking the beam on and off. To re-enter a ONE into memory, the target is brought to the proper potential and scanned by the electron beam.

The reading mechanism, White explains, is essentially the same as the write mechanism, except that the driving voltage on the target changes to a value that is almost nondestructive. The beam is then swept over the target and an output signal is generated.

In explaining "almost" nondestructive, White says that for about 10 or 20 accesses to a block of data, the memory can be considered nondestructive. However, if the same block of data is going to be accessed several hundred times, it is definitely destructive, and at some point the data must be restored, he adds.

Since the data rate for reading information out of a storage tube is 0.5 μs and the restore time is the same, the effective data rate of a tube with the restore mechanism is 1 μs or 1 MHz.



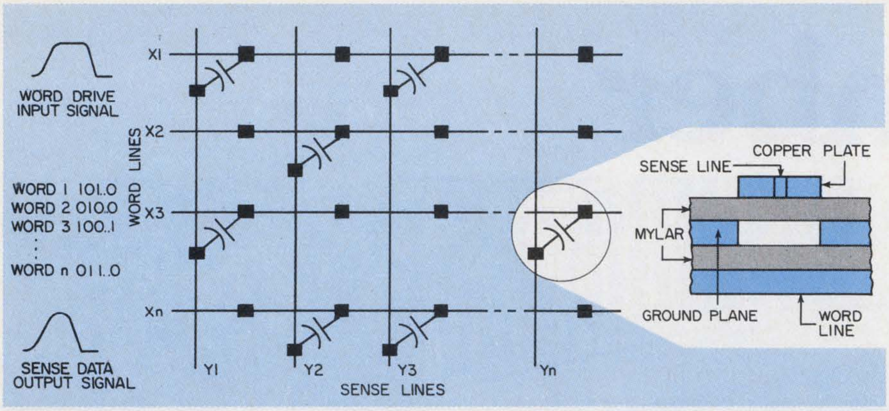
Micro-Bit's new electron-beam memory stores one million bits of data on the tube's target. An eight-plate deflection system is used to control the astigmatism and the ellipticity of the spot produced by the electron beam.

Customer option available

The restore circuitry is a customer option, White notes. If the usual operation doesn't call for repetitive accesses to a given block, the customer can eliminate it and double the memory's speed.

The write mode of operation is slower, White continues. Data can be written in at 10 μs/bit. "That's really a conservative figure, though," he says. "We can easily write at 8 μs but would like to do it at 5 μs. That's not easy."

The memory, reports White, is



Information is entered into the CROM by placing a capacitor where a ONE is required. A cross-section of the memory (right) illustrates its simple construction. The sense line is perpendicular to the word line.

block-oriented, but within each block it is random access. Work is under way, he notes, to make the entire memory random access.

Another development that he predicts is a 144-million-bit system for a large computer like Control Data manufactures. This could come as soon as the end of next year, he says, adding that the problem is primarily packaging, not technology.

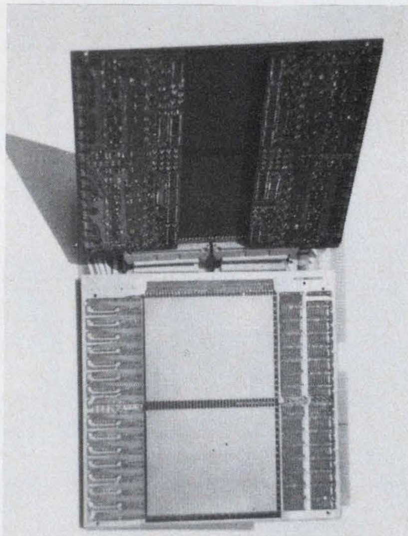
CROMs moving ahead

Meanwhile capacitive-memory technology, developed two years ago by Integrated Memories of Wilmington, Mass., is scoring points against semiconductors and even core.

The latest system from Integrated Memories, according to John H. Kefalas, president, is a 40-kilobit unit designed to replace core in point-of-sale applications. Since it is replacing core, speed is not as important as low power operation.

To achieve low power and increased versatility, Kefalas notes, the designers borrowed from core technology. The new system is a stackable memory, with the memory and the electronics separate, much the same as in core stacks.

He says a CROM is constructed from a copper-coated Mylar sheet that is etched and then laminated onto a printed-circuit board. The pattern on the coated Mylar consists of sense lines and small rectangular plates. The plates are present at a memory location and connected to the sense line only if there is a ONE at that particular



A new 40-kilobit CROM stack borrows from core technology. The memory boards plug into the mother board (not shown), which contains interface and power-supply circuitry.

site. In addition wherever there is a plate, the manufacturer has punched a hole in a ground plane that is also part of the laminate. In this way a signal can be coupled to a word line that is etched onto the PC board directly under the plate.

Absence of both this copper plate and a hole in the ground plane indicates the presence of a ZERO at that location.

According to Kefalas, CROMs are cheaper than their semiconductor counterparts. The cost is about 0.5 cent/bit, while pROMs cost about 1 cent/bit.

Reprogramming for the CROM costs about 0.1 cent/bit, while most semiconductor devices are not reprogrammable.

Those that are, Kefalas notes, are expensive.

The new stackable CROM, Kefalas reports, eliminates the driving and decoding ICs used in previous CROM systems; instead a resistor-diode matrix is used, similar to the diode matrix used with core. While this slows the system, it does reduce power dissipation. "Where the decoders require power all the time, the resistor diode pair draw power only when energized," Kefalas says.

Cores are not the only competitors for CROMs. In fact, Kefalas says, CROMs will have their biggest impact in applications now handled by pROMs and ROMs.

"CROMs are less expensive, faster and reprogrammable," he points out. "The reason we can compete with pROMs is that the minute a pROM user must change even one bit in the memory, he has to throw it away. That's at least $15 each time."

A problem with size

Kefalas admits that there are some problems with CROMs, the biggest being size. The CROM is inherently larger than a semiconductor, and the memory boards must be the same size as the pROM boards they will replace.

Kefalas points out, however, that while some memories can be constructed on smaller boards with ICs, they may not be fast enough. In that case, he continues, the pROM memory designer must go to smaller devices and the size advantage of semiconductors is lost.

He explains this by noting that the more bits put on an IC, the slower it becomes. With the CROM, the delay in the memory itself is only 3 ns. The decoding electronics bring it up to about 60 ns. The trend, Kefalas notes, is toward more bits and faster memories.

Michael Graff, memory products marketing manager for Harris Semiconductor, Melbourne, Fla., disagrees. He says that CROM technology is bucking the trend, which is toward smaller, denser monolithic devices.

Graff does admit, however, that pROM speed may be a problem in some cases. That should change soon, he says, with the availability of 40-ns, 1-k pROMs. ■■

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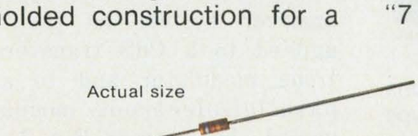
Actual size



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A major advance in OICs hastens the day of optic communications

Before a fiber-optic communications system can become reality, optical integrated circuits must be developed to provide the interfaces between the system's various transmission links. A major advance toward achieving this is reported by scientists at the Naval Electronics Research Center in San Diego.

D. B. Hall, a physicist at the center, says that optical integrated circuits fabricated there are able to guide laser energy in passive waveguide structures as well as modulate the energy in electro-optically active waveguides. Unique elements that the center has been working on—three dimensional channel waveguides made with diffusion techniques—have shown losses of less than 3 dB/cm.

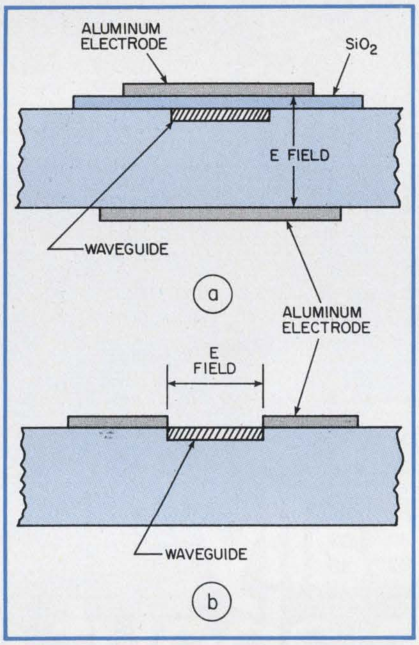
Optical integrated circuits—called OICs by researchers—perform the tasks of repeaters, amplifiers, modulators and switching devices to process the optical signals and to switch them between operational optical communication channels.

Work at the naval center has focused not only on the diffused OIC waveguides but also on planar epitaxial structures.

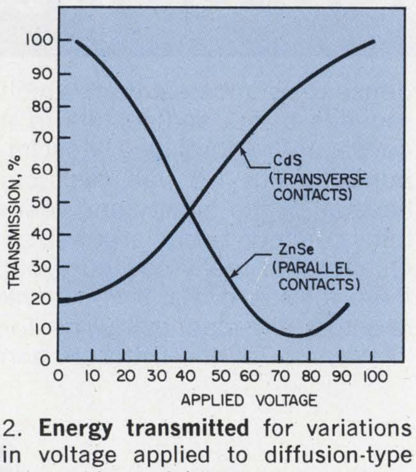
The diffused elements are mixed, single-crystal layers formed by the diffusion of cadmium or selenium into single crystal substrates of zinc selenide (ZnSe), cadmium sulfide (CdS) and zinc sulfide (ZnS).

The planar structures are heteroepitaxial layers of ZnS and ZnSe deposited on gallium-arsenide (GaAs) substrates.

"To my knowledge, we are the only one fabricating waveguides on a regular basis that have controlled lateral dimensions," says William E. Martin, another physicist at the center who is engaged in OIC work. "These devices also turn out to be efficient electro-optical modulators with lengths on the order of 0.5 cm."



1. **Arrangement of modulator electrodes** for (a) transverse and (b) parallel electric (E) fields.



2. **Energy transmitted** for variations in voltage applied to diffusion-type waveguide modulators.

A significant feature of the diffused waveguide modulators is that they can be fabricated by standard photoresist technology.

The diffused modulators are much faster than the epitaxial Zn and ZnSe on GaAs, Martin points out. "In the epitaxial," he says, "we're talking about rise times around 100 ns, depending upon how big the area is."

In the diffused modulator, which have parallel electrodes—aluminum strips running along both sides of the waveguide (Fig. 1b)—the rise time is less than 5 ns.

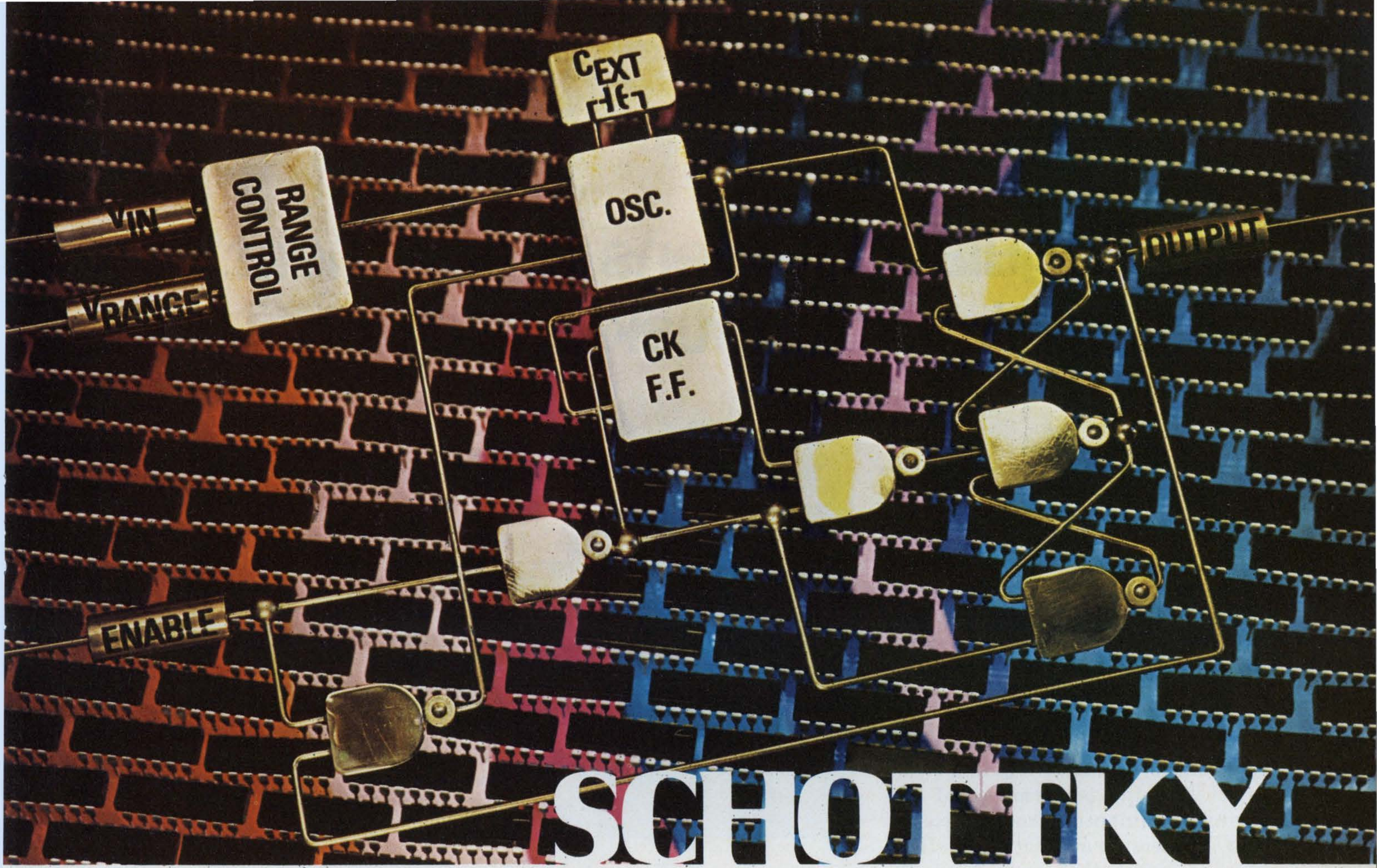
This fast modulation capability is necessary for the ultimate development of OICs, Martin says, adding: "There's no intrinsic reason why subnanosecond response is not possible."

The diffused-waveguide dimensions, Martin says, are typically 1.6 by 2 by 19 μm. Electrodes are placed so that the electric field is at right angles to the thickness of the waveguide (Fig. 1a) or is at right angles to the width (Fig. 1b). With this construction, Martin points out, the electric field across the waveguide can be very large for reasonably low voltages because of the small dimensions of the waveguide.

The waveguide with the E-field at right angles to its thickness requires low substrate resistivity to form a ground plane. To get the highest modulating frequency, Martin says, electrodes are deposited on each side of the waveguide, thereby substantially reducing capacitance.

The percentage of laser energy transmitted through a polarized/analyzer system—as the voltage applied to a CdS transverse-electrode modulator and to a ZnSe parallel-electrode modulator is varied—is shown in Fig. 2. ■■

Jim McDermott
Eastern Editor



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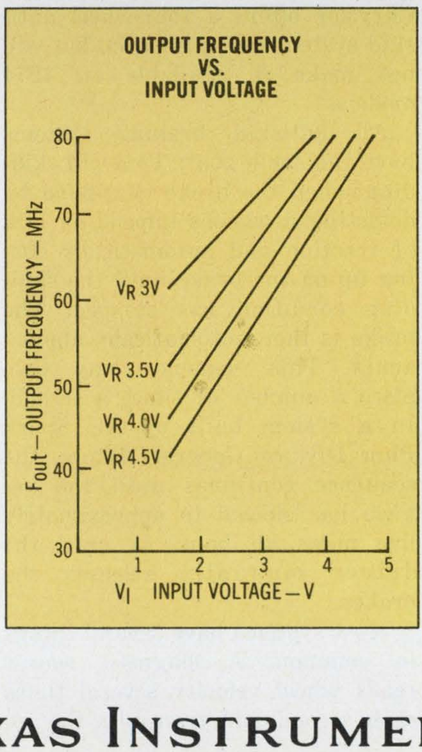
Center frequency is determined by an external component—either a crystal for a fixed frequency, or a capacitor for variable frequency operation. There are 2 voltage-sensitive inputs. One varies output frequency from the capacitor-set center. The other determines frequency range.

Set it to operate at any frequency between 0.12 Hz and 85 MHz. Use a capacitor and your control frequency range will be ± 1% to ± 100%. A single 5-volt supply operates it.



Operating at a center frequency of 1 Hz, the change in output frequency from −55° to 125°C is a stable ∓ 0.5% with V_r at 5 volts and V_i at 3 volts.

S124 is available in a plastic or ceramic 16-pin dual-in-line-package, or ceramic flat pack.

The 74S124N is priced at $2.61 in 100 piece quantities.

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INFORMATION RETRIEVAL NUMBER 20

U.S. regulation opens a new field: electronics for antiskid braking

A battle is stirring among a dozen or so manufacturers to snare as much as possible of the estimated $100-million market for electronic antiskid braking systems for trucks. And that's probably only the beginning. An even bigger market in such systems for cars does not appear far off.

The truck market has suddenly emerged, full blown, because of a new regulation of the U.S. Dept. of Transportation. It requires such strict stopping performance of all air-brake-equipped trucks, buses and trailers manufactured after Sept. 1, 1974, that some kind of antiskid braking system will be needed.

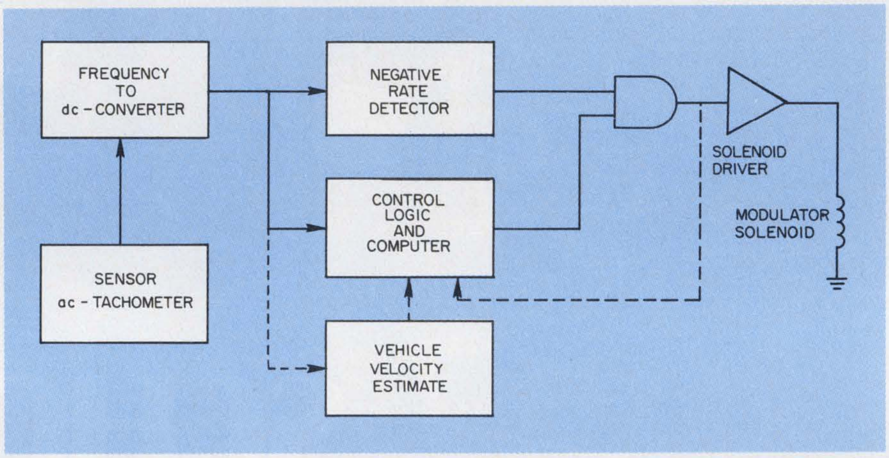
Besides a complex table of required stopping distances, based on combinations of vehicle weight, speed and road conditions, the regulation stipulates that the vehicle must stop within a 12-foot-wide lane and not jackknife across adjoining lanes.

Cars may be next

By Sept. 1, 1975, vehicles equipped with hydraulic brakes—which, of course, include passenger cars—must also meet certain stopping specifications. While the 12-foot-lane requirement holds for hydraulically braked cars, the stopping distances are not as severe, "and whether or not manufacturers go to automatic systems is up to them," a spokesman for the Dept. of Transportation says.

"Eventually, however," he adds, "we will get stronger regulations—similar to those for air-braked vehicles—and automatic systems will then be the only solution."

John F. Mason
Associate Editor



Kelsey-Hayes system senses average rear wheel speed. The speed is checked by computer for sudden deceleration, which means a skidding condition.

General Motors and Ford are already offering antiskid systems in cars on a limited basis. Ford, for example, provides them as an option with its Lincoln, Thunderbird and Continental Mark IV models. Chrysler offers a four-wheel antiskid system on its Imperial but will not make it available on 1974 models.

All antiskid braking systems have the same goal: To avoid skidding when the brake is applied by detecting a wheel's impending lack of traction and automatically easing up on the brake until the skidding condition has stopped. The brake is then automatically applied again. This sequence may take place a number of times a second. In a system built by AC Spark Plug Div. of General Motors, the sequence continues until the vehicle has slowed to approximately five miles an hour, or until the driver manually releases the brakes.

Most systems have several things in common. A magnetic sensor reads wheel velocity several times each second and transmits the information by electrical pulses to a logic unit. When sudden deceleration is noted, the unit concludes that skidding has begun and automatically activates a variable valve that releases some of the air pressure going to the brakes. The wheel unlocks momentarily—long enough to start spinning freely.

The main difference in competing systems is in the logic unit: Is it analog or digital?

Eaton Corp.'s Brake Div., Southfield, Mich., uses an analog computer laid out compactly on two circuit boards. The computer is supplied by Sylvania and Magnavox.

Rockwell-Standard Div. of Rockwell International, Detroit, uses a microcellular chip that works digitally. Although this is expensive—40% of the total system's cost—Rockwell feels its compatibility and reliability will pay off in the long run.

RCA is working both approaches. The company's Solid State Div. in Somerville, N.J., is designing the electronics control portion of

INFORMATION RETRIEVAL NUMBER 21

two systems, one using a digital computer and another analog—both for the same undisclosed customer.

"The digital approach has several advantages," according to Ralph Hartz, manager of packaged circuit functions in the RCA division. "Digital systems can perform more functions than analog systems can; they have better resolution; they can operate over wide ranges of voltages and draw very little power; and they have excellent noise immunity because they're built with CMOS digital ICs.

"I'm convinced that the heart of future systems will be digital, to which analog data will be converted and transmitted."

The president of Rockwell-Standard Div., William P. Panny, agrees: "Everyone will have to go to digital in the future. It's just that much better."

Panny adds: "If an analog system were capable of performing everything our digital system can, it would be the size of a breadbox, while ours is the size of a couple of packs of cigarettes."

Rockwell claims other advantages for its system: Its digital computer is 30% more reliable than analog systems, and it has four times the computational capability of bigger analog computers. An analog system has a 30% variation in response time when subjected to extreme cold, while the digital antiskid has only a 5% change. And the digital system is not affected by random radio signals or even a brake squeal, which frequently gives false brake-release information to an analog system.

Panny anticipates a failure rate of approximately 3% with a digital system, as opposed to 5 to 7% for an analog.

Front-wheel braking, too

Either antiskid system will eliminate one current hazard. Many trucks now operate without front brakes, because their drivers know that a front-wheel lockup could be fatal. When antiskid systems are installed, front brakes will be used again.

The AC Spark Plug Air Brake Wheel Lock Control system consists of two-speed sensors, a modulator assembly mounted on the vehicle frame between the wheels, an electrical harness, pneumatic plumbing and a warning light mounted in view of the driver.

The speed sensor at each wheel consists of two parts: A toothed rotor revolves at wheel speed. A magnetic pickup device reacts to the speed of the rotor and produces an ac voltage that carries information to the electronic controller.

Another difference in antiskid systems is in the number of wheels the system controls. A system built by Kelsey-Hayes Corp., Romulus, Mich., now installed on some 120,000 Ford vehicles, uses one controller for a rear-wheel-only system. The unit operates by sensing the average rear wheel speed. Chrysler, on the other hand, is using a four-wheel system built by Bendix-Westinghouse Air Brake Div., Elyria, Ohio.

Kelsey-Hayes says that its system costs the consumer about $180 to $200, "while a four-wheel system would be roughly double that amount."

A more sophisticated approach to an antiskid system is under study by several companies. It would trade in the magnetic wheel-revolution counter for a doppler radar to provide accurate "ground speed" continuously, even after a vehicle began to skid. The radar was developed by RCA's Microwave Technology Center in Princeton, N.J.

Other companies working on antiskid systems for the September, 1974, deadline include B. F. Goodrich, Troy, Mich., and Wagner Electric Corp.'s Automotive Products Div., Newark, N.J. And in Europe, Fiat, Daimler-Benz and Robert Bosch are in the race. ■■

Low-noise paramp reaches 65 GHz

A nondegenerate (single-sideband) millimeter-wave parametric amplifier that incorporates a solid-state pump source has been developed and tested for operation in the 55-to-65-GHz band. The highest frequency heretofore for a nondegenerate paramp is reported to have been in the 20-to-25-GHz region.

The new device is expected to find use in high data-rate communications systems. Also, since the oxygen in the upper atmosphere has a high absorption rate at this frequency range, applications are seen in interference-free high-altitude communications systems—aircraft to aircraft or satellite to aircraft, for example.

David N. Kaye
Senior Western Editor

The paramp was described at the IEEE International Microwave Symposium in Boulder, Colo., in a paper by J. Whelehan, E. Kraemer, H. Paczkowski, F. Bourne, J. Taub, E. Wendt and A. Larsen of the AIL Div. of Cutler-Hammer, Melville, N.Y.

The single-stage double-tuned device has a midband gain of 14 dB and a 1-dB bandwidth of 670 MHz. The measured average single-sideband noise figure is 5.9 dB across the operating passband.

Jesse Taub, a consultant in the Applied Electronics Div. of AIL says that the key to the development of the paramp was a new AIL-produced varactor with a 0-V bias cut-off frequency of over 600 GHz, as measured at 70 GHz. An unpackaged gallium-arsenide varactor chip is mounted on a stud holder. The series inductance of the varactor is about 0.1 nH. The capacitance of the varactor is about 0.02 pF. It has a natural resonance of from 50 to 60 GHz.

The pump power for the paramp was produced by a fundamental 35-GHz, Gunn-effect oscillator that feeds a varactor tripler to provide 30 mW of power at 105 GHz. Taub notes that the same type of varactor that is in the paramp has been used in the multiplier. The measured efficiency of the tripler is greater than 20%. An avalanche oscillator was also tried as a pump

source, Taub points out, but the AM noise out of the oscillator limited the paramp's noise figure.

Signal above idler frequency

Taub describes the mount as single-ended (one varactor) with and idler resonance below the signal frequency. In this paramp the idler frequency is the difference between the pump and the signal frequencies.

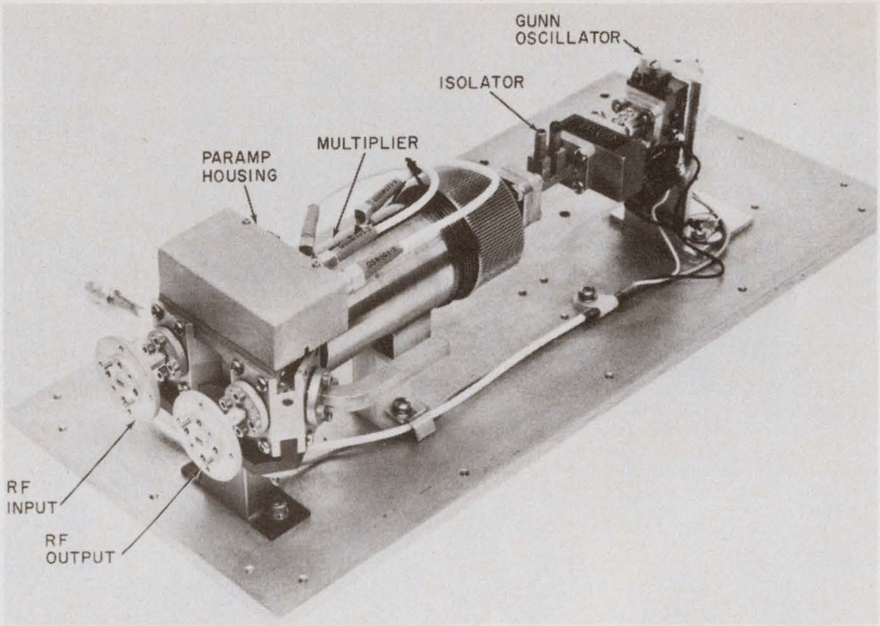
The varactor was mounted in the center of a reduced-height waveguide in which the series resonance of the varactor was used for the signal circuit in the 55-to-65-GHz range. A homogeneous quarter-wave transformer converted the nominal waveguide characteristic impedance to that required for proper operation of the paramp. The reduced-height waveguide was cut off at the idler frequency, and the equivalent inductance of the waveguide, presented in series with the varactor, formed the idler resonant circuit.

Pump power was coupled through a waveguide that allowed the pump frequency to propagate, but the waveguide was cut off at both the signal and the idler frequencies. A resonant iris at the input to the reduced-height varactor mount prevented propagation of the pump power in the signal circuit.

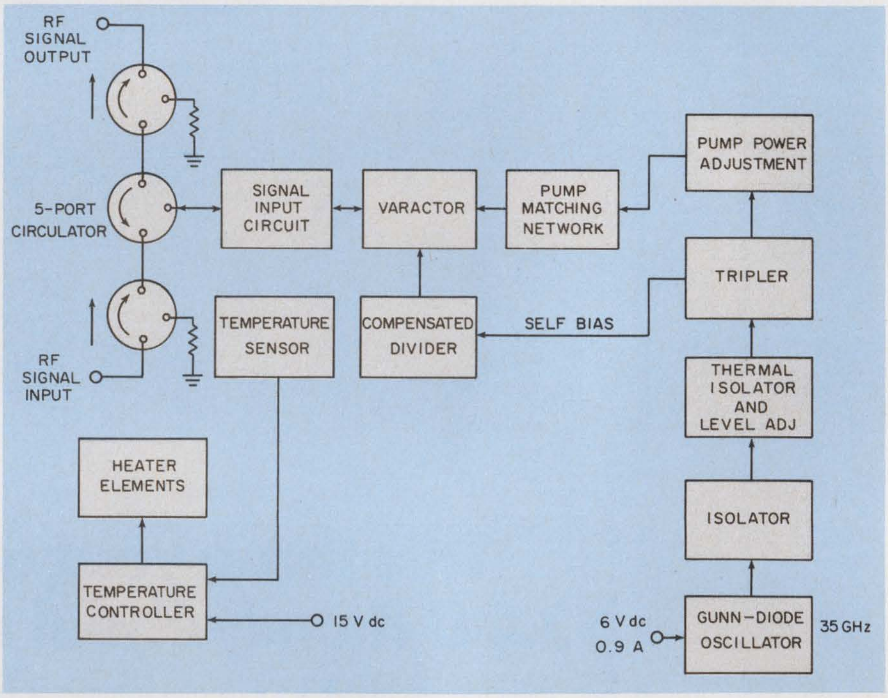
The paramp was then double-tuned by an iris-coupled filter whose susceptance slope was chosen to obtain a maximally flat, double-tuned response. A five-port circulator was used on the signal input to separate the incoming signal from the outgoing amplified signal.

Temperature stabilization was built into the paramp system, which was operated from −5 to +40 C with a measured gain variation of less than ±1 dB.

Taub notes that with higher pump frequencies—at least 200 GHz—he expects an additional 1.5-dB reduction in paramp noise figure.



Millimeter-wave paramp from the AIL Div. of Cutler-Hammer has a gain of about 14 dB with a 1-dB bandwidth of over 600 MHz and an average noise figure of 5.9 dB.



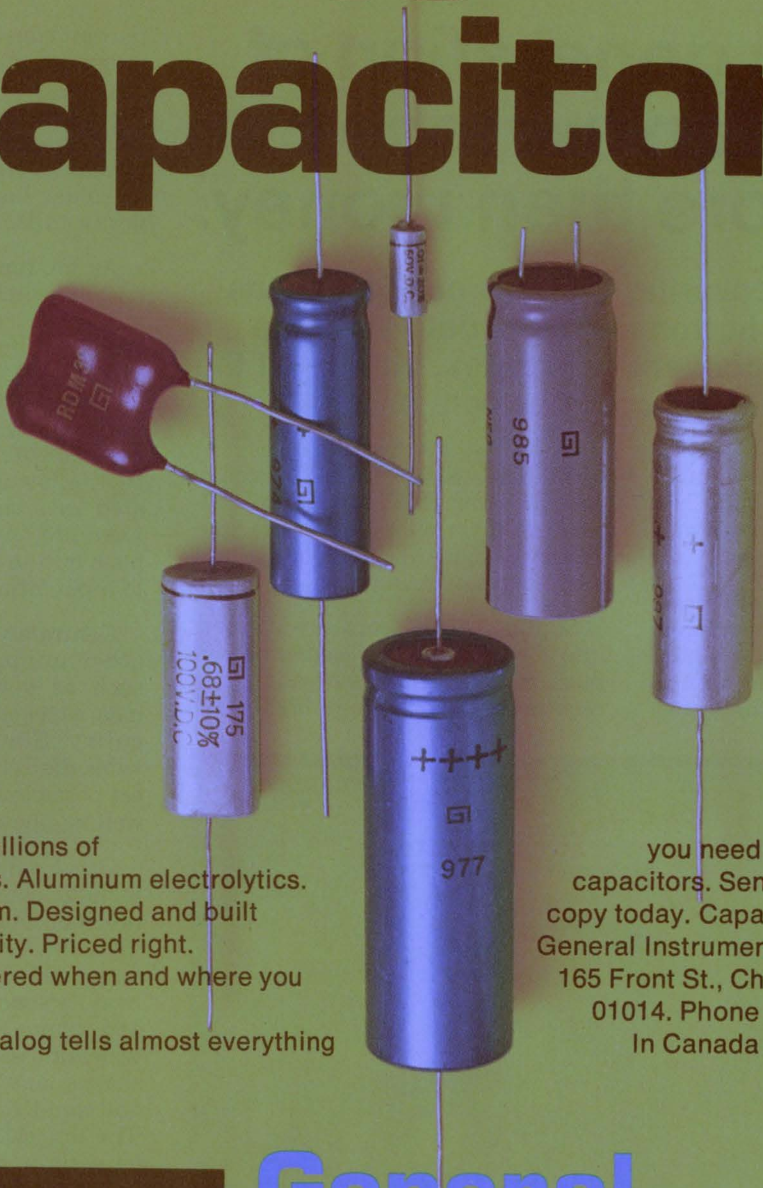
A 55-to-65-GHz paramp pumped at 105 GHz is reported to be the highest-frequency, nondegenerate paramp in existence. With a temperature stabilization system, it operates from −5 to +40 C with gain variation of less than ±1 dB. The pump is a Gunn oscillator at 35 GHz, tied to a varactor tripler. About 30 mW is produced.

Up to 94 GHz

A paper by Herman Okean, J. Asmus and L. Steffek of LNR Communications, Farmingdale, N. Y., described research in the development of a nondegenerate 94-GHz paramp. Okean, director of research and development at LNR, has told Electronic Design: "We are still at an early stage of development. We have produced a varactor that has a cut-off frequency of about 700 GHz as measured at 94 GHz and −0.5-V bias. We have characterized the paramp mount and we have decided on a klystron pump source at about 170 GHz. However, we have not yet optimized the paramp for best gain, bandwidth or noise figure."

He says that solid-state pumps are being considered but have not yet been developed to work at 170 GHz. ■■

GI is capacitors



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Centralab perspectives

FOR USERS OF ELECTRONIC COMPONENTS

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This new generation of push button switches saves more than money.

Designers are discovering the new configurations of Centralab push button switches deliver all the functions of most conventional types, but in half the space and at 1/10th the cost per pole or less.

Can a domestic producer of push button switches compete with imports? Centralab customers will answer with a resounding yes!

Centralab spokesmen readily admit their automated process of manufacture makes Centralab push button switches prudent choices on a competitive basis vs. both imported and other U.S. types. They hasten to add, however, that prompt availability, a reliable sampling service, and unique design are equally important advantages over imports.

Sophisticated users are looking into Centralab's new generation of push button switches because they require so little space — highly important considerations in aircraft instrumentation, computers and oscilloscopes, for example. The fact that the terminal pins interface with printed circuit boards (optionally available with selective pin cutting or solder lug terminations) simplifies installation.

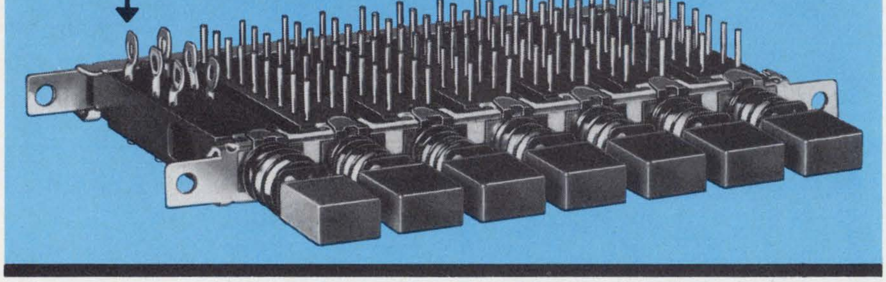
As for functions, Centralab push button switches feature momentary, push-push, and push-pull actions. Standard interlock with 4 optional lockouts are offered for ganged assemblies. The switches can also be horizontally or vertically ganged, rear coupled, or coupled back to back allowing 16 poles to be operated by a single button. And as an example of versatility, Centralab push button switches can be coupled to a potentiometer.

Centralab can lay claim to several other unique product properties, such as gold contacts and terminals, especially important in dry circuitry. Similarly, Centralab provides diallyl phthalate for the highest possible insulation resistance, as well as phenolic or glass alkyd.

Other salient features of the line include epoxy sealed terminals to preclude flux penetration. Up to 29 individual modules can be ganged on a common bracket with optional module spacing of 10, 12.5, 15, 17.5, and 20mm. You can choose from a wide range of button colors, sizes, shapes and legends. Both lighted and non-lighted types are available. The line switch can be gang mounted with or without interlock and is interchangeable with other modules in any position.

Why not consider Centralab push button switches in your upcoming applications by requesting samples. Write Centralab for complete information.

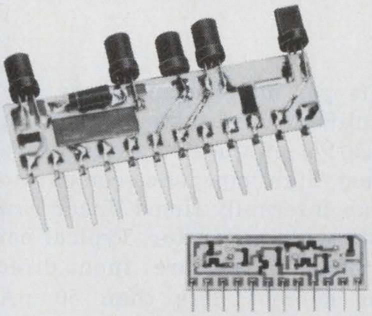
*Isostat licensed.



Centralab push button switches* are available as single modules (wrap-around support bracket optional) or as ganged assemblies. They are rated .45 Amp at 115 VAC or 1 Amp at 28 VAC. Other options include epoxy seal and modular size line switches.

INFORMATION RETRIEVAL NUMBER 141

Centralab perspective:



Two thick film hybrid systems. PEC and MEC.

Centralab offers the flexibility to design and fabricate thick film modules to fit virtually any application and cost parameter.

Low-cost silver/carbon or PEC® systems for consumer applications:

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- Resistor Tolerance..±10% preferred minimum
- Ratio Matching...............±5% minimum
- Capacitor Types..........Ceramic and tantalum
- Active Devices.......Diodes, transistors & IC's
- Operating Temp. Range.... −55° C to +85° C

Noble metal/cermet or MEC systems for commercial and industrial uses:

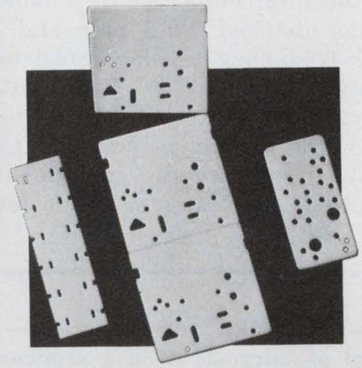
- Resistor Range..........3 ohms to 3 megohms
- Resistor Tolerance...........±.5% minimum
- Ratio Matching...............±1% minimum
- Capacitor Types..........Ceramic and tantalum
- Active Devices.......Diodes, transistors & IC's
- Operating Temp. Range... −55° C to +150° C

For more information write A. R. Wartchow, Marketing Manager, Electroceramic Products. Or ask for Centralab Bulletin No. 1429H.

INFORMATION RETRIEVAL NUMBER 142

Centralab perspective:

Ceramic Substrates/ ScoreStrates.®



Get your circuits started right.

Need ceramic substrates for your hybrid circuits? For resistor networks? Capacitor networks? Centralab's got them in every shape and size. In aluminas of 99.5% and 95%. Plain or metallized. With holes, slots, notches, scorelines or plain. With accurate dimensions and a surface finish compatible with your particular needs.

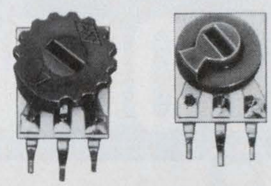
The pay off with Centralab is high performance reliability right from the start. So start right and specify Substrate / ScoreStrate ceramics from Centralab. You'll end up with the same high reliability substrate found in Centralab thick-film circuits (we're using them at the rate of 50 million per year).

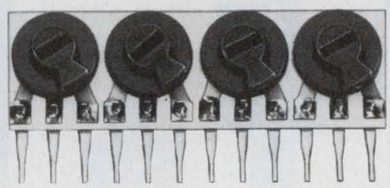
For assistance on specifications, price and delivery, call Chuck Thompson, 414/228-2942 or write Centralab for Bulletin No. 1057TC.

INFORMATION RETRIEVAL NUMBER 143

Centralab perspective:

Ceramic Trimmer Resistors. Double the wattage of phenolics.





Centralab Slim-Trim carbon and Centrim cermet trimmer resistors give twice the wattage capability of phenolics, yet cost no more. Ceramic substrates mean higher wattage in a smaller space. Plus the ability to withstand high operating temperatures without shrinkage. No flux migration during flow soldering either.

Centralab design and smooth positive adjustment eliminate erratic "slip-stick" effect in setting. Choose from single or multiple sections; ½ to ¾ watt; TC low as 150 PPM/°C. And if you want we can add fixed resistors to any of our standard trimmers. Easy.

See your Centralab Distributor or write Centralab for Bulletin No. 1096.

INFORMATION RETRIEVAL NUMBER 144

technology abroad

A fast, high-input-impedance, unity-gain buffer store without passive components is provided by the interconnection of a monolithic matched FET pair and a high-frequency bipolar transistor array. Developed at Portsmouth Polytechnic, Portsmouth, England, the circuit is designed for applications where operational-amplifier slew rates of only a few volts per microsecond make such amplifiers unsuitable. Typical application of the new circuit is as a fast, high-impedance comparator in an internally timed linear sawtooth-wave generator. Typical performance figures are: input direct bias current, less than 50 pA; output impedance, less than 50 Ω; power consumption, below 60 mW.

CHECK NO. 441

The Schottky contact line—a form of microstrip on a semiconducting substrate—behaves in the same manner as a parallel-plate waveguide under small-signal conditions, workers at the University of Munster in West Germany have learned. The contact line consists of a large-area, Schottky-barrier diode fabricated in strip form. The strips have nearly ideal rectifying properties. The German experiments have shown that phase-delay tuning is achieved by variations in the bias voltage applied to the line. It is suggested that this property could have applications for this type of microstrip in components where transmission-line constants have to be adjusted continually.

CHECK NO. 442

A device that combines the properties of a temperature sensor and a switch has been developed at Standard Telecommunication Laboratories in Harlow, England. The device, made from vanadium phosphate glass, is in the form of a bead, or thin film, of glass and two electrodes. It has a high and a low resistance state. The switching voltage between the two states is linearly dependent on temperature, decreasing at a rate of 1.4% per degree Celsius. The switch may be used in three ways. First, the variation of transition voltage with temperature may be compared with a fixed voltage, with the difference voltage used as a control signal. Second, a dc bias may be applied to switch the device at a specified temperature. Or, third, ac may be applied, in which case the device switches at a predetermined point in the ac cycle to control a heating or cooling element through a thyristor circuit.

CHECK NO. 443

Surface-acoustic-wave oscillators with fundamental frequencies of up to 490 MHz have been made at the Royal Radar Establishment in England. Because of the frequency-modulation capability of such devices, they are potentially useful as high-frequency sources. By conventional photolithographic techniques, the fundamental frequencies can be extended to about 1 GHz, while for still higher frequencies, the Royal Radar Establishment scientists are looking at other possibilities, such as electron-beam fabrication or the use of surface-acoustic-wave transducers at harmonics of the fundamental frequency.

CHECK NO. 444

washington report

Heather M. David
Washington Bureau

The plane that refuses to die

The Air Force's F-111 aircraft, with which the adjective "controversial" has been synonymous, now promises a last round of fireworks. Although Deputy Defense Secretary William Clements has ordered the production line closed this year, both the House Armed Services chairman Rep. F. Edward Hebert (D-La.), and the House Appropriations Committee chairman, Rep. George Mahon (D-Tex.), have protested the action, pointing out that Congress is likely to add funds to the budget to continue production. The Defense Secretary-designate, James Schlesinger, has not made his current feelings known, but as a Bureau of the Budget official in years back, he urged continuance of the program as a hedge against failure of the B-1 bomber design to meet approval. Another argument being posed for building more F-111s is the fact that 42 of the current aircraft fleet will be outfitted with electronic countermeasure equipment and shifted to jamming missions in the EF-111 program.

New radio service seems assured

The Federal Communications Commission will make a final decision around the end of the year on the establishment of a new Citizens Band "E class" radio service. It would be on the 224-to-225 MHz band. Forty channels would be available, with 25-kHz spacing. Although amateur radio operators, some of whom have used some of these frequencies, have opposed the allocation, the Office of Telecommunications has thrown its weight behind the proposal. Comments from interested parties will be received until Sept. 20 and reply comments until Oct. 22. The Electronic Industries Association has predicted that the allocation will result in annual sales of several hundred million dollars worth of new equipment, with receiving and transmitting equipment in the $200-to-$300 range.

New entries backed in race to replace F-14

Two new entries have been suggested in the race for a low-cost substitute for the Navy's F-14 Grumman Tomcat fighter aircraft. Deputy Defense Secretary William Clements, who is proving to be a strong administrator in the absence of a Congressionally confirmed Secretary of Defense, told the Navy to build two models each of a stripped-down F-14, a Navy version of the Air Force's F-15 McDonnell-Douglas fighter, and an uprated F-4M, also built by McDonnell-Douglas. These are to be flown competitively and a choice between them made within two or three years.

However, the House Appropriations Committee reportedly is extremely interested in getting the Navy to consider also the two aircraft being built by General Dynamics and Northrop Corp. for the Air Force's lightweight fighter program.

Clements' decision to curtail purchase of the fully loaded F-14 to only 50 this year and to permit only a few more in future years, along with the decision to look for a low-cost substitute, puts electronic subcontractors in a whole new round of competition. Hughes and Westinghouse are once again pitted against each other as radar and fire-control subcontractors.

Much of the F-14 cost problem was due to the ambitious, high-performance AWG-9 fire-control and Phoenix missile systems built by Hughes. They were designed to track 24 incoming aircraft or missiles and attack as many as six targets simultaneously.

Job outlook for EEs: Growth in some areas

The Dept. of Labor forecasts very rapid growth in the employment of electrical engineers for the automation and mechanization of industrial production processes, especially in work on computers and numerical controls for machine tools. Demand for electrical and electronic consumer goods also will play an important part in generating approximately 12,200 new engineering job openings a year to 1980, the department says in its biannual handbook, "Occupational Outlook." The outlook for aerospace engineers is not so good, with more engineers than jobs at present.

Capital Capsules:

The Federal Aviation Administration has issued a new ruling that will **require aircraft to carry identity and automatic altitude reporting equipment.** Data from the aircraft radar beacon transponders and altitude encoders will appear in digital form on ground-based radar systems in the FAA system. . . . The International Coordinating Committee, which regulates technology exports to Eastern Europe and Red China, has **failed to agree on lifting export controls of computer products to mainland China.** The decision is a blow to computer companies who already are planning an exhibit in China this fall. . . . A General Accounting Office report prepared at the request of Sen. Walter F. Mondale (D-Minn.) **differs with the cost figures used by NASA to justify the space-shuttle program.** The GAO's conclusion that NASA may have underestimated shuttle costs is being used in the Congressional fight over NASA funding. . . . **The Air Force has award Raytheon Corp. a $39.6-million contract for a new phased-array radar station,** code-named Cobra Dane, to be built in the Aleutian Islands. The radar will be part of the space-tracking network. . . . Honeywell's V.P. for science and engineering, Dr. Van Bearinger, told the House Space Committee's subcommittee on energy that **the basic technology to generate electric power from solar energy is available.** More Federal leadership is needed, he said. . . . **The next generation Worldwide Military Command and Control System will be run by computers that are larger and faster than any now in use,** according to Rear Admiral J. E. Langille 3d, deputy director of the program to devise such a system. Built with hybrid architecture, the computer will have both associative and serial processing capability.

editorial

Shall we buck the Establishment?

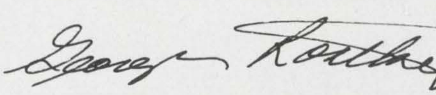
A buddy of mine went to a platoon of conventional doctors before a chiropractor cured his ulcer. Another chap I know barely survived a half-life, half-death existence that doctors prescribed for his bad heart. A man in his 50's, he now trots around like a youngster while he's taking the vitamins, minerals and additive-free foods prescribed by a nutritionist. And a gal I know almost accepted surgery before an acupuncturist healed her bad knee.

These and other "miracle cures" by nonconventional "healers" may all be lucky accidents. Maybe chiropractic is a hoax. The nutritionists, who feel that most of us are vitamin-starved and poisoned by food additives—perhaps they're all wet, too. Perhaps they appeal only to the psychological needs of "health nuts." Maybe acupuncture is just for the Chinese. They've used it as a painless healing method for thousands of years, but maybe they were too primitive to recognize the "advantages" of Western surgery and drugs.

Maybe not. Maybe the off-beat healers have a great deal to offer. But maybe there's an Establishment that's trying to still their voices. Maybe there's an Establishment similar to the one that drove Ignaz Semmelweiss to suicide when, in the 19th century, he introduced the absurd notion that doctors should clean their hands and instruments before they deliver babies. Perhaps there's an Establishment (or more than one) with sufficient power to mold people's attitudes—not only on medical matters—but on dozens of other issues, too.

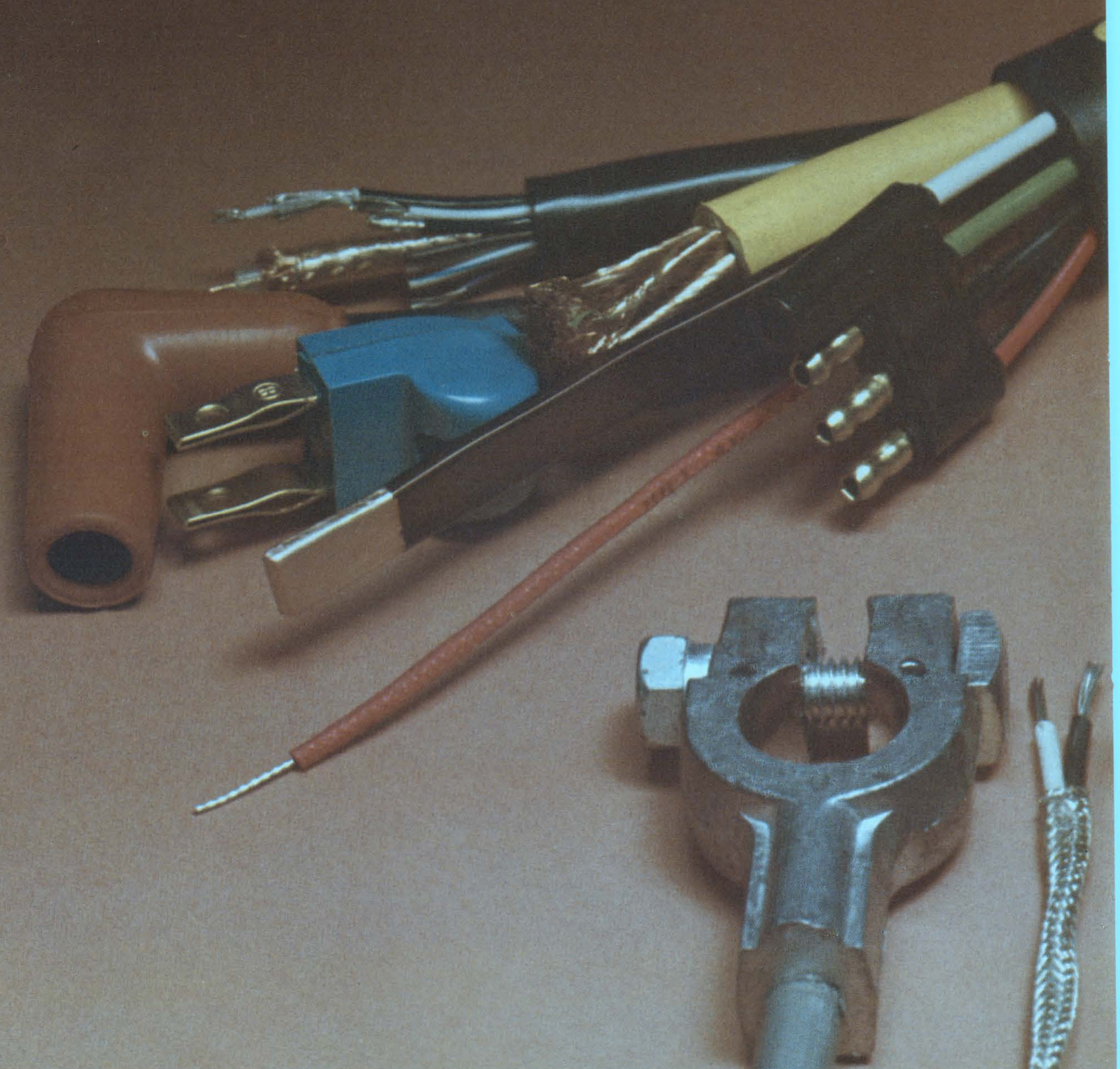
Aren't we fortunate that in the electronics industry there is no Establishment to pressure us into design conformity? We can design as we like, giving full rein to our imaginative powers. And if our design meets the needs of the marketplace and the specifications of a customer, we are successful designers. We don't have to worry about pressure from an Establishment. Or do we?

Within ourselves—in each of us—there is an Establishment. Bred and nourished by the experiences of a lifetime, that Establishment molds everything we do—personally and professionally. Is it always for the best?



George Rostky
Editor-in-Chief

decoding the codes



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H-3-3

BELDEN

INFORMATION RETRIEVAL NUMBER 234

FOCUS on IC voltage regulators

Designers faced with the many performance claims promoted for monolithic voltage regulators might conclude that one of these little gems can solve all their power-supply problems. After all, if a tiny IC can dissipate over 20 W and deliver about 2 A of regulated power, who needs a conventional power supply?

With objective examination of the data sheets, however, a different picture emerges. That high dissipation can be tolerated only at 25-C case temperature. The free-air dissipation is considerably lower. And you can't draw the 2 A if you exceed the dissipation rating.

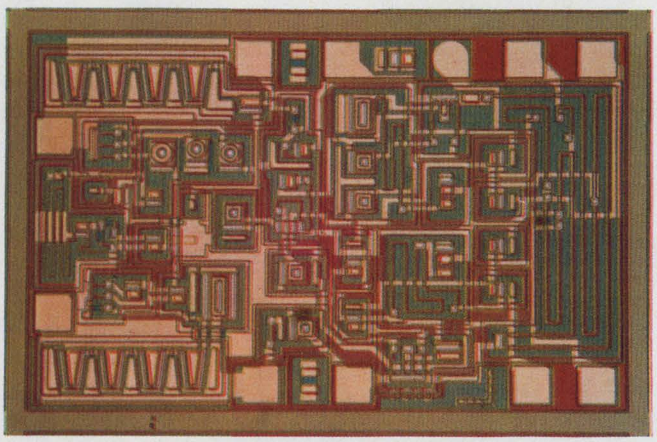
That's just one problem in choosing the right regulator for the job. Adding to the task are the different types of regulators: positive, negative and now dual-tracking (or dual-voltage) devices. You can't always eliminate one type simply because the required output voltage happens to be, say, negative. Often a simple connection of positive regulators results in an equivalent negative-voltage regulator. And you can combine a positive and negative regulator for dual-voltage applications, though the output voltages don't track each other, as they do with a device designed for dual voltages.

Spec sheets may not help the selection process either. The universal use of automatic test equipment to keep costs down is a case in point. Such equipment can test a regulator in less than a second; so there's little heating of the device during the test period. Manufacturers therefore specify most parameters at a constant-junction temperature, while temperature drift is specified separately. But a user performing bench tests will seldom have the regulator at a constant-junction temperature. One result: The line and load regulation that you measure, both temperature-dependent, probably isn't what you see on the data sheet.

Still the advantages of IC regulators easily outweigh the problems of selection. Their use permits tailoring of voltage level and regulation to the requirements of individual system stages and also improves the isolation and decoupling of these stages.

And use of local regulators rather than a large central regulator means that unregulated voltage can be distributed to parts of the system that can tolerate it. Hence the regulators keep equipment costs down.

Monolithic regulators offer tight load and input-regulation specs, a wide range of output voltages and package styles, and soon several will be able to supply up to 3 A of load current. The emergence of low-cost, three-terminal devices



Silicon General's dual-voltage regulator—the SG1501A —provides ±15-V outputs with load currents up to 200 mA. Output levels ranging from 8 to 23 V can be obtained with an external resistor. The chip has a built-in thermal shutdown feature that takes effect above 170 C.

Edward A. Torrero
Associate Editor

with short-circuit overload protection built into the chip makes monolithic regulators easier to use.

Find out what's left out

A major consideration in buying an IC regulator is not what's inside the package but what's left out. The newer three-terminal devices generally don't require external components. But others do. Some manufacturers leave you the job of providing the bulk of the circuitry with external discrete components—and these can take up several times as much board space as the basic regulator.

Here are some additional components that you may need:

- Power transistors for higher-than-rated load currents.
- Potentiometers or resistance dividers for external voltage adjustment.
- Capacitors for stabilization, ripple reduction, noise reduction and improved transient response.
- Series resistors to calibrate the overload protection circuit.
- Differential amplifiers for even tighter-than-rated regulation.
- External voltage references to replace the internal zener diode for higher and lower voltages or for improved stability.

And don't forget that you must always supply the dc for the device. Some regulators may be promoted as capable of working from an unfiltered, rectified ac input, but most require at least partial filtering at the input. For optimum regulator performance, you may even have to provide a stable input or constant reference supply.

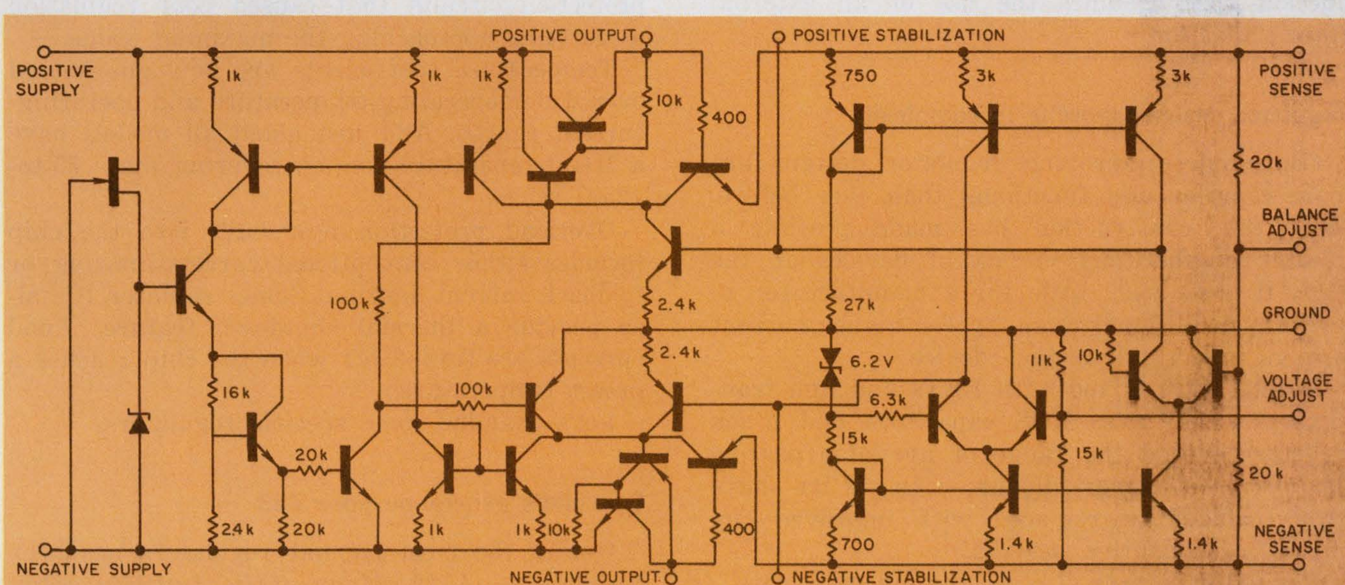
Specifying IC regulators poses special problems beyond those introduced by automated testing, because of the lack of uniform standards in defining key parameters. For example, on some data sheets the critical spec—load regulation—may be listed for a small change in load current rather than for a no-load-to-full-load change. This may not be a problem for relatively constant loads, but it makes a comparison of different regulators more difficult.

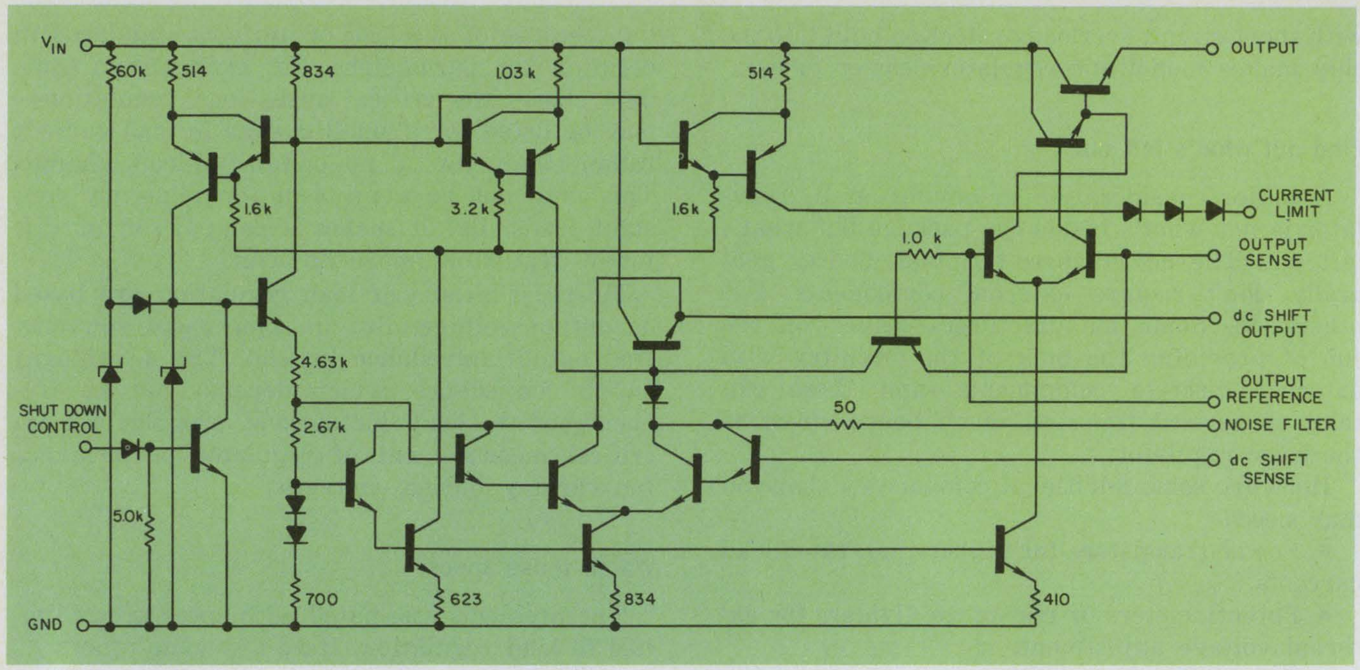
Most definitions of load regulation are based on output voltage. But in some cases you may find output impedance instead. The advantage: Output impedance, which depends on the frequency of the load fluctuations, provides a more critical measurement of regulator performance for varying output voltages.

Watch those specs

The problems associated with specs aren't limited to load regulation. Here are some others:

- Maximum current, voltage and dissipation ratings may not correspond. Some manufacturers list separate specs for these parameters but when you multiply the maximum voltage drop and the maximum load current, you may find the maximum allowable dissipation has been exceeded. The solution is to do some cross-checking to find the allowable load current.
- Shunt, or standby, current to operate the regulator circuitry may be defined as the minimum input current or the minimum allowable voltage across the device. In either case, allow for sufficient current—it can be significant in the case of older regulator designs. When external feedback resistors are required, the feedback current must be subtracted from the load current to obtain the reduced allowable current.
- Temperature changes can cause voltage variations in excess of those from all other causes. A check of the temperature coefficient will de-





Motorola's MC1560 voltage regulator features load currents up to 500 mA and a typical tempco of only 0.002% per °C. The IC has an output impedance that is relatively constant over a wide range of output voltages. The Motorola regulator can provide regulated voltages ranging from 2.5 to 17 V.

termine what to expect. But watch out for tempcos measured at low load currents only. At high load currents, temperature stability can be several times worse than the value listed.

- Ripple reduction may be incompletely specified. If you don't see it on the spec sheet, don't assume dc information can be applied instead. Usually the regulator's response to an ac signal will be quite different from that for a dc signal. Most manufacturers assume that the input ripple is a 120-Hz sine wave.

Because ripple rejection generally gets worse at higher frequencies, published specs may be impossible to achieve if the input-voltage waveform has high-frequency spikes superimposed on it. Also, check to see whether the ripple-reduction spec assumes the use of an external filter capacitor.

Regulator designs growing in complexity

Continually improving regulator designs are more complex and functional than ever before. Monolithic construction has made possible a greater number and variety of devices on the chip. It costs very little for a manufacturer to add, say, additional circuitry for higher current ratings in a single-voltage device.

Bipolars are mixed with FETs and npn transistors with pnp's. MOS capacitors and pinch resistors extend the range of available passive devices. And zener diodes—even SCRs—have been included or replaced with improved circuitry in monolithic designs.

Regulator designs also use the inherent matching of monolithic devices. Many active elements, for example, are used to balance out variations in operating conditions caused by other devices. And some devices may operate only under special conditions: in the event of overload, for example; or when the circuit is initially turned on; or when the circuit regulates negative instead of positive voltages; or when the device is operated in a switching mode. Of course, many IC regulators are externally programmable to be turned on or off by IC logic signals.

The resulting improvements have also overcome some of the limitations of early models.

The annoying variations of load regulation with operating voltage have been reduced or minimized. Gone, too, are the adverse effects of overload-protection circuits that caused poor regulation at currents approaching the maximum value.

Temperature coefficients are now guaranteed over wider operating-temperature and operating-current ranges. And just about all models have a MIL-temperature version covering the −55-to-125-C range.

Overload protection now built into the chip includes either conventional current-limiting or foldback current-limiting. Some regulator ICs also provide a thermal shutdown feature: Load currents are turned off when the chip reaches a preset temperature.

Let's examine some specific regulators.

Fairchild's general-purpose 723

One of the most popular regulators has been Fairchild's μA723. Many of its features result

Table 1. Representative adjustable voltage regulators

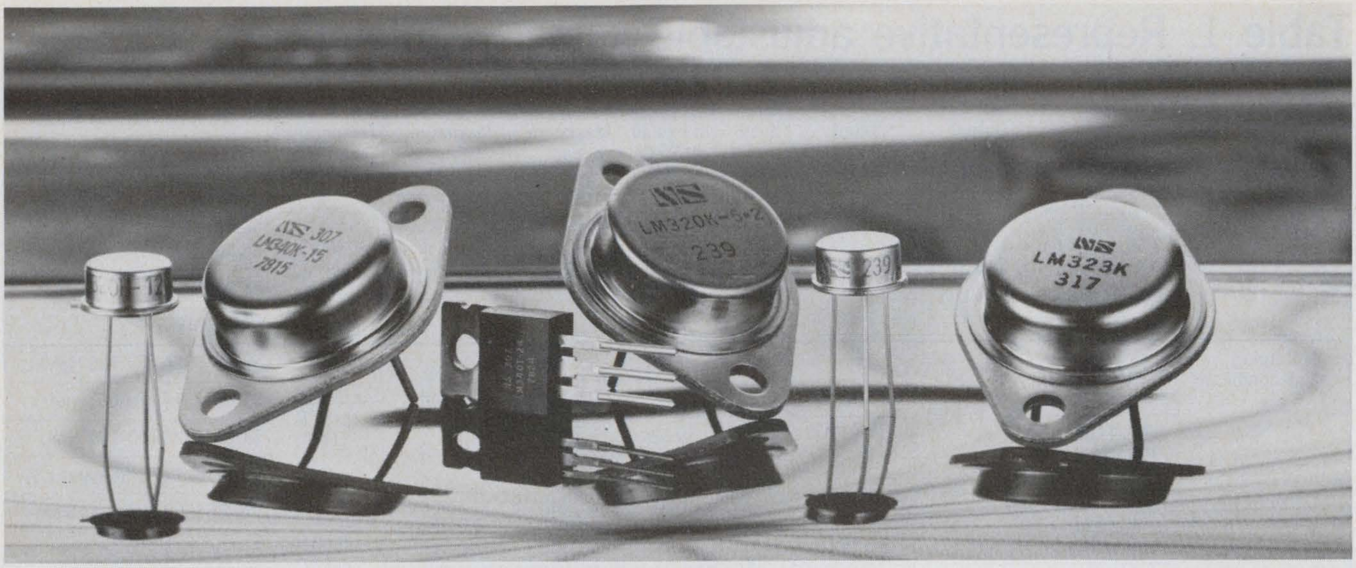
Company	Type no. (temperature range)	Output volts, V dc	Input volts (V_{IN}), V dc	Maximum load current, mA	Maximum dissipation in free air at 25 C, W	Maximum load regulation	Maximum line regulation	Temperature coefficient or stability	Price (25-99)/package
Fairchild Semiconductor	μA 723 (−55 to 125 C)	2 to 37	9.5 to 40	150	0.8	0.6%	0.3%	0.015% per °C (MAX)	$4.74/TO-5
					0.9				$5.10/DIP
	μA 723 C (0 to 70 C)				0.8				$2.34/TO-5
					0.9				$2.34/DIP
Motorola Semiconductor	MC 1560 (−55 to 125 C)	2.5 to 17	8.5 to 20	500	0.68	0.13%	0.015% per volt	±0.002% per °C (TYP)	$8.75/602A (TO-100 type)
					3.0	0.05%			$10.65/614 (TO-66 type)
	MC 1460 (0 to 70 C)		9 to 20		0.68	0.13%	0.030% per volt		$3.10/602A (TO-100 type)
					3.0	0.05%			$4.35/614 (TO-66 type)
	MC 1561 (−55 to 125 C)	2.5 to 37	8.5 to 40	500	0.68	0.13%	0.015% per volt	±0.002% per °C (TYP)	$10.65/602A(TO-100 type)
					3.0	0.05%			$12.50/614 (TO-66 type)
	MC 1461 (0 to 70 C)	2.5 to 32	9.0 to 35		0.68	0.13%	0.030% per volt		$4.35/602A (TO-100 type)
					3.0	0.05%			$5.60/614 (TO-66 type)
	MC 1563 (−55 to 125 C)	−3.6 to −37	−8.5 to −40	500	0.68	0.13%	0.015% per volt	±0.002% per °C (TYP)	$6.55/602A (TO-100 type)
					2.4	0.05%			$8.15/614 (TO-66 type)
	MC 1463 (0 to 70 C)	−3.8 to −32	−9 to −35		0.68	0.13%	0.030% per volt		$3.45/602A (TO-100 type)
					2.4	0.05%			$4.40/614 (TO-66 type)
National Semiconductor	LM 105 (−55 to 125 C)	4.5 to 40	8.5 to 50	40	0.8	0.1%	0.03% per volt	1% (MAX)	$18.00/TO-5
	LM 305 (0 to 70 C)	4.5 to 30	8.5 to 40		0.5				$3.90/TO-5
	LM 104 (−55 to 125 C)	−0.015 to −40	−8 to −50	40	0.5	5 mV	0.1% ($\Delta V_{IN} = 0.1 V_{IN}$)	1% (MAX)	$18.00/TO-5
	LM 304 (0 to 70 C)	−0.035 to −30	−8 to −40						$3.90/TO-5
RCA	CA 3085 (−55 to 125 C)	1.8 to 26	7.5 to 30	12	0.63	0.1%	0.15% per volt	0.0035% per °C (TYP)	$0.98/TO-5
	CA 3085 A (−55 to 125 C)	1.7 to 36	7.5 to 40	100		0.15%	0.1% per volt		$2.39/TO-5
	CA 3085 B (−55 to 125 C)	1.7 to 46	7.5 to 50	100		0.15%	0.08% per volt		$6.52/TO-5
Transitron	TRV 2000 (−55 to 125 C)	3 to 37.8	8 to 40	200	0.8	Output impedance 50 mΩ	0.05% per volt	0.102% per °C (MAX)	$3.65/TO-5
	TRV 2001 (0 to 70 C)	3 to 37.5	8 to 40	200		Output impedance 100 mΩ	0.1% per volt	0.015% per °C (MAX)	$2.50/TO-5
	TRV 2002 (0 to 70 C)	3 to 27	8.5 to 30	100		Output impedance 100 mΩ	0.2% per volt	0.02% per °C (MAX)	$2.45/TO-5

from the inclusion of a greater variety of devices on the chip. It contains an n-channel JFET and an MOS capacitor, along with conventional bipolar devices. The JFET acts as current source, maintaining a constant reference that is independent of the input voltage. The MOS capacitor provides frequency compensation.

The μA723 offers a typical tempco of 0.002% per degree C and capability for device shutdown by an external signal. The regulator lists a maximum load current of 150 mA, and has a standby current drain of about 2 mA and a ripple rejection of 74 dB (with no reference capacitor) over the frequencies of 50 Hz to 10 kHz.

In addition the μA723 can operate as a positive or negative regulator with the appropriate circuitry. It can also be used as a floating regulator for outputs up to 100 V or as a switching regulator. It comes in either a TO-5 or dual-in-line package.

Because of its versatility, Fairchild's 723 has achieved wide acceptance as a general-purpose regulator. However, for higher load currents and ease of use, Fairchild has come out with the 7800



National Semiconductor's regulator line includes several three-terminal, fixed voltage ICs. The LM340 series provides output voltages ranging from 5 to 24 V; the LM320 series, from −5 to −15 V. The newest three-terminal regulator is the LM323 with a maximum load current of up to 3 A at 5 V.

series of fixed-voltage, three-terminal regulators.

The series covers the 5-to-24-V range with load currents of 1 A (the 7800 models) and 0.5 A (the 78M00 models). The package styles are standard transistor types, since input, output and ground are the only terminals. The 0.5-A regulators come in TO-5 cans and the 1-A in TO-3 and TO-220.

Another part of the 7800 series—the 78N00 models—offer negative voltages ranging from −2 to about −5 V. Available in TO-3 packages, these regulators provide voltage levels commonly required for emitter-coupled logic circuits. Their load current is listed as 3 A.

Overload protection of all the regulators in the series is provided by internal thermal shutdown and internal current-limiting circuitry.

The regulator chips include a 3-A npn power transistor that is protected against short circuits and secondary breakdown effects. A 30-pF MOS capacitor is also included for internal compensation.

The new regulators don't use zener diodes as voltage references. These diodes are generally noisy and have a sharp breakdown voltage above 6 V that tends to limit the regulator's minimum output. The zeners have been replaced by an emitter-base junction. Temperature compensation is achieved by the balancing of positive and negative tempcos among active devices. The temperature-compensated emitter-base voltage is then multiplied on the chip to the required reference level.

Motorola's MC1560

Motorola's entry into the monolithic regulator field began with the introduction of the MC1560—a positive regulator capable of delivering load currents up to 500 mA with a typical tempco (like the 723) of only ±0.002% per degree C. The maximum input regulation is only 0.015% per volt, and the worst-case output impedance is a low 100 mΩ.

The output impedance of the MC1560 is essentially constant with increasing output voltages, in contrast with regulators that exhibit increasing impedances. The device achieves constant impedance by comparing the output voltage directly with a reference provided by a separate, low-level series regulator on the chip. Since there is no resistive voltage divider across the output of the main regulator, the feedback—and hence the output regulation—doesn't depend on output voltage.

Another feature of the MC1560 is shutdown control. Both the load and regulator bias current can be turned off by an external signal, supplied by standard digital ICs.

The MC1560 and its higher-voltage version—the 1561—never quite caught on as some of its early promoters expected. For many applications, the high-frequency characteristics of the device could not be controlled against oscillations without the use of special rf techniques.

The result was the introduction of the 1569, an easier-to-use 1560. The 1569 differed from its predecessor only in its metallization pattern at the output. It allowed the user to adjust the device's response time externally with a capacitor, thus avoiding the stability problems of the 1560.

Other versions are available to regulate negative voltage levels: the MC1563 for MIL-temperature ranges and the MC1463 for commercial ranges. More recently, Motorola has introduced

Table 2. Three-terminal, fixed-voltage regulators.

Company	Type no. (Temperature Range)	Typical output Volts (V_o), V dc	Input volts, V dc	Maximum load current, A	Maximum dissipation in free air at 25 C, W	Maximum load regulation	Maximum line regulation	Prices (25-99)/package
Fairchild Semiconductor	* μA78XX (−55 to 125 C)	5,6,8,12,15 18,24	** $(2+V_o)$ to 35	1	3.5	1%	1%	$28.25/TO-3
	μA78XXC (0 to 85 C)				2.0	2%	2%	$2.70 to $2.85/TO-220
					3.0			$2.85 to $3.70/TO-3
	μA78MXX (0 to 85 C)	5,6,8,12,15 20,24	$(2+V_o)$ to † 30	0.5	1	1%	1%	NOT AVAILABLE/TO-39
	μA78NXX (0 to 70 C)	−2, −5.2	$(-7\frac{1}{2}+V_o)$ to −15	3	3.5	1%	1%	NOT AVAILABLE/TO-3
National Semiconductor	LM 340-XX (0 to 70 C)	5,6,8,12 15,18,24	** $(2+V_o)$ to 35	>1	2.0	2%	2%	$2.70/TO-220
					3.5			$2.85/TO-3
	LM 120-XX (−55 to 150 C)	−5, −5.2, −12, −15	*** $(1+V_o)$ to −25	0.2	1	80 mV	25 mV	$11.35/TO-5
				1	3.5			$11.95/TO-3
	LM 320-XX (0 to 125 C)			0.2	1	100 mV	50 mV	$4.40/TO-5
				1	3.5			$4.75/TO-3
	LM 123 (−55 to 150 C)	5	20 (MAX)	3	3.5	100 mV	25 mV	$6.00/TO-3
	LM 323 (0 to 125 C)							$18.00/TO-3
Teledyne Semiconductor	829 (−30 to 85 C)	12	15 to 40	0.05	1	24 mV	18 mV	$1.10/TO-39
	830 (−30 to 85 C)	15	18 to 40					

*XX denotes the typical output voltage.
**For V_o = 24 V, the maximum input voltage is 40 V.
***For V_o = −12 and −15 V, the respective maximum input voltages are −35 and −40 V.
†For V_o = 12 and 15 V, the maximum input voltage is 35 V; for V_o = 20 and 24 V, it's 40 V.

three-terminal regulators. These supply over 1 A of load currents in the 5-to-24-V range. The maximum input voltages reach 40 V.

National Semiconductor broadens line

At National Semiconductor the IC regulator line began with the LM100—a 2-to-30-V device with better than 1% line and load regulation. Output currents exceeding 5 A are possible with the aid of external transistors.

The LM100, however, has been largely superceded by newer circuits. For tighter regulation, higher input voltages and higher output currents, National has the pin-compatible LM105 for positive-voltage levels. For negative levels, the LM104 is available. Compared with the LM100, the LM105 has an extra stage of gain, permitting load and line regulations of 0.1% and 0.03% per volt, respectively. Inputs can range from 4.5 to 40 V, and output currents can reach 10 A if external transistors are added.

Without the external transistors, both the LM100 and LM105 can handle currents only up to about 40 mA. Both devices have comparable load regulations at low load currents. However, the LM105 has much lower internal power consumption; so it's more efficient. It needs no minimum preload current and can work at higher input voltages. Moreover the overload-protection circuit has sharper turnover characteristics and thus does not constrain regulator performance before load currents reach a preset limit.

More recently, efforts at National Semiconductor have concentrated on even higher-current, easier-to-use devices. The LM109 series, which preceded the 7800 series, pioneered three-terminal regulator ICs. It reduced the number of terminals to the minimum and provides 5 V of regulated voltage with 1 A of load current. The LM109 has internal current limiting as well as thermal shutdown circuitry.

National now has a complementary line of positive and negative three-terminal, fixed-voltage regulators—the LM340 and LM320 series, respectively—in the same package types that the 309 and 7800 ICs come in. The positive regulators require an external capacitor, and they cover the same ranges as positive-voltage 7800 devices. The negative regulators extend from −5 to −15 V. Both types have the same overload protection features as the LM109.

National has also announced a 3-A version of its LM109 regulator. Called the LM123 series, it is a three-terminal device for 5-V applications and can be used without external components. Available in a TO-3 package, the power dissipation is specified as 30 W.

RCA regulates low voltages

The CA3085 family of positive-voltage regulators from RCA features a low reference voltage of 1.7 V, which allows regulation of voltages down to that level. The ICs can supply up to 100 mA over the −55-to-125-C temperature range, and they have a 50-V input voltage capability.

The basic circuit consists of a frequency-compensated error-amplifier that compares an internally generated reference voltage with a sample of the output voltage. The error-amplifier also controls a series-pass amplifier to regulate the output, while a starting circuit on the chip provides a stable latch-in of the voltage-reference circuitry. Overload protection is provided by an external current-limiting resistor.

A maximum current of 250 μA from the internal source can be supplied for external use without adverse effects on the reference-voltage stability. To regulate currents in excess of 100 mA, the collector of the series-pass output transistor is brought out to a separate terminal to drive the base of an external pnp transistor.

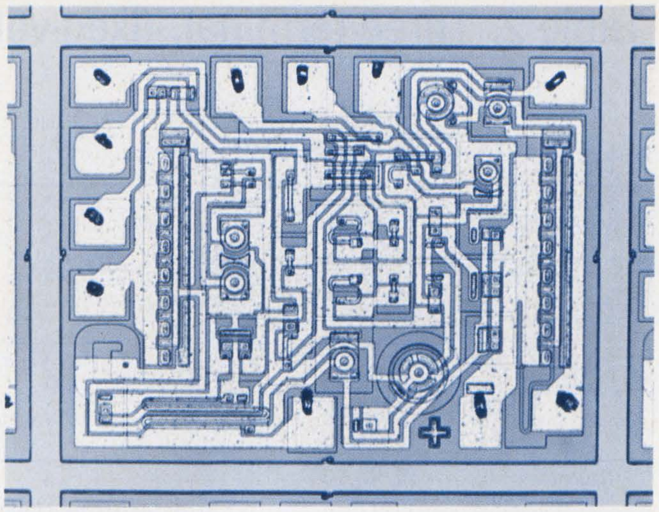
The maximum load regulation is 0.15% for a maximum output voltage of 46 V (suffix-B version). Load regulation can be decreased to 0.1% in the CA3085, but the maximum output current drops to 12 mA and the output voltage to 26 V. The family is supplied in eight-lead, TO-5 packages and also with the dual-inline, formed leads.

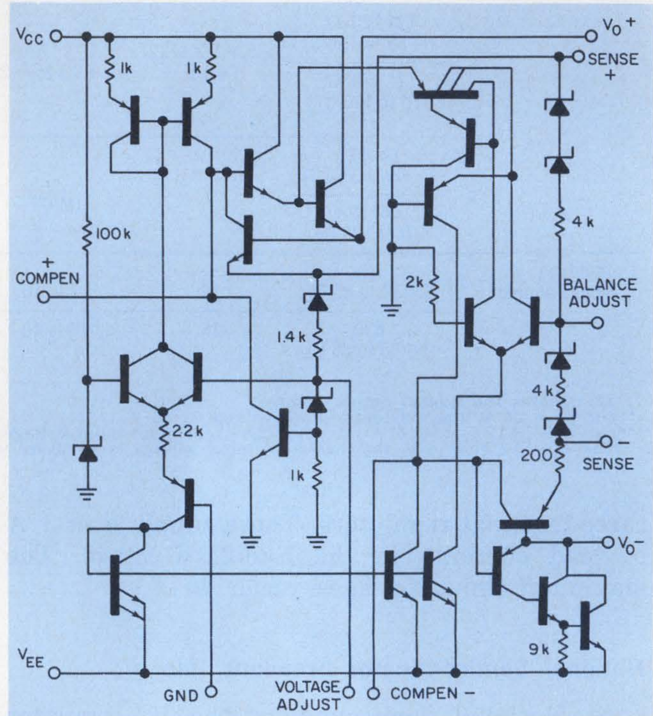
Dual-tracking regulators emerge

For dual-voltage applications, monolithic voltage regulators that provide tracking of positive and negative voltages are available from three manufacturers—Motorola, Raytheon and Silicon General. The tracking capability is achieved by employing a single reference diode on the chip to regulate one voltage polarity and using that output for the other polarity.

Motorola offers the MC1568 and 1468 for MIL-temperature and commercial ranges, respectively. The MC1568 provides ±15 V outputs within ±1.3% without the use of voltage-calibration resistors. The output levels match within ±1.0%.

These Motorola regulators require two external, current-limiting resistors. The current at which limiting begins can be set by the user to fit the application. In addition these resistors allow remote voltage sensing of variations caused by supply-line resistance when the load is re-





The MC1568 dual-voltage regulator from Motorola offers ±15-V levels balanced to 1% at currents to 100 mA. Input voltages up to ±30 V can be handled and there is provision for adjustable current limiting. Maximum load regulation is listed at 30 mV; line regulation, 20 mV.

mote from the regulator. The MC1568 also requires four external capacitors for operation.

While the Motorola regulators are intended as ±15 V op-amp supplies, an additional variable resistor can be used to obtain from ±14.5 to ±20 V (suffix R and G models). In one model (suffix L), the minimum can go to ±8 V with additional resistors and some sacrifice in the temperature coefficient of the output voltage.

Raytheon has a variable, dual-voltage regulator—the RM/RC4194—as well as the fixed ±15 V RC4195. The variable voltage regulator accepts inputs of ±45 V. Load currents reach 200 mA while maintaining rated load regulation.

The output voltage of the 4194 is set by an

Table 3. Dual-tracking regulator ICs.

Company	Type No. (temperature range)	Output volts, V dc	Input volts, V dc	Maximum load current, mA	Maximum dissipation in free air at 25 C, W	Maximum load regulation	Maximum line regulation	Temperature coefficient or stability	Price (25-99)/package
Motorola Semiconductor	MC 1568 (−55 to 125 C)	±14.8 to ±15.2	±30 (MAX)	100	0.8	30 mV	20 mV	1% (MAX)	$7.88/TO-100
					2.4				$8.75/614 (TO-66 type)
					1.0				$8.12/Ceramic DIP
	MC 1468 (0 to 75 C)	±14.5 to ±15.5			0.8				$3.50/TO-100
					2.4				$4.68/614 (TO-66 type)
					1.0				$3.62/Ceramic DIP
Raytheon Semiconductor	RM 4194 (−55 to 125 C)	0.05 to ±42	±9.5 to ±45	150	0.9	0.002% per mA	0.1 % ($\Delta V_{IN} = 0.1 V_{IN}$)	0.015% per °C (MAX)	$8.00/Ceramic DIP
				250	3.0				$11.70/TO-66
	RC 4194 (0 to 70 C)	0.05 to ±32	±9.5 to ±35	150	0.9	0.004 % per mA			$3.20/DIP
				250	3.0				$4.70/TO-66
	RM 4195 (−55 to 125 C)	±14.8 to ±15.2	18 to 30	* 150	0.8	30 mV	20 mV	0.015% per °C (MAX)	$6.50/TO-99 type
					2.4				$10.00/TO-66
	RC 4195 (0 to 70 C)	±14.5 to ±15.5			0.8				$3.00/TO-99 type
					2.4				$4.10/TO-66
					0.6				$2.60/8-pin DIP
Silicon General	SG 1501 A (−55 to 125 C)	±14.8 to ±15.2	±35 (MAX)	200	0.68	30 mV	20 mV	1% (MAX)	$8.10/TO-100
					1.0				$9.30/Ceramic DIP
	SG 3501 A (0 to 70 C)	±14.5 to ±15.5	±30 (MAX)		0.68				$4.75/TO-100
					1.0				$5.95/Ceramic DIP
	SG 4501 (0 to 70 C)	±14.25 to ±15.75	±30 (MAX)	100	0.600	30 mV	20 mV	1% (MAX)	$2.35/DIP or TO-100
	SG 1502 (−55 to 125 C)	±10 to ±28	±12 to ±30	100	1.0	0.3 %	0.2 %	1% (MAX)	$8.35/Ceramic DIP
	SG 3502 (0 to 70 C)	±10 to ±23	±12 to ±25		0.6				$4.20/DIP

*Maximum load current reaches 200 mA in TO-66 package

external resistor. Its value is calculated from the calibration factor 2.5 kΩ/V; the user simply multiplies the required voltage by 2.5 to get the resistance in kΩ. The regulator also requires capacitors and another external resistor that allows a matching of tempcos for both resistors.

An internal reference section performs thermal shutdown. At about 175 C, there is a complete shutdown of the regulator. Internal short-circuit limiting takes effect when the current for either voltage level reaches a preset level.

A balance terminal permits asymmetrical as well as symmetrical voltage combinations between 50 mV and 42 V. For unbalanced outputs, an additional resistor is required.

For ±15-V applications, the RC4195 delivers these voltage levels within a tracking spec of 50 mV. Line regulation is listed at 2 mV and load regulation at 5 mV, with a ±0.005% drift per degree centigrade.

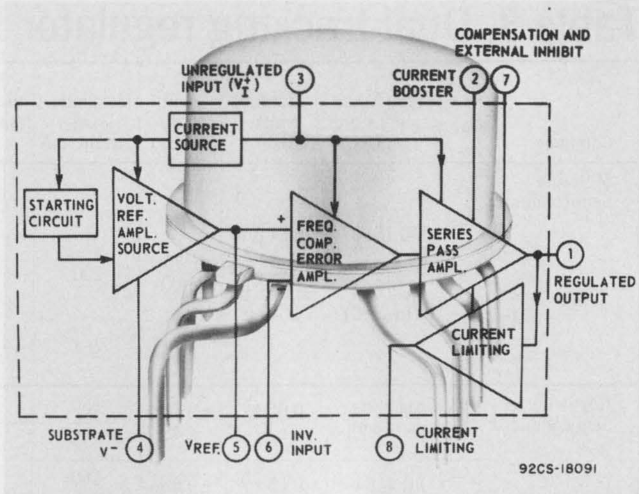
The RC4195 can deliver 100 mA at each output, and it has the same thermal-shutdown feature as the 4194. Two bypass capacitors are required for operation.

From Silicon General comes the variable, dual-voltage SG1502 and the ±15-V SG1501A ICs. The 1502 accepts input voltages of ±12 to ±30 V and provides regulated output levels of ±10 to ±28 V. External calibration resistors set the output-voltage levels. Output currents reach 100 mA, while line and load regulation are 0.1%.

Current-limit inputs are not connected to the pass transistors in the 1502. The availability of these inputs simplifies the use of foldback current limiting for overload protection. This can be an important advantage when the major portion of the power is dissipated in external pass transistors.

The 1501A delivers load currents up to 200 mA. And with an external resistor connected to the chip, outputs can be obtained in the range of ±8 to ±23 V. This device can be used with inputs of ±35 V, and it has provisions for adjustable current limiting. A built-in sensing circuit shuts down the 1501A when junction temperatures exceed 170 C.

Both the 1501A and 1502 are designed to minimize the effects of temperature gradients across the chip. Over the full −55-to-125-C temperature range, maximum variations in the out-



RCA's CA3085 family consists of positive-voltage regulators with an output voltage range of 1.7 to 46 V. Maximum load currents can reach 100 mA, and all ICs operate over the −55-to-125-C temperature range. Packaging for the CA3085 family includes 8-lead TO-5 types with dual-inline formed leads.

put are held to 1%. And from low to full regulator power, less than 2-mV change due to temperature gradients can be achieved.

Silicon General plans to join other manufacturers with regulators equivalent to the Fairchild 7800 and National Semiconductor LM340/320 three-terminal, spot-regulator lines. Silicon General is also alternate-sourcing Motorola's 1568 dual regulator. ■■

Need more information?

The products cited in this report don't represent the manufacturers' full lines. For additional details, check the appropriate information retrieval number:

- Advanced Micro Devices, 901 Thompson Pl., Sunnyvale, Calif. 94086. (408) 732-2400. (Leonard Brown) **Check 429**
- European Electronic Products, 10150 W. Jefferson Blvd., Culver City, Calif. 90230. (213) 838-1912. (Willi Bacher) **Check 430**
- Fairchild Semiconductor, 464 Ellis St., Mountain View, Calif. 94040. (415) 962-5011. (Max Gilbert) **Check 431**
- ITT Semiconductor, 3301 Electronics Way, West Palm Beach, Fla. 33407. (305) 842-2411. (Suhael Ahmed) **Check 432**
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- National Semiconductor, 2900 Semiconductor Dr., Santa Clara, Calif. 95051. (408) 732-5000. (Art Fury) **INQUIRE DIRECT**
- RCA Solid State, Route 202, Somerville, N.J. 08876. (201) 722-3200. (Abel Sheng) **Check 436**
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- Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700. (Eugene Hnatek) **INQUIRE DIRECT**
- Silicon General, 7382 Bolsa Ave., Westminster, Calif. 92683. (714) 892-5531. (Steve Thompson) **Check 438**
- Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040. (415) 969-9112. (Joel Scheinberg) **Check 439**
- Transitron, 168 Albion St., Wakefield, Mass. 01880. (617) 245-4500. (Al Berry) **Check 440**

Acoustic-wave filters improve radar

by processing signals in the system with fewer and smaller components. Time-domain matching boosts S/N ratios.

The development of acoustic surface-wave devices can provide significant advances in the design of radar systems. As matched filters for analog signal processing, they are smaller, cheaper and require less power than equivalent digital-processing systems.

When the devices are used in a correlator/sequence-generator combination (Fig. 1), further benefits result. In a radar receiving subsystem, the correlator processes the received signal at the i-f, or subcarrier frequency. There is no need to convert to baseband until after the received signal has been correlated.[1] Thus the designer can avoid some of the problems associated with signal-to-noise degradation caused by the baseband conversion required in conventional digital processing.[2]

In a radar transmitting subsystem, the acoustic surface-wave sequence generator—physically almost identical to the correlator—provides its own rf signal, generated by a narrow video input pulse. Hence the expensive and bulky local oscillators normally required with conventional sequence generators can be eliminated.

Moreover acoustic surface-wave devices allow analog-signal processing of coded rf waveforms. As a result, the processing gain can be improved by 3 dB, compared with the standard digital signal-processing techniques. This improvement helps to reduce the high power levels normally required in a radar transmitter.

Acoustic-wave devices as matched filters

In general, a matched filter maximizes the signal-to-noise ratio prior to detection, by shaping the received pulses.[3] This is done by restricting the bandwidth of the matched filter to the reciprocal of the pulse width. In this context, "noise" means any unwanted signal from any source, including thermal noise, intentional jamming and adjacent channel interference.

A matched filter can be described as a delayed reproduction, $H(\omega)$, of the spectral properties of the transmitted pulse, $F(\omega)$:

$$H(\omega) = F(\omega) e^{-j\omega t_o} \qquad (1)$$

For example, the output signal of a filter, $S(t)$, is described by the following inverse Fourier transform:

$$S(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega)\, H(\omega) e^{j\omega t}\, d\omega, \qquad (2)$$

where $F(\omega)$ is the Fourier transform of the input signal and $H(\omega)$ is the filter frequency response. In the case of a matched filter,

$$|S(t_o)| \sim \int_{-\infty}^{\infty} |F(\omega)|^2\, df \sim E, \qquad (3)$$

indicating that the peak signal power is proportional to the energy, E, of the received waveform. In the case of a rectangular rf or video pulse, Eq. 3 says that the matched filter output waveform, $|S(t_o)|$, will be a triangular waveform with twice the pulse width of the original waveform (Fig. 2a).

Now apply the matched-filter condition (Eq. 3) to the Schwarz inequality, which expresses the relationship between the integrals of products involving complex functions. The result is that the output signal-to-noise ratio, SNR_L, of the matched filter is a function of the energy of the received signal and the input noise spectral density, N_o:

$$SNR_L = 2E/N_o \qquad (4)$$

Eq. 4 indicates that the output signal-to-noise ratio for a simple rf or video-pulse matched filter is twice the input signal-to-noise ratio. Therefore the rf or video-pulse matched filter will improve the signal-to-noise ratio by 3 dB, resulting in a higher probability of detection and a lower probability of error compared with conventional filter techniques.

A wide selection of matched filters is available. Simple R-C low-pass or L-C bandpass matched filters can be synthesized in the frequency domain to provide a signal-to-noise enhancement of approximately 1.5 to 2.5 dB.

Time-domain, or dispersive, matched filters can

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also provide matched-filter capability by correlating long phase-modulated, or frequency modulated, rf sequences. However, conventional matched filters require sampling and conversion to baseband. Also, they are very sensitive to waveform distortion, interference and noise.

Acoustic surface-wave technology offers a method to build time-domain matched filters that is not limited by standard filter techniques using conventional R-L-C circuit elements. Instead the entire response of the matched filter is synthesized by a metallized pattern deposited on a piezoelectric substrate[4] (see box). Two acoustic surface-wave matched filters with this basic configuration are shown in Fig. 2.

Fig. 2a shows a 60-MHz, rf-pulse matched filter with 0.1-μs input pulse and 0.2-μs output triangular pulse. The matched filter consists of aluminum interdigital elements on a lithium-niobate substrate. In the output pulse, note the absence of ripple normally associated with conventional matched filters.

A multi-element (32-bit), 60-MHz, biphase-coded matched filter on quartz is shown in Fig. 2b. The input sequence bit time is 0.1 μs, and the output waveform has a basewidth of 0.2 μs.

A radar system using acoustic surface-wave devices is shown in block form in Fig. 1. The diagram represents an S-band, search radar requiring the following key specifications: a multiple target-range discrimination capability of approximately 40 ft, or a signal-return time-delay difference of approximately 0.04 μs, and a dynamic range—or ratio of maximum to minimum signal levels that can be unambiguously and simultaneously processed—of greater than 13 dB with a transmitter peak output power of less than 100 kW.

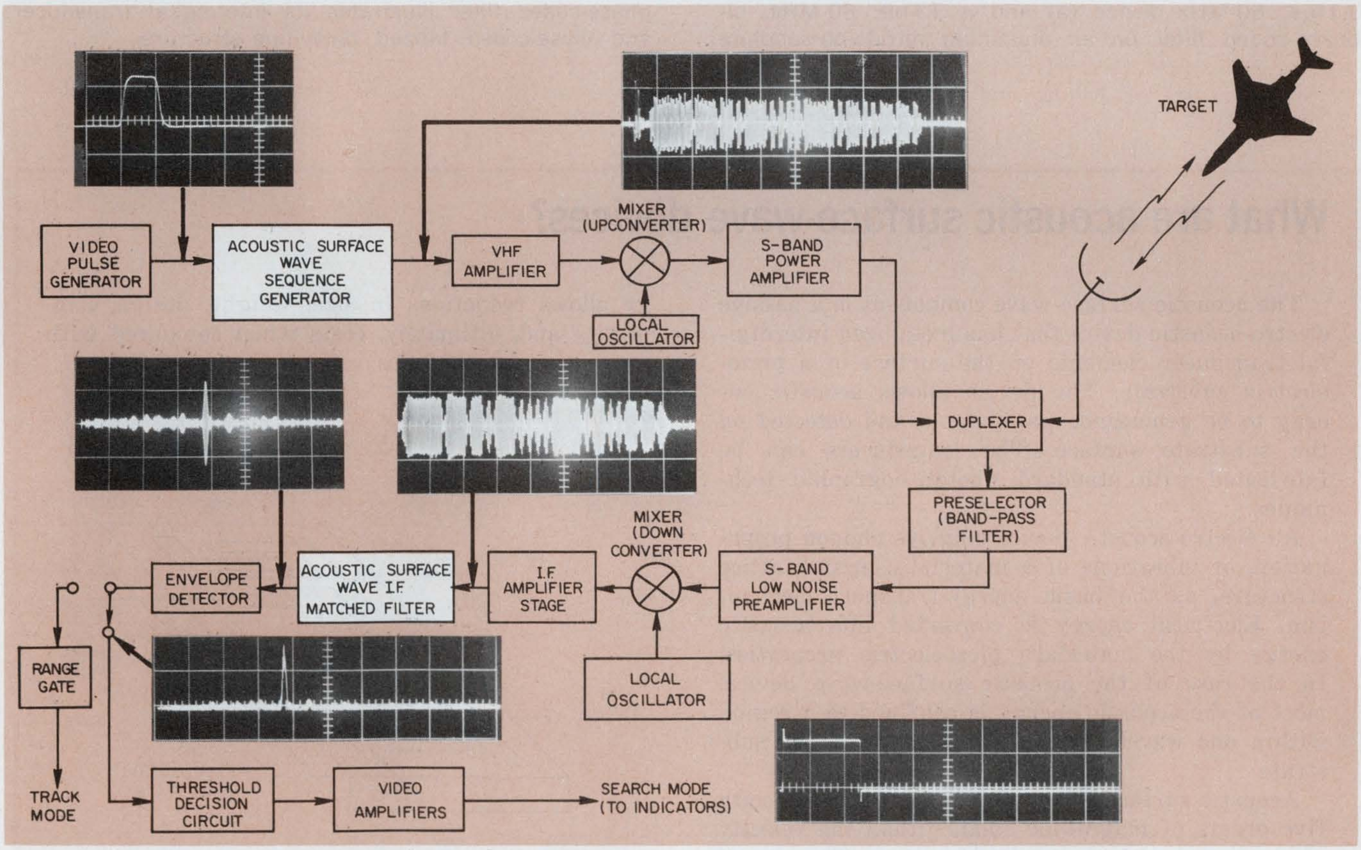
The radar-range equation reflects the effect of the matched filter:

$$R_{MAX} = \sqrt[4]{\frac{P_0 G^2 \lambda^2 \sigma_0 \Delta (S/N)_M}{B F L \quad (S/N)_D}}, \quad (5)$$

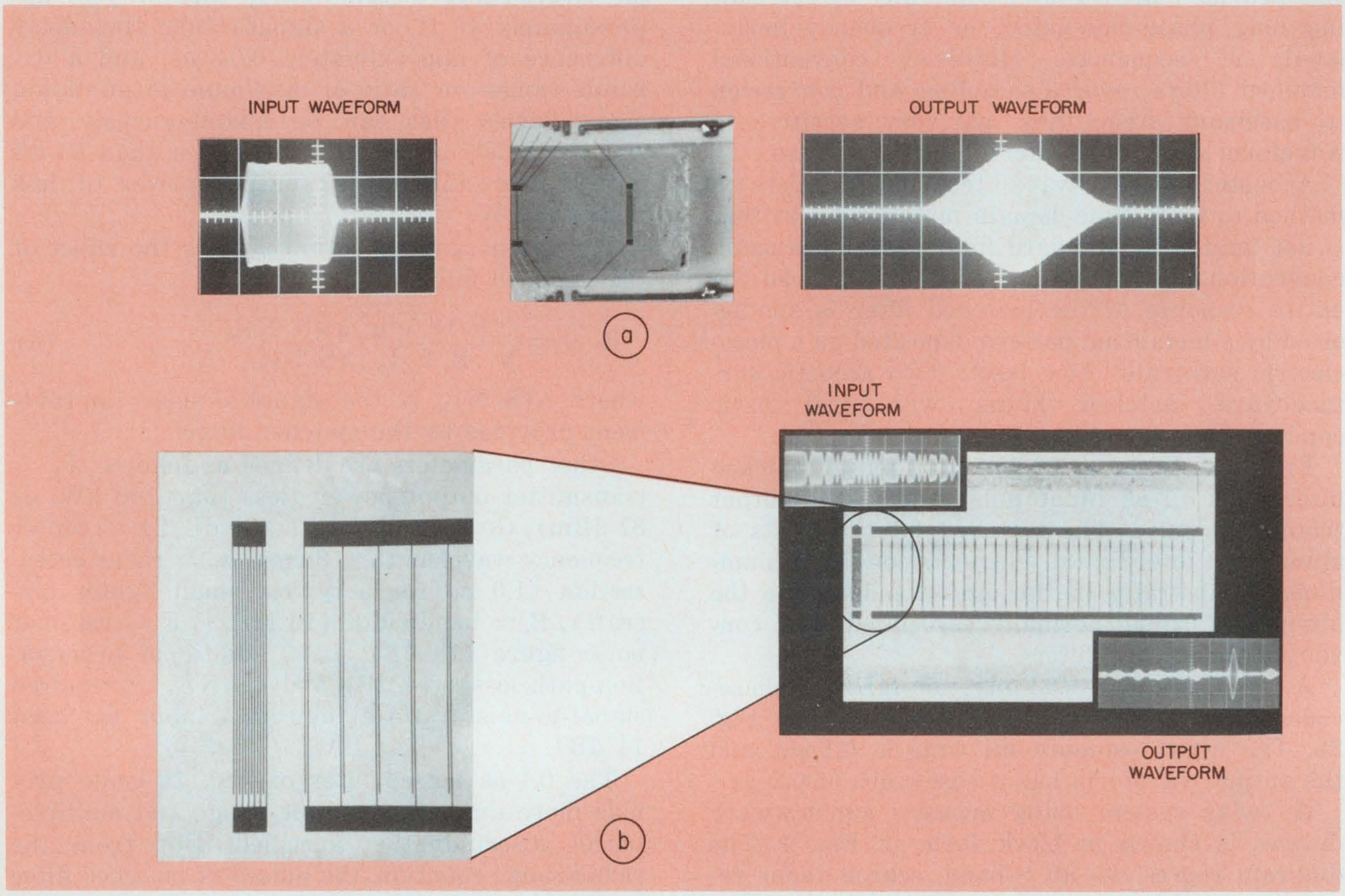
where $\Delta(S/N)_M$ is the signal-to-noise improvement provided by the matched filter.

Other parameters are defined as follows: P_0 = transmitter output power (less than 100 kW, or 87 dBm), G = antenna gain (30 dB), λ = center frequency wavelength (12 cm), σ_0 = radar cross-section (1.0 m^2 for a typical small fighter aircraft), B = bandwidth (10 MHz), F = receiver noise figure (10 dB), L = additional propagation-path losses (4 dB) and $(S/N)_D$ = required signal-to-noise ratio at detection input (at least 14 dB).

The 0.1-μs pulsed filter of Fig. 2a could provide more than the dynamic range and multiple-target discrimination specified. But from the radar-range equation, the pulsed rf matched filter would require a transmitter power of approxi-



1. **Phase-coded S-band radar** uses an acoustic surface-wave device for the sequence generator and the correlator. At the sequence generator, a narrow video pulse produces a 60-MHz center frequency, 10-MHz bit rate phase-coded rf sequence subcarrier that modulates an S-band carrier. The return signal reflected from a target is demodulated with the original phase-coded sequence extracted and subsequently correlated.



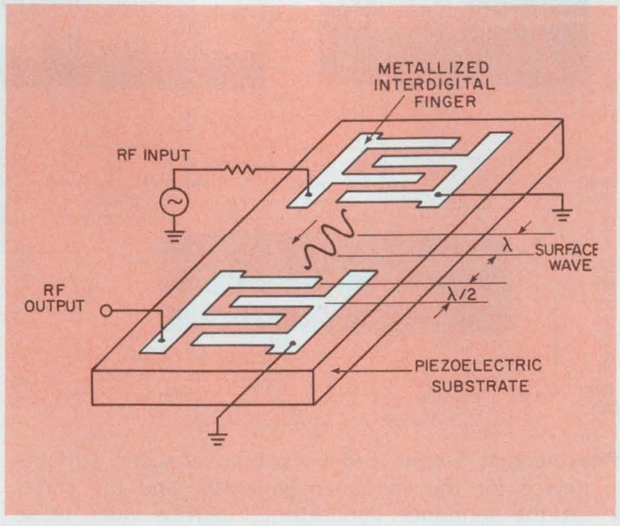
2. **Two acoustic surface-wave matched filters:** a simple 0.1-μs, 60-MHz device (a) and a 32-bit, 60-MHz, bi-phase-coded filter on an aluminum nitride-on-sapphire composite structure (b). An expanded ($\times$ 20) view of the phase-coded filter illustrates its interdigital transducer and phase-coded, tapped, delay-line structure.

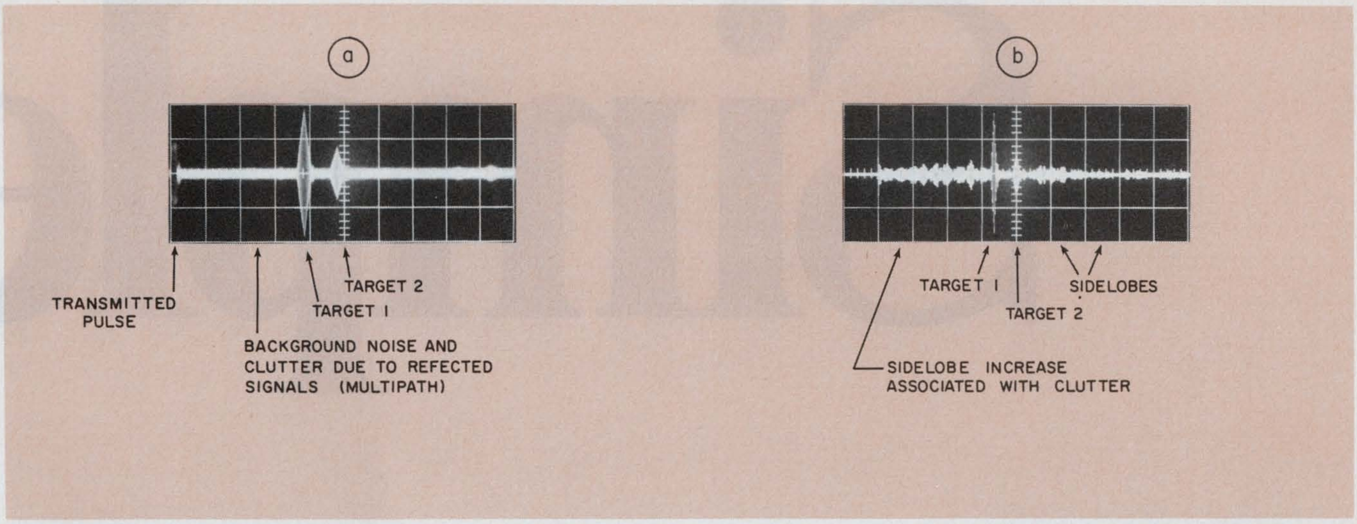
What are acoustic surface-wave devices?

The acoustic surface-wave component is a passive electro-acoustic device that has metallized interdigital transducer elements on the surface of a piezoelectric substrate. The device allows acoustic energy to be generated, manipulated and detected on the substrate surface. The transducers can be fabricated with standard photolithographic techniques.

An electro-acoustic device employs phonon propagation, or vibrations of a material's crystal lattice structure, as the basic energy-transport mechanism. Electrical energy is converted into acoustic energy by the material's piezoelectric properties. In the case of the acoustic surface-wave device, most of the acoustic energy is confined to a region within one wavelength of the surface of the substrate.

Acoustic surface waves propagate with a velocity five orders of magnitude smaller than the velocity of electromagnetic waves in free space. The size of many signal-processing devices depends directly on wavelength. Hence acoustic surface-wave technology allows reductions in size, weight, design complexity and, ultimately, costs when compared with conventional techniques.



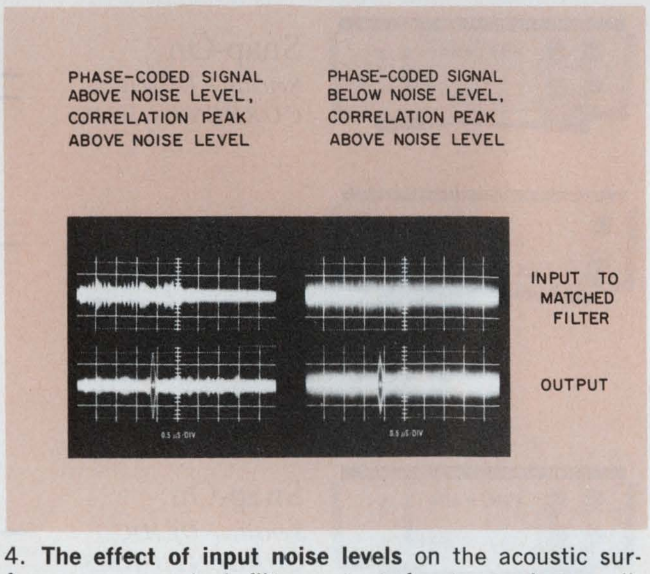


3. **Simulated radar return signals for the two filters** are shown for the simple device (a) and the 32-bit, phase-coded filter (b). Although the input waveforms have the same pk-pk voltage levels, the signal-to-noise ratio of the 32-bit filter is about 12 dB higher than the ratio for the rf pulse matched filter.

mately 1.0 MW, which is much higher than the transmitter power specified.

To get around this problem, we turn to the matched filter of Fig. 2b, which uses pulse-compression techniques. It provides an effective increase in transmitter power by correlating long phase-coded or linear-FM sequences.[5] In this example a long rf pulse is divided into contiguous subpulses, with the phase of each modulated by a coded binary sequence.

The simulated radar signal return for this type of matched filter is shown in Fig. 3. Fig. 4 provides an indication of the signal-to-noise improvement offered by a filter that is matched to a long phase-coded rf sequence. If the rf sequence is of a sufficient length, the matched filter can provide a detectable signal level, even when the input rf sequence is below the input noise level.



4. **The effect of input noise levels** on the acoustic surface-wave, matched filter output for two noise conditions. With a long-enough rf sequence, the matched filters can provide a detectable signal level when the rf sequence is below the matched-filter input noise level.

For the waveform of the phase-coded matched filter, signal-to-noise improvement is given by the following expression:

$$SNR_M = N\,(SNR)_i\,, \qquad (6)$$

where N is the number of coded subpulses and SNR_i is the signal-to-noise ratio at the input to the matched filter.[6] With the 32-bit filter replacing the simpler design, the resulting increase in the SNR_M of about 12 dB reduces the transmitter power requirement to approximately 62 kW.

A disadvantage of phase-coded matched filter techniques is their susceptibility to doppler variations. For the waveform shown in Fig. 2b, a 175-kHz variation in the center frequency reduces the SNR_M by approximately 3 dB. Where doppler effects become significant, a linear frequency-modulated sequence can be used to reduce the matched filter's sensitivity to frequency variations. ■■

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BCD multiplication: You can multiply digits by successive addition, or use a ROM multiplication table. Bit serial or bit parallel, here's how it's done.

This article, the second of a series on BCD logic, shows how BCD multiplication is performed.

To multiply two n-digit decimal numbers, a BCD system, like any other, must be able to:

- Store the multiplicand and multiplier.
- Generate the product of two individual digits.
- Shift the multiplicand to correspond to the decade of the multiplier digit.
- Accumulate the partial results.
- Present the output in an accumulator that holds 2n digits for a so-called double-precision product or n digits for a single precision product.

Although the circuit details of a BCD multiplier differ for bit-parallel and bit-serial inputs and outputs, the over-all organization does not. Hence the same system block diagram (Fig. 1) can describe both cases.

In the diagram, the inputs to a multiplier are designated as multiplicand X and multiplier Y, and both numbers are BCD digit-serial pulse trains. However, each digit may be either in bit-serial or bit-parallel form. The output signal, or product Z, then follows suit—it is a digit-serial pulse train in a corresponding bit-serial or bit-parallel format.

In general, an n-digit BCD multiplier needs three 4n-stage registers, an adder-multiplier unit (AMU), control logic and a timing generator. The multiplicand and the multiplier are stored in the input MC and MR registers, respectively. The input registers each feed the AMU one digit at a time, and the AMU multiplies them to form a partial product. Then the AMU sums each partial product with the content of the P register and shifts the result back into the P register. After n such operations, the total product is stored in the P register.

The AMU holds each multiplier digit, Y_i, for one word period, W_i, while it multiplies the multiplicand to generate the partial product, XY_i. The partial product is then added to the contents of the P register.

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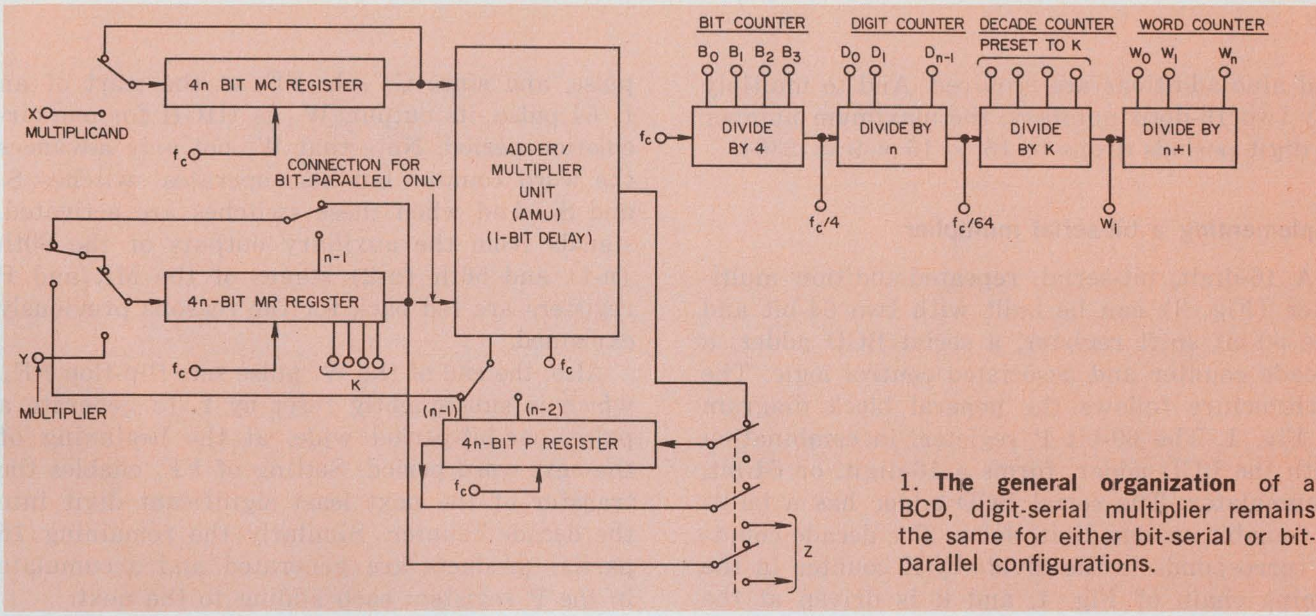
Though specific details of the timing generator can vary considerably for different multiplier types, many features are common to all. The timing generator must always include a divide-by-n counter to generate the digit intervals, D_0 to D_{n-1}. Also, a divide-by-(n + 1) counter generates the word intervals, W_0 to W_n. In a bit-serial multiplier, the timing chain must include a divide-by-four counter to generate the four intervals, B_0 to B_3—one for each BCD bit. Finally, a divide-by-K counter may be needed to keep track of the number of times the multiplicand is added into the output accumulator, as repeat-addition multipliers must.

The three 4n stage registers shift at the clock frequency, f_c. The output of each register is circulated back to the input, and the contents make a complete circuit once every n-digit interval, T_{CI}. During each D_0 interval the contents of the three registers will be in the original position. In the MC and MR registers the least-significant digit is at the right-hand end of the register and the most-significant at the left. During D_0 the least-significant digit is shifted out to the AMU and also back to the register's input. Similarly all the digits are successively shifted until at D_{n-1} the most-significant digit is presented to the AMU.

The time required to generate one partial product is one word period, W_i. And the number of T_{CI} periods in one word period varies from one, for a table look-up multiplier method, to several for repeated-addition multipliers. Generation of the total n-digit product requires n word periods. However, to allow register loading, n + 1 word periods must be provided. During W_0, or the first word period, the new inputs are shifted into the MC and MR registers and the contents of the P register are presented to the output.

The MR and P shift registers have auxiliary outputs. These provide a signal before it appears at the final output. The $n - 1$ output from the P register compensates for a one-digit delay in the AMU and the $n - 2$ divides the partial product by 10 to properly position it for addition to the next AMU output. In the MR register, the $n - 1$ out-



1. **The general organization** of a BCD, digit-serial multiplier remains the same for either bit-serial or bit-parallel configurations.

put is fed back to the input to advance the next least-significant digit into the MR final output stages.

The system of Fig. 1 is a double-precision multiplier; thus with two n-digit inputs, the output has 2n digits, and storage for 2n digits must be provided. This is done by using the MR register to store the n least-significant digits, while the n most-significant are in the P register.

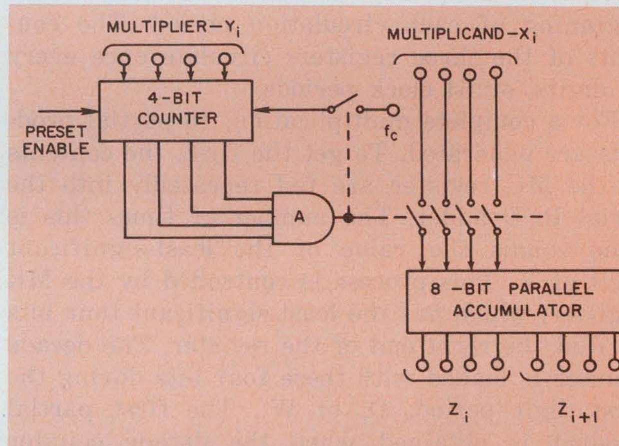
The register configuration, of course, changes with the form of the input/output signal. For bit-parallel signals, each of the three registers has four n-bit registers that operate in parallel. Thus in Fig. 1 each line that enters or leaves a register is then really four parallel signal lines. Similarly four-pole switches are needed instead of the single-pole switches shown. And the circulation time, T_{CI}, is n-clock periods, not 4n, as shown.

Examining the multiplying process

The digit multiplier is the most important part of an AMU. It generates the product of two single BCD digits. For example, if $X_i = 6$ and $Y_i = 7$, the digit multiplier generates the two-digit product Z_i and Z_{i+1}, which is equal to 42. For BCD, the digit multiplier has eight inputs—four for each X_i and Y_i,—and eight outputs—four for each Z_i and Z_{i+1}. And bit-serial signals must be first converted to parallel format before they can be applied to a digit multiplier.

In the simplest type of multiplication, the number representing the multiplicand X is added to an accumulator Y times, where Y is the number representing the multiplier. This repeated-addition technique can be applied at these levels:

- The digit-digit level. For example, the product of 789 × 234 is obtained by adding 789 to itself 234 times.



2. **This repeated-addition digit multiplier** requires, on the average, 4.5 clock periods to obtain the product of a pair of digits.

- The word-shift level. For example, the product of 789 × 234 is obtained by first adding 789 four times, then adding the shifted multiplicand, 7890, three times, and finally adding the twice-shifted multiplicant, 78900, two times.

Such a repeat-addition multiplier for single digits needs only an accumulator, a counter and some control logic (Fig. 2). The multiplier Y_i is preset into a counter. The counter is counted down at the clock frequency, and the multiplicand X_i is added to the accumulator—once for each clock pulse until the output of the counter is zero. Both the clock and X_i are then disconnected, and the accumulator contains the product.

But the execution time for the digit-digit approach is very long—as long as n × 10^n digit periods. Thus two 16-digit numbers may require a maximum of 16 × 10^{16} digit periods. However, significant improvement in execution time results with the word-shift approach. Thus, in the example 789 × 234, only two shift operations and nine additions are required. And to multiply any two 16-digit numbers, the maximum number of digit periods drops to $16 \times 16 \times 9 = 2304$.

Implementing a bit-serial multiplier

A 16-digit, bit-serial, repeated-addition multiplier (Fig. 3) can be built with two 64-bit and one 60-bit shift register, a serial BCD adder, a decade counter and associated control logic. The architecture follows the general block diagram in Fig. 1. The 60-bit P register, in combination with the BCD adder, forms a 16-digit, or 64-bit, accumulator. The serial BCD adder has a built-in four-bit, or one-digit, delay. The decade counter corresponds to the divide-by-K counter in the timing chain of Fig. 1, and it is driven at the circulation frequency, $f_c/64$, to advance at the beginning of each circulation period. The contents of the three registers circulate once every 16 digits, or 64 clock periods.

For a complete multiplication, 16 partial products are generated. To get the first, the contents of the MC register are fed repeatedly into the serial BCD adder. The number of times this is done equals the value of the least-significant digit of Y. This process is controlled by the MR register, which has the least-significant four bits of Y at the right end of the register. The decade counter is loaded with these four bits during the first digit period, D_0 of W_1. The first partial product is obtained when the decade counter reaches zero and the output of G_1 becomes LOW. The LOW signal disables G_2, opens switch S_4 and sets FF_1.

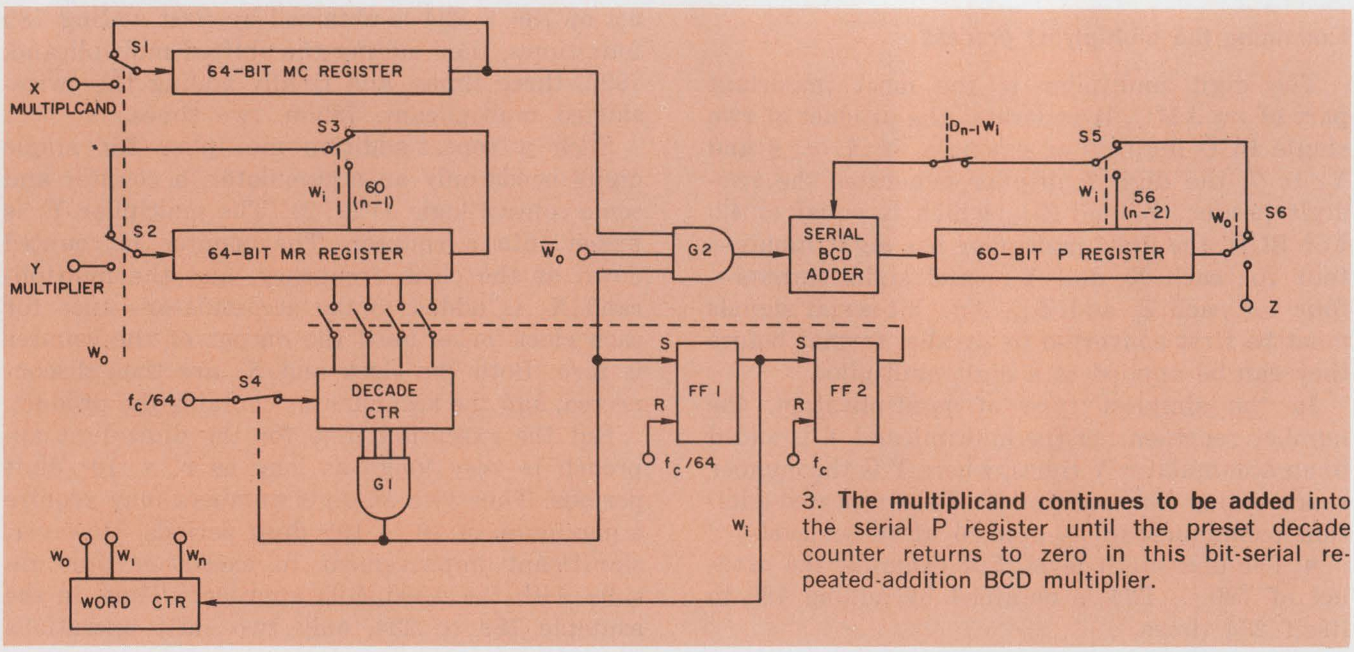
Flip-flop FF_1 resets at the end of each $f_c/64$ pulse, and since G_1 sets FF_1 at the start of an $f_c/64$ pulse, its output, W_i, is HIGH for one circulation period. Note that W_i not only advances the word counter but also operates switches S_3 and S_5. And when these switches are activated, signals from the auxiliary outputs of the 60th (n-1) and 56th (n-2) stages of the MR and P registers are fed back for the reasons previously explained.

Also, the end of the W_i pulse sets flip-flop FF_2, which is subsequently reset by f_c to generate a pulse, one-bit-period wide, at the beginning of the next word period. Setting of FF_2 enables the transfer of the next least significant digit into the decade counter. Similarly the remaining 15 partial products are generated and accumulate in the P register; each adding to the next.

This circuit requires a maximum of 9216 clock periods—$64 \times 9 \times 16$—to multiply two 16-digit numbers, or an average of 4608. Thus even with a clock frequency of only 100 kHz, multiplication will take only 46 ms on the average—fast enough for use in most calculators.

The doubling method needs half the steps

Whereas the digit-digit, repeated-addition technique requires an average of 4.5 additions to multiply two single digits, the doubling technique requires only 2.5. The principle here is, once again, repeated addition. But instead of adding only the multiplicand, X_i, either X_i or the doubled value, $2X_i$, is added to the accumulator in the successive addition operations. The magnitude of the multiplier digit, Y_i, determines whether X_i or $2X_i$ is added (Table 1a).



3. **The multiplicand continues to be added** into the serial P register until the preset decade counter returns to zero in this bit-serial repeated-addition BCD multiplier.

Since a binary number is doubled simply by shifting it one-bit position to the left, a four-bit BCD binary number is doubled in the same way. Of course, the result must be corrected if the doubled value is larger than 9 (as explained in the first article of this series, "BCD: Logic of Many Uses," ED No. 13, June 21, 1973, p. 90).

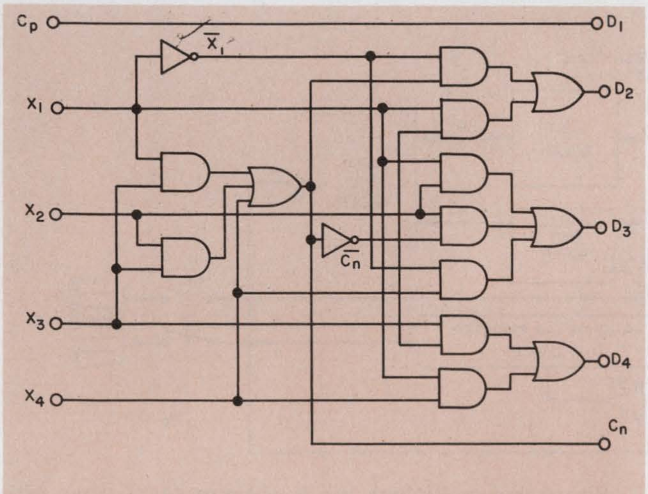
Though the shift-and-correction process is easy to understand, it is more complex for BCD numbers than the static-logic method described by the following logic equations. They express each bit, D_i, of the doubled value, $2X_i$, in terms of bits X_i and the previous carry bit, C_p:

$$D_1 = C_p$$
$$D_2 = X_1 \overline{C}_n + \overline{X}_1 C_n$$
$$D_3 = X_2 \overline{C}_n + X_2 \overline{X}_1 + X_4 \overline{X}_1$$
$$D_4 = X_4 X_1 + X_3 \overline{C}_n$$
$$C_n = X_4 + X_3 X_2 + X_3 X_1$$

These equations can be derived directly from the truth table (Table 1b), and they are easily implemented, as in Fig. 4. Other variations of this configuration are also possible. With additional control circuits, the circuit of Fig. 4 can be added ahead of the multiplicand input to the digit multiplier of Fig. 2.

The repeated-addition technique can also work with the value $5X_i$. However, the number of required additions still averages 2.5 per digit, as in the doubling method. And though generating $5X_i$ may be somewhat simpler than generating $2X_i$, the control logic is much more complex when the quintupler is incorporated into a digit multiplier. Thus the method is not particularly advantageous.

Also, though a nines-multiples technique can multiply two BCD digits in one addition time, the hardware requirements are too extensive to be practical for most calculator type applications. So let's move on to bit-parallel BCD multipliers.



4. **This multiply-by-two circuit** is implemented with combination logic only. The outputs D_1 to D_4 and the carry C_n have exactly twice the value of inputs X_1 to X_4 and carry C_p.

Bit-parallel BCD multipliers are fast

Bit-parallel multipliers are simpler to understand than bit-serial circuits because fewer operations are sequenced; they also operate faster. But bit-parallel multipliers use more hardware. Four parallel signal lines require four times as much circuitry, and four-bit parallel adders are

Table 1a. Multiply-by-two addition schedule

Value of multiplier Y_i		Number of additions
0	—	0
1	X_i	1
2	$2X_i$	1
3	$2X_i + X_i$	2
4	$2X_i + 2X_i$	2
5	$2X_i + 2X_i + X_i$	3
6	$2X_i + 2X_i + 2X_i$	3
7	$2X_i + 2X_i + 2X_i + X_i$	4
8	$2X_i + 2X_i + 2X_i + 2X_i$	4
9	$2X_i + 2X_i + 2X_i + 2X_i + X_i$	5

Table 1b. Multiply-by-two truth table

	Value of X_i					Value of $2X_i$			
C_p	X_4	X_3	X_2	X_1	C_n	D_4	D_3	D_2	D_1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	1	0
0	0	0	1	0	0	0	1	0	0
0	0	0	1	1	0	0	1	1	0
0	0	1	0	0	0	1	0	0	0
0	0	1	0	1	1	0	0	0	0
0	0	1	1	0	1	0	0	1	0
0	0	1	1	1	1	0	1	0	0
0	1	0	0	0	1	0	1	1	0
0	1	0	0	1	1	1	0	0	0
1	0	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	0	1	1
1	0	0	1	0	0	0	1	0	1
1	0	0	1	1	0	0	1	1	1
1	0	1	0	0	0	1	0	0	1
1	0	1	0	1	1	0	0	0	1
1	0	1	1	0	1	0	0	1	1
1	0	1	1	1	1	0	1	0	1
1	1	0	0	0	1	0	1	1	1
1	1	0	0	1	1	1	0	0	1

more complex than serial adders (Fig. 5).

Two divide-by-17 counters with decoding logic generate timing and strobe signals. For simplicity, Fig. 5 shows the multiplicand, multiplier and product registers as single blocks, the signal lines between the various circuit blocks as single lines, and some of the control logic as one-pole switch contacts.

Each of the four 16-stage shift registers can store one 16-digit BCD word in four-bit parallel form. One register is designated as the multiplicand (MC), another the multiplier (MR), the third the upper (U-P) product register and the fourth the lower (L-P) product register.

During input/output intervals, W_o, all registers are operated at the clock frequency, f_c. But during multiplication intervals, W_1 to W_{16}, only the MC and the U-P registers are clocked with f_c and the MR and L-P registers with the word frequency $f_c/16$, or D_o.

Two registers provide the 2n capacity to store the resulting product from two n-digit words. The U-P register stores the n most-significant product digits and the L-P register the n least-significant digits. During each circulation of the partial product, the least-significant digit in the U-P register transfers into the L-P register. This takes place during the first-digit clock period, D_o, of each 16-digit word. The contents of the MR and L-P registers also advance one digit. D_o is therefore referred to as the "spacing" interval.

Shift operations in the MC and U-P registers can be continuous. This is because all registers are made n stages long; each word period, W_i, is n + 1 digit periods long, and there is a one-bit delay in the feedback path of the MC register. Thus, during D_o, the MC register can circulate without stopping, while the U-P register transfers its least-significant digit into the L-P register.

Though the multiplier in Fig. 5 shows 2n stages of product registers, the lower product register can be eliminated by shifting the least-significant digit into the MR register, as in Fig. 1.

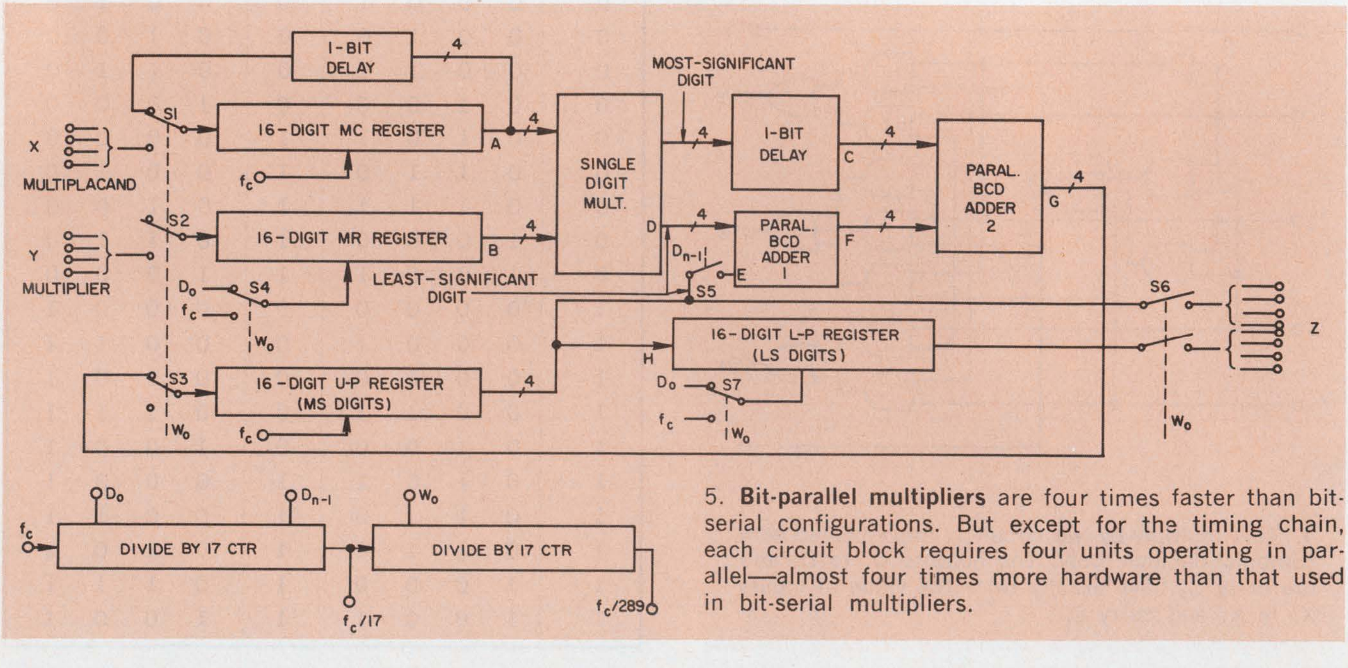
A ROM can multiply

The digit multiplier accepts the multiplicand and multiplier digits and provides a parallel two-digit product. Though any of the digit-multiplier methods previously described can be used, the simplest and fastest solution is a table look-up method. With a fast look-up multiplier—one that can multiply in less than 1 μs—and fast parallel adders, the Fig. 5 multiplier can multiply two BCD digits in one clock period.

An 800-bit semiconductor ROM on a small silicon chip area can easily store the 100 possible values of the product, Z, of two X_i and Y_i digits. Each location on the ROM is addressed by eight bits—four from X_i and four from Y_i.

The 100 ROM locations store the products listed in Table 2. At most, two decimal digits are needed to express a product. The maximum product is 81. Accordingly eight bits can provide the two-digit outputs. And, finally, parallel BCD adders sum the digit multiplier output with the U-P register output.

Though the signal format is bit-parallel, it is still digit-serial. Therefore digit functions occur sequentially, and a timing generator is needed to provide the necessary control signals. It is



5. **Bit-parallel multipliers** are four times faster than bit-serial configurations. But except for the timing chain, each circuit block requires four units operating in parallel—almost four times more hardware than that used in bit-serial multipliers.

convenient to use two modulo-17 counters to divide the clock frequency, f_c, into both the word frequency, $f_c/17$, and the over-all cycle frequency $f_c/289$. One cycle period, therefore, has 17 words with each word 17-digit-periods long. And only the digit period, D_0, and the word period, W_0, are needed to control the multiplier operation.

Timing is important

During the input or output functions, which take place during the word interval W_0, the numbers X and Y are loaded into the MC and MR registers. Simultaneously the contents of the two product registers, U-P and L-P, are shifted to the output and thus also cleared for the next multiplication. Further, the switches S_1 to S_4, S_6 and S_7 are in their lower position. Thus at the end of the period W_0 the two product registers are empty, and the MC and MR registers are loaded, with the least-significant digits at the right ends of the registers.

The multiplication function can be subdivided into 16 identical subfunctions, each of one word length. During each subfunction a new partial product is generated when the digit multiplier output is added to the previous partial product. The 16 subfunctions occur during word intervals W_1 to W_{16}. The timing and control operations for multiplication must ensure the following:

- That corresponding digits of the multiplicand and multiplier reach the digit multiplier.
- That the digit multiplier's outputs are summed with the proper partial product.
- That the resulting new partial product is properly fed back to the U-P register.
- That the least-significant digit of the new partial product is shifted into the L-P register.

During each word time all 16 digits of the multiplicand are multiplied with one digit of the multiplier. To achieve this, the multiplicand is shifted at the clock frequency, f_c, and the multiplier at the word frequency, $f_c/17$. The MR output is constant during digit intervals D_1 to D_{16}, and its contents are shifted only at the beginning of each digit period, D_0.

The detailed functions performed by the adders and multiplier during each clock period can be seen from Fig. 6, which uses the example

$$789 \times 987 = 778743.$$

To simplify the illustration, only three-digit numbers are used for the multiplicand and the multiplier. Consequently only three stages would be needed for the MC, MR, U-P and L-P registers, and only four digit times, D_0 to D_3, and four word times, W_0 to W_3 are shown.

For simplicity, the time is plotted from right to left—the way it would be if multiplication were done with paper and pencil. With a pencil, you proceed as follows:

$$\begin{array}{r} 987 \\ \times 789 \\ \hline 5523 \\ 6312 \\ 7101 \\ \hline 778743 \end{array}$$

Thus the multiplication operation starts at the right of Fig. 6 (D_0 of W_1) where the outputs of the MC and MR registers are 9 and 7. The digit multiplier generates the number 63. But the more-significant digit has a one-bit delay; thus only the 3 is presented to parallel BCD adder 2 via adder 1. Note that the contents of the product register U-P, is still zero and that thus the output of adder 1 is simply 3.

During the next interval (D_1 of W_1) the MC and MR register outputs are 8 and 7. Thus the digit multiplier output is 56. But the one-bit delay causes adder 2 to see a 6 + 6. The adder-1 output is 6, since the product register output is still zero. However, the adder-2 output becomes 12—the 6 from adder 1 and the delayed 6 from the previous multiplication. Thus adder-2 output is a 2 plus a carry stored in adder 2.

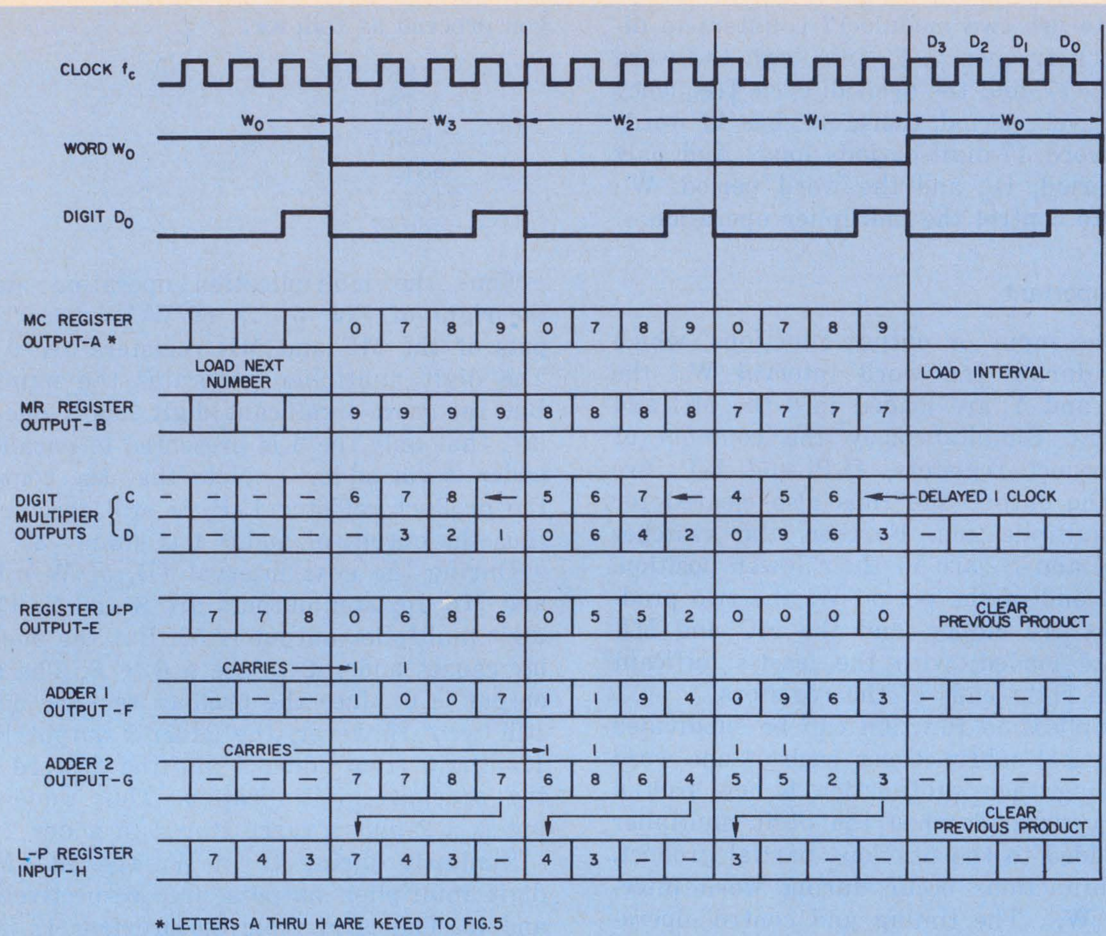
Similarly during D_2 of W_1, the MC, MR and digit multiplier outputs are, respectively, 7, 7 and 49. The carry from the previous 12 is stored in adder 2. Since the adder-1 output is $9 + 0 = 9$, the adder-2 output, together with its stored carry and previously delayed 5, becomes $1 + 5 + 9 = 5$, plus a carry stored in adder 2.

During D_3 of W_1 the MC and MR register outputs are zero and 7. Thus the digit multiplier output is zero. But there is still the delayed 4 from the previous digit, and a carry is stored in adder 2. Accordingly adder 1's output is zero, and adder 2's is $4 + 1 = 5$.

Each digit output from adder 2 is shifted into the U-P product register. But since the register is now only three digits long, when the 5 gen-

Table 2. ROM multiplier products

		Multiplier Y									
		0	1	2	3	4	5	6	7	8	9
	0	0	0	0	0	0	0	0	0	0	0
	1	0	1	2	3	4	5	6	7	8	9
	2	0	2	4	6	8	10	12	14	16	18
	3	0	3	6	9	12	15	18	21	24	27
Multiplicand	4	0	4	8	12	16	20	24	28	32	36
X	5	0	5	10	15	20	25	30	35	40	45
	6	0	6	12	18	24	30	36	42	48	54
	7	0	7	14	21	28	35	42	49	56	63
	8	0	8	16	24	32	40	48	56	64	72
	9	0	9	18	27	36	45	54	63	72	81



6. **Timing schedule** for multiplying 789 and 987.

erated during D_3 is shifted in, the 3 generated during D_0 of W_1 emerges from the output end and goes to the L-P register.

The time intervals that follow now have subproducts other than zero in the U-P register. Thus, during D_0 of W_2, the outputs of the MC and MR registers are 9 and 8. The digit multiplier output is 72, the seven is delayed and only the 2 is transferred to adder 2. But the U-P register output is 2; thus the adder-1 and adder-2 outputs are both 4.

During D_1 of W_2 the MC and MR outputs are both 8, and the digit multiplier output is 64. But because of the one-bit delay, 7 + 4 is transferred to the adders. With a U-P register output of 5, the adder-1 output is 4 + 5 = 9, and the adder-2 output is 7 + 9 = 6, plus a carry. In a similar fashion the subsequent steps of Fig. 6 are carried out.

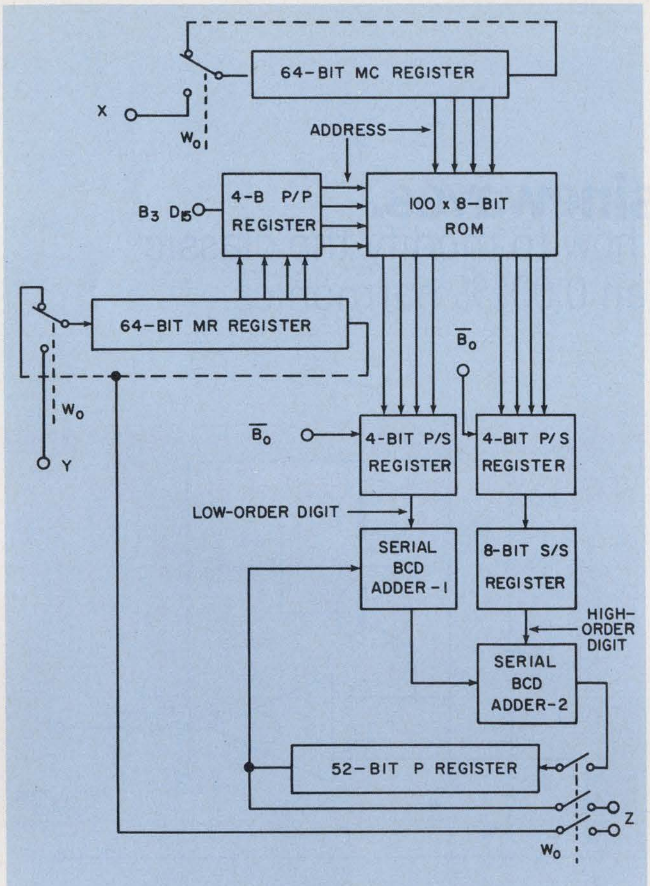
When two new numbers are presented to the multiplier system during W_0 of the next multiplication period, the new data enter the MC and MR registers, and the contents of the U-P and L-P registers are shifted out, least-significant bit first. In the conventional order the output reads 778743, which is the correct result.

To speed slow all-bit-serial multipliers, you can use a bit-parallel, table look-up digit multiplier (Fig. 7).

Other methods are possible

Many control details, such as the process that divides partial products by 10, have been left out of the figure, since they are similar to the methods used in the previously described multiplier systems. Thus we can concentrate on the salient points and differences more effectively. The required timing chain in the table look-up approach must provide 17 word intervals, W_0 to W_{16}, with 16 digit intervals, D_0 to D_{15} each. To multiply two 16-digit numbers, the circuit generates 16 partial products, and for each, 16 digit multiplications are performed. Thus, with one-digit multiplication executed every four bit intervals—B_0 to B_3— 1024 clock periods (4 × 16 × 16) are required. Hence, with a 100-kHz clock, one multiplication takes about 10 ms.

The last four stages of the MC register provide half of the ROM address signal. The ROM outputs are preset into buffers at the beginning of the second half of B_0; thus no input gating



7. **A good compromise between speed and hardware** is to use a parallel-configured look-up table for the digit multiplier and serial circuits for the shift registers, adders and control logic.

or buffering of the MC outputs is needed.

And the last four stages of the MR register provide the other half of the ROM address. Because this half must be constant for one word duration, it is loaded into a buffer register. This transfer is carried out one-half bit interval before the next word starts—at the beginning of the second half of bit-time B_3 and digit-time D_{15}. The ROM outputs are thus constant for one clock period—more than ample time to load them into the two four-bit registers at the beginning of the second half of B_0. The content of these two registers is then serially shifted to the two BCD adders. The low-order digit is connected directly to the first adder and the high-order goes to the second adder, but via an eight-bit delay.

From the previously described multiplier system, one might expect the high-order digit to be delayed only one digit time (four-bit intervals). In this implementation, however, it must be delayed two digit intervals, because the first BCD adder introduces a four-bit delay. And with two BCD adders in cascade, a total delay of eight-bit times is produced. Thus, the P register is only 52 stages long. ■■

The third article will discuss BCD dividers.

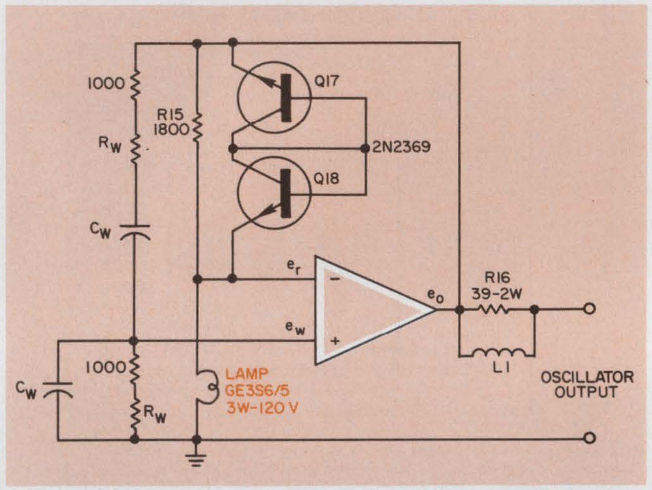
Generate low-distortion sinewaves.

Analysis of the error sources shows how to modify the classic Wien-bridge oscillator to get less than 0.001% harmonics.

Oscillators are widely used as sources of low-distortion test signals. But what do you do if standard circuits don't yield low enough distortion? There are two approaches you can take: You can use special measurement techniques to circumvent the intrinsic distortion of the best-available oscillator, or you can design your own low-distortion oscillator.

Let's assume you decide on the latter approach. You can design a circuit that has a harmonic distortion of less than 0.001% over most of the audio band, an output impedance of less than 1 Ω (which means you can drive low impedance or nonlinear loads), and a power-supply feedthrough of only 0.0002% of the output.

By contrast a typical commercial oscillator has a distortion of 0.5%, a 75-Ω output impedance and a power-supply feedthrough of 0.1% of the rated output.



1. **Complete Wien-bridge oscillator** uses a lamp for amplitude stabilization. The frequency-determining network consists of R_w and C_w.

Basic oscillator is Wien bridge

Basically the oscillator (Fig. 1) is a Wien-bridge circuit in which ultra-low distortion is achieved by reducing nonlinearities in both the input and output stages, reducing the output level and impedance, and taking special pains to analyze and reduce drastically distortion caused by the amplitude stabilizing network.

The amplifier portion of the oscillator (Fig. 2) is actually a high-gain, power op amp. The large dc gain (10^5) reduces both output impedance and nonlinearities in the output stage. Even so, the output is operated in Class A to avoid the higher harmonics produced by crossover distortion.

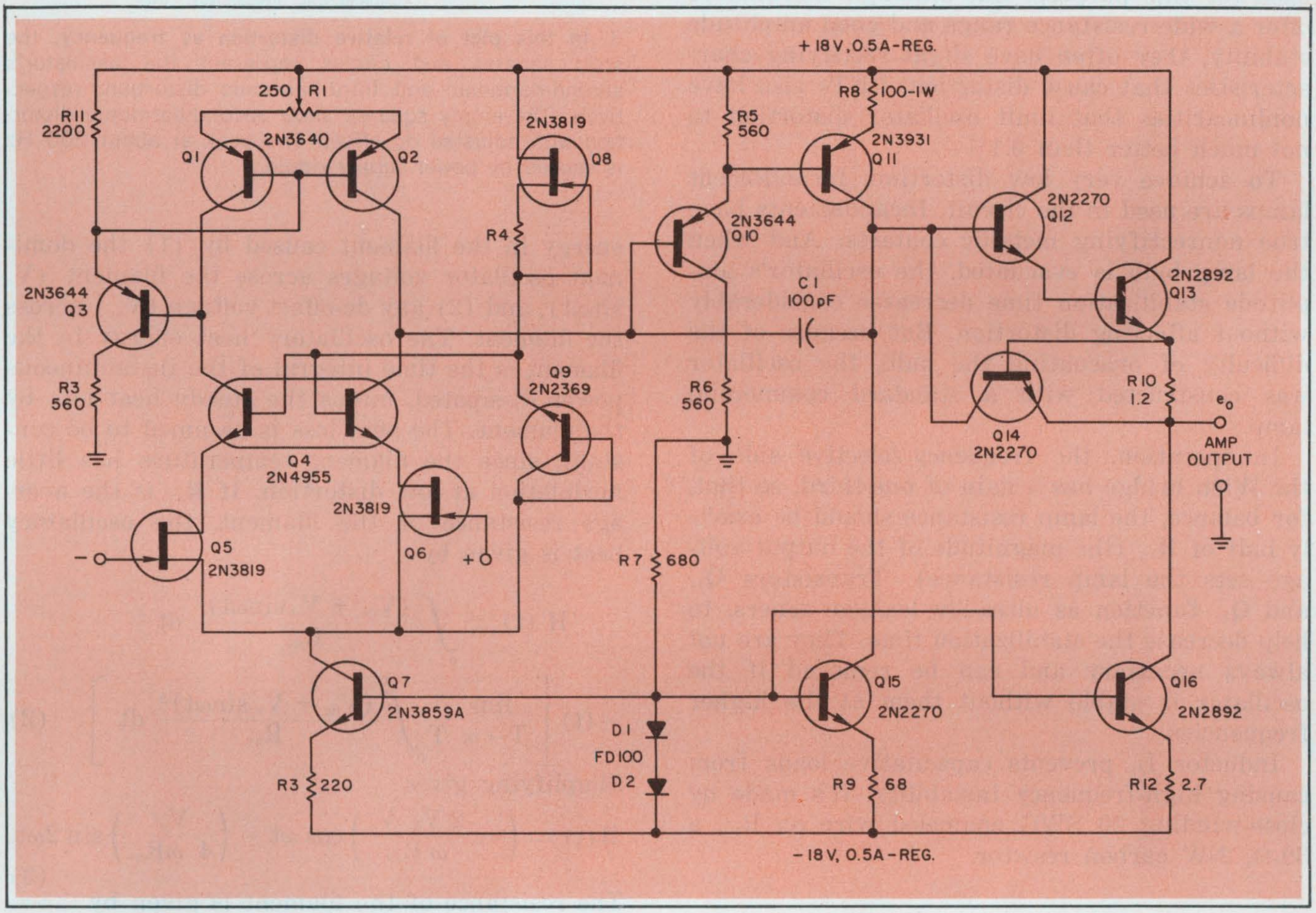
In the input stage two FETs (Q_5 and Q_6), matched for similar gate and drain characteristics, minimally load the feedback network. However, since the feedback network attenuates the output voltage by a factor of only three, a large common-mode signal can appear at the inputs. Any nonlinearities in the common-mode error signal will thus cause distortion.

To prevent this, the input FETs are boot-strapped in cascode fashion with a bipolar transistor, Q_4. The actual drain-to-source voltage of Q_5 and Q_6 is about 6.5 V, as determined by the emitter-base zener voltage of Q_9. The zener is operated at a constant current—set by R_4 and Q_8 to 1 mA —so as not to influence the constant-current condition of the input stage. Adjustment of R_1 allows the dc offset of the amplifier to be nulled.

The differential-current signal from the collectors of Q_4 is converted to a single-ended current source by the current mirror, Q_1, Q_2, and Q_3. This signal is amplified by the Darlington driver stage, Q_{10} and Q_{11}, which has single-pole compensation because of capacitor C_1 and high gain because of the dynamic load, Q_{15}. To reduce loading of the driver, the output stage is a Darlington emitter-follower with a gain of nearly unity. Current-source Q_{16} biases the output stage into Class-A conditions at about 250 mA.

Various protective elements are used in the circuit: R_2, R_8 and R_6 limit the currents to Q_3, Q_{11} and Q_{10}, respectively. Components R_{10} and Q_{14} limit the current in Q_{12} and Q_{13} to 500 mA,

John Vanderkooy and **Cameron J. Koch,** Physics Dept., University of Waterloo, Ontario, Canada
(Dr. Koch is presently with the Laboratory of Radiobiology, University of California Medical Centre, San Francisco)



2. **Schematic of power op amp** used in oscillator. The design of input and output stages is critical—nonlinearities in these stages plus output impedance are reduced to minimize distortion.

giving an output capability of 250 mA.

The oscillator thus has an output impedance of less than 1 Ω and is capable of driving a load as low as 30 Ω at 5 V rms with very little increase in distortion. This often obviates the need for auxiliary amplifiers, which inevitably contribute distortion.

Since all transistors are high-frequency types, care must be taken to lay out the circuit properly and to decouple the power supply.

The amplifier has high common-mode and power-supply rejection factors (greater than 110 dB) and gives good performance even with simple capacitor-input power-supply filters and a power-supply ripple voltage of 0.5 V pk-pk. But for highest performance, regulated supplies should be used. All current-carrying lines should be grounded at a single point. And it's especially important to use either a magnetically shielded power transformer or to place the transformer as far as practical from the oscillator circuit to avoid hum.

Unity gain bw is high

The measured unity-gain frequency of the amplifier is over 10 MHz, and its slewing rate is 20 V/μs, as determined from the 2-mA output-current capability of the input stage and the 100-pF compensation capacitor, C_1.

In the complete oscillator, the amplifier of Fig. 2 is replaced by the conventional op amp symbol. The frequency is changed by varying R_w, a dual 10-turn potentiometer of 10 kΩ that gives an 11-to-1 frequency ratio. Ganged capacitors, C_w, are switchable from 10 to 0.01 μf in four decade ranges. The total frequency range is 12 Hz to 120 kHz.

Amplitude stability is achieved by use of a power-sensitive, variable resistance in a negative-feedback loop. Thermistors or FETs are often used for this purpose. But although thermistors offer a wide resistance range and good amplitude stability, they often have slight rectifying characteristics that cause distortion. FETs also have nonlinearities that limit oscillator distortion to not much better than 0.1%.

To achieve very low distortion, incandescent lamps are used in the circuit. Incandescents have true nonrectifying metallic contacts. And when the lamp bulb is evacuated, the oscillator's amplitude stabilization time decreases considerably without affecting distortion. But because of the difficulty of evacuating the bulb, the oscillator was constructed with a standard commercial lamp.

In operation, the frequency-selective side of the Wien bridge has a gain of one-third, so that, for balance, the lamp resistance should be exactly half of R_{15} (the magnitude of the output voltage sets the lamp resistance). Transistors Q_{17} and Q_{18} function as ultra-low-leakage zeners, to help decrease the stabilization time. They are not always necessary and can be removed if the oscillator is stable without them at the higher frequencies.

Inductor L_1 prevents capacitative loads from causing high-frequency instability. It's made by close-winding 20 SWG enameled wire on R_{16}, a 39-Ω, 2-W carbon resistor.

Thermal modulation causes distortion

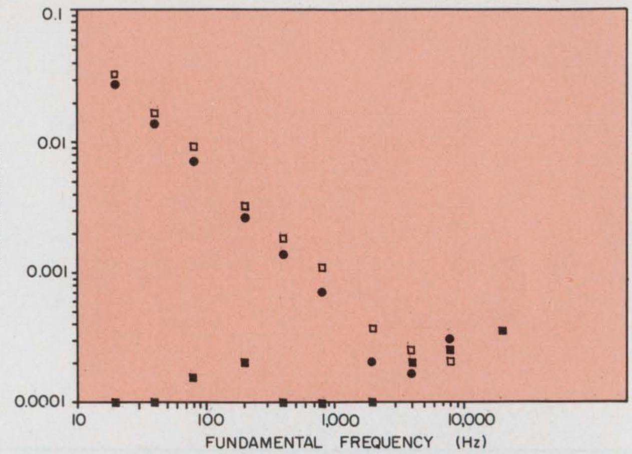
Analysis of the oscillator shows that thermal modulation of the lamp resistance causes third-harmonic distortion and that a dc bias across the lamp produces second-harmonic distortion as well.

Consider the voltages e_o, e_w, and e_r (Fig. 1). Let the output voltage e_o be described by

$$e_o = 3\,V_o(\sin\omega t + a_1 \sin 2\omega t + b_1 \cos 2\omega t + a_2 \sin 3\omega t + b_2 \cos 3\omega t), \qquad (1)$$

to first order, where a_1, b_1, a_2 and b_2 are quite small. The factor three is used so that the voltages e_w and e_r (which are forced to be equal by the amplifier) have dominant terms of $V_o \sin\omega t$.

To determine just how the resistance of the lamp fluctuates, calculate the oscillatory heat



3. **In this plot of relative distortion vs frequency,** the solid squares and circles represent the oscillator's second-harmonic and third-harmonic distortion, respectively. The empty squares show second-harmonic distortion with adjusted dc offset. The peak at about 200 Hz is caused by power-supply ripple.

energy in the filament caused by (1) the dominant oscillator voltages across the filament ($V_o \sin\omega t$), and (2) any dc-offset voltage (V_{dc}) across the filament. The oscillatory heat energy in the filament is the time integral of the instantaneous power dissipated, minus the steady heat loss by the filament. The heat loss is assumed to be constant, since the filament temperature has little modulation at low distortion. If R_{av} is the average resistance of the filament, the oscillatory heat is given by

$$H(t) = \int_0^t \frac{(V_{dc} + V_o \sin\omega t)^2}{R_{av}}\,dt - (t)\left[\lim_{T\to\infty} \frac{1}{T}\int_0^T \frac{(V_{dc} + V_o \sin\omega t)^2}{R_{av}}\,dt\right]. \qquad (2)$$

Simplifying gives

$$H(t) = \left(-\frac{2\,V_{dc}\,V_o}{\omega\,R_{av}}\right)\cos\omega t - \left(\frac{V_o^2}{4\;\omega R_{av}}\right)\sin 2\omega t. \qquad (3)$$

The resistance of the filament is given by

$$R(t) = R_{av} + \frac{\gamma\,H(t)}{\kappa}, \qquad (4)$$

where γ is the temperature coefficient of resistance and κ is the heat capacity of the filament. This gives

$$R(t) = R_{av}\,[1 - \alpha\cos\omega t - \beta\sin 2\omega t], \qquad (5)$$

where $\alpha = \dfrac{2\,V_{dc}\,V_o}{\omega\kappa\,R_{av}^2}$ and $\beta = \dfrac{\gamma\,V_o^2}{4\,\omega\kappa\,R_{av}^2}$

Now the average lamp resistance must equal one-half of R_{15} so that

$$e_r = \left(\frac{R(t)}{2R_{av} + R(t)}\right) e_o.$$

Substituting for $R(t)$, we get: $e_r = V_o\,[\sin\omega t - \frac{\beta}{3}\cos\omega t + (a_1 - \frac{\alpha}{3})\sin 2\,\omega t + b_1\cos 2\,\omega t + a_2 \sin 3\,\omega t + (b_2 + \beta/3)\cos 3\,\omega t]$. (6)

By using the transfer function of the frequency-selective side of the Wien bridge, we obtain:

$$e_w = V_o \left[\sin \omega t + \left(\frac{4\,a_1}{5} + \frac{2\,b_1}{5} \right) \sin 2\omega t + \left(-\frac{2\,a_1}{5} + \frac{4\,b_1}{5} \right) \cos 2\omega t + \left(\frac{81\,a_2}{145} + \frac{72\,b_2}{145} \right) \sin 3\omega t + \left(-\frac{72\,a_2}{145} + \frac{81\,b_2}{145} \right) \cos 3\,\omega t \right] . \quad (7)$$

The enforcing condition, $e_r = e_w$, leads to two sets of coupled linear equations that give:

$$a_1 = \frac{\alpha}{3},\ b_1 = \frac{2\,\alpha}{3},\ a_2 = -\frac{3\,\beta}{8},\ b_2 = -\frac{\beta}{3} . \quad (8)$$

The term in e_r of $\beta/3 \cos \omega t$ represents a small frequency shift that was not previously allowed for. Although it changes all the coefficients in e_w very slightly, the error is of second order and therefore negligible. In fact, the relative frequency shift can be shown to be

$$\frac{\Delta\omega}{\omega} = \frac{\beta}{2} .$$

Since in this oscillator β is less than 10^{-3}, the frequency shift is too small to measure.

The total second and third-harmonic distortions from the coefficient equations (8) are

$$D_2 = \frac{\sqrt{5}}{3}\,\alpha;\ D_3 = \frac{\sqrt{29}\,\sqrt{5}}{24}\,\beta, \text{ respectively.} \quad (9)$$

$$\frac{D_2}{D_3} = \frac{8\,\alpha}{\sqrt{29}\,\beta} = \frac{64}{\sqrt{29}} \left(\frac{V_{dc}}{V_o} \right) = 11.9 \left(\frac{V_{dc}}{V_o} \right) . \quad (10)$$

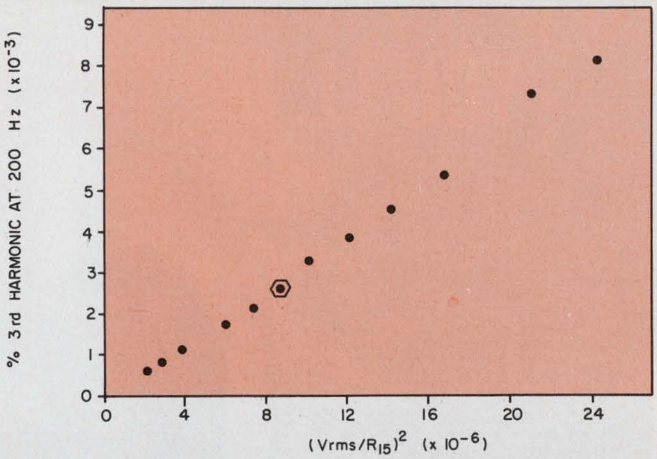
Thus we see that to eliminate the second harmonic, the amplitude-stabilizing lamp should have a negligible dc offset, compared with the peak output voltage across the lamp.

Measurements substantiate theory

Measurements of distortion have confirmed the theory (Fig. 3). The oscillator's fundamental signal was nulled by a switchable twin-T filter, and the harmonics were measured by a Hewlett-Packard 302A wave analyzer. As expected, the transfer characteristic of the twin-T filter was found to attenuate the second and third harmonics by factors of 2.86 and 1.79, respectively.

In Fig. 3, the shaded circles represent third harmonics and the shaded squares second harmonics when the dc offset is carefully trimmed to zero. A distortion of 0.0001% represents the limit of the measuring apparatus, corresponding to a measured wave-analyzer signal of about 2 μV for a 5-V oscillator output.

Note that the third-harmonic distortion varies inversely with frequency at the lower frequencies. Mathematically, this is illustrated by the single integration necessary to calculate the oscillatory heat energy of the filament. Beyond 1 kHz, the distortion is mainly third harmonic and well below 0.001%. At higher frequencies distortion begins to rise slightly, perhaps because of the decreasing gain of the op amp with frequency.



4. **Measured variation of third-harmonic distortion** with output voltage verifies the dependence of the lamp's thermal modulation on $(V_o/R_{av})^2$.

The empty squares of Fig. 3 represent second-harmonic distortion when the amplifier is offset with R_1, so that $V_{dc}/V_o = 0.089$. Eq. 10 predicts approximately equal second and third-harmonic distortion. In this case, the measured third harmonic was not significantly different, and the second harmonic rose 20% higher than expected.

Distortion at the lower frequencies can be further reduced by decreasing the output voltage. This is achieved by reducing R_{15}. Fig. 4 shows a plot of the third-harmonic distortion at 200 Hz vs $(V_{rms}/R_{15})^2$, which is proportional to $(V_o/R_{av})^2$. Eq. 5 predicts that the plot should be a straight line. The hexagon shows the normal operating point for the lamp chosen. The circles fit a straight line reasonably well.

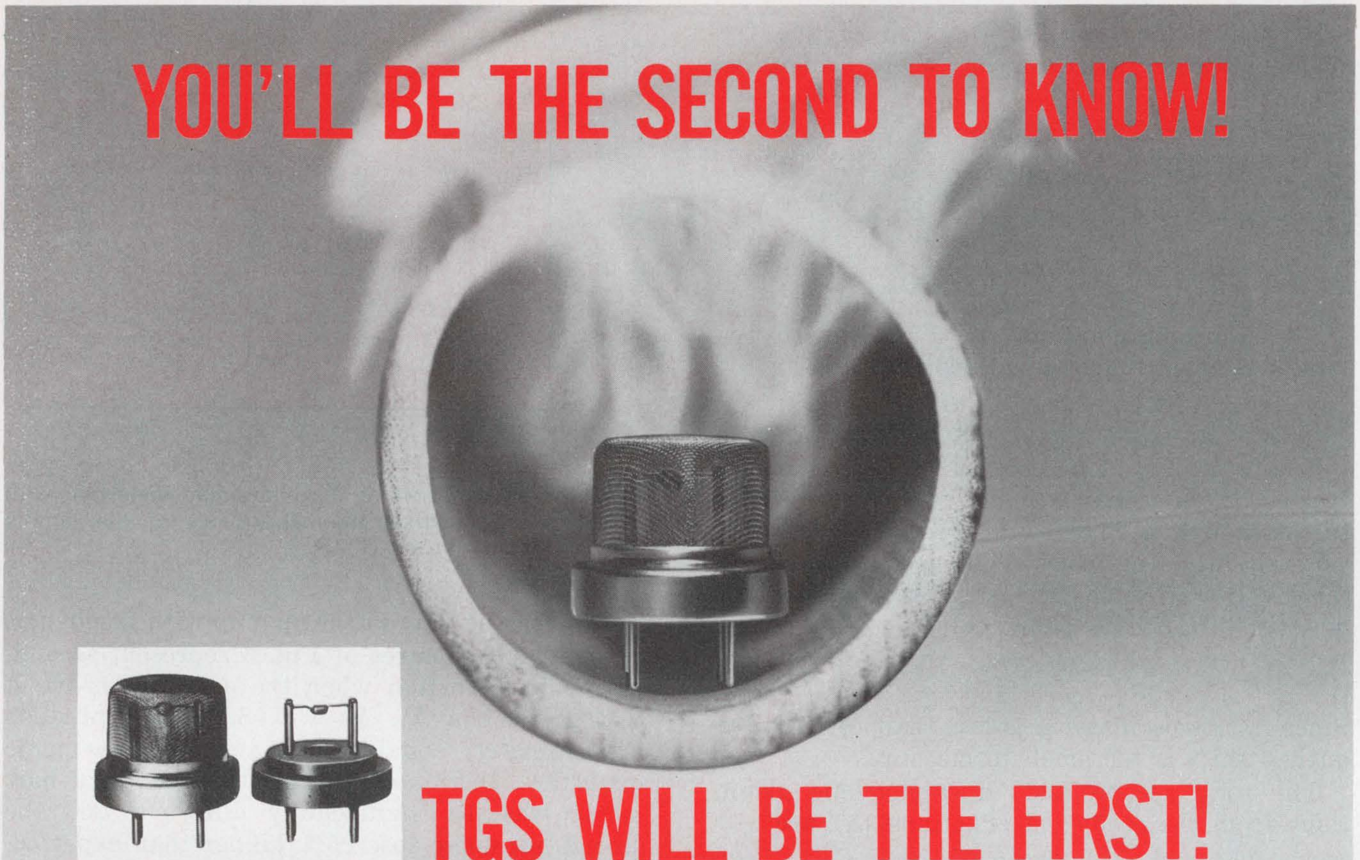
As the distortion gets lower, the oscillator takes longer to stabilize, especially at low frequencies, and this dictated the choice of operating point.

Oliver has shown that some distortion is essential to provide amplitude stability when using this type of amplitude-stabilizing network.[1,2] With the present design, envelope instabilities have been observed only at frequenices of greater than 100 kHz. Transistor Q_{17} and Q_{18} suppress these instabilities. However, the oscillator can't be used at frequencies of greater than 150 kHz, unless a thermistor is used as the amplitude stabilizer. The resulting increase in distortion substantiates Oliver's theory.

For audio frequencies, even the lowest operating points of Fig. 4 are usable, with the inconvenience only of long stabilization times and with none of the instabilities noted by Oliver. ■■

References

1. Oliver, B.M., *Hewlett-Packard Journal,* Vol. 7, No. 6, February, 1956.
2. Oliver, B.M., *Hewlett-Packard Journal,* Vol. 8 to 10, April to June, 1960.



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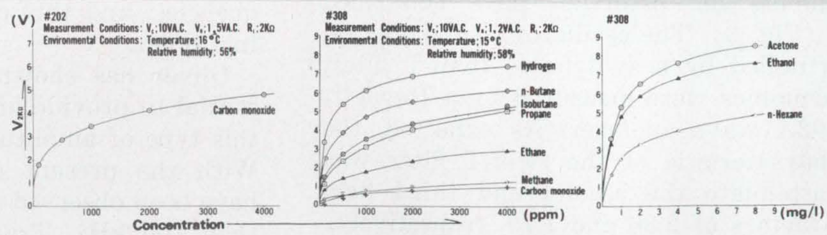
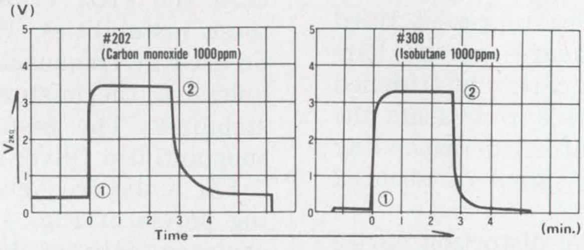


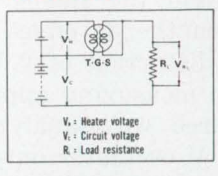
RESPONSE

① Point at which sensor is exposed to gas/air mixture.

② Point at which sensor is removed from gas/air mixture.



CIRCUIT



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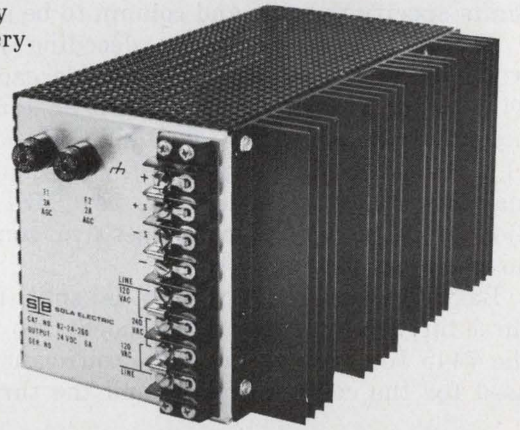

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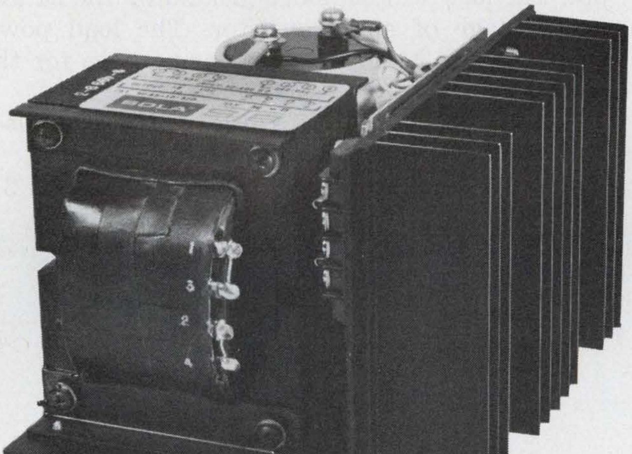

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INFORMATION RETRIEVAL NUMBER 36

Matrix approach cuts component count for decoding digital words

When a parallel digital word must be decoded to drive displays or other loads, the use of a matrix format can reduce considerably the number of components required and the cost. Convert the binary word into a number base that requires only two digits to represent the word. A matrix can then be formed in which the two digits specify the row and column to be activated.

As an example, consider decoding a six-bit word. The usual approach to decode each of the 64 possible states would require 32 dual, four-input expandable gates, 32 dual expanders and 11 hex buffers for output. With the matrix format shown in the schematic, two MSI ICs, 64 diodes and some other inexpensive components do the same job.

Basically the six-bit word is split into two three-bit octal words and decoded into octal by the 7445 ICs. The three least-significant bits are used for the column drivers and the three most-significant bits for row drivers. Transistors Q_0 through Q_7 invert the outputs of the column decoder to provide voltage sources for the columns. The row decoder acts as a current sink for the activated load. Diodes CR_0 through CR_{63} are steering devices. They prevent reverse current from flowing through undesired paths, which might result in false load activation.

This system can be easily expanded to handle longer words. For example, if an eight-bit word has to be decoded, make a hexadecimal decoder from two 7445s and expand the diode matrix accordingly. In all cases two transistor drops and one diode drop are associated with each output. The load will be above ground by the saturation voltage of one transistor. The load power supply should be adjusted to compensate for this difference.

John J. Murphy Jr., Naval Weapons Center, Code 40505, China Lake, Calif. 93555.

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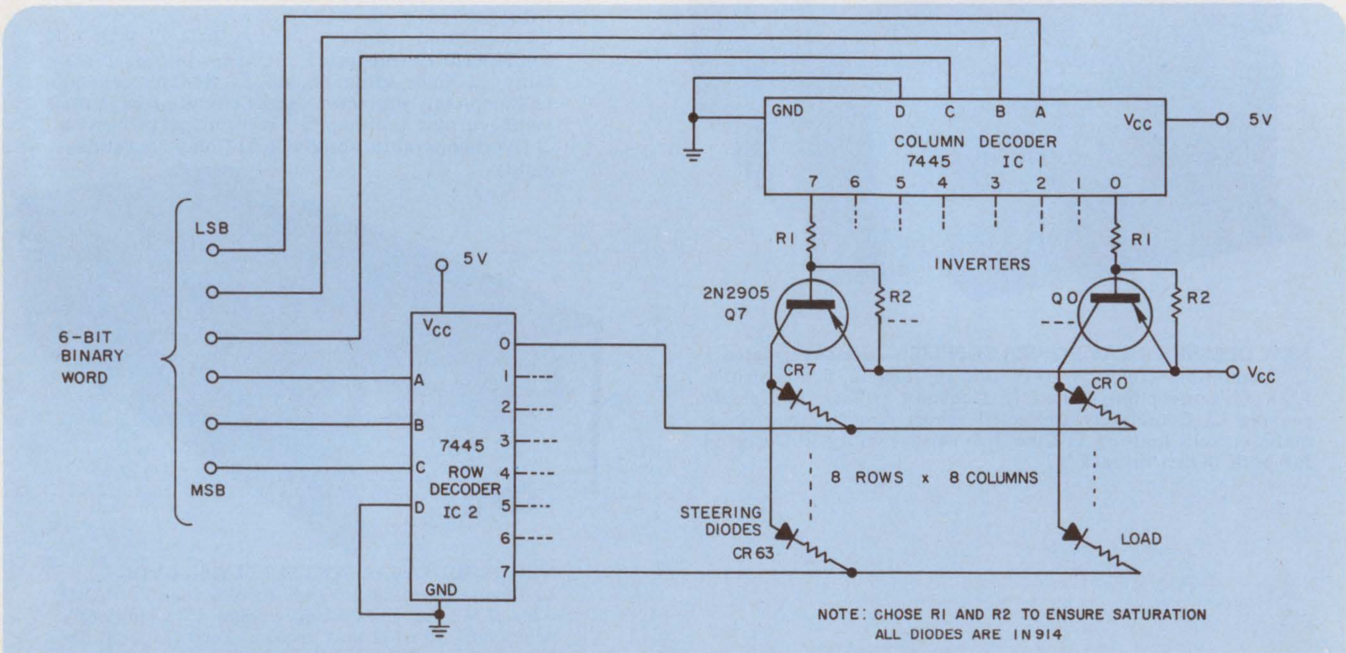

Decoding of a six-bit binary word to 64 discrete outputs is accomplished with inexpensive components. Loads of 80 mA at 30 V can be handled with the parts shown.

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INFORMATION RETRIEVAL NUMBER 37

Transistor and two resistors reduce noise and widen bandwidth of 101/748 op amps

Two of the biggest drawbacks of general-purpose IC op amps such as the 101 and 741/748 families are poor frequency response and relatively high input noise. The frequency response is generally limited to a 1-to-2-MHz unity gain frequency, because of the excess phase shift of the lateral PNP transistors used in the input stage for level shifting. This stage also has a low slewing rate of 0.5 V/μs with unity-gain compensation, because of the low emitter current used to obtain small input bias currents. For many ac applications, low input currents are of secondary importance to the need for adequate gain bandwidth and an input noise low enough to allow good S/N operation with small signals. A 101 or 748 amplifier can be adapted to satisfy both of these requirements with little added complexity and cost.

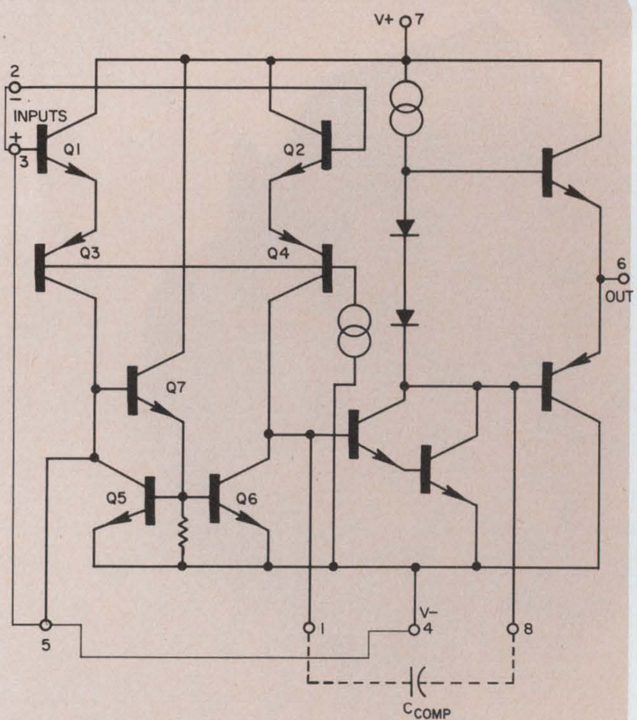
The simplified diagram of a 101 or 748 is shown in Fig. 1. As can be seen, all internal circuit nodes required to gain access to the input and second stages are available at pins 1, 2, 3 and 5. If pins 2, 3 and 5 are tied back to V^- (pin 4), the entire input stage is effectively removed from the circuit and the second stage can be used as a buffered common-emitter amplifier. This allows the high-gain second stage to be retained, with its bipolar output swing, good current capability and short-circuit protection.

The addition of a simple common-emitter PNP input stage (Fig. 2) restores a ground-referred input-voltage bias by driving the 101/748 second stage via pin 1. Compensation is added by a single capacitor, C_2. In this case the slewing rate is increased approximately thirtyfold because the emitter current in Q_1 has been raised and the direct capacitance reduced. The gain-bandwidth product is raised to nearly 100 MHz by this substitution, and the circuit has a typical input noise voltage of 0.5/μV rms for a 10-kHz bandwidth with a 600-Ω source resistance.

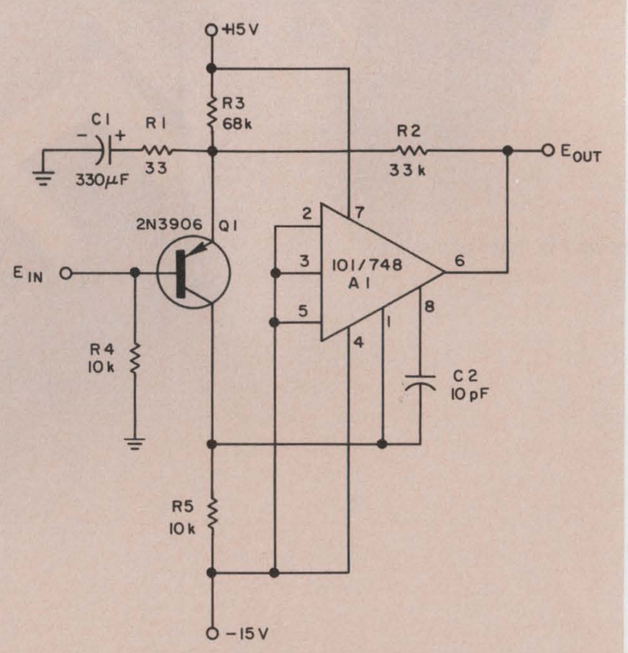
An interesting sidelight of the circuit is the fact that its improved performance is accomplished with only three components—R_3, Q_1 and R_5—more than those required for a circuit that has only the op amp. If fully differential-input operation is required, a second transistor may be used; however, this trades off speed and noise performance.

Walter Jung, 1946 Pleasantville Rd., Forrest Hill, Md. 21050.

CHECK NO. 312



1. **Simplified 101/748 diagram** has pins 2, 3 and 5 tied to V^- to eliminate the input stage.



2. **Low noise input stage,** consisting of Q_1, R_3 and R_5, replaces the internal differential amplifier.

Simple dc current controller adapts easily to any supply voltage and load current

Dc current controllers have a wide range of applications—from power-supply short-circuit protection to surge protection—and the circuit shown can meet these optimum circuit characteristics: rapid overload tripping; near-zero voltage drop; acceptance of capacitive or inductive loads; stable trip level regardless of temperature, power-supply voltage changes and trip time; and low cost.

Typically the trip time is 1.5 μs and the voltage drop 0.1 V. Loads of 24 μF don't affect operation. The trip level is stable to within 5% for a -25-to-$+220$-F temperature change, with almost no change over the 50-to-200-F range. And, for power-supply variations of 1%, the trip level varies 0.75%.

Transistor Q_3 detects an over-current condition by sensing the voltage between the base and collector of Q_1 (the voltage at those points changes polarity as Q_1 goes from the active to the saturation region). When Q_1 is in saturation, its base is more positive than its collector and transistor Q_3 is then forward-biased. This forces Q_2 to stay on and latch, thus holding Q_1 in saturation. If load current should increase, Q_1 becomes active (due to current starving) and its collector voltage goes higher than its base voltage. Thus Q_3 is forced off, since its base-emitter junction becomes reverse-biased. Because Q_3 is now off, Q_2 also turns off, and the base current to Q_1 is removed. Transistor Q_1 then turns off, and the load current drops to zero. To reset the circuit, the switch S_1 is momentarily closed, causing Q_2 to turn on and latch Q_1 on and the circuit then returns to operation.

Resistor R_b determines the overload trip current. It is calculated by

$$R_b = \frac{V_{CC} - V_{CE(Q2)} - V_{BE(Q1)}}{I_{b(Q1)}}.$$

For this current and with silicon transistors, $V_{CE(Q2)}$ is 0.5 V and $V_{BE(Q1)}$ is 1 V. Therefore the value of R_b is directly dependent on the inverse of I_b. For the values shown, I_{load} can be set for a 1-A nominal current with a 12-V supply.

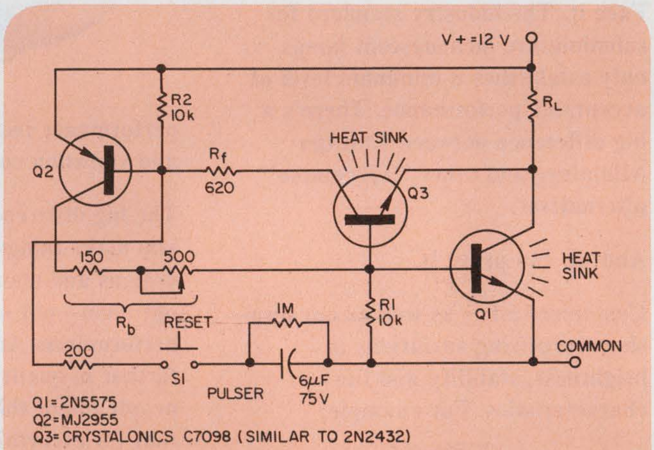
If other supply voltages and output currents are needed, the design criteria are as follows:

$$R_f = \frac{V_{CC} - (V_{CE(Q2)} + V_{BE(Q1)} + V_{CE(Q3)})}{I_{b2}}$$

Resistors R_1 and R_2 must be large enough so the effect on base-emitter currents is negligible. Q_1 and Q_2 must handle the required collector current and cause $V_{CEsat(Q1)}$ to be less than 0.5 V. Q_3 is selected to handle the current required in or near the active region and must be capable of withstanding a reverse voltage between emitter and base that is greater than V_{CC}.

A. Borges de Oliveira, 14615 S. E. 37th, Bellevue, Wash. 98006.

CHECK NO. 313



Transistor Q_3 detects overcurrent by sensing the voltage between the emitter and base of Q_1. As the load current increases, Q_1 becomes active, Q_3 reversed-biased and the load current is removed.

IFD Winner of March 1, 1973

T. W. James, Project Engineer, Medical Electronics Div., Hewlett-Packard, 175 Wyman St., Waltham, Mass. 02154. His idea "Single diode extends duty-cycle range of astable circuit built with timer IC" has been voted the Most Valuable of Issue Award.

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INFORMATION RETRIEVAL NUMBER 39

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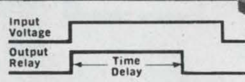

SENSITROL, INC.

Timing period begins when input voltage is applied and internal control relay energizes. Control relay de-energizes at the end of time delay period. Time delay resets when input voltage is removed. If the input voltage is removed before timing period is completed, control relay de-energizes and time delay resets.

The delay time can be set with the knob or by adjusting the external resistor to any period of .1 through 10 seconds, or 2.0 through 200 seconds. Delay time can also be pre-determined by customer and set at the factory from .1 through 200 seconds. **$28.50-35.50**

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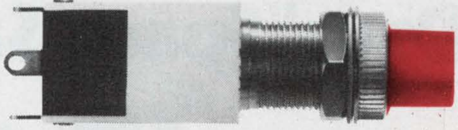
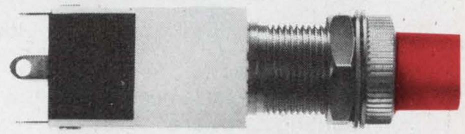
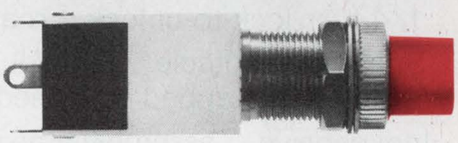


the Marco-Oak 670 series

latching Presslite



The latch controls the switch.



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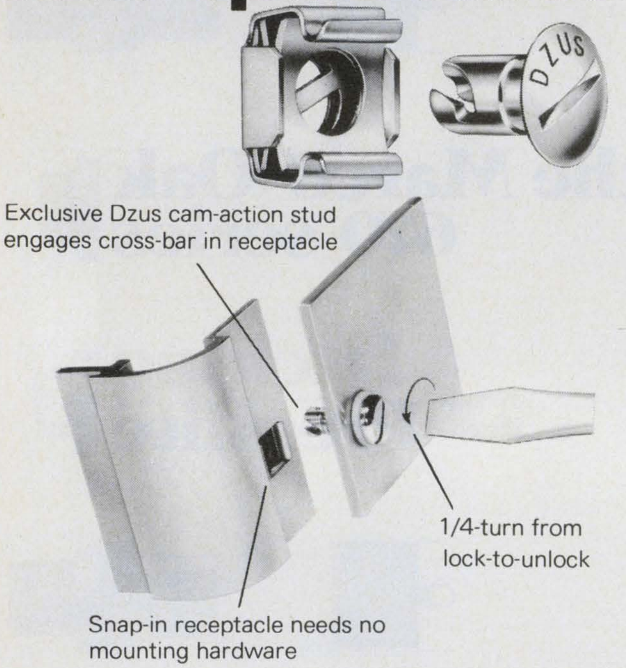
INFORMATION RETRIEVAL NUMBER 41

Now! Get rid of the captive screw. Use the new Dzus "Space-Saver."



Here is the SQA4, a quick access fastener receptacle designed specifically for today's electronics packages. Ideal for enclosure fastening, module mounting and the many former duties of the time-consuming and cumbersome captive screw.

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Snap-in receptacle...for reduced assembly time—no tapped hole needed

Inexpensive...assembly time reduced

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DZUS® means quick release fastening

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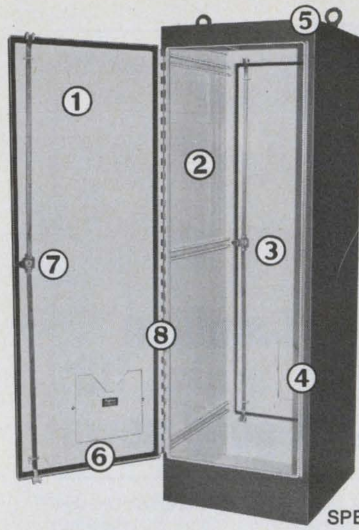

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INFORMATION RETRIEVAL NUMBER 43

Test record not required! Designed for CD-4 demodulator measurements

MSG-321

CD-4 System Record Signal Generator

The MSG-321 is a record signal generator of the discrete four-channel system type. It generates a signal corresponding to left and right components of one side of the groove of a CD-4 record, thereby eliminating the need for a test record. Applications include research, adjustment, and inspection for demodulator isolation, distortion, and signal-to-noise ratio.

Please see our catalog for details.

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INFORMATION RETRIEVAL NUMBER 44

Tape and disc share package and electronics

Tri-Data, 800 Maude Ave., Mountain View, Calif. 94040. (415) 969-3700. $5995; August.

Two can live as cheaply as one, they say. So can two kinds of magnetic storage—tape cartridges and a disc, both in the same enclosure and sharing a single controller. The tape cartridges (two) provide a bulk data availability of 1.44 Mbytes; the disc affords 312-k bytes of random-access storage with a transfer rate of 170-k bytes/s.

With the CartriFile 211 and 201 systems, the user has on-line tape and disc without the cost of separate peripherals. Sharing the controller between the two devices also helps keep the price down.

The CartriFile 211 sells for $5995; separate tape and disc systems with controllers average a total of $9000. The CartriFile 201, also $5995, provides compatibility with Tri-Data's existing CartriFile 40, 20 and 10 systems, which use lower cartridge recording densities than the new 211.

A single, direct-memory-access port or I/O slot of PDP-11 minis can address and control the system. (Interfaces to other minis are scheduled.) The user can read or write on the disc while simultaneously load-point searching the two tapes. Or he can read or write on one tape, load-point search the other and position the disc head.

One motor drives both the tape transport and the sealed movable-head disc unit. Two read/write heads (for odd and even bits) fly 75 microinches above the disc surface, which rotates at 1800 rev/min. The disc has a data capacity of 2.5 to 2.9 Mbits (312 k bytes formatted, 362 k bytes unformatted). There are 64 tracks per head with variable sectoring (1, 2, 4, 8 or 16) and a maximum recording density of 1600 bits/in. Data-access time includes 10-ms track-to-track motion, 10-ms settling time and an average rotational latency of 16.7 ms.

The tape drive in the CartriFile 211 provides a 6-k byte transfer rate with standard Tri-Data cartridges. The drive operates two cartridges, each capable of storing 720-k bytes on 150 feet of 1/4-in. tape. A 15 in/s tape speed and 1600-bit/in. recording density provide a 6-k byte/s data-transfer rate.

The slower CartriFile 201 operates at a 10-in/s, 900-bit/in. recording density for a transfer rate of 1800 bytes/s. Each cartridge is capable of storing 324-k bytes on a 150-ft. tape. Both tape units use Tri-Data's two-track, interlaced recording technique. And both systems have the same disc unit.

A 7-in.-high-by-17-in.wide-by-20-in. deep enclosure houses an entire system. A belt and idler assembly, which drives the disc, allows the user to swing transport outward from the front of the unit without need to disconnect and realign the belt.

The disc unit's head carriage is positioned by a stepper motor. The sealed unit features an integral air-pumping and filtering system. No field maintenance or adjustments are needed, Tri-Data says.

The 211 and 201 operate at temperatures from 32 to 120 F with relative noncondensing humidity of 10 to 90%. Tri-Data also supplies driver software and diagnostic routines.

CHECK NO. 250

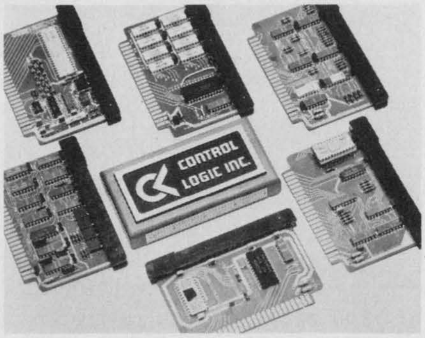
Adapter mates 5-level terminals to Telex

Multiplex Communications, Inc., 123 Marcus Blvd., Hauppauge, N.Y. 11787. (516) 213-5350. $133 (qty); 90 days.

The Multiplex Communications CU 300 Adapter, as it is called, interfaces any five-level teletypewriter or other terminal with the Telex network. The system contains both the operator control panel (rotary dial, sonalert and operating switch indicators) and an electronic line interface, which provides all the controls and signals necessary for normal Telex operation.

CHECK NO. 251

Roll your own mini from logic cards



Control Logic, Inc., Nine Tech Circle, Natick, Mass. 01760. (617) 655-1170. See text; 30 days.

A set of 11 small (approx. 3 by 5 in.) logic cards allows the user to assemble a wide variety of minicomputers. The basic eight-bit processor (three cards) has a repertoire of 48 instructions with a typical execution time of 20 μs and is based on the Intel 8008 computer chip. Other members of the L-500 series include pROMS, RAMs priority interrupt controls, serial interface and a buss port. The basic processor is supplied with one 256-byte (eight-bit) pROM and costs $400. Additional memory, for example, RAM costs $150 for 256 bytes or $420 for 1024 bytes. The L series is compatible with the manufacturer's C-series logic as well as the I series. The latter's 21 logic modules are designed for industrial applications in severe environments.

CHECK NO. 252

Fixed-head disc system offers 8.35 ms access

Progress Electronics Co. of Oregon, 5160 N. Lagoon Ave., Portland, Ore. 97217. (503) 285-0581. From $8575; 90-120 days.

A single controller handles up to four fixed-head discs for a total storage capacity of up to 33 M words. The discs provide an average word-transfer rate of 3.8 μs at rotational speeds of either 3600 rev/min. or 1800 rev/min., but with average access times of 8.35 or 16.7 ms, respectively. The units are compatible with Data General's Nova 800, 1200 and Supernovas, Digital Computer Controls D-116 and the Interdata 70, 74 and 80 minicomputers.

CHECK NO. 253

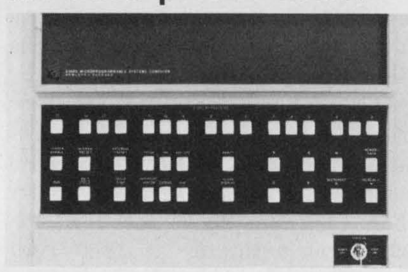
Process-control display features graphics

Ramtek Corp., 292 Commercial St., Sunnyvale, Calif. 94086. (415) 941-8860. See text.

The GX-1000 is an industry-oriented raster system with complete graphics capability—color, grey scale or black-and-white. Standard black-and-white and RGB TV monitors provide the output display, and the system is field expandable. Key capabilities of the GX-1000 include alphanumeric generation, graphic plotting, cartesian graphics, selectable erase and reverse background. All the functions are accomplished in the system controller. Available resolutions are 256 elements by 256 lines and 512 elements by 256 lines. The GX-1000 operates in hostile environments where acid, fumes or dust can damage more conventional systems. In quantity, GX-1000 costs (per channel) $4500 for color or grey scale and $1500 for black-and-white graphics.

CHECK NO. 254

Microprogrammed mini includes pROM writer

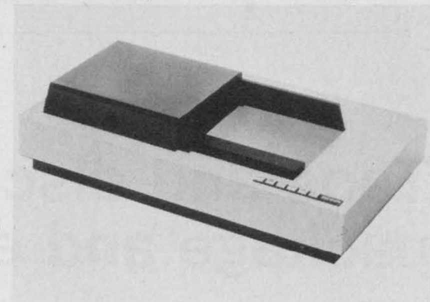


Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 493-1501. $16,000; July.

Microprogramming hardware and software support complement the Model 2100-S minicomputer. The computer configuration includes a 16-k × 16-bit memory, communications-control channel, hardware floating point and two direct-memory-access channels. Users can store 256, 24-bit, microinstructions on each of three writable control-store cards. Microprocessor cycle time is 196 ns. Debugged microinstructions can be transferred to pROMS, by a card temporarily inserted into the computer's I/O slot. Microprogrammed chips are automatically verified and any missed bits are fused immediately.

CHECK NO. 255

Optical mark reader gives input flexibility



Decision, Inc., 5601 College Ave., Oakland, Calif. 94618. (415) 654-8626. From $4900; see text.

Paper may be fed manually or, if desired, automatically with the OMR-6500 optical mark reader. Optical scanning devices read the fixed page. According to the manufacturer, even folded, mutilated and spindled paper can be read. The OMR 6500 reads data off-line or can be placed under program control. The unit operates as a remote terminal or attaches directly to a computer through standard EIA or teletypewriter ports. It reads 9 by 11 in. documents at rates up to 400/hr. and 3 by 5-in. cards at speeds to 900/hr. The OMR 6500 accepts data in such forms as pencil and ink marks, punched holes, block numerics and pre-printed data. The manual feed version costs $4900 (delivery; 60-90 days) and the "auto-feed" version costs $7000 (delivery: 90-120 days).

CHECK NO. 256

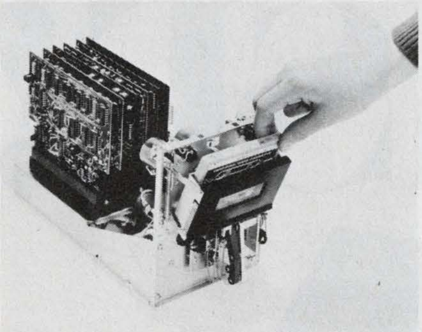
Baseplate attachment mates typewriter to mini

Terminal Equipment Corp., 26 Just Rd., Fairfield, N.J. 07006. (201) 227-4141.

Users of PDP-8E and M minicomputers can have quality typewriter hardcopy for use with the DEC text editor and other business-oriented programs. The computer interface, Model CSR-8E, uses an IBM Selectric typewriter supplied by the customer, the Holmes Tycom baseplate, a power supply, and an omnibus interface. The factory-installed baseplate operates at 15 char/s using standard DEC TTY software. All 128 ASCII characters can be generated from the typewriter keyboard.

CHECK NO. 257

Cassette recorder gives flexible operation



Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif. 91109. (213) 796-9381. $360 (51-100); stock.

Available in single or dual-track models, the Autoload digital cassette recorder provides 2 to 20 in/s selectable operating speed (forward or reverse) and search speeds of 50 in/s. The unit operates in either incremental or continuous mode and can be used in synchronous or asynchronous environments as a replacement for paper-tape units or reel-to-reel magnetic-tape equipment. The packing density is 800 bit/in. Recordings can be made in biphase or NRZ formats with simultaneous read or write operations occurring on each of two data channels.

CHECK NO. 258

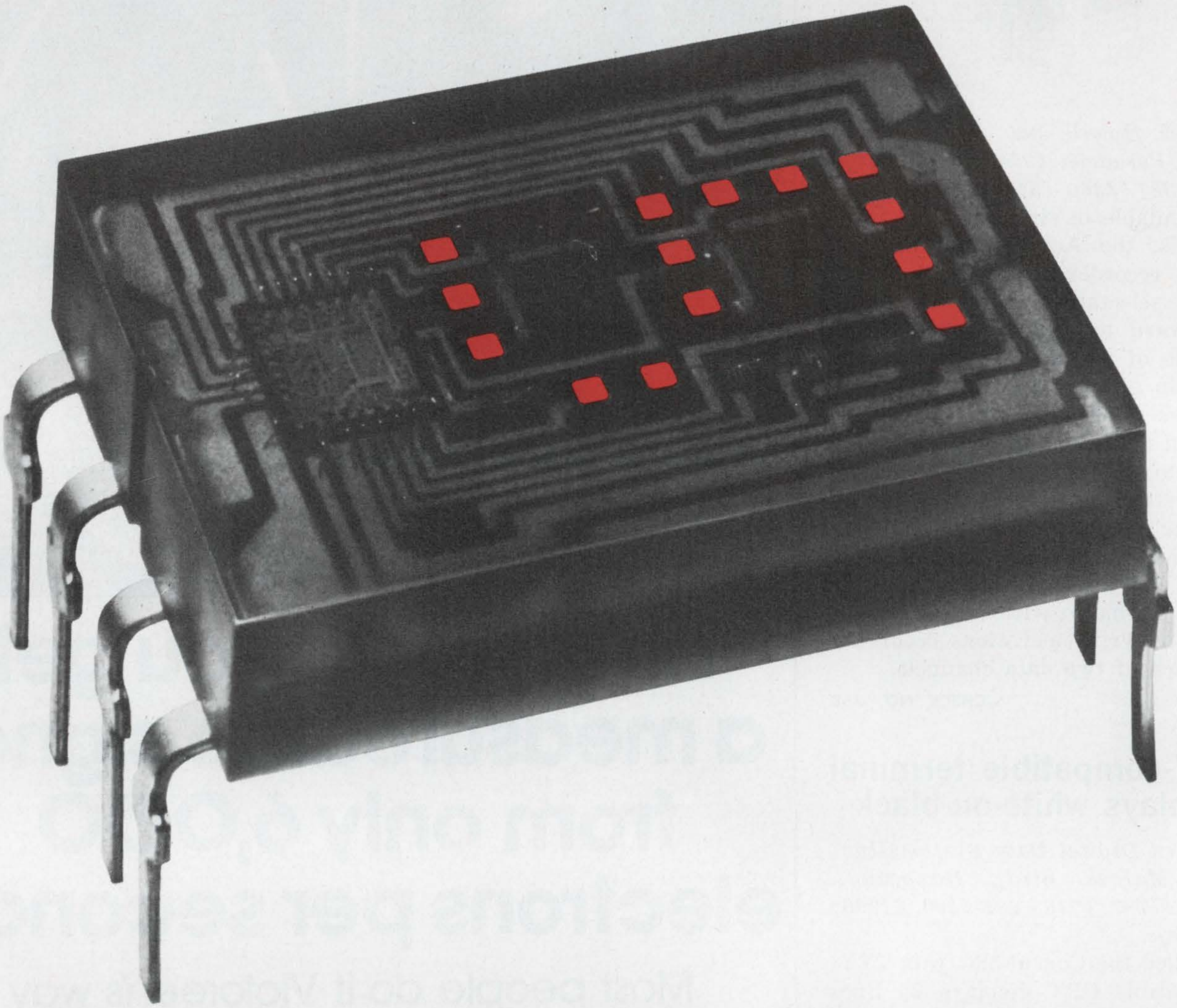
TTY-compatible terminal displays white-on-black

Applied Digital Data Systems Inc., 100 Marcus Blvd., Hauppauge, N.Y. 11787. (516) 231-5400. $1795; 60 days.

Called the Consul 580, this TTY-compatible CRT displays 24 lines of data with 80 characters per line. It displays black characters on a white background—which is said to reduce eye fatigue. An EIA RS232C interface, with switch selectable transmission speeds of 110, 300, 1200, 2400 and 9600 baud, is standard on the 580. An optional 20-mA current-loop interface is also offered. Operators of the terminal can manually inhibit or enable upward scrolling of data across the screen. They can also control the flow of data to the printer interface which drives any serial ASCII printer having an EIA interface. Cursor controls and various erase functions are available.

CHECK NO. 259

SURPRISE!



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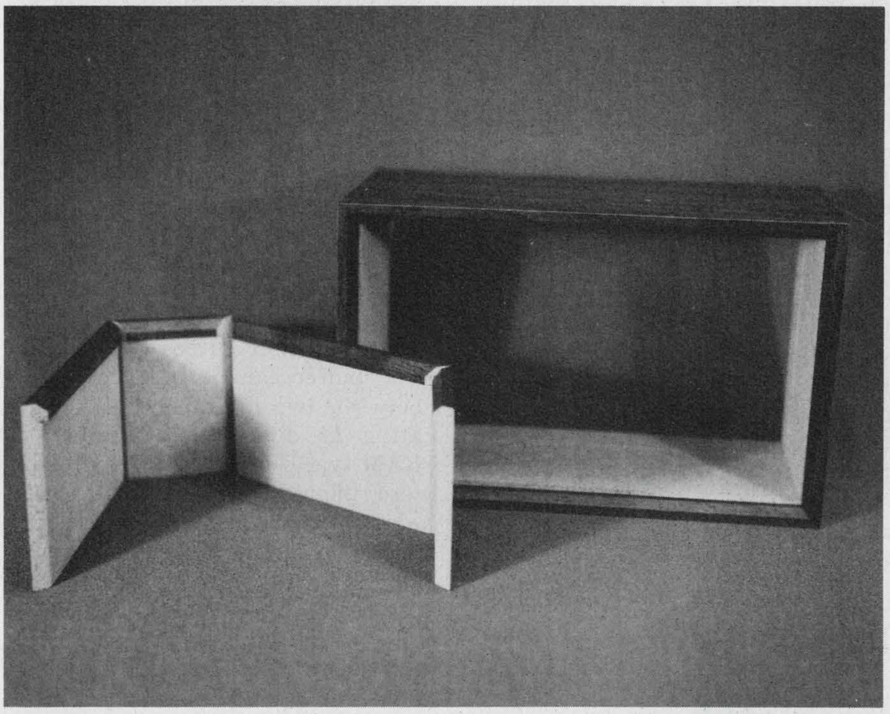
INFORMATION RETRIEVAL NUMBER 46

Wrap-around cabinets meet tight production tolerances



Iota Corp., 46 Old Camplain Rd., Somerville, N.J. 08876. (201) 722-4511. P&A: see text.

Making one-piece, wrap-around wooden (particle board) enclosures for electronic equipment is not new. Most manufacturers, though, assemble several separately machined pieces and cannot guarantee consistently tight production-line industrial tolerances.

The Iota Corp. has developed a new process machine that controls mitre-grooving tolerances to within ± 0.001 in. Due to the controlled tolerances and one-piece construction of the new enclosures, a user can cut his assembly costs by as much as 60%.

Because of the close control, a thinner vinyl skin can be laminated to the particle board. Thus Iota uses 6-mil vinyl instead of the commonly used 8 or 10-mil material. The result is a large reduction in material cost.

There are no standard stock items, since each enclosure is custom-designed. Iota examines all of a customer's production factors—his design engineering, production methods, even the way the finished product is shipped.

The particle-board thicknesses can run from 0.125 to 0.75 in., while lengths and widths of any standard boards up to about 5 by 10 feet can be accommodated. Prices depend heavily upon size, quantity and delivery schedule, but they range from as little as 75 cents each for a 5000-piece contract.

Iota can supply all phases of production, if desired. The company can ship knocked-down units ready for assembly, or assembled shells ready for equipment mounting, or it can handle full production—including assembly, wiring, testing and packaging for delivery.

Traditionally, when a cabinet is made from four or eight pieces, the user must contend with the tolerance errors of each piece. This usually involves a high labor cost. Also, it may not produce the almost airtight seal that results from the one-piece construction process.

CHECK NO. 260

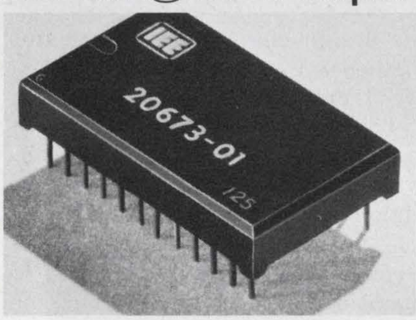
LSI-chip has calendar and clock circuitry

Cal-Tex Semiconductor, 3090 Alfred St., Santa Clara, Calif. 95050. (408) 247-7660. $8 (50 k).

The CT7001 is a MOS/LSI digital clock/calendar circuit in a 28-pin DIP. It has many features which can be selected by wiring to selected pins. The chip can use either a four or six-digit display of either common-anode luminescent display tubes or common-cathode LEDs. Outputs of the chip can be wire-ORed to other chips thus allowing the clock to share a display with another chip. The circuit operates from either a 50/60 Hz line or an external 100.8 kHz signal. If a battery backup is available, a 50/60 Hz on-chip backup oscillator provides timing to continue operation in the event of power failure. Also included on the chip are a "snooze" alarm and an auxiliary timer that can be used for a clock-radio.

CHECK NO. 261

Decoder supplies up to 300 mA @ 30 V/output

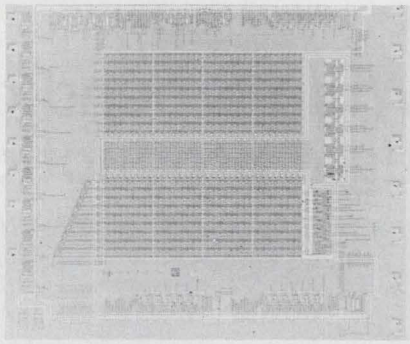


IEE Inc., 7720 Lemona Ave., Van Nuys, Calif. 91405. (213) 787-0311. $17 (1000-up); 4 to 6 wk.

The 20673 is an "all in one" decoder in a 24-pin DIP-like package, with a drive capability of 300 mA at 30 V for each output. Operating on a 5-V logic supply, the chip decodes standard 8421 BCD data to 12 outputs, or, if only 10 decoded outputs are required, the two remaining may be connected as lamp buffers. The 20673 is DTL/TTL compatible, with or without memory and features lamp blanking as standard. The hybrid chip differs from previous IEE decoders in that a logic "ONE" on data inputs is represented by a low state rather than a high.

CHECK NO. 262

9 × 64-bit digital buffer largest yet

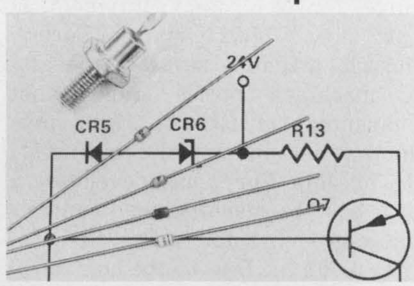


Texas Instruments, P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. TMS4024NC: $13.80 (100-999); stock.

The TMS4024 digital storage buffer, at 9 bits wide and 64 bits deep, is the largest first-in/first-out (FIFO) buffer currently available. The buffer can be used as a link between two digital systems operating at different data rates. A RAM-type organization permits zero ripple-through time. Data written at the input when the register is empty is immediately available at the output. The device processes data at any rate from dc to one-half the continuous clock frequency. Minimum guaranteed data rate is 250 kHz, with processing in a parallel format, word by word.

CHECK NO. 263

3-W zeners conserve board space



Microsemiconductor Corp., 2830 S. Fairview St., Santa Ana, Calif. 92704. (714) 979-8220. 70¢ to $1.40 (100 up).

Measuring only 0.155 inch long by 0.085 inch in diameter, the IN5063 through IN5117 zener diodes can dissipate up to 3 W in 25 C free air with normal mounting. Reverse current limits can be specified as low as 25 nA at 70% of zener voltage. The line consists of 70 devices with breakdown voltages from 6.8 to 400 V.

CHECK NO. 264

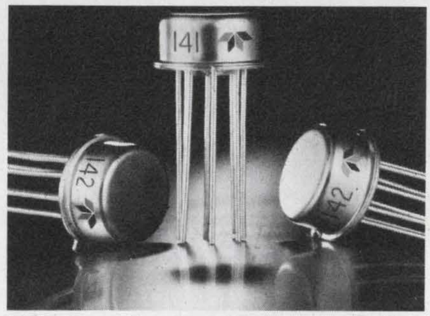
8k-bit character generator at 1/4¢/bit

Motorola Semiconductor Products, P.O. Box 20924, Phoenix, Ariz. 85036. (602) 244-3466. P: See below; stock.

The MCM6570L, an 8192-bit programmable-ROM/character-generator, contains 128 characters in a 7 × 9 matrix and has capability for internally shifting characters that ordinarily extend below the normal base line (y, g and p, for example). A pre-programmed version of the MCM6570L, the MCM6571L, is available with a modified USASCII code. This device sells for $18 (100 up) for a cost per bit of $0.0022. Access time is typically 300 ns with power dissipation typically 600 mW. The static ROM uses n-channel MOS, metal-gate technology. Operation is possible from a single 5-V supply.

CHECK NO. 265

Op amps span 741, 108 performance gap

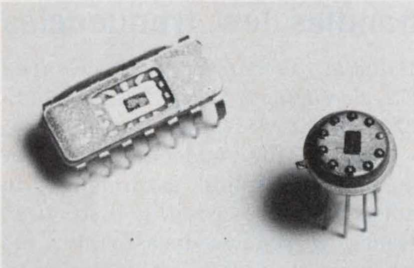


Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040. (415) 968-9241. LM 141: $4.25; LM 142: $3.95. (100-up); stock.

A general-purpose op amp series, the LM 141/142, fills the performance gap between the 741 and 108-type op amps. The series features a slew rate of 2 V/μs and provides a full output voltage swing through the audio frequency range. Input bias current is 30 mA maximum and input offset current is 5 mA maximum. The LM 141 series offers full internal compensation and is compatible with existing designs using the 741, 107 and 1556 op amps. The uncompensated LM 142 series can replace 101A, 748 and 777 op amps. The LM 141/142 operates over the −55 to 125 C temperature range.

CHECK NO. 266

Multiplier/divider needs no trimming

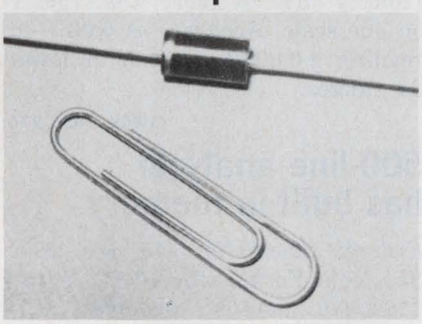


Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, Mass. 02062. (617) 329-4700. AD-532J: $25 (1-24); stock to 3 wks.

A multiplier/divider provides a guaranteed maximum multiplying error of 1.0% and a ±10 V output swing without the need for any external trimming resistors or an output op amp. Called the AD532, the device multiplies in four quadrants with a transfer function of XY/10, divides in two quadrants with a 10Z/X transfer function, and square roots in one quadrant with a transfer function of $\pm\sqrt{10Z}$. The AD532J and AD532K feature maximum full scale multiplying errors of two percent and one percent, respectively, at +25 C, and are rated for operation from 0 to +70 C.

CHECK NO. 267

Transient suppressor has 5 ns response time



Transtector Systems, 532 Monterey Pass Rd., Monterey Park, Calif. 91754. (213) 283-9278. $4.75 (100 up); stock to 4 wk.

Available in two models, the VZ series of transient suppressors is rated for a peak power of 1200 W for 1 ms at 25 C, and responds to rising transients in less than 5 ns. The clamp point of the VZ6 is 6.5 V dc, and for the VZ16 it is 16.5 V dc, ±5% tolerance. Peak pulse current for 1 ms is 20 A. The operating temperature range is −55 to +100 C.

CHECK NO. 268

INFORMATION RETRIEVAL NUMBER 47

INSTRUMENTATION

Frequency multiplier handles low frequencies

Valhalla Scientific, 7707 Convoy Ct., San Diego, Calif. 92111. (714) 277-2732. $295; stock.

Model 2100 wideband low-frequency multiplier is immune to noise and zero-crossing distortion. Hence, it reduces measuring time by several orders of magnitude. For example, a 10-Hz signal is easily resolved to 0.1% in 1 s, essentially error free. Engineering units such as rpm, gallons/hour, etc., are conveniently generated with multiplication factors of 2, 4, 5, 6, 10, 12, 20, 30, 60, 100, 120, etc., are conveniently generated nique is a phase-lock loop/frequency comparitor-multiplier combination.

CHECK NO. 269

5-digit DMM snaps on to counter, costs $450

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 493-1501. $450; stock.

Here's a snap-on module that converts HP's lowest-cost electronic counter, the 5300A, into a five-digit multimeter that measures volts (ac or dc), ohms and frequency. The 5306A measures frequency to 10 MHz and can show voltage from 1 mV to more than 99 V on one scale. Accuracy is 0.03% of reading ±0.003% of scale on lower dc ranges.

CHECK NO. 270

500-line analyzer has built-in memory

Federal Scientific, 615 W. 131st St., New York, N.Y. 10027. (212) 286-4400. UA500: $10,800; UA-500-1: $12,800; July.

Claimed to be the most powerful analyzer of its type, the UA-500 real-time spectrum analyzer-averager offers a standard, dual-memory averager. A digital cursor reads directly in hertz. The UA-500's 8-3/4-in. size allows use in the field. Additional features include: real-time speed to 10 kHz with a maximum range of 100 kHz and 20 sweeps/sec display rate; a 24 dB/octave filter slope, so that the 500-line analyzer has 650 lines, effectively.

CHECK NO. 271

Digital stopwatch reads to 0.01 s

Continental, 1727 Wilshire Blvd., Santa Monica, Calif. 90403. (213) 451-1910. $200.

ACCUSPLIT 1 is an electronic digital stopwatch that provides an immediate numerical readout for all timing applications. The unit combines the functions provided by approximately 100 different mechanical stopwatch models. It can show and hold intermediate readings while continuing to time an over-all event. Or, by moving a selector switch, .it can give successive lap or sequence times, the latter being a function usually requiring three or more conventional watches. The ACCUSPLIT 1 is quartz crystal controlled to provide an accuracy of 0.005%. Resolution is 0.01 s. Weight is 15 oz.

CHECK NO. 272

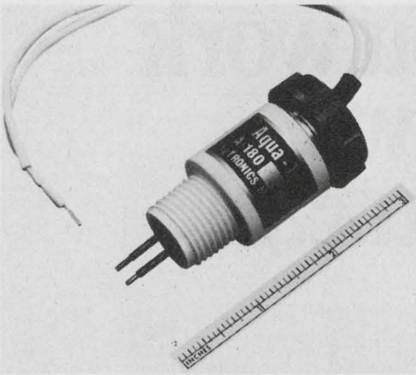
Programmable source outputs 10 Hz to 10 MHz

Progress Electronics, 5160 N. Lagoon Ave., Portland, Ore. 97217. (503) 285-0581. Base price: under $1000.

Model 110 series programmable digital test oscillator offers sine waves from 10 Hz to 10 MHz. The unit's output is constant throughout the full frequency range. Both the 50 and 600-Ω outputs are short-circuit protected. As a voltage-controlled generator the oscillator features FM and AM.

CHECK NO. 273

Liquid-level switch resists corrosion

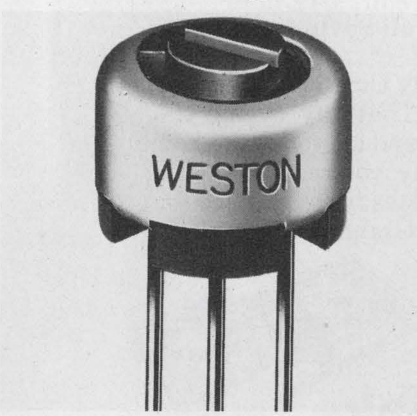


AgTronics Manufacturing Co., P. O. Box 1248, Barstow, Calif. 92311. (714) 256-4755. $24.50 (unit qty).

The A-180 liquid-level switch combines the sensing probe and all circuitry in one hermetically sealed package. The unit is fabricated from corrosion-resistant 316 stainless steel, Teflon, and CPVC, which allows its use in most corrosive liquids. And although the A-180 is a conductance-actuated control, its extremely high sensitivity (10 MΩ/cm) permits the unit's application to liquids of low electrical conductivity. Probe current is limited to 5 μA for safe operation and long life.

CHECK NO. 274

Cermet trimmer meets MIL-R-22097 specs



Weston Components, Archbald Pa. 18403. (717) 876-1500. Stock to 6 wks.

Model 567-105HS, a single-turn, round, 1/4-in. cermet trimmer meets MIL-R-22097 for style RJ50 with both C and F characteristics. Resistance values range from 10 Ω through 100 kΩ.

CHECK NO. 275

Sensor detects excess equipment vibrations

Endevco Dynamic Instrument Div., 801 S. Arroyo Parkway, Pasadena, Calif. 91109. (213) 681-2401. $95 (unit qty).

Based on the same principles as piezoelectric accelerometers, the Models 7281-25/100 vibration sensors are designed to detect changes in the vibration levels of equipment, and via a relay, provide a warning or initiate corrective action. The sensors weigh 2 oz, have a 1.25 in. diameter and are 1.7 in. high. They operate in temperatures of 0 to 150 F and can survive without damage in temperatures up to 210 F. The Model 7281-25 operates to 480 g peak and its sensitivity is 25 mV/g. The Model 7281-100 has a range to 120 g peak and a sensitivity rating of 100 mV/g. The typical frequency response for both models is 1 to 2000 Hz. Both units have an aluminum-alloy case.

CHECK NO. 276

Indicator latches magnetically

Minelco, 135 S. Main St., Thomaston, Conn. 06787. (203) 283-8261.

Model MI51LP, a manually-resettable, magnetic-latching indicator, requires only a 50 mW, 25 ms pulse to operate. The indicator displays a red or white color upon actuation. The unit magnetically latches until a knob is rotated 60-degrees clockwise to reset the display to an all black color. The device is available for 1.5, 3, 6, 12, 24 and 28 V dc operation in a temperature range from −65 to 125 C. It weighs 6.5 g, and it is enclosed in a black anodized-aluminum case with a sealed-glass window. Display colors can be in any combinations of black, white and red.

CHECK NO. 277

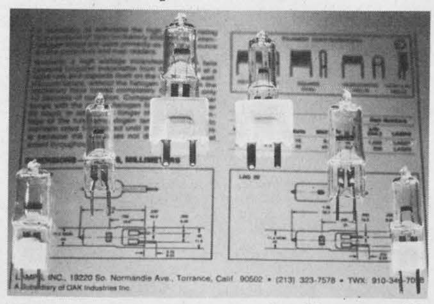
Mercury-wetted relay has 250 $\times 10^6$ life

Fifth Dimension Inc., Box 483, Princeton, N.J. 08450. (609) 924-5990. $4 (OEM qty); stock to 8 wks.

The Series LC2R mercury-wetted relay is built around a hermetically sealed switching capsule that is rated for 250 million operations. Loads of 1 A at 24 V dc or 0.1 A at 200 V dc can be switched for the rated life. Dry-circuit loads can also be switched reliably. Contact resistance remains less than 0.05 Ω whether measured at power level or at 50 mV, and the resistance is stable, varying by less than 0.002 Ω over the life of the switch. Operate time is less than 2.5 ms, and there is no contact bounce. The LC2R is available in SPST form-A nonlatching model. Coil voltages of 5, 12 and 24 V dc are standard.

CHECK NO. 278

Tungsten-halogen lamps feature quartz bulbs

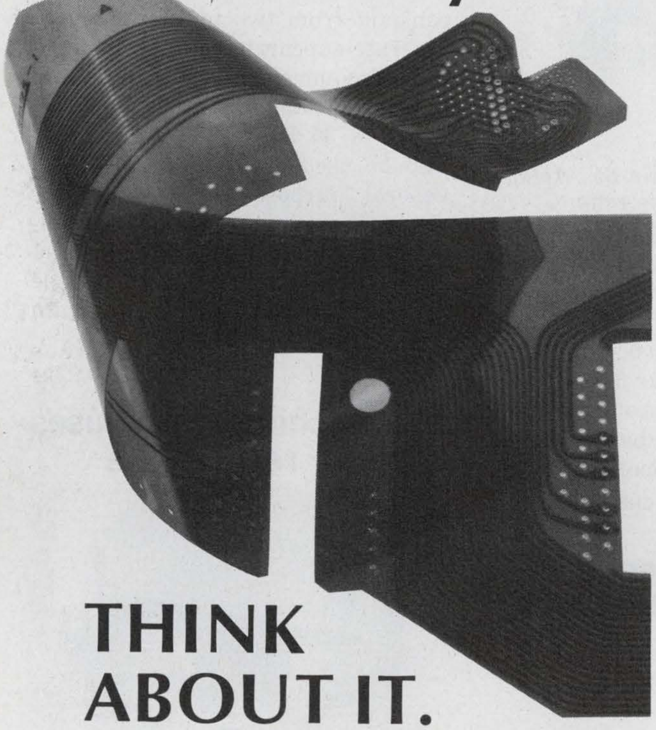


Lamps, Inc., 19220 S. Normandie Ave., Torrance, Calif. 90502. (213) 323-7578.

Six new tungsten-halogen lamps can operate at high ambient temperatures—650 C on the bulb. Thus they do not have to be cooled in many applications. Quartz bulbs reduce breakage, because of greater resistance to thermal shock, and they also improve ultra-violet and infrared transmission over that provided by glass. Ratings of 6 to 24 V, 10 to 200 W are offered, and life is 50 to 5000 hr. Color temperature ratings range from 2000 to 3400 K.

CHECK NO. 279

Flexible Circuitry?



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INFORMATION RETRIEVAL NUMBER 51

Good Books-

They're Still a Sound Investment

MICROWAVE SEMICONDUCTOR DEVICES:
Fundamentals and Radiation Effects
By **R. J. Chaffin**, *Sandia Laboratories*
Written to provide electronic circuit designers and system planners with the understanding needed to design radiation-tolerant microwave semiconductor devices, this is the first book to present a comprehensive discussion of radiation effects in microwave semiconductor devices.
1973 In press

INTRODUCTION TO COMPUTER-AIDED MANUFACTURING IN ELECTRONICS
By **Douglas A. Cassell**, *Control Logic Incorporated*
"This is a skillful, highly practical book in a fast-growing field where there has been virtually no guidance of this caliber before. . . . The orientation is toward both the engineer and manager who might get involved in developing and installing a system involving both computer-aided design (CAD) and computer-aided manufacturing (CAM). Through examples and illustrations he shows how many of the central engineering or selection decisions can be handled. . . . We recommend it highly whether your shop is in the electronics or any other industry."
—Computer Decisions
1972 248 pages $13.95

INTEGRATED CIRCUITS IN DIGITAL ELECTRONICS
By **Arpad Barna**, *Hewlett-Packard Laboratories*, and **Dan I. Porat**, *Stanford University*
This up-to-date text provides the digital electronic engineer with a link between the theoretical bases for the design of digital electronics and their practical implementation. The book's self-contained chapters cover topics ranging from number systems to sequential circuits to large scale integrated circuits.
1973 In press

MODERN FILTER THEORY AND DESIGN
Edited by **Gabor Temes**, *University of California, Los Angeles*, and **Sanjit K. Mitra**, *University of California, Davis*
Written for senior- and graduate-level students as well as industrial circuit design engineers, *Modern Filter Theory and Design* is the first book to present papers on both the theory and design techniques of electric filters. Discussions are included not only on conventional passive analog filters, but also on digital, switched, active, and microwave filters—filters which previously had never been discussed together in a single volume.
1973 In press

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INFORMATION RETRIEVAL NUMBER 52

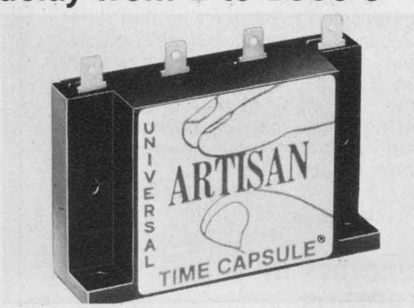
Four decades of BCD are converted by small DAC

Hybrid Systems, 87 Second Ave., Burlington, Mass. 01803. (617) 272-1522. $69 (1-9); stock to 2 wk.

The DAC328-4-BCD is a complete 4-decade BCD current-output d/a converter in a 2 × 2 × 0.4 in. module. It is TTL/DTL compatible, operates from ±15 V power supplies and is complete with an internal reference. Other specifications include linearity of ±0.01%, compliance of +1.25 V, settling time of 1 μs, accuracy vs temperature of 30 ppm/°C and an operating temperature range of 0 to 70 C.

CHECK NO. 300

Use one resistor to vary delay from 1 to 1000 s

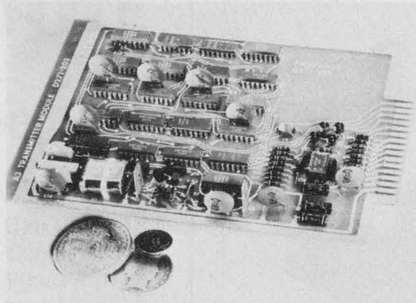


Artisan Electronics, 5 Eastman Rd., Parsippany, N.J. 07054. (201) 887-7100.

A solid-state electronic timing device, called the universal time capsule, can delay any ac or dc load between 24 and 240 V. The unit can generate a delay from 1 to 1000 s with a current capacity of up to 1 A. It is UL recognized and can replace any ac or dc timing device within the ranges specified.

CHECK NO. 301

Pattern generator sends Bell T-1 test pattern



Bowmar/AIL, 531 Main St., Acton, Mass. 01729. (617) 263-7756.

A quasi-random T-1 pattern generator on a 5 × 7 in. circuit card uses all solid state devices to generate signals compatible with Bell Systems 1,048,575-bit test pattern. The generator has four T-1 bipolar outputs with undershoot and uses a standard 18-pin edge-connector as its input/output access.

CHECK NO. 302

Decode multifrequency pairs into an 8-bit code

Comex Systems, 720 Union St., Manchester, N.H. 03104. (603) 669-3600.

The model TD500 tone decoder can decode 16 frequency pairs as used in pushbutton telephone systems. The use of a programmable read-only memory provides any desired eight-bit output code, including BCD, ASCII, two of eight, and Baudot. The unit is available as a plug-in card for integration into OEM and special systems or with a card-cage/power module. The model TD500 with rotary-dial option card, converts tone signals to dial pulsing for interfacing with standard telephone systems.

CHECK NO. 303

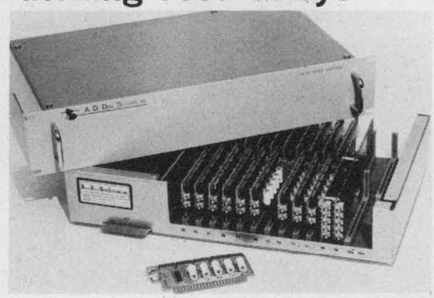
Amplifier can mix 18 or more audio channel

Solid State Electronics, 15321 Rayen St., Sepulveda, Calif. 91343. (213) 894-2271. $98 (100 up); 2 wk.

The MA-531 mixer/amplifier can mix from two to 18 (or more) separate subcarrier signal frequencies (frequency multiplexing) onto a single channel. It has a bandwidth of 30 Hz to 800 kHz. It can also be used as a linear wideband general purpose ac amplifier for low-level signals or as an ac summing amplifier from 100 Hz to 1 MHz. The MA-531 uses a single 28-V supply and has variable gain from 2 to 100.

CHECK NO. 304

XY switching matrix uses latching reed relays



Analog Digital Data Systems, 830 Linden Ave., Rochester, N.Y. 14625. (716) 381-2370. From $895.

A 19-in. rack-mounting coaxial reed-relay switching matrix, model 56-005, has a 50-Ω characteristic impedance to 15 MHz. Its insertion loss is less than 0.5 dB. Crosstalk isolation is better than 60 dB. It is controlled with either DTL or TTL logic levels. Access time for latching and unlatching is less than 5 μs per crosspoint.

CHECK NO. 305

design aids

Conversion chart

An easy-to-read chart for retaining-ring users converts fractions and decimals to millimeters. The 8-1/2 × 11-in. laminated chart lists conversions for sizes ranging from 0.01 millimeters to 20 inches. Anderton Darby Inc.

CHECK NO. 306

Pressure-sensitive tapes

Structure, backing, tensile strength, adhesion properties, elongation, color, printability of pressure-sensitive tapes are shown in a swatch and data chart. Armak Co.

CHECK NO. 307

Metric drafting aids

A line of metric templates includes circles, squares, diamonds, ellipses, triangles, hex bolts and nuts, screw threads, parallel spacers, radius guides. RapiDesign.

CHECK NO. 308

Ceramic materials chart

A properties chart outlines typical physical, electrical, mechanical and thermal characteristics of the company's technical ceramic materials. Included are four grades of beryllia, thoria, three grades of alumina and three grades of Carberlox, a proprietary ceramic material containing beryllia and silicon carbide. National Beryllia Corp.

CHECK NO. 309

Guide to MOS ICs

A combination cross-reference guide and selector of MOS devices comes in a handy slide rule. One side contains a MOS device selector that provides the user with key specifications on any standard Signetics MOS circuit. Categories include shift registers, RAMs, ROMs, character generators and special circuits, such as a universal asynchronous receiver transmitter and a FIFO buffer register. On the reverse side is a directory to identify alternate sources for MOS devices. Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086.

new literature

Push-button switches

Bulletin 2803 provides description, applications and specifications for standard pushbutton switches. Airpax Electronics, Fort Lauderdale, Fla.

CHECK NO. 320

Silicone molding compounds

"Silicone Semiconductor Molding Compounds and Selection Guide," an eight-page bulletin, describes a line of silicone molding compounds that can be transfer or injection-molded. Dow Corning, Midland, Mich.

CHECK NO. 321

Capacitors

A 60-page catalog covers glass, ceramic and solid-tantalum capacitors, metal-film resistors and Cordip discrete-component networks. Physical specifications for all products are presented in English and metric units. Performance specifications and curves are presented. Corning Glass Works, Corning, N.Y.

CHECK NO. 322

Programmable controllers

Mark I Un-Computer Programmable Controller Systems are described in a two-color, 20-page bulletin. The bulletin is illustrated with block diagrams and halftones. It includes specifications for the basic controller. FX Systems, Saugerties, N.Y.

CHECK NO. 323

Display technique

Basic information on a new technique called Direct Digital Graphics, developed to present organized digital data in a combined digital/analog form for rapid visual inspection, is described in an eight-page catalog. Digicom, North Chelmsford, Mass.

CHECK NO. 324

Maxi-memories

A 24-page, spiral-bound manual includes schematics and specifications of the Data Miser moving-head disc drives and the Data Miser controller. International Memory Systems, Scottsdale, Ariz.

CHECK NO. 325

Circuit breakers

Technical specifications and Mil-spec compliance details of the series HE ruggedized, subminiature hydraulic-magnet circuit breakers are detailed in a 12-page bulletin. In addition to showing time-delay curves, applications information and dimensional data, the bulletin gives a tabulation of specifications as they relate to specific MIL-C-39019 requirements. Heinemann Electric Co., Trenton, N.J.

CHECK NO. 326

Instrumentation modules

Specifications, illustrations and prices for instrumentation modules are provided in an eight-page catalog. Two housings with power supplies and 19 plug-in units are described. Over 60 measuring and control applications are listed. McKee-Pedersen Instruments, Danville, Calif.

CHECK NO. 327

Circular connector

An all-plastic circular connector that combines the features of metal cylindricals with the cost and weight advantages of plastic-bodied commercial connectors is featured in a 16-page data sheet. A full complement of application tooling, from hand-crimping tools to semiautomatic presses and automatic lead-making machines, is described. AMP, Harrisburg, Pa.

CHECK NO. 328

Wire and cable

A 112-page wire and cable catalog includes the following five sections: technical information, glossary of terminology, coaxial cable, comparison chart and general wire tables, charts and conversion factors. Standard Wire and Cable Co., Los Angeles, Calif.

CHECK NO. 329

Pinhole apertures

A four-page brochure describes standard pinhole apertures, optical slits and X-Y positioning equipment. PBL/International/Inc., Newburyport, Mass.

CHECK NO. 330

Linear Xenon flashtubes

Electrical and mechanical ratings for linear Xenon flashtubes together with spectral output data, explosion-energy and life expectancy curves, typical operating circuits and simple formulas for calculating impedance and circuit constants are given in an eight-page catalog. EG&G, Salem, Mass.

CHECK NO. 331

High-intensity LED lamps

A data sheet describes narrow-beam, high-intensity LED lamps for photoelectric applications. Genisco Technology Corp., Eldema Div., Compton, Calif.

CHECK NO. 332

Wire and cable sealants

A 15-page brochure describes DPR-based wire and cable sealants used in both strand and valley sealing. Hardman, Belleville, N.J.

CHECK NO. 333

Dc magnetic hysteresigraphs

"Direct-Current Magnetic Hysteresigraphs—STP 526" presents state-of-the-art dc recording hysteresigraphs. Contents of the 62-page book are recording fluxmeter of high-accuracy and sensitivity with galvanometer-photoelectric integrators, all-electronic magnetic hysteresigraph, electronic hysteresigraphs, some measurements of inhomogeneous permanent magnets by the pole-coil method and an integrating type of electronic hysterisigraphy. The books costs $6. American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa.

Data terminals

Data-communications terminals that provide a solution to the high operating costs of today's corporate communications networks are described in a 24-page brochure. Text and simple diagrams explain that the company's buffers incorporated into the terminals are the key to this breakthrough. The brochure describes features and provides a description of system maintenance capability. Wiltek, Inc., Norwalk, Conn.

CHECK NO. 334

Cylindrical connectors

Cylindrical high-density connectors are featured in a 32-page catalog. The publication contains descriptions of the 100% no-scoop connector design, along with information on shell styles, dimensions, contacts, insert arrangements, performance characteristics, accessories and adaptors. Assembly and disassembly instruction procedures are included. Cinch Connectors div. of TRW, Elk Grove Village, Ill.

CHECK NO. 335

Instrument rental

A 68-page catalog contains specifications and rental prices of all electronic equipment offered by the company. Amplifiers, power supplies, generators, attenuators, meters and oscilloscopes are among the equipment listed. Rental Electronics, Inc., Lexington, Mass.

CHECK NO. 336

Shaft encoders

Electrical and mechanical specifications for the English/metric incremental shaft encoder are detailed in a four-page bulletin. Trump-Ross, North Billerica, Mass.

CHECK NO. 337

Measurement equipment

Automatic electro-optical inspection and control systems that provide practical solutions to such problems as edge sensing, dimensional inspection, parts positioning, tracking and defect detection are described in a four-page brochure. New Jersey Div. of Conrac, Caldwell, N.J.

CHECK NO. 338

Modem

A six-page brochure describes the model 2011, a Bell 201A compatible modem capable of synchronous operation at 2000 bits per second over dial-up telephone lines. Included are descriptions of features, theory of operation and specifications. An outline drawing of the PC card is included, as well as a block diagram, a data-mode timing diagram, an illustration showing transmitted signal-frequency spectrum, and a block diagram of both calling and answering station call-procedure sequences. Intertel, Inc., Burlington, Mass.

CHECK NO. 339

Signal sources

Seventeen versatile signal sources for applications from dc to 2 GHz are described in a 20-page booklet. Featured are nine models of synthesizers including a high-performance 500-MHz unit, six low-noise oscillators and two standard-signal generators. General Radio, Concord, Mass.

CHECK NO. 340

Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card.
(Advertisement)

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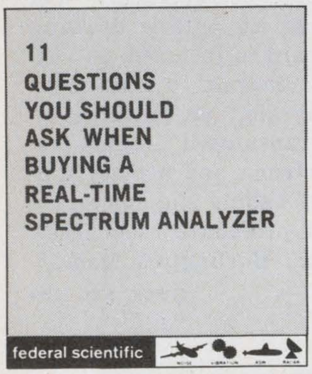

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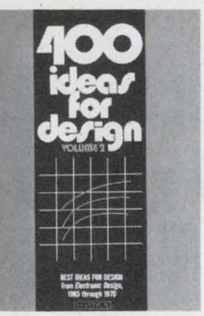

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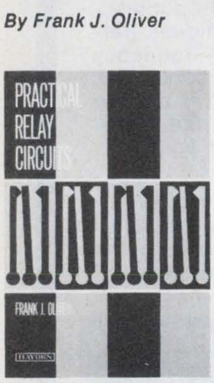

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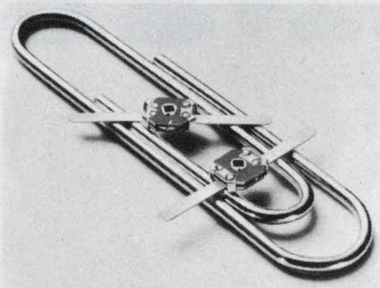

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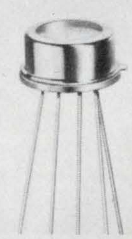

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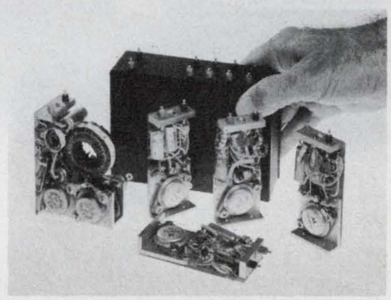

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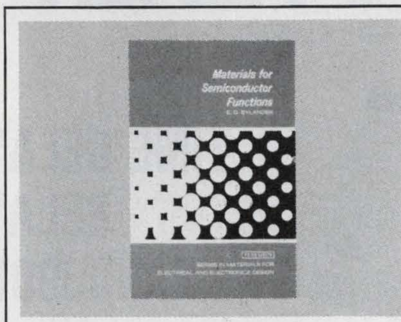

Materials for Semiconductor Functions, by E. G. Bylander. Practical handbook for selecting materials for diodes and transistors for applications in amplifiers, generators, and multi-junction devices. 220 pp., 6 x 9, illus., cloth, $13.50. Circle number below for 15-day examination copy. Hayden Book Company, Rochelle Park, N.J. 07662.

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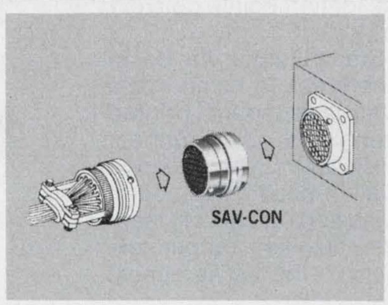

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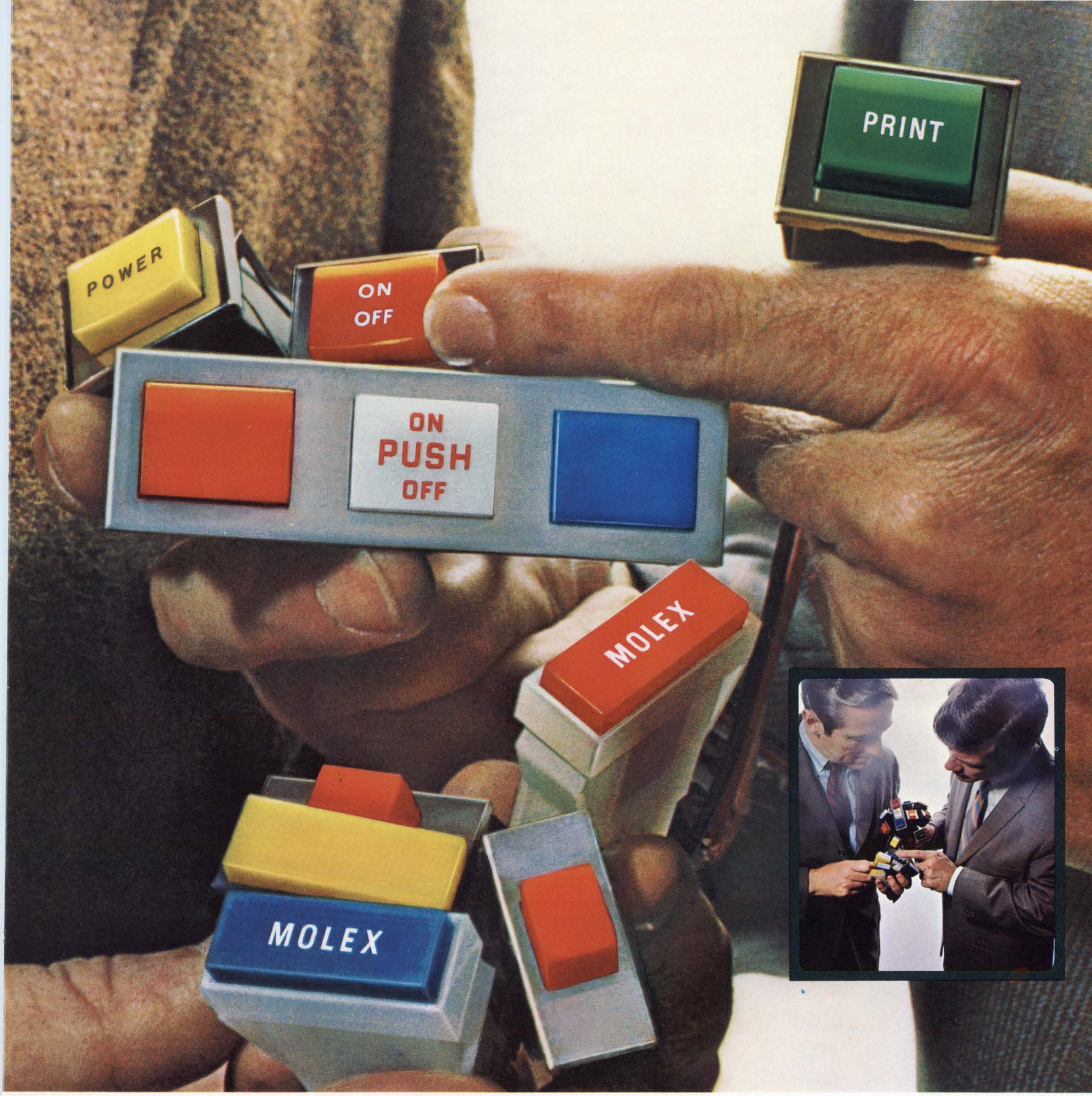

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